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SIMATIC

SM 335 – High-Speed Analog Input/Output Module for the SIMATIC S7-300

Manual

08/2004 Edition

6ES7 335-7HG00-8BA1

Safety-Related Guidelines

This manual contains notices intended to ensure personal safety, as well as to protect the products and connected equipment against damage. These notices are highlighted by a warning triangle and are graded according to severity by the following texts:

Danger

Indicates that death, severe personal injury or substantial property damage **will** result if proper precautions are not taken.

Warning

Indicates that death, severe personal injury or substantial property damage **can** result if proper precautions are not taken.

Caution

Indicates that minor personal injury or property damage can result if proper precautions are not taken.

Caution

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

Notice

contains important information about the product, its operation or a part of the document, to which special attention is drawn.

Qualified Personnel

A device/system may only be commissioned or operated by **qualified personnel**. Qualified personnel as referred to in the safety guidelines in this document are persons authorized to start up, ground and tag circuits, equipment and systems in accordance with established safety practice.

Proper Usage

Please observe the following:

Warning

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The product will function correctly and safely only if it is transported, stored, set up, and installed as intended, and operated and maintained with care.

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Exclusion of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

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Preface

Important

In order to obtain SIMATIC interference immunity, the SM 335 module **must** always be operated with an interference suppression filter (see Section 2.6).

Content of this manual

This manual describes the function of the SM 335 analog input/output module; AI4/AO4 x 14/12 bits. In the following, this module will simply be called SM 335.

Aim of this manual

The information contained in this manual will enable you to:

- Use a SM 335 in a SIMATIC S7-300.
- See operator inputs, function descriptions and technical specifications in connection with the SM 335.

Scope of this manual

The manual is valid for the following modules:

Module	Order Number	From Revision Level
SM 335	6ES7 335-7HG01-0AB0	02

This manual contains the descriptions of these modules that are valid at the time the manual is released. For new modules and new versions of modules, we reserve the right to add to the manual a product information containing the current information about this module. Section 1.2 describes how to determine the revision level of a module.

Scope of the documentation package

You can order the documentation for the SM 335 separately from the module. The order number for the manual appears in the table below:

Documentation	Order Number
• *SM 335 - High-Speed Analog Input/Output Module for the SIMATIC S7-300*	6ES7 335-7HG00-8BA1

Other references

More information about using and installing SIMATIC S7-300 analog modules can be found in:

- *SIMATIC Programmable Controller, S7-300 Module Data* Reference Manual
- *SIMATIC S7-300, Hardware and Installation* Manual

The installation guidelines described in this document also relate to the SM 335.

Required basic knowledge

This manual assumes general knowledge of automation engineering.

Knowledge of the SIMATIC S7 programmable controller and the STEP 7 Engineering System is also required.

Approbations

The S7-300 programmable controller has obtained the following approvals:

- Underwriters Laboratories, Inc.: UL 508 registered (Industrial Control Equipment)
- Canadian Standards Association: CSA C22.2 number 142, (Process Control Equipment)
- Factory Mutual Research: Approval Standard Class Number 3611.

CE Approval

The S7-300 programmable controller meets the requirements and safety-related requirements of the following EC directives:

- EC Directive 73/23/EEC “Low-Voltage Directive”
- EC Directive 89/336/EEC “EMC Directive”

C-Tick-Mark

The S7-300 programmable controller meets the requirements of the AS/NZS 2064 standard (Australia and New Zealand).

Standards

The S7-300 programmable controller meets the requirements and criteria of the IEC 61131-2 standard (Programmable Controllers, Part 2: Equipment Requirements and Tests).

How the manual fits in

Manual • CPU 31xC and CPU 31x, Technical Specifications	Operation and display elements, communication, memory concept, cycle and response times, technical specifications.
Reference Manual • CPU data: CPU 312 IFM - 318-2 DP	Operation and display elements, communication, memory concept, cycle and response times, technical specifications.
Manual • S7-300, CPU 31xC and CPU 31x: Hardware and Installation	Configuration, installation, wiring, addressing, commissioning, maintenance, diagnostics, and interference suppression.
Installation Manual • S7-300 Programmable Controller: Hardware and Installation: CPU 312 IFM - 318-2 DP	Configuration, installation, wiring, addressing, commissioning, maintenance, diagnostics, and interference suppression.
System Manual • PROFINET system description	Basic information about PROFINET: Network components, data exchange and communication, PROFINET IO, component based automation, application example PROFINET IO and component based automation.
Programming Manual • From PROFIBUS DP to PROFINET IO	Guide to migration from PROFIBUS DP to PROFINET IO.
Manual • CPU 31xC: Technological Functions • Examples	Description of individual technological functions: Positioning, counting, point-to-point coupling, control. The CD contains examples for the technological functions.
Reference Manual • S7-300 Programmable Controller:Module Data	Descriptions of functions and technical specifications of signal modules, power supply modules and interface modules.
Instruction List • CPU 312 IFM - 318-2 DP • CPU 31xC and CPU 31x	The instruction set lists of the CPUs and their execution times; A list of executable blocks.

Getting Started The Getting Started documents below are available as an anthology: • CPU 31x: Commissioning • CPU 31xC: Commissioning • CPU 31xC: Positioning with analog output • CPU 314C: Positioning with digital output • CPU 31xC: Counting • CPU 31xC: Rules • CPU 31xC: Point-to-point connection • CPU 31x-2 PN/DP: Commissioning of a PROFINET IO subnet	Getting Started documents use a concrete example to guide you through the individual commissioning steps until you have a functioning application.
Manual You are reading manual • SM 335 - High-Speed Analog Input/Output Module for the SIMATIC S7-300	Description of how you use the SM 335 module in a SIMATIC S7-300. Overview of operations, descriptions of functions and technical specifications of the SM 335.
Reference Manual System software for the S7-300/400 system and standard functions	Description of system functions (SFC), system function blocks (SFB) and organization blocks (OB). This manual is part of the STEP 7 documentation package. The description can also be found in the STEP 7 online help.
Manual SIMATIC NET: Twisted Pair and Fiber Optic Networks	Description of industrial Ethernet networks, network configuration, components, installation guidelines for networked automation systems in buildings, etc.
Manual Component based Automation: Configuring systems with SIMATIC iMap	Description of SIMATIC iMAP configuration software.
Manual Programming with STEP 7 V5.3	Programming with STEP 7.
Manual Communication with SIMATIC	Fundamentals, services, networks, communication functions, connection of PG/OP, configuration in STEP 7.

Additional Support

Please contact your local Siemens representative if you have any queries about the product described in this manual, which are not answered here.

`http://www.ad.siemens.com/automation/partner`

Training center

We offer a range of relevant courses to help you to get started with the SIMATIC S7 programmable controller. Please contact your local training center or the central training center in Nuremberg, D 90327 Germany.
Phone: +49 (911) 895-3200

Internet: `http://www.sitrain.com`

A&D Technical Support

Worldwide, available 24 hours a day:

Technical Support

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The languages of the technical support and authorization hotlines are generally German and English.		

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In addition to our documentation, our whole range of expertise can be accessed online at:

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Where you will find:

- The Newsletter, which constantly provides you with up-to-date information about your products.
- The documents you need via our Search function in Service & Support.
- A forum, where users and experts from all over the world exchange their experiences.
- Your local representative for Automation & Drives, via our database of representatives.
- Information about field service, repairs and spare parts. Much more can be found under “Services”.

Queries

If you have any queries about the S7-300 programmable controller, please contact your local Siemens representative.

In case you have any questions or suggestions concerning this manual, please fill in the correction sheet and return it to us. The correction sheet can be found at the end of the manual.

Contents

Characteristics and Technical Specifications of the SM 335 1

SIMATIC S7-300

The SM 335 is an input/output module (signal module) for the SIMATIC S7-300. The SM 335 has the same general technical specifications as all signal modules of the SIMATIC S7-300.

Order number

Order the SM 335 under the following order number:
6ES7 335-7HG01-0AB0

In this chapter

We deal with the following topics in this chapter:

1.1 Characteristics features of the SM 335

Characteristic features

The SM 335; AI4/AO4 14/12 bit has the following characteristic features:

Analog inputs:

- Four isolated analog inputs
- Integrated 10 V/25 mA sensor power supply
- Measured-value resolution:
  - Bipolar: 13 bits + sign
  - Unipolar: 14 bits
- Selectable measured value:
  - Two voltage inputs
  - Two inputs, which can be used as either current or voltage inputs

Analog outputs:

- Four isolated analog outputs
- Selectable range for each analog output

  For the analog outputs, you can connect loads over a two-wire connection only!
- Analog value resolution:
  - Bipolar: 11 bits + sign
  - Unipolar: 12 bits

Operating modes:

- 2 standard operating modes:
  - Free cycle
  - Conditional cycle
- 2 special operating modes:
  - Comparator
  - Measuring Only

Interrupts/diagnostics:

- Programmable diagnostics
- Programmable diagnostic interrupt
- Programmable end-of-cycle interrupt (generates a hardware interrupt on the CPU)

1.2 Terminal connection diagram for the SM 335

Terminal connection diagram

Figure 1-1 shows the terminal connections for the SM 335 analog input/output module.

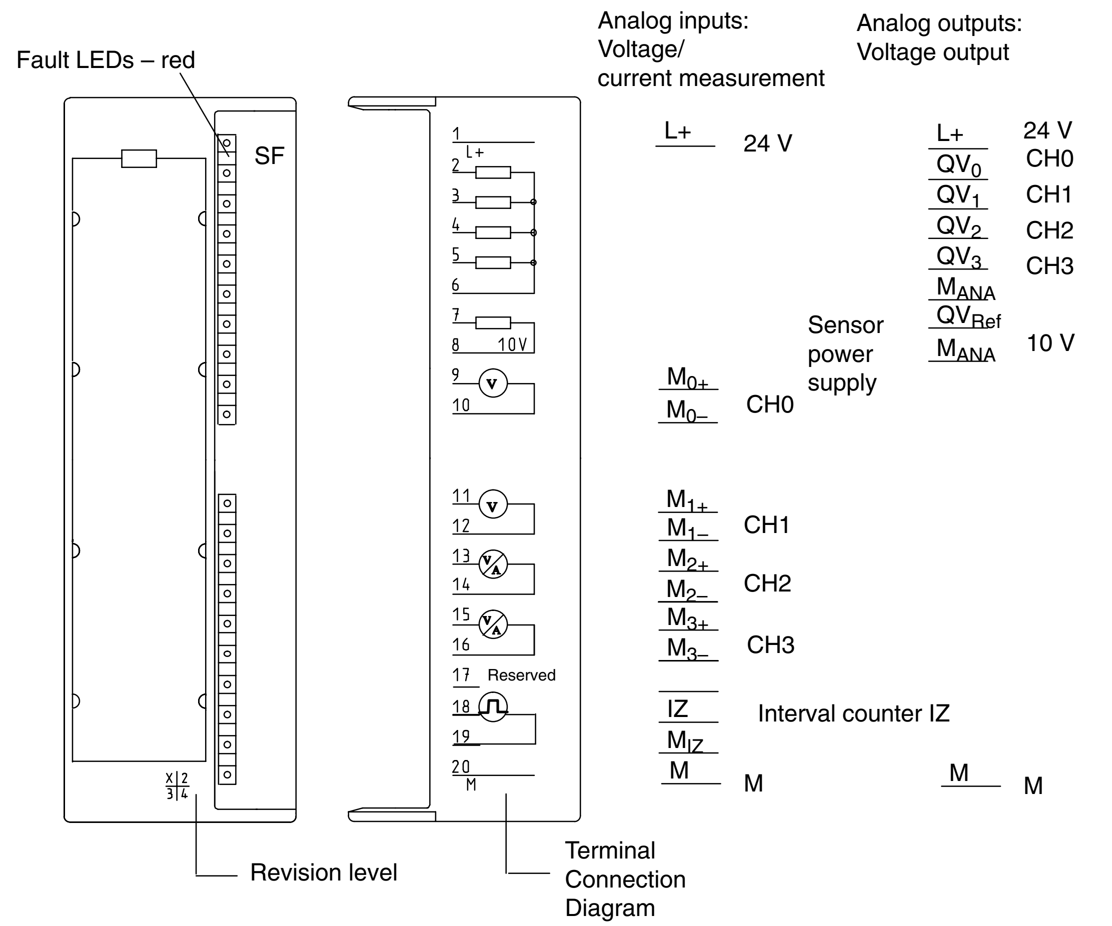

Fig. 1-1 Terminal connection diagram of the SM 335

Wiring

See Chapter 2 and to the *SIMATIC S7-300, Hardware and Installation* Manual for information about how to wire inputs and outputs on the SM 335.

Revision Level

Products with the same number can be distinguished by the revision level.
The revision level is incremented by upwardly-compatible function expansions or fault corrections.
The revision level of the module is identified by “X” (see Figure 1-1); in this case the revision level is 1.

1.3 Block diagram of the SM 335

Block diagram

Figure 1-2 shows the block diagram of the SM 335. You will find detailed technical specifications for the SM 335 on the following pages.

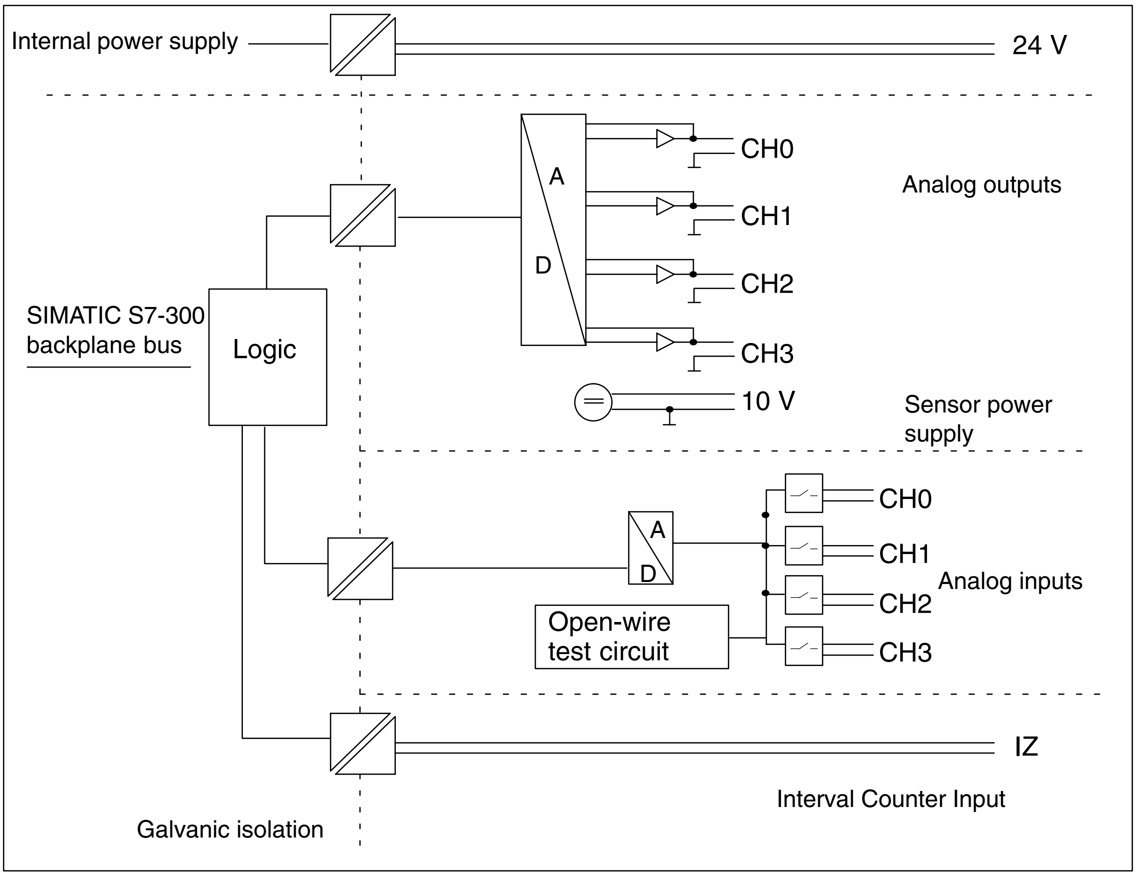

Fig. 1-2 Block Diagram of the SM 335

Galvanic isolation

As you can see from Figure 1-2, the SM 335 contains different analog parts.
The analog outputs are isolated from the backplane bus of the SIMATIC S7-300. The outputs are on the same potential M_{ANA}. The output for sensor supply has the same potential M_{ANA} as the analog outputs.

The analog inputs are isolated from each other and from the backplane bus of the SIMATIC S7-300.

The input for the interval counter IZ is isolated from the other analog parts and from the backplane bus of the SIMATIC S7-300.

1.4 Setting the measuring range with the measuring range module

Measuring range module

A measuring range module is located on the left of the input/output module. The measuring range module is used to set the method of measuring on the analog inputs, that is, to choose between voltage and current measuring.

Settings

The measuring range module can be set for “A”, “C” or “D”.

The default setting is “D”.

Table 1-1 shows the allocation of measuring range module settings to possible connections of the analog inputs.

The measuring range is set using HW Config. You can select from different current or voltage ranges (see Section 3.2).
The required measuring range module setting is also displayed in HW Config.

Table 1-1 Measuring range module settings and measuring range defaults on the SM 335

Setting of the measuring range module	Analog input wiring	Measuring range (default value)
A	Input 0: Voltage	± 10 V
	Input 1: Voltage	± 10 V
	Input 2: Voltage	± 10 V
	Input 3: Current	4 to 20 mA
B	Not assigned	–
C	Input 0: Voltage	± 10 V
	Input 1: Voltage	± 10 V
	Input 2: Current	4 to 20 mA
	Input 3: Current	4 to 20 mA
D	Input 0: Voltage	± 10 V
	Input 1: Voltage	± 10 V
	Input 2: Voltage	± 10 V
	Input 3: Voltage	± 10 V

1.5 Technical specifications for the SM 335

1.5.1 General technical specifications

Table 1-2 General technical specifications

Dimensions and weight	
Dimensions W x H x D (mm)	40 x 125 x 120
Weight	Approx. 300 g
Module-specific data	
Number of inputs	4
Number of outputs	4
Cable length shielded	200 m
With open-wire test in the range 0 to 10 V	30 m
Voltages, currents, potentials	
Rated load voltage L+ • Polarized Galvanic isolation	24 V DC Yes Yes
Permissible potential difference • Between inputs (U_{CM}) • Between input (M terminal) and central grounding point • Isolation tested with 500 V DC	 3 V/1.5 V (10 V ranges) 75 V DC/60 V AC
Power consumption • From SIMATIC S7-300 backplane bus • From L+ • Module power loss	 Max. 75 mA Max. 150 mA Max. 3.6 W
Status, interrupts, diagnostics	
Interrupts • Comparator interrupt • End-of-cycle interrupt • Diagnostic interrupt	 NO Yes, programmable Yes, programmable
Diagnostic functions • Fault indication on the module in the event of a group fault • Diagnostic information can be read out	Yes, programmable Yes, red LED Yes
Miscellaneous	
UL/CSA/FM	Yes

1.5.2 Technical specifications for the analog inputs

Table 1-3 Technical specifications for the analog inputs

Noise suppression and error limits for the inputs		
Suppression of noise voltage for f = n x (f1 ± 1%), (f1 = interference frequency) • Common-mode noise (U_{pp} < 3 V) • Series-mode noise (peak noise value < rated value of the input range)	> 65 dB 0 dB	
Crosstalk between inputs • At 50 Hz • At 60 Hz	–65 dB –65 dB	
Operational limit for voltage measuring (over entire temperature range, based on input range)	± 0.15% (for 14-bit resolution)	
Operational limit for current measuring (over entire temperature range, based on input range)	0.25%	
Basic error (operational limit at 25 °C, based on input range)	± 0.1% (for 14-bit resolution)	
Temperature drift (based on input range)	± 0.13%	
Linearity error (based on input range)	± 0.015%	
Repeatability (in steady state at 25 °C, based on input range)	± 0.05%	
Sensor selection data		
Input ranges (rated values)/input resistance • Voltage • Current (max. 2 channels)	± 1 V ± 10 V ± 2.5 V 0 to 2 V 0 to 10 V ± 10 mA 0 to 20 mA 4 to 20 mA	10 MΩ 10 MΩ 10 MΩ 10 MΩ 10 MΩ 100 Ω 100 Ω 100 Ω
Permissible input voltage for voltage input (destruction limit)	± 30 V	
Permissible input current for current input (destruction limit)	25 mA	
Connecting of sensors • For measuring voltage • For measuring current – As 2-wire measuring transducer – As 4-wire measuring transducer • For measuring resistance	Possible Not possible Possible Not possible	

Table 1-3 Technical specifications for the analog inputs

Analog value formation for the outputs	
Measuring principle	Successive approximation
Conversion time (per channel) in μs • Basic conversion time for 4 channels in ms	Max. 200 Max. 1
Resolution • Bipolar • Unipolar	 13 bits + sign 14 bits
Data of output to sensor supply	
Rated voltage	10 V
Max. output current	25 mA
Short-circuit-proof	Yes
Operational limit (over entire temperature range)	0.2%
Temperature drift	0.002%/K
Basic error for rated voltage	0.1%

1.5.3 Technical specifications for the analog outputs

Table 1-4 Technical specifications for the analog outputs

Analog value formation for the outputs	
Resolution (incl. overrange) • ± 10 V • From 0 to 10 V	 11 bits + sign 12 bits (+ sign)
Conversion time in µs	Max. 800
Setting time • For resistive load • For capacitive load • For inductive load	 < 0.1 ms ≤ 3.3 ms < 0.5 ms
Injection of substitute values	Yes
Noise suppression and error limits for the outputs	
Crosstalk between outputs	–40 dB
Operational limit (over entire temperature range, based on output range)	0.5%
Basic error (operational limit at 25°C, based on output range)	0.2%
Temperature drift (based on output range)	0.02%/K
Linearity error (based on output range)	± 0.05%
Repeatability (in steady state at 25 °C, based on output range)	± 0.05%
Output ripple (based on output range)	± 0.05%
Actuator Selection Data	
Output range (rated values)	± 10 V From 0 to 10 V
Burden resistance • For voltage outputs • For capacitive load • For inductive load	 Min. 3 kΩ Max. 1 µF Max. 1 mH
Voltage output • Short-circuit protection • Short-circuit current	 Yes Max. 8 mA
Connection of actuators • For voltage output – 2-wire connection – 4-wire connection (measuring circuit)	 Possible Not possible

1.5.4 Technical specifications for the interval counter

Table 1-5 Technical specifications for the interval counter

Interval-counter-specific data	
Number of inputs	1
Cable length shielded	200 m
Voltages, currents, potentials	
Rated load voltage L+ • Polarized	24 V DC Yes
Galvanic isolation	Yes
Permissible potential difference • Interval counter input (M_{IZ} terminal) to the four analog inputs • Between input (M_{IZ} terminal) and central grounding point	 75 V DC/60 V AC 75 V DC/60 V AC
Analog value formation for the interval counter input	
Measuring principle	Detection of a rising edge and measuring the amount of time between two edges
Resolution of the time difference	0.5 μs
Max. frequency • Programmable • Interference suppression for interference frequency f1 in dB	400 Hz NO 0
Noise suppression and error limits for the input	
Noise suppression for F = n × (f1 ± 1%), (f1 = interference frequency) • Common-mode noise (U_{pp} < 3 V) • Series-mode noise (peak noise value < rated value of the input range)	 > 80 dB 0 dB
Operational limit (over entire temperature range)	Max. 1% at 400 Hz
Basic error (operational limit at 25 °C)	0.005%
Temperature drift (0 to 60 °C)	± 0.003%/K
Linearity error	0

Table 1-5 Technical specifications for the interval counter

Sensor selection data	
Permissible input voltage (destruction limit)	± 30 V
Permissible input current for interval input (destruction limit)	5 mA
Minimum permissible pulse widths at the counter input • “Low” • “High”	 1 ms 1 ms
Permissible voltage range between IZ and M_{IZ} terminals • For “Low” pulse • For “High” pulse	 – 30 V to + 5 V (– 4.4 mA to 0.7 mA) + 18 V to + 30 V (2.5 mA to 4.4 mA)

1.6 SM 335 operating modes

Operating modes

The SM 335 can operate in the following modes:

- Free cycle (corresponds to HW Config setting for SM 335: 0.5 ms cycle time)
- Conditional cycle (corresponds to HW Config setting for SM 335: 1 to 16 ms cycle time)

Special operating modes

In addition, the SM 335 can be switched to the following modes for a brief period of time:

- “Comparator” special mode
- “Measuring Only” special mode

The special operating modes are described in Chapter 5, where there is also a description of how to switch to the special operating modes.

1.6.1 Free Cycle mode

Cycle

In conjunction with the SM 335, the word “cycle” is used to mean the measuring of the analog value at all analog inputs in succession. Once the measuring cycle is complete and all inputs have been read, the cycle starts again from the beginning. This cycle has nothing to do with cyclic program scanning on a SIMATIC S7 CPU.

Free Cycle

When the SM 335 operates in Free Cycle mode, all SM 335 analog inputs and outputs are processed successively and without interruption. After all inputs and outputs have been processed, conversion once again begins with the first analog input.

Free Cycle mode is activated when a cycle time of 0.5 ms is set for the SM 335 in HW Config.

Figure 1-3 shows the various components of the cycle time for a free cycle.

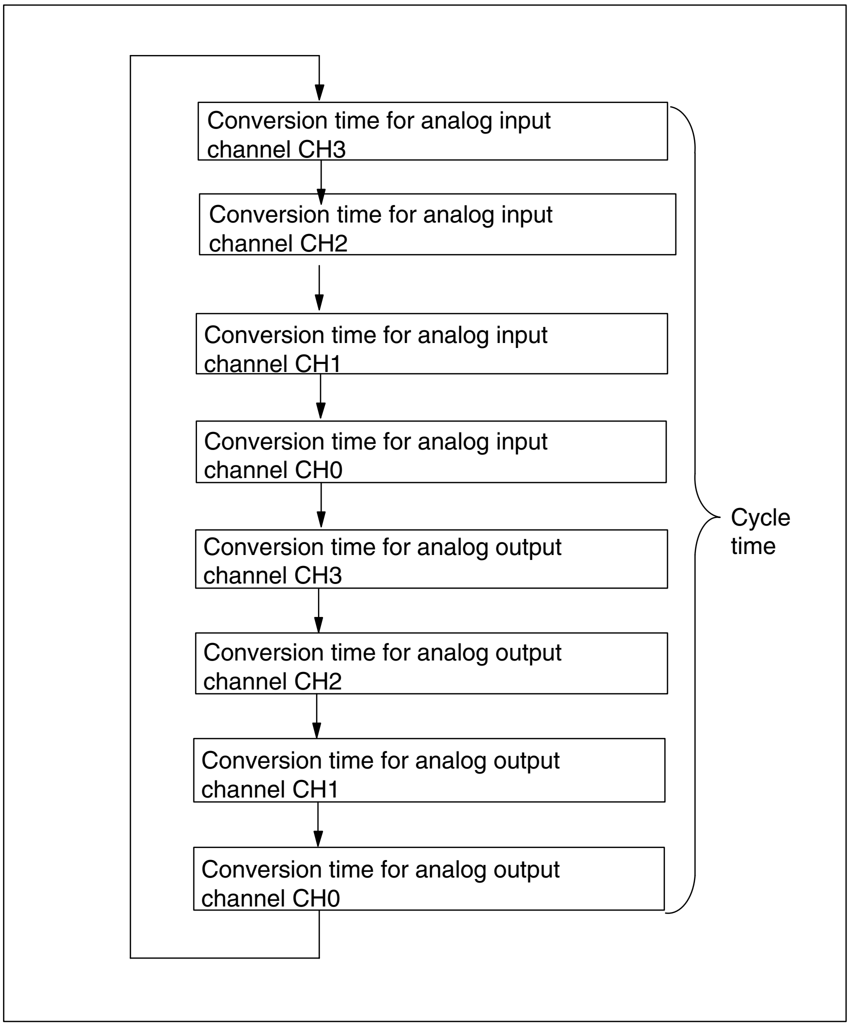

Fig. 1-3 Cycle time for the SM 335 free cycle

The execution times in Free Cycle mode are comprised as follows:

- Base load of a cycle: approx. 200 μs
- Execution times for the reading in of an analog channel: approx. 200 μs
- Execution time for the output of an analog value: approx. 50 μs

The SM 335 only updates the relevant analog output channel when modifications are made to the output value.

- Four activated input channels and four activated output channels with the required output, which is dependent on constantly changing values, yields a cycle time of 1200 µs (200 µs + 4 x 200 µs + 4 x 50 µs).
- Four activated input channels and four activated output channels with unchanged or rarely changing output values, yields a cycle time of 1000 µs (200 µs + 4 x 200 µs + 4 x 0 µs).
- One activated input channel and four activated output channels with unchanged or rarely changing output values, yields a cycle time of 400 µs (200 µs + 1 x 200 µs + 4 x 0 µs).

Deselecting diagnostics does not affect the cycle time.

1.6.2 Conditional Cycle mode

Conditional Cycle

In the conditional cycle operating mode, you can define the cycle time. Following conversion of all analog inputs, the SM 335 can generate an end-of-cycle interrupt to the CPU (see Subsection 3.4.1 Hardware Interrupt). The SM 335 then waits while the analog outputs are updated and begins the next processing cycle after the specified cycle time has expired.

The end-of-cycle interrupt can be used to synchronize a user program via OB 40. Furthermore, the interrupt enables high-speed processing of the user program (e.g., for closed-loop control routines).

Conditional Cycle mode is activated when a cycle time of 1 to 16 ms is set for the SM 335 in HW Config.

Figure 1-4 shows the various components of the cycle time for a conditional cycle.

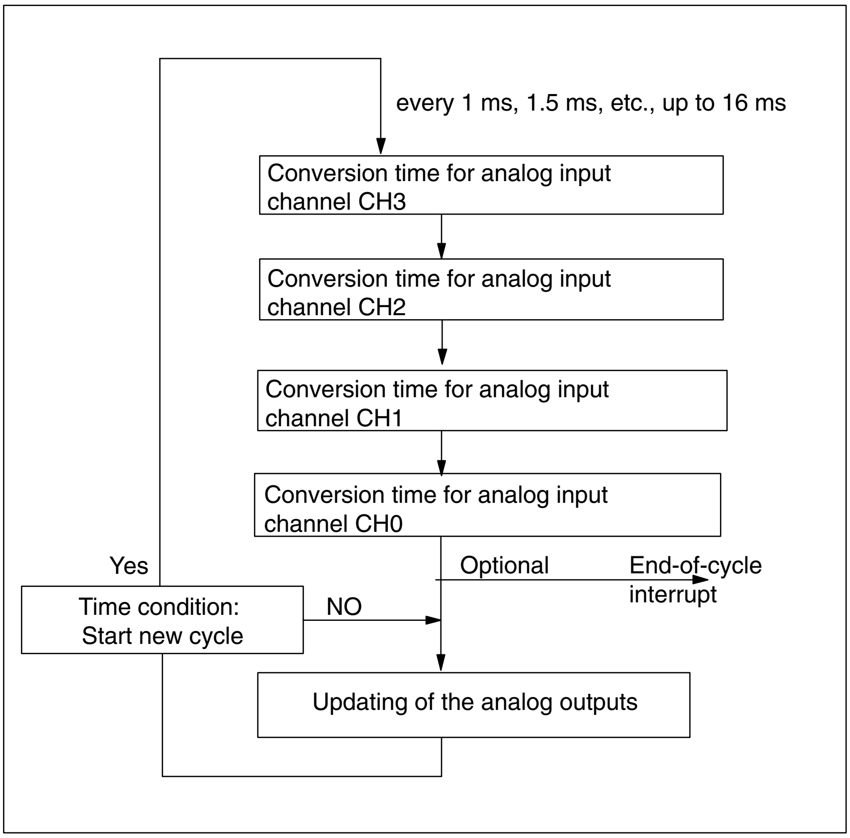

Fig. 1-4 Cycle time for a conditional SM 335 cycle

Connecting the Inputs and Outputs of the SM 335

2

Assembly

Before connecting the SM 335, you must first assemble the SM 335. The SM 335 is assembled in the same way as all other SIMATIC S7-300 I/O modules. Please read the *SIMATIC S7-300 Hardware and Installation Manual*.

SIMATIC S7-300

When connecting the SM 335, please note the installation guidelines in the *SIMATIC S7-300 Hardware and Installation Manual*. In the SM 335 Manual, we describe special features that only apply to the SM 335.

In this chapter

We deal with the following topics in this chapter:

Topic	Section
Basic information about connecting the SM 335	2.1
Connecting the analog inputs	2.2
Connecting the analog outputs	2.3
Connecting the interval counter input	2.4
Connecting the sensor supply	2.5
Interference suppression filter for 24 V supply voltage	2.6

2.1 Basic information about connecting the SM 335

Connecting the analog inputs and outputs

You can find detailed information about connecting the analog inputs and outputs in the *SIMATIC Programmable Logic Controller, S7-300 Module Data* Reference Manual.

Rules

The following applies:

- The cables must be twisted-pair cables, protected against interference and shielded.
- The accuracy of your measurements depends on the following:
  - Load
  - Cable between the SM 335 and the load
  - Reference voltage

Power supply

The SM 335 must be supplied with 24 V DC. The 24 V must be connected to L+ (PIN 1), the 24 V's zero potential to M (PIN 20).

Grounding

You can ground the 24 V power supply in the following way:

- Direct on the 24 V power supply unit or
- On the S7 CPU (if you use the 24 V power supply on the CPU).

2.2 Connecting the analog inputs

Recommendation

The high conversion speed of the SM 335 means that the interference produced can have a negative effect on the measurement input voltages in particular. The configuration described below is in general the configuration, which is least susceptible to interference.

The SM 335's analog inputs and the associated zero potential should be connected to a terminal block, and the zero potential for the analog inputs distributed over the block.

Configuration

The result is the following basic configuration:

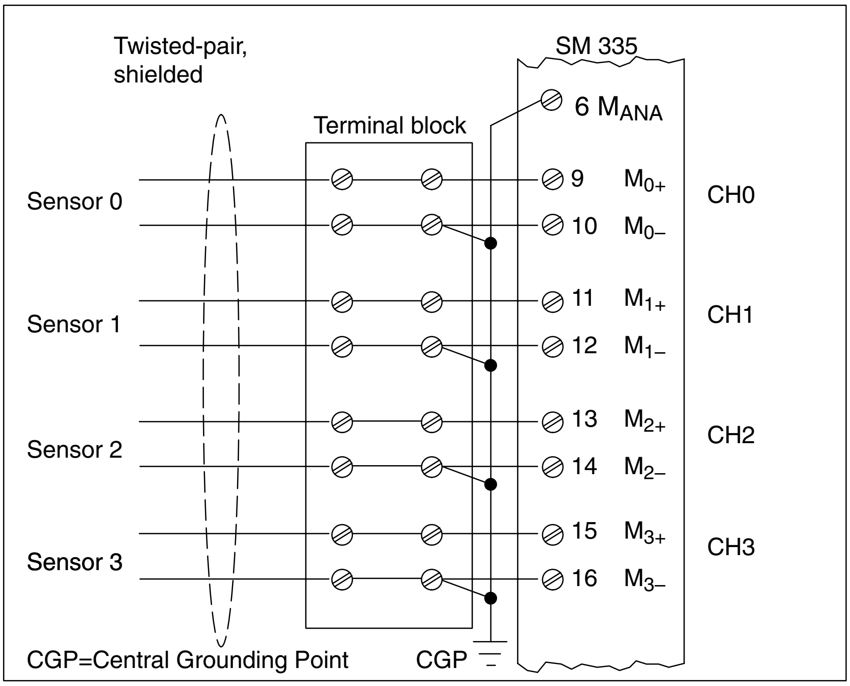

Fig. 2-1 Connecting Sensors to the Analog Inputs on the SM 335

Non-Isolated

In contrast to other applications (e. g., when connecting thermocouples), you should ground the sensors' analog zero potential in the vicinity of the SM 335. The easiest way to do so is to connect pins 10, 12, 14 and 16 with analog zero potential M_{ANA} (PIN 6) and connect M_{ANA} in the vicinity of the module in the rack with the central grounding point (CGP) of the module. This connection should be as short as possible.

Do not ground the sensors twice, however, as this would produce ground loops, which could result in interference. When using sensors, which are shielded and whose shields are connected to the analog zero potential, you must disconnect the shield from the analog zero potential.

Limited potential difference U_{CM}

Only a limited potential difference U_{CM} (common mode voltage) may occur between the measuring lines M- of the input channels and the reference point of the measuring circuit M_{ANA}.

In order to prevent the permissible value being exceeded, you must take various action, described below, depending on the potential connection of the sensors.

For details please see the *SIMATIC Programmable Logic Controller, S7-300 Module Data* Reference Manual.

If you use the SM 335 isolated, the maximum permissible common mode voltage must not be exceeded between the zero potential of the sensor and M_{ANA}, otherwise the SM 335 triggers a diagnostic alarm and $7FFF_H$ is read in from the relevant channel.

60 V AC/75 V DC must not be exceeded between M_{ANA} and the ground of the 24 V voltage supply.

Unused analog inputs

Unused analog inputs on the SM 335 must be short-circuited and connected to M_{ANA}. Deactivate the unused analog inputs as described in HW Config. This achieves the optimum in interference immunity for the SM 335 and the cycle time is reduced in the operating mode “free cycle”.

You can also employ unused analog inputs to monitor the sensor power supply or analog outputs. This also enhances interference immunity.

2.3 Connecting the analog outputs

Connecting the analog outputs

The analog outputs must be connected as voltage outputs. Detailed information can be found in the *SIMATIC Programmable Logic Controller, S7-300 Module Data* Reference Manual.

Recommendation

If possible, the SM 335's analog outputs, with the associated zero potential, should be connected to a terminal block from where you can tap the zero potential for the analog outputs.

Configuration

The result is the following basic configuration:

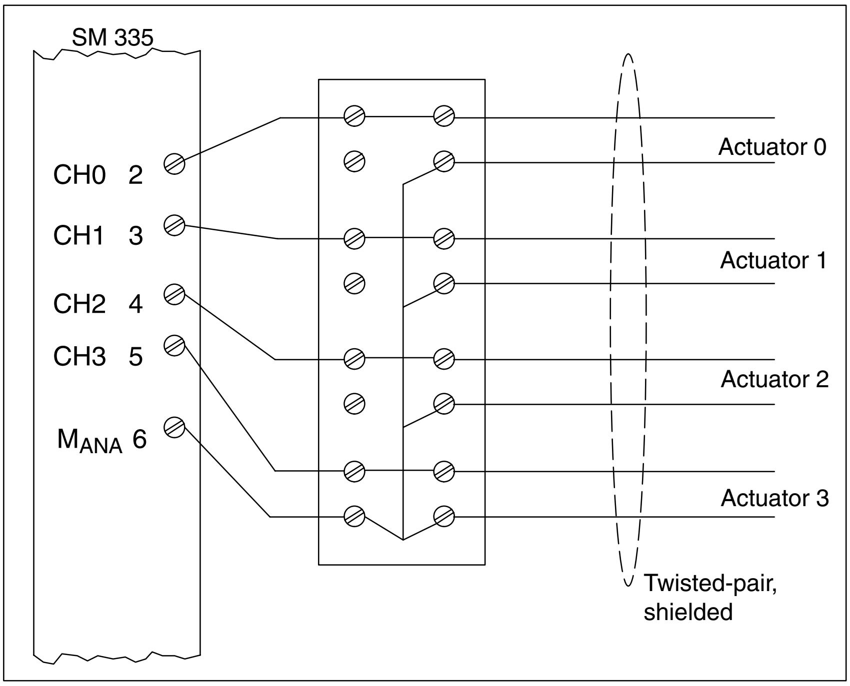

Fig. 2-2 Connecting Actuators to the SM 335

Non-Isolated

Actuators, which are shielded and whose shields are grounded and connected to the actuator's zero potential conductor, form a ground loop. You must therefore break the connection between shield and zero potential conductor on the actuator or use an actuator whose zero potential conductor is not connected to ground.

Unused analog outputs

To ensure that unused analog outputs on the SM 335 are dead, you must deactivate them and leave them open. An analog output is deactivated with HW Config.

2.4 Connecting the interval counter input

Non-Isolated

If you wire the interval counter input as a non-isolated input, connect pin 19 (M_{IZ}) and pin 20 (24 V power supply's zero potential).

Isolated

If you wire the interval counter input as an isolated input, you may not connect pin 19 (M_{IZ}) to pin 20 (24 V power supply's zero potential).

Additional information

See Section 4.3 for more information about connecting the interval counter input.

2.5 Connecting the sensor power supply

Purpose

The sensor power supply is designed for resistance-type sensors (e. g., linear potentiometers).

Connections

Figure 2-3 shows an example of how to connect the sensor power supply.

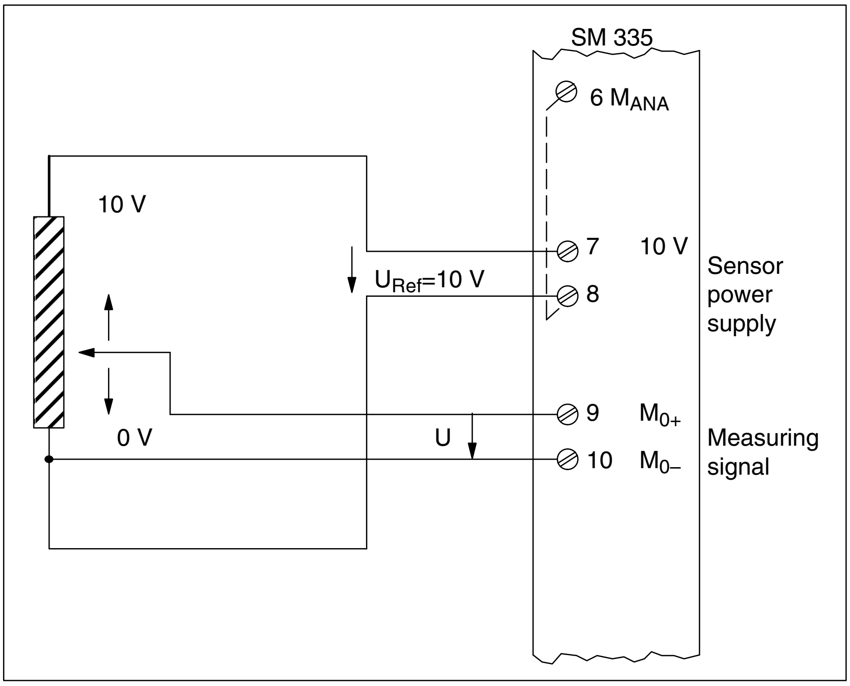

Fig. 2-3 Example of How to Supply the Sensors with Power via the SM 335

Non-isolated configuration

Internally, the SM 335's analog zero potential (pin 6) is connected with the 10 V sensor power supply's zero potential.

If you use the four-wire measuring method shown in Figure 2-3, you must not connect pin 10 to pin 6 or to zero potential. To do so would create a ground loop, which could cause interference.

Cable

There is a voltage drop on the cable between SM 335 and the linear potentiometer. Because of the SM 335's high resolution, this can play a role in the measuring of the analog signal. You can compute the voltage drop on an electric cable as follows:

$$U = \frac{r_0 \cdot I \cdot L}{A}$$

U: Voltage drop along the cable

r_0: Resistivity of the cable used (for Cu: 0,0172 Ω mm^2/m)

I: Current flowing through the cable in amperes

L: Length of the cable in meters

A: Cross-section of the cable in mm^2

Because of this, we would recommend keeping the cables as short as possible and using a cable with the largest possible cross-section.

2.5.1 Correcting the sensor power supply

Purpose

The power supply for the sensors is a 10 V output voltage. This voltage may deviate slightly from 10 V. The deviation results from the tolerances of the components used on the SM 335. You can therefore read off the exact value of the sensor power supply for applications requiring very high accuracy.

Sensor voltage (ModAdd + 10, 11)

The analog value of the sensor voltage (U_G) is factory-set and stored in the module. The SM 335 supplies the analog value of the sensor voltage U_G in input bytes ModAdd + 10 and ModAdd + 11 (see Table 3-1 in Subsection 3.1.1).

Correction factor

The correction factor K is computed from the sensor voltage U_G and the desired voltage.

$$K = \frac{27648\ (6C00_H)}{U_G}$$

U_G lies between 27620 ($6BE4_H$) and 27676 ($6C1C_H$), producing correction factors from 0.9989883 to 1.0010127.

Measured value

The corrected analog measured value is computed as follows:

$$U_{Corr} = K \cdot U_{AI}$$

U_{Corr} = Corrected analog value

K = Correction factor

U_{AI} = Analog value measured at the analog input

2.6 Interference suppression filter for 24 V supply voltage

Caution

The SM 335 module must always be used with an interference suppression filter to obtain interference immunity for SIMATIC.

Interference

Interference may reach the SM 335 via the 24 V voltage supply. One cause of such interference is the switching of loads connected to the 24 V circuit. The interference has a high-frequency content, which can impair proper functioning of the SM 335.

Interference suppression filter

The SM 335 is protected from the high-frequency content by an interference suppression filter. Connect this filter to the 24 V voltage supply circuit of the SM 335 module (see Figure 2-4).

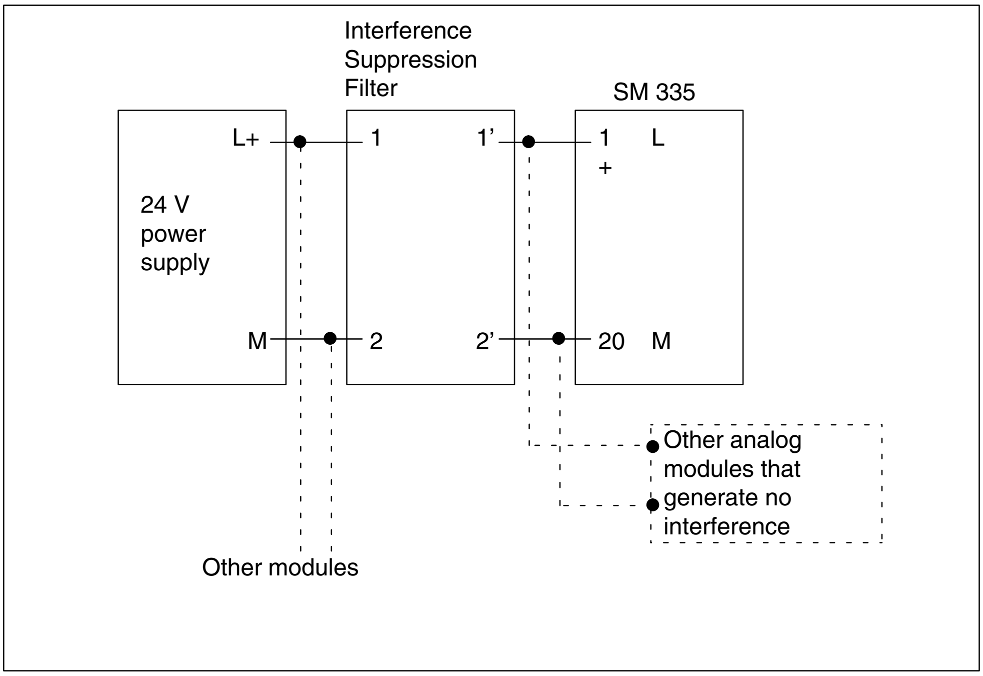

Fig. 2-4 Interference Suppression Filter for the 24 V Power Supply of the SM 335

The interference suppression filter can be used for a maximum of 4 SM 335 modules and should be located as close as possible to the SM 335.
The interference suppression filter is brought into the 24 V supply circuit even if it can be used with a higher voltage.

The interference suppression filter can be obtained by quoting order number: 6ES7 335-7HG00-6AA0

Type: e. g., EPCOS SIFI C, order reference B84113-C-B30

Please contact your local Siemens representative for more information.

Data Exchange with the SM 335 3

Preliminary remark

Data exchange with the SM 335 is defined here as follows:

- Transfer of data to the SM 335 from the CPU and
- Reading of data from the SM 335 by the CPU.

Overview

In this chapter, we have summarized all the data that can be transferred to the SM 335 or supplied by the SM 335.

Methods

There are basically several methods of reading or writing data:

- Access via the I/O addresses (e. g., with L PIW, T PQW)
- Setting parameters via HW Config
- Writing parameters with the help of system function 55
- Reading diagnostics data via system function 59
- Other methods: see Reference Manual *System Software for S7-300/400 System and Standard Functions*.

Measuring range module

Before you plug in the SM 335, you must insert the measuring range module into the SM 335. The *SIMATIC Programmable Logic Controller, S7-300 Module Data* Reference Manual describes how to insert the measuring range module into the SM 335.
The measuring method (current/voltage measurement) is set for the analog inputs depending on the position in which you plug in the measuring range module.

In this chapter

We deal with the following topics in this chapter:

Topic	Section
Access via the I/O addresses	3.1
Setting parameters via HW Config	3.2
Modifying SM 335 parameters with the help of system function 55	3.3
Evaluating SM 335 diagnostics	3.4

3.1 Access via the I/O addresses

Principle

You can access the SM 335 via I/O addresses.

Input values

Input values are values supplied by the SM 335. The input values contain measured values of the SM 335.

You can load the input values via L PIB (or L PIW or L PID) operation. As an alternative, read access is possible within the process image via L IB (or L IW or L ID). (see Table 3-1, Subsection 3.1.1)

Output values

Output values are values you write to the SM 335 via T PQB (or T PQW or T PQD) operation. As an alternative, write access is possible within the process image via T IB (or T IW or T ID).

You can transfer analog values to the SM 335 via output values. The output values are output via the SM 355's analog outputs. (see Table 3-4, Subsection 3.1.2)

3.1.1 Output values

Principle

The SM 335 converts the signals measured at the inputs into binary values.

Configuration

The input values are located in bytes ModAdd (module start address) to ModAdd + 15. See the *SIMATIC Programmable Logic Controller, S7-300 Module Data* Reference Manual for information about how to compute the module start address. Table 3-1 lists the input values, their addresses, and their default values.

Table 3-1 SM 335 Input Values

Byte	Content	Value
ModAdd + 0	High-order byte of the measuring value from measuring channel CH0	$7F_H$ *) or ***)
ModAdd + 1	Low-order byte of the measuring value from measuring channel CH0	FF_H *) or ***)
ModAdd + 2	High-order byte of the measuring value from measuring channel CH1	$7F_H$ *) or ***)
ModAdd + 3	Low-order byte of the measuring value from measuring channel CH1	FF_H *) or ***)
ModAdd + 4	High-order byte of the measuring value from measuring channel CH2	$7F_H$ *) or ***)
ModAdd + 5	Low-order byte of the measuring value from measuring channel CH2	FF_H *) or ***)
ModAdd + 6	High-order byte of the measuring value from measuring channel CH3	$7F_H$ *) or ***)
ModAdd + 7	Low-order byte of the measuring value from measuring channel CH3	FF_H *) or ***)
ModAdd + 8	Number of end-of-cycle interrupts, only for “Comparator” and “Measuring Only” modes Default = 1; If end-of-cycle interrupts have been suppressed: 1 + number of suppressed end-of-cycle interrupts	00_H *) or ***)
ModAdd + 9	Comparator mode (on power-up) or Return code for “Comparator” and “Measuring Only” modes.	00_H *) or 01_H *) or ***)
ModAdd + 10	High-order byte of the sensor voltage (see Subsection 2.5.1)	**)
ModAdd + 11	Low-order byte of the sensor voltage (see Subsection 2.5.1)	**)
ModAdd + 12	Interval counter (see Section 4.5)	00_H *) or ***)
ModAdd + 13	Interval time values in bits 16 to 24 (see Section 4.5)	FF_H *) or ***)
ModAdd + 14	Interval time values in bits 8 to 15 (see Section 4.5)	FF_H *) or ***)
ModAdd + 15	Interval time values in bits 0 to 7 (see Section 4.5)	FF_H *) or ***)

*) Initial value
**) factory-set
***) current value

Analog values (ModAdd + 0...7)

See Subsections 3.1.3 and 3.1.4 for information about how an analog value is represented in binary in the CPU and on which binary value corresponds to which analog value.

Number of end-of-cycle interrupts (ModAdd + 8)

A user program can be synchronized via OB 40 using the end-of-cycle interrupt. Fast processing of the user program is also possible via the interrupt (e. g., for adjustment routines).
There are however situations in which the SM 335 cannot send an interrupt:

- when several hardware interrupts occur simultaneously, or
- in the special “Comparator” mode.

The SM 335 suppresses end-of-cycle interrupts when the Comparator mode is enabled.

The SM 335 enters the number of suppressed end-of-cycle interrupts (1 + number of suppressed end-of-cycle interrupts) in byte ModAdd + 8 when the “Comparator mode” is exited.

Example: Content of byte 8 = 5, i. e., for 5 end-of-cycle interrupts, OB 40 is called only once.

The value is also stored in the local data of OB 40 (see Subsection 3.4.1, Hardware interrupt). Evaluation via OB 40 has the advantage of ensuring the consistency of the measured value and the number end-of-cycle interrupts.

Return code (ModAdd + 9)

When the “Comparator” or “Measuring Only” mode is activated, the SM 335
SM 335 enters the return code in byte ModAdd + 9. Figure 3-1 shows the format of the return code:

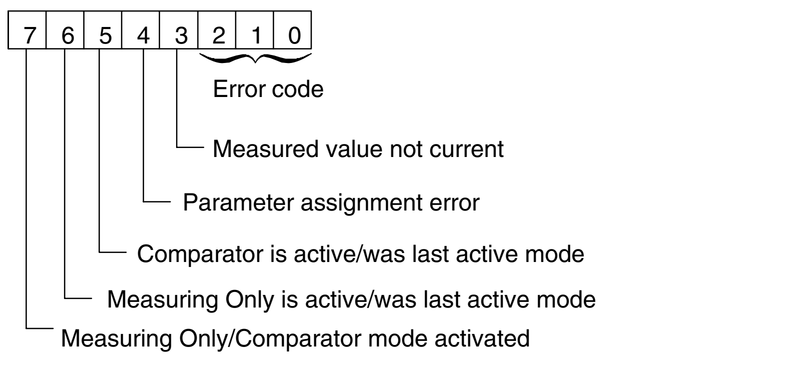

Fig. 3-1 SM 335 Return Codes

The return code bits, with their descriptions, are shown in Table 3-2.

Comparator mode is displayed instead of the return code on power-up of the SM 335.

Table 3-2 Meaning of the bits in the SM 335 return code

Bit	Description
7	= 1: SM 335 is in "Measuring Only" or "Comparator" mode = 0: SM 335 is in "Conditional Cycle" or "Free Cycle" mode
6[1)]	= 1: "Measuring Only" mode is activated / was last activated
5[1)]	= 1: "Comparator" mode is activated / was last activated
4	= 1: Mode cannot be activated. Reason: • The "Comparator" mode cannot be activated when "Measuring Only" mode is enabled. • The "Measuring Only" mode cannot be activated when the "Comparator" mode is enabled or when the "Measuring Only" mode is already active.
3	= 1: The measured value from the analog inputs is not current (for "Comparator" mode only – with Comparator 2, see Subsection 5.2.1, Principle of special "Comparator" mode)
2, 1, 0	Error code see Table 3-3

[1)] Only bit 5 or 6 can be set but not both

Table 3-3 Description of Bits 0, 1, 2 in the Return Code of the SM 335

Bit2	Bit1	Bit0	Description
0	0	0	No error
0	0	1	Parameter for operating mode 'Comparator' faulty (no analog input designated as comparator input).
0	1	0	Analog input to be used for measuring is disabled.
0	1	1	Error detected at the analog input assigned to the comparator while 'Comparator' mode was in force.
1	0	0	Operating mode exited. Reason: • Comparator: Comparator time expired (see Subsection 5.2.2) • Measuring Only (see Section 5.3): Measurement at one analog input: 60 ms expired. Measurement at 2, 3 or 4 analog inputs: 40 ms expired.
1	0	1	"Comparator" mode exited because new parameters were transferred via system function to the SM 335.

3.1.2 Output values

Principle

The analog output values converted into binary in the CPU can be transferred to the SM 335 e. g., with the command “T PQW”.
The SM 335 converts the binary form of the analog output signals into analog signals and forwards them to the relevant outputs.

Configuration

The output values can be transferred to bytes ModAdd (module start address) to ModAdd + 7 (module start address + 7).
See Configuring the SM 335 in HW Config from STEP 7 onwards for how to compute the module start address.

Table 3-4 SM 335 Output Values

Byte	Content
ModAdd + 0	High-order byte of the output value for analog output channel CH0
ModAdd + 1	Low-order byte of the output value for analog output channel CH0
ModAdd + 2	High-order byte of the output value for analog output channel CH1
ModAdd + 3	Low-order byte of the output value for analog output channel CH1
ModAdd + 4	High-order byte of the output value for analog output channel CH2
ModAdd + 5	Low-order byte of the output value for analog output channel CH2
ModAdd + 6	High-order byte of the output value for analog output channel CH3
ModAdd + 7	Low-order byte of the output value for analog output channel CH3

Analog values

See Subsections 3.1.3 and 3.1.4 for information about how an analog value is represented in binary in the CPU and on which binary value corresponds to which analog value.

3.1.3 Analog value representation for analog input channels

The tables contain representations of the measuring values of individual measuring ranges of the analog inputs.

Table 3-5 Analog Value Representation in the Bipolar Input Ranges

Measuring Range				Units		Range
± 1 V	± 10 V	± 2.5 V	± 10 mA	decimal	hexa-decimal	
1.185 V : :	11.851 V : :	2.963 V : :	11,85 mA : :	32767 : 32512	$7FFF_H$: $7F00_H$	Overflow
1,1758 V : :	11,758 V : :	2,938 V : :	11,758 mA : :	32508 : 27652	$7EFC_H$: $6C04_H$	Over-range
1 V : 0.75 V : 144.68 µV 0 V –144.68 µV : –0.75 : –1 V	10 V : 7.5 V : 1446.8 µV 0 V –1446.8 µV : –7.5 V : –10 V	2.5 V : 1.875 V : 361.69 µV 0 V –361.69 µV : –1.875 V : –2.5 V	10 mA : 7.5 mA : 1446.8 nA 0 mA –1446.8 nA : –7.5 mA : –10 mA	27648 : 20736 : 4 0 –4 : –20736 : –27648	$6C00_H$: 5100_H : 4_H 0 $FFFC_H$: $AF00_H$: 9400_H	Rated range
: : –1.176 V	: : –11.759 V	: : –2.940 V	: : –11.76 mA	–27652 : –32512	$93FC_H$: 8100_H	Under-range
: : –1.185 V	: : –11.851 V	: : –2.963 V	: : –11.85 mA	–32516 : –32768	$80FC_H$: 8000_H	Underflow

Table 3-6 Analog Value Representation in the Unipolar Input Ranges

Measuring Range				**Units**		**Range**
0 – 2 V	**0 –10 V**	**0 – 20 mA**	**4 – 20 mA**	**decimal**	**hexa-decimal**	
2.370 V : :	11.852 V : :	23.70 mA : :	22.96 mA : :	32767 : 32512	$7FFF_H$: $7F00_H$	Overflow
2.35 V : :	11,75 V : :	23.5 mA : :	22.8 mA : :	32510 : 27650	$7EFE_H$: $6C02_H$	Overrange
2 V : 1.5 V : 144.68 µV 0 V	10 V : 7.5 V : 723.4µV 0 V	20 mA : 15 mA : 1446.8 nA 0 mA	20 mA : 15 mA : 4 mA + 1157.4 nA 4 mA	27648 : 20736 : 2 0	$6C00_H$: 5100_H : 2_H 0	Rated range
–144,68 µV : –18.446 mV	–723,4 µV : –92.223 mV	1446.8 nA : 18.448 µA	<4 mA Open wire ($7FFF_H$)	–2 : –255	$FFFE_H$: $FF00_H$	Underrange
<–18.446 mV	<–92.223 mV	<–18.448 µA		–32768	8000_H	Underflow

3.1.4 Analog value representation for analog output channels

The table contains the analog value representation of the SM 335's output channels.

12 bits (+VZ) of the output value are converted in the 0-10 Volt range.
Bit 0, Bit 1 and Bit 2 are not converted.

11 bits + VZ of the output value are converted in the ± 10 Volt range.
Bit 0, Bit 1, Bit 2 and Bit 3 are not converted.

Table 3-7 Analog Value Representation in the Output Ranges from 0 to 10 V and ± 10 V

Output Value		Range	Output Voltage	
decimal	**hexa-decimal**		**0-10 V**	**±10 V**
32767 : 32512	$7FFF_H$: $7F00_H$	Overflow (off circuit and de-energized)	0 V : 0 V	0 V : 0 V
32504 32496 : 27664 27656	$7EF8_H$ $7EF0_H$: $6C10_H$ $6C08_H$	Overrange	11.756 V 11.753 V : 10.006 V 10.003 V	11.753 V 11.753 V : 10.006 V 10 V
27648 : 20736 : 16 8 0 –8 –16 : –20736 : –27648	$6C00_H$: 5100_H : 10_H 8_H 0_H $FFF8_H$ $FFF0_H$: $AF00_H$: 9400_H	Rated range	10 V : 7.5 V : 5.787 mV 2.8936 mV 0 V 0 V 0 V : 0 V : 0 V	10 V : 7.5 V : 5.787 mV 0 V 0 V 0 V –5.787 mV : –7.5 V : –10 V
–27656 –27648 : –32496 –32504	$93F8_H$ $93F0_H$: 8110_H 8108_H	Underrange	0 V 0 V : 0 V 0 V	–10 V –10.006 V : –11.753 V –11.753 V
–32512 : –32768	8100_H : 8000_H	Underflow (off circuit and de-energized)	0 V : 0 V	0 V : 0 V

3.2 Setting parameters via HW Config

Measuring Range Module

You must plug in the measuring range module into the side of the SM 335.
You can learn how to do this in Reference Manual *SIMATIC Programmable Logic Controller, S7-300 Module Data*. Section 1.4 describes the measuring ranges to be set.

HW Config

Certain features of the SM 335 (e. g., cycle time, A/D conversion) are explained in HW Config, Parameter Assignment of STEP 7.

The measuring range modules in the module must also be set to the necessary settings if required (see Section 1.4).

3.2.1 SM 335 default settings

Default settings

The analog input/output module has default settings. These default settings are used when no parameters are set using the STEP 7 “HW Config” tool.

The defaults are listed in table 3-8.

Table 3-8 SM 335 Default Settings

Parameters	Default Setting for Analog Inputs	Default Setting for Analog Outputs
Cycle time *)	Free Cycle (equivalent to 0.5 ms [SM 335 cycle time] setting)	
Measuring method	U or I (4 DMU) as per measuring range module setting (see Table 1-1)	U
Measuring Range	with U: +/– 10 V with I (4 DMU): 4 - 20 mA	+/– 10 V
Diagnostic interrupt *)	no	no
Hardware interrupt on end-of-cycle	no	no
Group diagnostics (= short-circuit test on analog output)	no	no
Open-wire test	no	–
Response with CPU-STOP	–	OCV (output have no current or voltage)
Number of active channels	4	4

*) Setting is valid for entire module.

3.2.2 SM 335 parameters assignable with HW Config

Parameter assignment application

The STEP 7 tool used to initialize the analog modules in a STEP 7 environment is called “HW Config”.

SM 335 parameters

Table 3-9 provides an overview of the SM 335 parameters which can be assigned with HW Config.

Table 3-9 SM 335 parameters in HW Config

Parameters	SM 335	
	Value Range	Default
Basic settings for inputs		
• Hardware interrupt for end-of-cycle	yes/no	no
• Diagnostic interrupt enable	yes/no	no
Diagnostics for inputs: Enable includes: • Measuring range underrange • Measuring range overrange • Overrange of permitted common mode voltage	yes/no	no
Open-wire test	yes/no	no
Measurement		
• Method	Deactivated Voltage Current (4-wire transducer)	Voltage
• Range	Voltage: ± 1 V; ± 2.5 V; 0 to 10 V; 0 V to + 2 V (channel CH0 to CH3) default ± 10 V; Current: ± 10 mA; 0 mA to + 20 mA + 4 mA to + 20 mA (channel CH2 to CH3)	
• Cycle time for A/D conversion	0,5;*) 1 to 16 ms	0.5 ms*)
Diagnostics for outputs (short-circuit test)	yes/no	no
Response with CPU-STOP	“Keep last value (KLV)” or “Output have no current or voltage (OCV)”	“Output have no current or voltage (OCV)”

*) The setting 0.5 ms in HW Config means: Free Cycle
The setting of 1 to 16 ms in HW Config means: Conditional Cycle

Table 3-9 SM 335 parameters in HW Config

Parameters	SM 335	
	Value Range	Default
Output • Method	Deactivated / Voltage	Voltage
• Range	from – 10 V to + 10 V from 0 V to + 10 V	

*) The setting 0.5 ms in HW Config means: Free Cycle
The setting 1 to 16 ms in HW Config means: Conditional Cycle

End-of-cycle interrupt enable

When you enable the end-of-cycle interrupt, the SM 335 generates a hardware interrupt after A/D conversion of the active channels. You can use this to call OB 40 at fixed intervals. You can set the cycle time for the A/D conversion. The SM 335 can generate the end-of-cycle interrupt starting from a cycle time for A/D conversion of 1 ms.
(see Subsection 3.4.1, Hardware Interrupt)

Diagnostic interrupt enable

When diagnostic interrupts are enabled, the SM 335 generates a diagnostic interrupt as soon as an error is found.

Enable diagnostics

If the diagnostics for inputs are enabled, the SM 335 checks for common-mode errors and measuring range violations. When you enable diagnostics for the outputs, the SM 335 executes a short-circuit test on the outputs.

Open-wire test

You can activate the open-wire test for any analog input.
An open-wire test is possible in measuring ranges:

- 0 to 10 V (when the A/D conversion cycle time is 2 ms or longer)
- 4 to 20 mA (when the A/D conversion cycle time is 1.5 ms or longer or with Free Cycle).

Response with CPU-STOP

When the CPU is at STOP or executing the startup routine, the SM 335 outputs the substitute value to the relevant analog output until a new value is specified. The SM 335 uses the following as a substitute value:

- 0 V
  (if “Outputs off circuit and de-energized” has been set in HW Config) or
- the analog value last output
  (if “Retain last value” has been set in HW Config).

3.3 Modifying SM 335 parameters with the help of system function 55

HW Config

In RUN mode of the CPU, you can modify some parameters (dynamic parameters) via system function 55.

For other methods of modifying parameters: see Reference Manual *System Software for S7-300/400 System and Standard Functions*.

Parameters

The SM 335 parameters are 16 bytes long and are divided into two data records (DR0 and DR1).

The SM 335 parameters (complete DR1 to be transferred to the module) must be stored in a data area on the CPU (e.g., in a bit memory or data block). System function 55 WR_PARAM is used to transfer the parameters to the SM 335.

Note

You must always initialize the SM 335 parameters with HW Config before transferring them with system function 55.
Reason: The system function accesses SDB 1XX, which is generated with HW Config.

Data Records

The SM 335 parameters are stored in two data records (DR0 and DR1).

Data Record 0 (DR0)

Data record 0 of the SM 335 is 2 bytes long and contains the static parameters of the SM 335. You cannot modify these parameters with system function 55.

Data Record 1 (DR1)

Data record 1 contains the dynamic parameters of the SM 335. SM 335. You can modify these parameters with system function 55.
The complete data record 1 (bytes 0 to 13) must always be transferred.

3.3.1 SM 335 static parameters

The static parameters can only be modified via HW Config.

Data Record 0

Data record 0 of the SM 335 contains static parameters (see Table 3-10)

Table 3-10 SM 335 parameters in Data Record 0

Byte	Content	Default
0	Input and output diagnostics	00_H
1	Reserved	00_H

Diagnostics

The “Input and output diagnostics” parameter is used to specify in HW Config which analog inputs and outputs are to trigger a diagnostic interrupt in the event of an error.

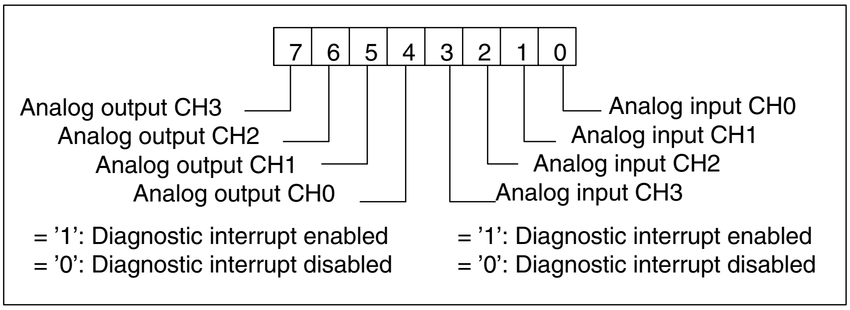

Fig. 3-2 Meaning of the bits in the “input and output diagnostics” byte

If the diagnostics for inputs are enabled, the SM 335 checks for common-mode errors and measuring range violations.
When you enable diagnostics for the outputs, the SM 335 executes a short-circuit test on the outputs.

3.3.2 SM 335 parameters in the Free Cycle and Conditional Cycle Modes

Data Record 1 (DR1)

Data record 1 (DR1) of the SM 335 contains dynamic parameters (see Table 3-11).

The parameters are set via HW Config, or can be modified via system function 55. Data record DR1 must always be completely transferred using system function 55.

Table 3-11 SM 335 parameters in Data Record 1 (DR1)

Byte	Content	Default
0	Interrupt and substitute value output	00_H
1	Reserved	00_H
2	Measuring range for analog input channel CH0	19_H
3	Measuring range for analog input channel CH1	19_H
4	Measuring range for analog input channel CH2	depends on measuring range mod-ule setting (see Table 3-12)
5	Measuring range for analog input channel CH3	
6	Output range for analog output channel CH0	19_H
7	Output range for analog output channel CH1	19_H
8	Output range for analog output channel CH2	19_H
9	Output range for analog output channel CH3	19_H
10	Measuring cycle time	01_H
11	Dynamic measurement cycle control: fixed in Free Cycle and Conditional Cycle modes: 00_H	00_H
12	Open-wire test	00_H
13	Factor for interval counter monitoring time (see Section 4.4)	00_H

Interrupt and substitute value output (DR1, Byte 0)

The interrupt and substitute value output parameter defines the following:

- Whether a hardware interrupt (conditional cycle only) is to be generated
- Whether a diagnostics interrupt is to be generated
- Whether the last valid analog value or 0 V is to be output as a substitute value

The hardware and diagnostic interrupt settings are effective on all module channels.

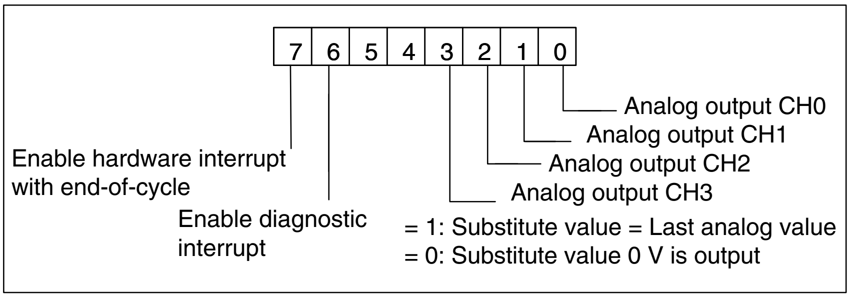

Fig. 3-3 Meaning of the bits in the “interrupt and substitute value output” byte (DR1, byte 0)

Analog input measuring range (DR1, Byte 2-5)

The default parameters for the analog input measuring range depend on the setting on the SM 335’s measuring range module.

Table 3-12 Parameters for the analog input measuring range

<table>
<tr><th>Measuring range module setting</th><th>Default parameters (byte address in relation to data record 1)</th><th>Permissible parameters and measuring ranges (bytes 2 to 5)</th></tr>
<tr><td>A</td><td>Byte 2 (CH0): 19_H (Voltage)
Byte 3 (CH1): 19_H (Voltage)
Byte 4 (CH2): 19_H (Voltage)
Byte 5 (CH3): 23_H (Current)</td><td rowspan="4">For measuring voltage
14_H: – 1 V to + 1 V
15_H: – 2.5 V to + 2.5 V
18_H: 0 V to + 10 V
19_H: – 10 V to + 10 V
$1C_H$: 0 V to + 2 V

For measuring current
21_H: – 10 to + 10 mA
22_H: 0 mA to + 20 mA
23_H: 4 mA to + 20 mA</td></tr>
<tr><td>B
This measuring range module setting is not allowed.</td><td>Byte 2 (CH0): 00_H
Byte 3 (CH1): 00_H
Byte 4 (CH2): 00_H
Byte 5 (CH3): 00_H</td></tr>
<tr><td>C</td><td>Byte 2 (CH0): 19_H (Voltage)
Byte 3 (CH1): 19_H (Voltage)
Byte 4 (CH2): 23_H (Current)
Byte 5 (CH3): 23_H (Current)</td></tr>
<tr><td>D</td><td>Byte 2 (CH0): 19_H (Voltage)
Byte 3 (CH1): 19_H (Voltage)
Byte 4 (CH2): 19_H (Voltage)
Byte 5 (CH3): 19_H (Voltage)</td></tr>
</table>

Output range for analog output (DR1, Bytes 6-9)

Permissible measuring ranges:

- 19_H = +/–10 V (default)
- 18_H = 0 –10 V

Channel assignment:

- Byte 6 = Analog output channel CH0
- Byte 7 = Analog output channel CH1
- Byte 8 = Analog output channel CH2
- Byte 9 = Analog output channel CH3

Measuring cycle time (DR1, Byte 10)

The “measuring cycle time” parameter specifies the length of a measuring cycle. Permissible values are those from 01_H to 00_H.
The default value is 01_H.
The value 01_H specifies a free cycle, i.e., a measuring cycle has a duration of about 0.9 ms (if additional analog outputs are updated, 1 to 1.2 ms are required, depending on the number of analog outputs).
02_H corresponds to a measuring cycle of 1 ms, 03_H to a measuring cycle of 1.5 ms, and so on.
00_H corresponds to a measuring cycle of 16 ms.

Note

Measuring cycle time of 1 ms:
The output values are modified before the first measurement (channel CH3). The measurements are then made. To ensure that all input and output channels are serviced within 1 ms, there are no short-circuit or measuring range violation diagnostics for a measuring cycle time of 1 ms. The Comparator function is not executed in a 1 ms cycle.
The lack of time means that Comparator 1 cannot be executed!

Dynamic measuring cycle control (DR1, Byte 11)

The “dynamic measuring cycle control” parameter cannot be set with HW Config. It is used for switching to special operating modes. This byte always has the value 00_H in Free Cycle and Conditional Cycle modes.

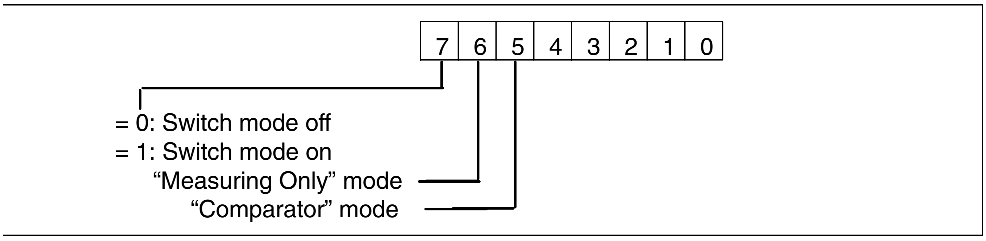

Fig. 3-4 Meaning of the bits in the “dynamic measuring cycle control” byte

Open-wire test (DR1, Byte 12)

You use the open-wire test parameter (byte 12 in data record 1) to determine whether an open-wire test is to be executed for the relevant analog input.

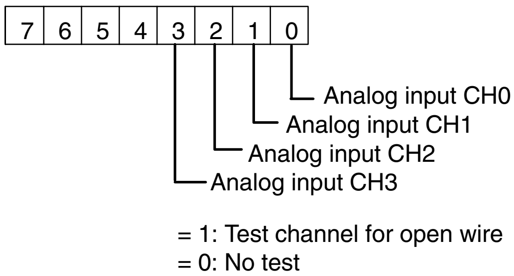

Fig. 3-5 Meaning of the bits in the “open-wire test” byte

3.3.3 SM 335 parameter for “Comparator” mode

In “Comparator” special mode, the SM 335 compares a specified analog value with the analog value measured on one of the analog inputs. The SM 335 behaves like a comparator in this operating mode. For detailed information about “Comparator” mode, see Section 5.2.

Switching

Chapter 5 describes how to switch to the “Comparator” mode.

Restrictions

The parameters for “Comparator“ mode can be transferred with system function 55 WR_PARA only.
Data record DR1 must always be transferred completely (bytes 0 to 13).

Data Record 1

The parameters that can be switched dynamically are stored in data record 1 of the SM 335 (see Table 3-13).

Table 3-13 SM 335 data record 1 for “Comparator” special mode

Byte	Content
0	High-order byte of analog output value 1
1	Low-order byte of analog output value 1
2	High-order byte of analog output value 2
3	Low-order byte of analog output value 2
4	High-order byte of analog output value 3
5	Low-order byte of analog output value 3
6	High-order byte of comparison value for “Comparator 1”
7	Low-order byte of comparison value for “Comparator 1”
8	High-order byte of comparison value for “Comparator 2”
9	Low-order byte of comparison value for “Comparator 2”
10	Comparator time
11	Dynamic measuring cycle control
12	Comparator control byte
13	Reserved

Analog output value

With Comparator 1 or 2, the SM 335 outputs the specified analog values on up to 3 analog outputs (see Section 5.2).

Comparator time (DR1, Byte 10)

During the time Comparator 2 is active, the SM 335 cannot generate a hardware interrupt for the end-of-cycle. It can therefore happen that the SM 335 does not generate an end-of-cycle interrupt for an extended period.

You can use the comparator time to specify how long the comparator can remain active.

If the comparator is active and the comparator time has expired, the SM 335 switches back autonomously to “Conditional Cycle” or “Free Cycle” mode.

The comparator time is specified in milliseconds (1 = 1 ms, 2 = 2 ms, to 0 = 256 ms).

Dynamic measuring cycle control (DR1, byte 11)

The dynamic measuring cycle control byte has the following assignments in “Comparator Mode 1”:

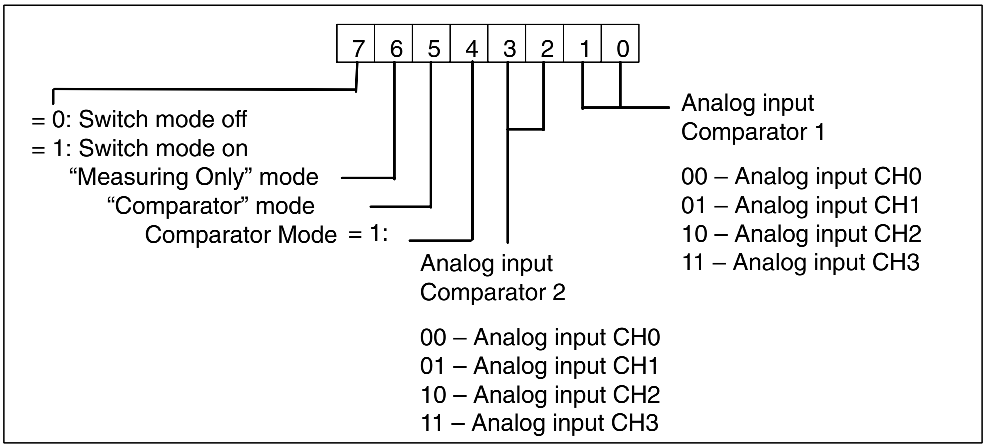

Fig. 3-6 Meaning of the bits in the “dynamic measuring cycle control” byte

Bit 4 in the “dynamic measuring control” byte must be ’1’.

Note

For reasons of compatibility with older module versions, the SM 335 has two comparator modes.

Comparator mode is set via bit 4:
Bit 4 = 0: Mode 0 (comparator 1 and comparator 2 work on one measuring channel only; this mode should only be used for reasons of compatibility with older module states.)

Bit 4 = 1: Mode 1 (comparator 1 and comparator 2 work on different or the same measuring channels – see Figure 3-6, Bit 3 to Bit 0.)

With comparator mode 0, the bit assignment in Figure 3-6 changes (Bit 3 to Bit 0) as follows:

- 0001 – Analog input CH0
- 0010 – Analog input CH1
- 0100 – Analog input CH2
- 1000 – Analog input CH3

Comparator check byte (DR1, byte 12)

You can additionally check the comparator in the comparator check byte: The comparator check byte has the following structure:

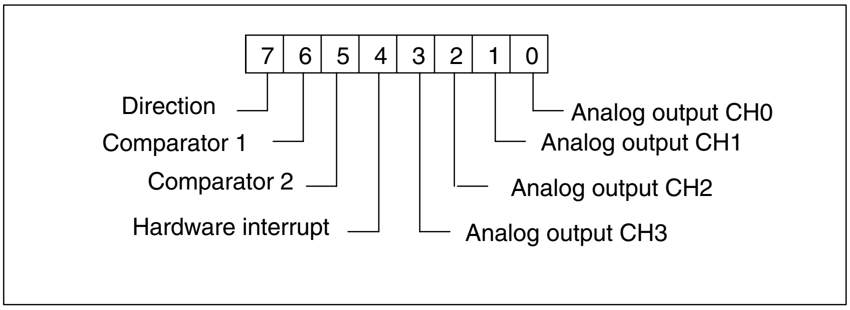

Fig. 3-7 Comparator Check Byte for “Comparator” Mode

Direction (DR1, bit 12.7)

If bit 7 in the comparator check byte is set to ’0’, the comparison is made in the direction of rising analog values.
If bit 7 is set to ’1’, the comparison is made in the direction of falling analog values.

Comparator 1 and Comparator 2 (DR1, bits 12.6 + 12.5)

You switch Comparator 1 and 2 on with the Comparator 1 and 2 bits (see Table 3-14).

Table 3-14 Checking the comparator with check bits 1 and 2

Bit 6	Bit 5	Behavior of the comparator
1	1	Switch on Comparators 1 and 2 in succession
0	1	Switch on Comparator 2
1	0	Switch on Comparator 1
0	0	“Comparator” mode exited immediately.

Hardware interrupt (DR1, bit 12.4)

If you set bit 4 in the comparator check byte to ‘1’, the SM 335 generates a hardware interrupt at the reversing point.

Comparator 1 to Comparator 2 Reversing Point

Comparator 1 is monitored in the Free and Conditional Cycles. If the measuring value has reached or exceeded the Comparator 1 value and a Comparator 2 has been defined, only the Comparator 2 channel is cyclically measured (approximately every 40 µs) from the reversing point.

If the measuring value has reached or exceeded the Comparator 2 value, or the parameterized monitoring time (max. 8.3 seconds) is exceeded, the Free or Conditional Cycles continue.

Analog output (DR1, Bit 12.3 to 12.0)

In bits 0 to 3 of the comparator check byte (DR1, byte 12, see Figure 3-7), you specify the analog outputs that the analog values specified in DR1 (byte 0 to 5 in Table 3-13) are to be output to.

- Bit i = 1: Specified value is output
- Bit i = 0: Old analog value is retained

You can set up to 3 bits. The analog values are output until a new value is written to the output.

3.3.4 SM 335 parameters for "Measuring Only" special mode

In "Measuring Only" special mode, the SM 335 only measures the analog inputs in Free Cycle and does not update the analog outputs. For detailed information about "Measuring Only" mode, see Section 5.3.

Switching

Chapter 5 describes how to switch to "Measuring Only" mode.

Data Record 1

You can transfer the dynamic parameters (data record 1) for "Measuring Only" mode with system function 55 WR_PARA. The data record must always be transferred completely.

Note

The parameters in data record 1 that you transfer to switch to "Measuring Only" mode must be identical with the parameters that you transferred for Free Cycle or Conditional Cycle modes, with the exception of byte 11.

Table 3-15 SM 335 Data record 1 for "Measuring Only" special mode

Byte	Content
0	Assigned as in Free Cycle and Conditional Cycle modes (see Table 3-11)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	Dynamic measuring cycle control
12	Assigned as in Free Cycle and Conditional Cycle modes (see Table 3-11)
13	

Dynamic measuring cycle control

Byte 11, “dynamic measuring cycle control”, has two tasks:

- To switch on ‘Measuring Only’ mode
- To disable/enable analog inputs

Switching on the operating mode (DR1, Byte 11)

To switch on “Measuring Only” mode, you must transfer all the SM 335 parameters and set bit 6 + 7 in byte 11:

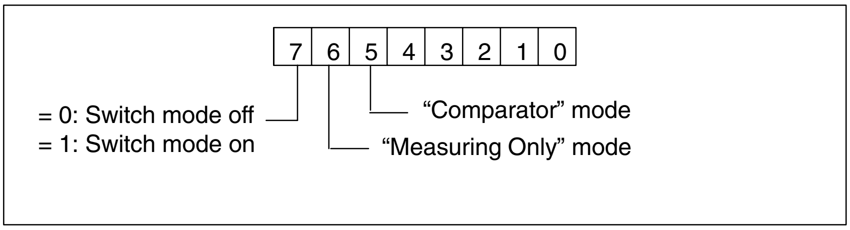

Fig. 3-8 Dynamic measuring cycle control for “Measuring Only” mode

Dynamic disabling of analog inputs (DR1, Byte 11)

You disable the associated analog input with bits 0 to 3. The default for bits 0 to 3 is ’0’. Setting a bit to ‘1’ disables the associated analog input. If you disable three analog inputs, it is possible to attain a measuring cycle time of < 0.5 ms.

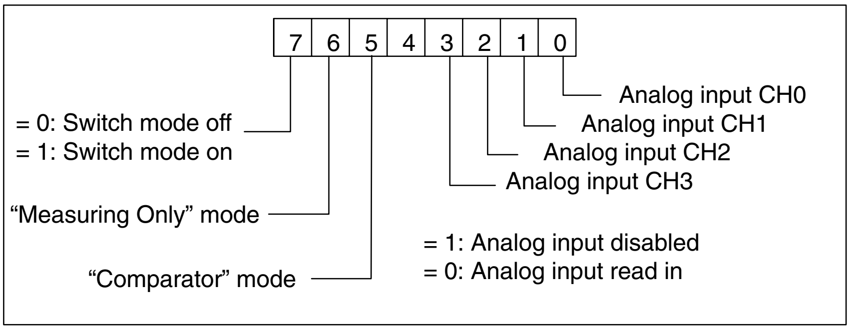

Fig. 3-9 Meaning of the bits in the “dynamic measuring cycle control” byte

Bit 4 in the “dynamic measuring control” byte must be ’0’.

3.4 Evaluating SM 335 diagnostics

Methods

There are several methods of accessing SM 335 diagnostics:

- With an enabled diagnostics interrupt via the local data in OB 82
- With a hardware interrupt via the local data of the interrupt OB (e. g., OB 40)
- By reading the diagnostics data with system function 59 (RD_REC)
- Other methods: see Reference Manual *System Software for S7-300/400 System and Standard Functions*.

Diagnostics interrupt

If you have enabled the diagnostics interrupt for the SM 335 and the SM 335 generates a diagnostics interrupt, the CPU processes OB 82. The local data of OB 82 contain some of the diagnostics data of the SM 335 (see Subsection 3.4.2).

Hardware interrupt

If the SM 335 generates a hardware interrupt, this hardware interrupt can have two causes:

- Interrupt triggered by comparator
- End-of-cycle interrupt

The cause leading to the SM 335 interrupt is stored in the local data of OB 40 (see Subsection 3.4.1)

Principle

The complete diagnostics data of the SM 335 can be accessed via system function 59.
The structure of the diagnostics data is explained in Subsection 3.4.2.

3.4.1 Hardware interrupt

OB 40

OB 40 is invoked when the SM 335 generates a hardware interrupt. Information about the cause of the hardware interrupt is entered in the local data section of OB 40.

Local data

The reasons for the SM 335 hardware interrupt are entered in byte 8 of the local data (see Figure 3-10).

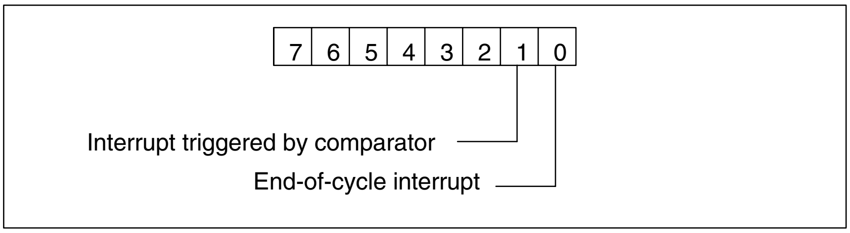

Fig. 3-10 Byte 8 in local data in the event of a hardware interrupt generated by the SM 335

Table 3-16 End-of-cycle interrupt

Byte	Content
8	Cause of hardware interrupt (see Figure 3-10) = 2#0000 0001
9	Number of measuring cycles 1)
10	not assigned
11	not assigned

1) The number of measuring cycles can also be read in the input range ModAdd+8. (see Subsection 3.1.1, Input Values)

Table 3-17 Interrupt triggered by comparator

Byte	Content
8	Cause of hardware interrupt (see Figure 3-10) = 2#0000 0010
9 [1)]	Comparator time [ms] The comparator time is set in byte 10 of the parameter assignment data record DR1 (see Subsection 5.2.2).
10 [1)]	Low-order byte measuring value of Comparator 2
11 [1)]	High-order byte measuring value of Comparator 2

1) In comparator mode 0, bytes 9 to 11 are not assigned.

3.4.2 Format of diagnostic data for the SM 335

Format

Once diagnostic data record DR1 has been read by system function 59, the SM 335 diagnostic data are available in the specified memory.
The diagnostic data are formatted as shown in Table 3-18.

Table 3-18 SM 335 Diagnostic Data

Module diagnostic byte	Content	Default
0	Module diagnostic byte 1 (see Subsection 3.4.3)	40_H
1	Module diagnostic byte 2 (see Subsection 3.4.4)	Fixed: 35_H
2	Module diagnostic byte 3 (see Subsection 3.4.5)	00_H
3	Module diagnostic byte 4 (see Subsection 3.4.6)	00_H
4	Channel-specific diagnostic byte (see Subsection 3.4.7) Channel type: 00_H (general error), 71_H (input), 73_H (output)	00_H
5	Number of diagnostic bits per channel	Fixed: 08_H
6	Number of inputs/outputs	Fixed: 08_H
7	Change in diagnostic byte for input/output (set bit corresponds to changes in bytes 8 to 15)	00_H
8	Channel-specific diagnostic byte for analog input CH0	00_H
9	Channel-specific diagnostic byte for analog input CH1	00_H
10	Channel-specific diagnostic byte for analog input CH2	00_H
11	Channel-specific diagnostic byte for analog input CH3	00_H
12	Channel-specific diagnostic byte for analog output CH0	00_H
13	Channel-specific diagnostic byte for analog output CH1	00_H
14	Channel-specific diagnostic byte for analog output CH2	00_H
15	Channel-specific diagnostic byte for analog output CH3	00_H

3.4.3 Module diagnostic byte 1 (byte 0)

Format

The SM 335 module diagnostic byte 1 contains group error information. Byte 1 has the format shown in Figure 3-11.

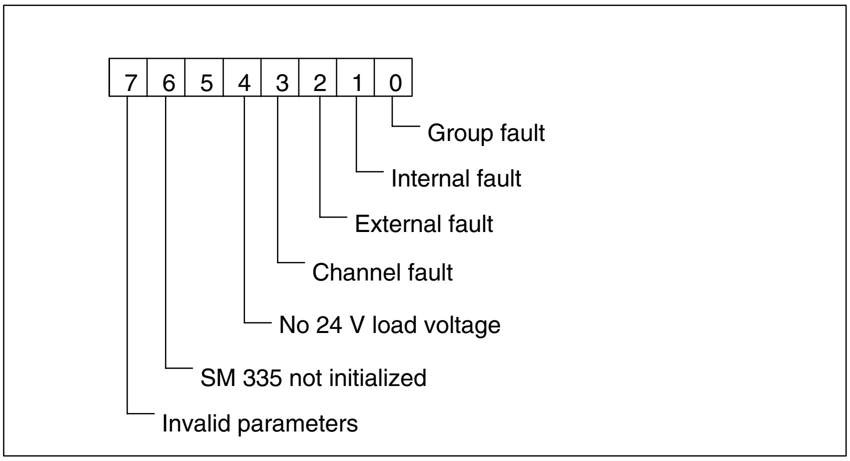

Fig. 3-11 Module diagnostic byte 1

Group fault

Bit 0 in module diagnostic byte 1 is set when the SM 335 flags an error/fault (the only exception being: SM 335 not initialized).

Internal fault

Bit 1 is set in module diagnostic byte 1 when the SM 335 detects one of the following:

- Watchdog
- EEPROM fault
- ADC/DAC error

External fault

Bit 2 is set in module diagnostic byte 1 when one of the following errors/faults occurs:

- Measuring range module not connected
- Measuring range module not connected correctly (default parameters do not match the measuring range module setting)
- External auxiliary power supply failed
- Fault on one of the inputs
  - Common-mode error
  - Open wire
  - Measuring range violation (overrange)
  - Measuring range violation (underrange)
- Fault on one of the outputs (ground short)

Channel error

If bit 3 in the module diagnostic byte has been set, the SM 335 has detected a channel-specific error in one of the channels. You will find more detailed information in the channel-specific diagnostics bytes (bytes 8 to 15).

No 24 V load voltage

Bit 4 in module diagnostic byte 1 is set when the 24 V load voltage has dropped below 10 V.

SM 335 not initialized

Bit 6 in module diagnostic byte 1 is set when no parameters were assigned for the SM 335.

Invalid parameters

Bit 7 in module diagnostic byte 1 is set when the SM 335 was incorrectly initialized, that is, the parameters do not coincide with the measuring range module setting on the SM 335. This bit is set if parameter assignment failed (e. g., when system function 55 WR_PARA is called to transfer the parameters).

3.4.4 Module diagnostic byte 2 (byte 1)

Content

Module diagnostic byte 2 always contains the fixed value 35_H.

3.4.5 Module diagnostic byte 3 (byte 2)

Format

Three different errors are flagged in Module Diagnostic Byte 3
(see Figure 3-12).

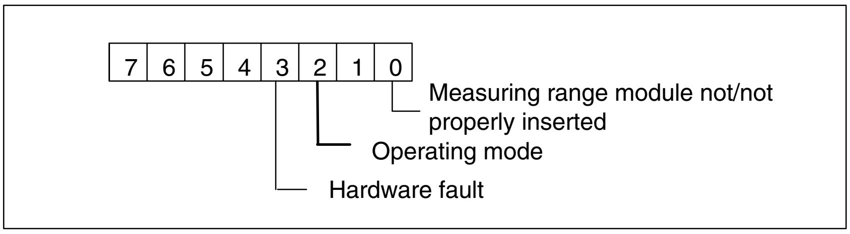

Fig. 3-12 Module diagnostic byte 3

Measuring range module not connected/not connected correctly

Bit 0 is set in module diagnostic byte 3 when the SM 335 recognizes that no measuring range module has been inserted, or when the measuring range module has not been properly inserted.

Operating mode

Bit 2 in module diagnostic byte 3 is set when the SM 335 parameter assignment is invalid.

Hardware fault

Bit 3 is set in module diagnostic byte 3 when the SM 335 detects an internal hardware fault: In this case, the SM 335 outputs 0 V, and all inputs are set to $7FFF_H$ and the counter input to FF FF FF_H.

3.4.6 Module diagnostic byte 4 (byte 3)

Format

Two different errors are flagged in module diagnostic byte 4 (see Figure 3-13).

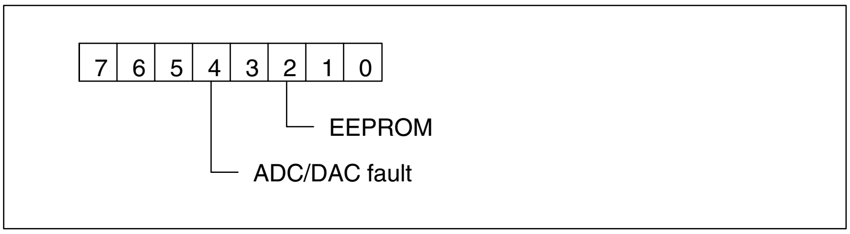

Fig. 3-13 Module diagnostic byte 4

EEPROM fault

Bit 2 is set in module diagnostic byte 4 when the SM 335 detects an internal error in the EEPROM.

ADC/DAC fault

Bit 4 is set in module diagnostic byte 4 when the SM 335 detects an analog-digital or digital-analog conversion fault.

Such an error might occur for one of three reasons:

- No 24 V load voltage or below 15 V
- EMC problem
- Internal hardware fault

3.4.7 Channel-specific diagnostic bytes (bytes 4-15)

Channel type (byte 4)

The SM 335 flags the type of channel in which the error occurred in byte 4 of the diagnostic data (00_H: general error; 71_H input; 73_H output).

Channel vector (byte 7)

In byte 7 of the diagnostic data, the SM 335 flags the input or output on which a channel-specific error has been detected.

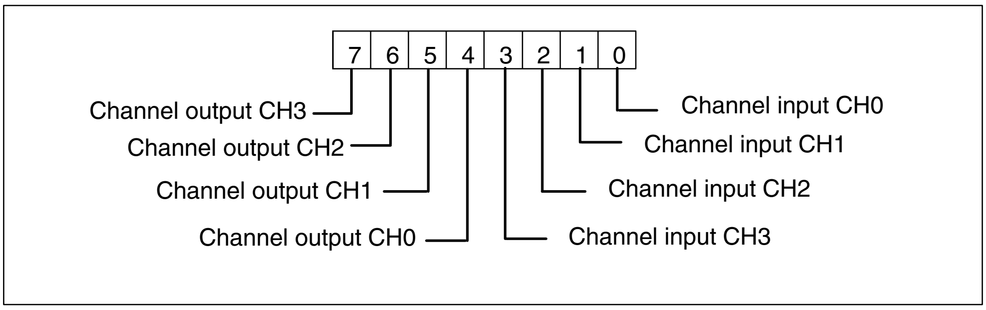

Fig. 3-14 Modification indicator bits for channel-specific diagnostic bytes

Analog input (bytes 8-11)

The SM 335 sets bits in the channel-specific diagnostic bytes for inputs when an error/fault is detected at one of the inputs. The channel-specific diagnostic bytes for inputs have the following format:

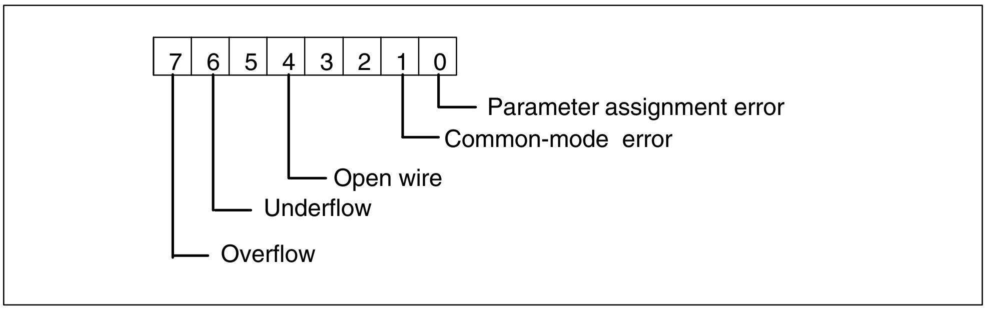

Fig. 3-15 Channel-specific diagnostic byte for an analog input

Parameter assignment error (bytes 8-11, bit 0)

A parameter assignment error has occurred if the bit is set.

Common mode error (bytes 8-11, bit 1)

There is an excessive common mode voltage at the analog input. If the common mode voltage is too high, the SM 335 simultaneously sets bit 2 in the module diagnostic byte 1 to “1” and the measured value to $7FFF_H$.

As soon as the common-mode voltage returns to a permissible level, the SM 335 resets the bit. (see also Section 2.2, Connecting the Analog Inputs)

Open wire (bytes 8-11, bit 4)

Bit 4 is set in the channel-specific diagnostic byte for an analog input when a open wire is detected at that input.

Underrange and overrange (byte 8-11, bit 6+7)

The measured value at the input is checked for violation (overrange: bit 6; underrange: bit 7). Depending on the direction of the range violation, the SM 335 sets either the overrange or the underrange bit.

Analog output (bytes 12-15)

The SM 335 sets bits in the channel-specific diagnostic byte for an analog output when it detects a short circuit or a parameter assignment error at the analog input.

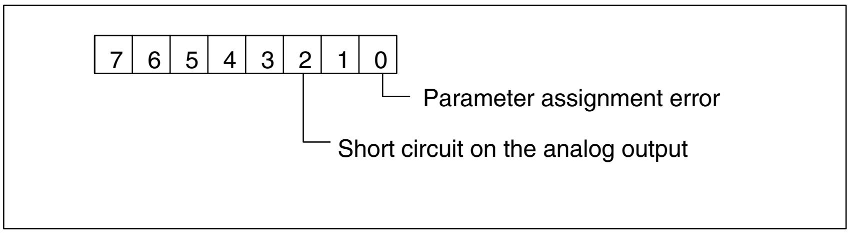

Fig. 3-16 Channel-specific diagnostic byte for an analog output

Interval Counter Input

4

Purpose

With an interval counter, you can measure the number of intervals (continuous counter from 0 to 255) and the duration of an interval.

You can use this data to calculate a speed, for example, if you know the path covered during the interval.

You can also acquire signals from simple rotary sensors and determine the rotational speed from the interval duration.

Alternatively, you can use the number of intervals to measure positions or the number of intervals per time unit to measure speeds.

Principle

You can acquire the following with the interval counter input:

- Number of intervals
- Duration of an interval

In this chapter

We deal with the following topics in this chapter

Topic	Section
Principle of an interval counter	4.1
Principle of measuring with an interval counter	4.2
Wiring the interval counter input	4.3
Parameterizing the SM 335 interval counter input	4.4
Values of the interval counter	4.5
Example of determining a rotational speed with the interval counter	4.6

4.1 Principle of an interval counter

Principle

An interval counter counts the number of time intervals. Figure 4-1 shows a simple sensor. The sensor returns a ’1’ when light falls through one of the slots in the disc. When the disc rotates, the sensor returns the signal shown in the diagram.

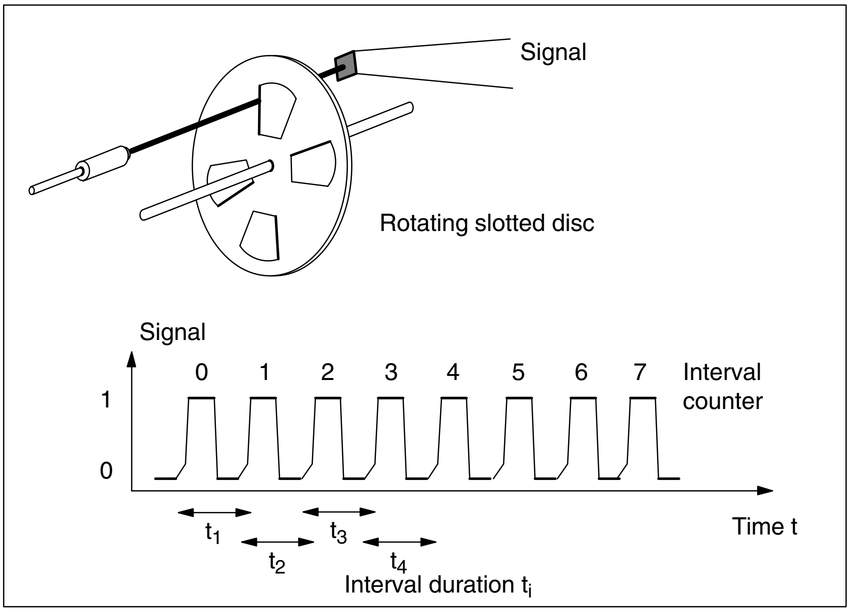

Fig. 4-1 Simple Sensor, e.g., With a Slotted Disc on a Shaft

Interval counter

The interval counter counts the number of intervals. The first interval begins on the first transition from ’0’ to ’1’ (positive edge), and ends with the next positive edge, which is also the start of the next interval.

Interval duration counter

The interval-counting procedure also includes acquiring the interval duration. On each positive edge, a counter is started, which is incremented by 1 every 0.5 µs until the next positive edge is detected. This is called an interval duration counter.

4.2 Principles of measuring with the interval counter

Purpose

Pulses from a simple sensor are acquired via an interval counter input. The sensor might, for example, be located on the barrel extruder of an injection molding machine. You can determine the rotational speed of the barrel from the interval between the 2 pulses.

Principle

The SM 335 measures the amount of time (time interval) that passes between two pulses. The SM 335 determines the interval with a resolution of 0.5 µs. The number of intervals measured is also tallied.

If you know the number of pulses the sensor generates for each revolution of the barrel extruder, you can compute the speed, at which the barrel extruder rotates.

Example

N = 16 pulses are generated per barrel extruder revolution (N is also referred to as the sensor's number of pulses per revolution). The interval between two pulses is 50,000 increments. The rotational speed of the barrel extruder is thus computed as follows:

$$v = \frac{1}{T \cdot N} = \frac{1}{50000 \cdot 0.5\,\mu s \cdot 16} = 2.5\ rps = 150\ rpm$$

Lower limiting value

The interval duration counter returns a 3-byte value, enabling representation of up to FF FF FF_H (16777215 in decimal representation). For N = 1, the critical frequency thus computes to:

$$v = \frac{1}{T \cdot N} = \frac{1}{16777215 \cdot 0.5\,\mu s} = 0.1192.5 rps = 7,15 rpm$$

Upper limiting value

The upper limiting value results from the condition that the interval between two positive edges must be at least 2.5 ms. The critical frequency is thus 400 Hz (equivalent to 24,000 revolutions per minute).

At least 1 ms must be available for the high levels and the low level.

These limiting values apply for sensors, which generate one pulse per revolution. When sensors generating several pulses per revolution are used, you must re-assess the critical frequencies. A number of examples are listed in Table 4-1.

Table 4-1 Limiting Values for Different Numbers of Pulses N

N	Lower limit	Upper limit
1	7.15 rev/min	24000 rev/min
4	1.79 rev/min	6000 rev/min
8	0.89 rev/min	3000 rev/min
16	0.45 rev/min	1500 rev/min

4.3 Wiring the interval counter input

Principle

Figure 4-2 shows how to connect the interval counter input with a switch. The switch is actuated by a cam. The cam is on a rotating shaft, such as the barrel extruder of an injection molding machine.

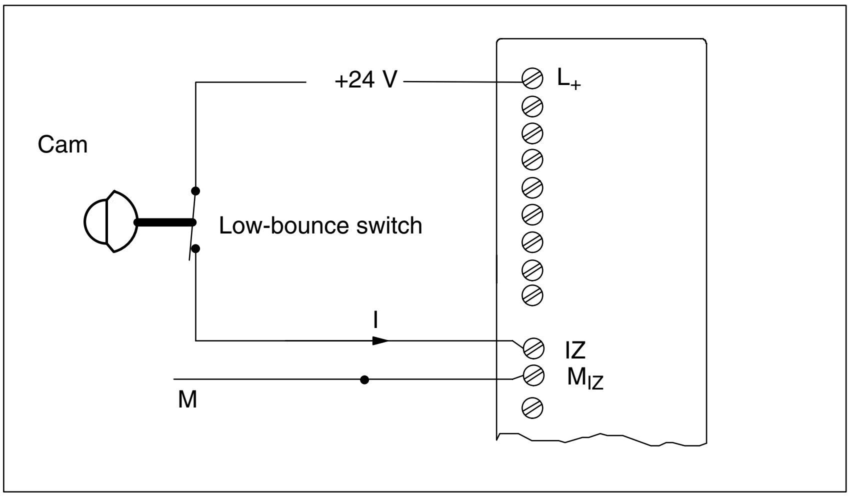

Fig. 4-2 Connecting a Sensor to the Interval Counter Input

Voltage supply

A 24 V voltage is required for the interval counter input. Utilization of the load voltage (24 V) is recommended.

Current

In the ’1’ state (+ 24 V present), a current of no less than 2.5 mA and no more than 4.4 mA must flow through the signal line.

The minimum current must be observed, for example, when an electronic switch (such as an initiator) with a certain voltage drop is used in place of the mechanical, low-bounce switch shown in Figure 4-2. The maximum current must be observed if you wish to use a voltage higher than 24 V to compensate for the voltage drop.

Cable

A shielded, twisted-pair cable must be used. Connect the cable shield with the grounded rack via the shield connection in the same manner as all the other analog cables.

Switch

The switch and the cam must be such that the former remains closed for at least 1 ms and open for at least 1 ms at the highest attainable speed.

Grounding

The interval counter input is isolated from the other connections, and can thus form no ground loops with them.

The input is sufficiently grounded when the 24 V load voltage is used to power it and the frame of the 24 V load voltage source has been grounded (see *SIMATIC S7-300, Hardware and Installation*Module).

4.4 Initializing the SM 335's interval counter input

Parameter assignments

The interval counter on the SM 335 requires no parameters. The pulse input functions independently of the parameters assigned to the remaining analog channels. The pulse input, therefore, does not have to be parameterized. The external counter can be retrospectively parameterized with a timeout.

Monitoring time

After the monitoring time has expired, the interval duration $FFFFFF_H$ is initialized. This means that a failure can be detected early (not only after 8.3 seconds).

The monitoring time is calculated as follows:

$$Monitoring\ time\ =\frac{8.388}{256}\cdot Byte\ 13\ of\ DS1\ [unit\ seconds]$$

Special case: As a default, '0' equates to 8.388 seconds.

Examples:

- Byte 13 (DS1) = 1 → monitoring time = 0.032765625 seconds
- Byte 13 (DS1) = 2 → monitoring time = 0.016382812 seconds

4.5 Interval counter values

Address

The values, which the SM 335 computes for the pulse input, are stored at the I/O address module start address + 12.

Table 4-2 Pulse input values

Module address	Content
+ 12	Interval counter
+ 13	Interval duration, byte 1
+ 14	Interval duration, byte 2
+ 15	Interval duration, byte 3

Interval counter (module address + 12)

The interval counter is a ring counter in the range 0 to 255. The first pulse to arrive initializes the counter internally. When the second pulse arrives, the counter is incremented by ’1’. Each subsequent pulse increments the counter by ’1’.

The SM 335 stores the number of intervals acquired to date in the data byte at “module address + 12”. This data byte is ’0’ as long as no interval has been detected. Each time an interval is detected, the counter is incremented by ’1’.

Interval duration (module address +13 to 15)

During an interval, the SM 335 counts the time until the interval ends in increments, or time slices, of 0.5 μs. The SM 335 enters the duration of the interval in three bytes, beginning with the byte at “module start address + 13”.
The byte at “module start address + 13” is of a higher order than the byte at “module start address + 14”. The byte at “module start address + 15” has the lowest order of all.

Overflow

If an interval is longer than 16777215 (FF FF $FF_{\text{in hexadecimal}}$) times 0.5 μs (8.3886075 s), the SM 335 interprets it as an overflow rather than as an interval. The value for the interval duration is left at ’FF FF $FF_{\text{in hexadecimal}}$’, and the interval counter stops. When the next pulse arrives, the interval duration is measured once again and, if it is of valid duration, the interval counter is again incremented by ’1’.

4.6 Example for determining the speed by means of the interval counter

Prerequisites

It has been assumed that the SM 335 is in slot 4 and has module start address 256. The pulse counter input receives pulses from a sensor located on a barrel extruder.
The sensor generates 16 pulses per revolution.

Procedure

Proceed as follows:

1. Read the value from the module.
2. Compute the speed of the barrel extruder.

Ascertaining interval duration

In order to be able to consistently access data from the pulse input, the interval counter and interval duration must be read out with double word access (address: module address + byte 12, 13, 14, 15). You must subsequently delete byte 12, in order to retain the value for the interval duration in double word format.

Example:

Interval duration = 00 00 A7 $F8_H$, which corresponds to 43000 in decimal

The interval number can be found in the byte (module address + 12).

Computing the speed

N = 16 pulses are generated per barrel extruder revolution (N is also referred to as the sensor's number of pulses per revolution). The interval between two pulses was 43,000 times 0.5 µs long. The speed of the barrel extruder can then be computed as follows:

$$v = \frac{1}{T \cdot N} = \frac{1}{43000 \cdot 0.5\,\mu s \cdot 16} = 2.907\ rps = 174.4\ rpm$$

Special SM 335 Operating Modes 5

Definition

The SM 335 has two special operating modes:

- “Comparator” mode and
- “Measuring Only” mode

Comparator

In “Comparator” mode, the SM 335 compares an analog value with the analog value measured at one of the analog inputs.

The SM 335 behaves like a comparator in this mode.
In this way, particularly short response times are possible when parameterized limits are crossed.

Measuring Only

In “Measuring Only” mode, the SM 335 constantly measures without updating the analog outputs.
In this way, particularly short cycle times are possible when acquiring analog inputs.

In this chapter

We deal with the following topics in this chapter

5.1 Switching to the special operating modes

Dynamic measuring cycle control

To switch to one of the special operating modes, you must set the relevant control bits in data record 1, byte 11 and then transfer the entire data record 1 to the CPU using system function 55.

Note

A special operating mode may only be activated if a previously called special operating mode has been exited. If this is not observed, diagnostics signal an internal error.

Comparator (DS1, byte 11)

To switch on “Comparator” mode, you must transfer all the SM 335 parameters and set bits 5 and 7 in byte 11:

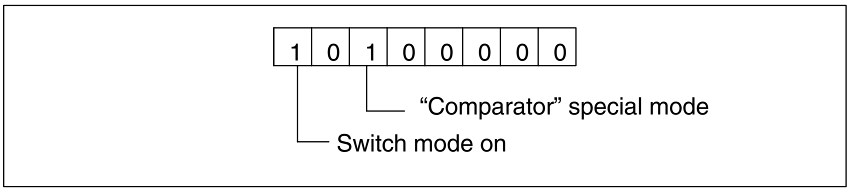

Fig. 5-1 Dynamic measuring cycle control for “Comparator” mode

Measuring Only (DS1, byte 11)

To switch on “Measuring Only” mode, you must transfer all the SM 335 parameters and set bits 6 and 7 in byte 11:

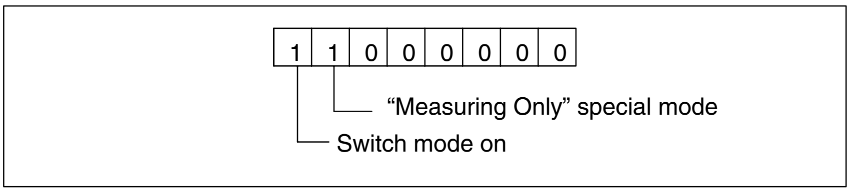

Fig. 5-2 Dynamic measuring cycle control for “Measuring Only” mode

5.2 “Comparator” mode

Introduction

Sometimes an analog value must be read frequently in order to make it possible to react quickly when it reaches a specific value. In very high-speed processes, the usual method employed by programmable controllers – read signal, process signal in the CPU, output the response – is not fast enough. To help solve this problem, the SM 335 has a special mode called “Comparator” mode.

Definition of comparator

A comparator, as its name implies, compares the measured analog value with a specified analog value (called the comparison value). If the measured analog value reaches the comparison value, the comparator initiates a specific response.

A comparison value can be specified for every two comparators.

Two comparators

“Comparator” mode uses two comparators with different characteristic features.

Table 5-1 Characteristics of the two comparators

Comparator	Measures	End-of-cycle interrupts	When the comparison value is reached
1	Analog input of Comparator 1	Will continue to be generated	• The SM 335 outputs the specified analog values to as many as three analog outputs • Generates a hardware interrupt • The SM 335 returns to “Free Cycle” or “Conditional Cycle” mode or • Switches over to Comparator 2
2	Analog input of Comparator 2	Are suppressed	• The SM 335 outputs the specified analog values to as many as three analog outputs • Generates a hardware interrupt • Writes the number of suppressed end-of-cycle interrupts • Returns to “Free Cycle” or “Conditional Cycle” mode

Detailed information about parameterizing in “Comparator” mode can be found in Subsection 3.3.3.

5.2.1 How comparator mode works

Three methods

Comparator mode provides three methods of comparing a measured analog value with a specified analog value:

- Comparator 1: As in normal mode, measuring at the parameterized inputs. Simultaneous comparison of the comparator input with a comparison value: when a comparison value is reached, a hardware interrupt is generated and the specified analog values are output.
  With Comparator 1, the analog inputs can be accessed using peripheral input words.
- Comparator 2: Measuring only at the comparator input. When the comparison value is reached, a process interrupt is generated and specified analog values are output.
  With Comparator 2, the comparator input value cannot be accessed.
- Connection of Comparator 1 to Comparator 2 in series.
  Comparator 1 does not generate a hardware interrupt and does not output any analog values, but switches to Comparator 2.

Comparator 1

Figure 5-3 shows how Comparator 1 works:

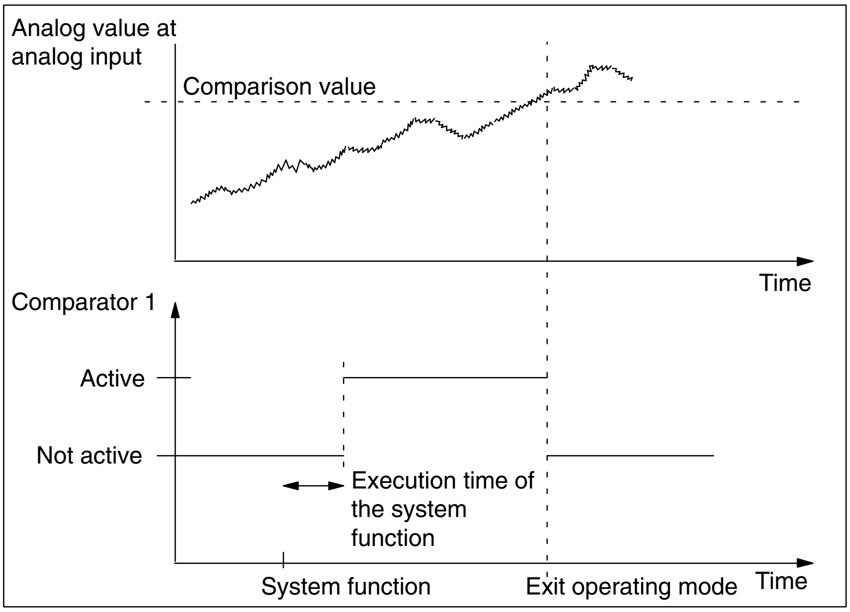

Fig. 5-3 How Comparator 1 works

After you have called system function 55, switched the SM 335 to “Comparator” mode and switched on only comparator 1, the SM 335 compares the analog value at the specified analog input with the comparison value.

The analog inputs continue to be updated and can be read using peripheral input words. During this special operating mode, analog outputs are frozen.

When the specified analog value is reached, the SM 335 exits “Comparator” mode.

After exiting “Comparator” mode, the SM 335 outputs the analog values specified in system function 55. It continues to output these analog values until you forward a new analog value. The new analog value must differ in at least one bit from the one output in “Comparator” mode.

Note

Comparator 1 does not run with cycle time 1 ms.

Comparator 2

Figure 5-4 shows how Comparator 2 works:

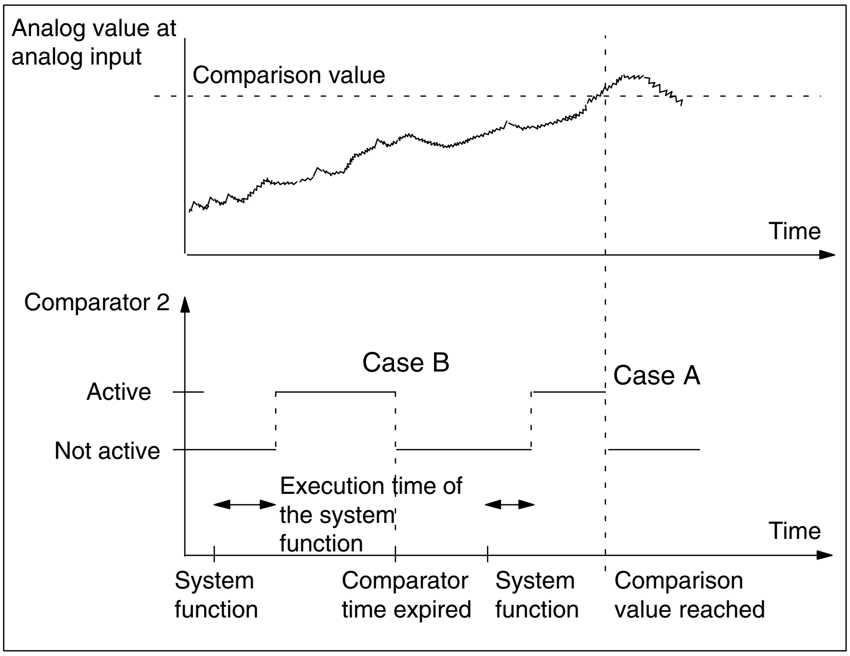

Fig. 5-4 How Comparator 2 works

Case A: Comparison value reached

As soon as the measured analog value has reached the comparison value:

- The SM 335 generates a hardware interrupt.
- It outputs the specified analog values to the specified analog outputs.
- It writes the number of suppressed end-of-cycle interrupts to the input value area (module address byte + 8) and
- It exits “Comparator” mode.

After exiting “Comparator” mode, the SM 335 outputs the analog values specified in system function 55. It continues to output these analog values until you forward a new analog value. The new analog value must differ in at least one bit from the one output in “Comparator” mode (see also the Hint under “Case A and B”).

Case B: Comparator time expired

The SM 335 remains in “Comparator” mode until the comparison value has been reached or the comparator time has expired. If the comparison value is not reached before the comparator time expires, the SM 335 exits “Comparator” mode and returns to Free Cycle or Conditional Cycle mode without modifying the analog outputs.

Case A and B

After calling the system function and switching the SM 335 to “Comparator” mode, when only Comparator 2 is activated, the SM 335 operates as follows:

- It measures only at one analog input (as fast as possible).
- It suppresses and counts the end-of-cycle interrupts.
- It compares the measured analog value with the comparison value.

Hint: If you want to output the same analog value that was output in “Comparator” mode, change the least significant bit in the analog value’s binary code. This has no effect on the analog value, since the least significant bit is truncated, but the SM 335 will interpret the new binary code as a new analog value.

Note

When “Comparator” mode is exited with Comparator 2, the values at the SM 335’s analog inputs are not current. The analog inputs are not updated until the next measuring cycle.

Remedy: Do not read the values from the analog inputs until the next end-of-cycle interrupt has been generated.

Comparators 1 and 2

Figure 5-5 shows how the SM 335 works when both comparators are active:

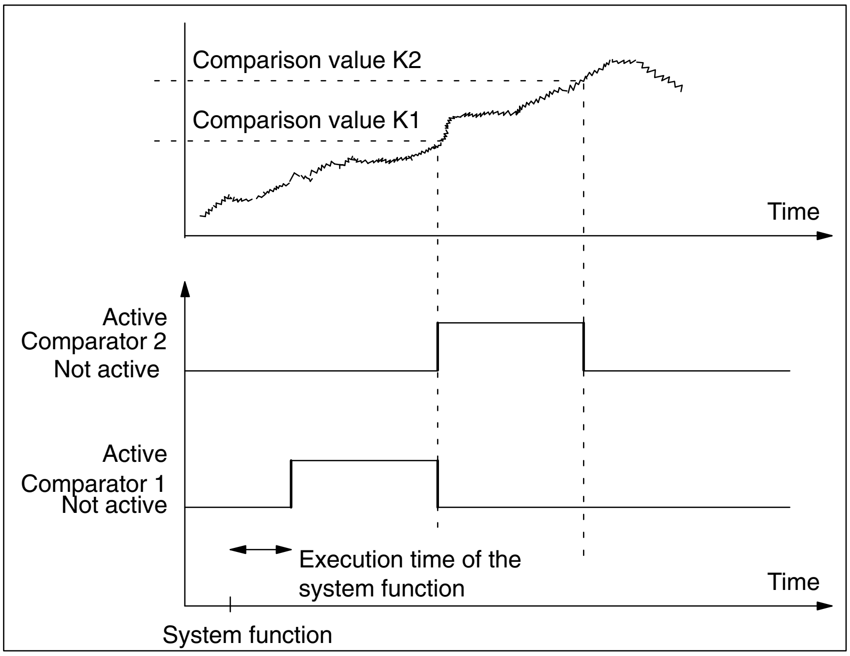

Fig. 5-5 Comparators 1 and 2 in series

Operation of Comparator 2

While Comparator 2 is being executed, the analog inputs on the control side are not updated. The module operates as a stand-alone module.

Message via SM 335 return code, see Table 3-2, Subsec. 3.1.1.

Application

Figure 5-6 shows an application for the comparator function:

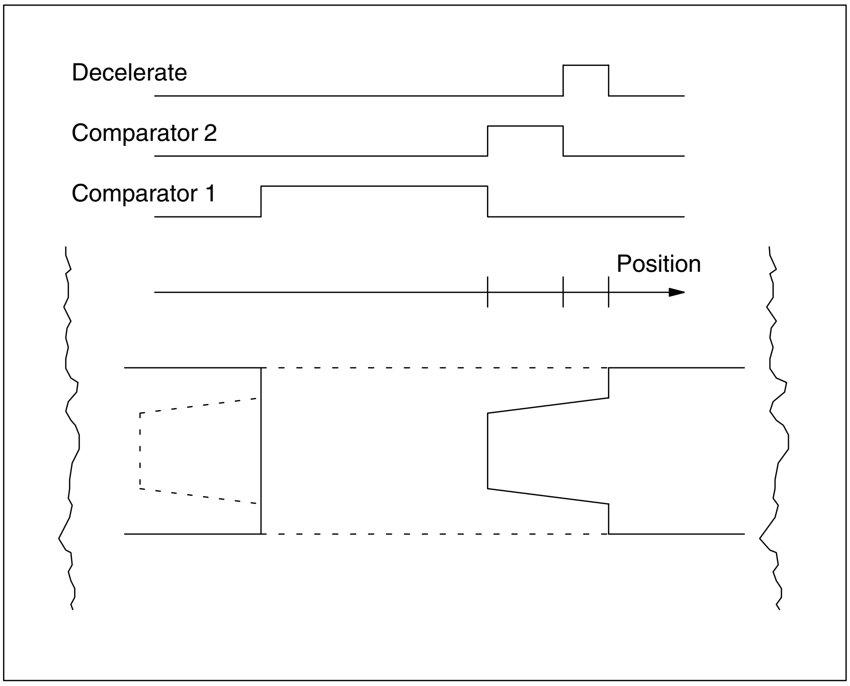

Fig. 5-6 Application for “Comparator” Mode

A mold is closed. The closing motion must be extremely fast. The position of the tool can be acquired, for example, using a linear potentiometer.
The linear potentiometer’s analog signal is measured by the SM 335.

When the mold closes, the SM 335 switches to “Comparator” mode, with Comparators 1 and 2 switched in series.

While the mold is being closed, Comparator 1 compares the measured analog value with the comparison value for Comparator 1. The analog value is reached when the form has assumed a certain position. The SM 335 now activates Comparator 2, and measures only the values at this analog input. Shortly before the mold is closed, the measured analog value reaches the comparison value for Comparator 2. A hardware interrupt is generated. You can initiate deceleration in the interrupt OB. If the whole process is to be performed even faster, specify an analog value that the SM 335 forwards to one of its analog outputs. Use this analog output for direct control of the drive that moves the mold. In this way, you will achieve fast closing and fast, repeatable deceleration.

5.2.2 SM 335 parameters for Comparator mode

Restrictions

The parameters for “Comparator” mode can be passed with system function 55 WR_PARA.

Data Record 1

The dynamic parameters are entered in data record 1 on the SM 335 (see Table 5-2).

Table 5-2 Data record 1 on the SM 335 for “Comparator” mode

Byte	Content
0	Analog output value 1, high-order byte
1	Analog output value 1, low-order byte
2	Analog output value 2, high-order byte
3	Analog output value 2, low-order byte
4	Analog output value 3, high-order byte
5	Analog output value 3, low-order byte
6	Comparison value for “Comparator 1”, high-order byte
7	Comparison value for “Comparator 1”, low-order byte
8	Comparison value for “Comparator 2”, high-order byte
9	Comparison value for “Comparator 2”, low-order byte
10	Comparator time
11	Dynamic measuring cycle control
12	Comparator control byte
13	Reserved

Comparator time (DS1, byte 10)

While Comparator 2 is active, the SM 335 can not generate a hardware interrupt for end-of-cycle. It is therefore possible that the SM 335 will fail to generate an end-of-cycle interrupt for a longer period of time. You can set the Comparator Time parameter to define the amount of time the comparator may remain active. If the comparator time expires while the comparator is active, the SM 335 automatically returns to Free Cycle or Conditional Cycle mode. The comparator time is specified in milliseconds (1 = 1 ms, 2 = 2 ms, up to 0 = 256 ms).

The set comparator time is acknowledged in the local data of the OB 40, as long as a corresponding hardware interrupt has been generated by the SM 335 (see also Subsection 3.4.1, Table 3-17)

Dynamic Measuring Cycle Control (DS1, byte 11)

The Dynamic Measuring Cycle Control byte has the following format in "Comparator Mode 1":

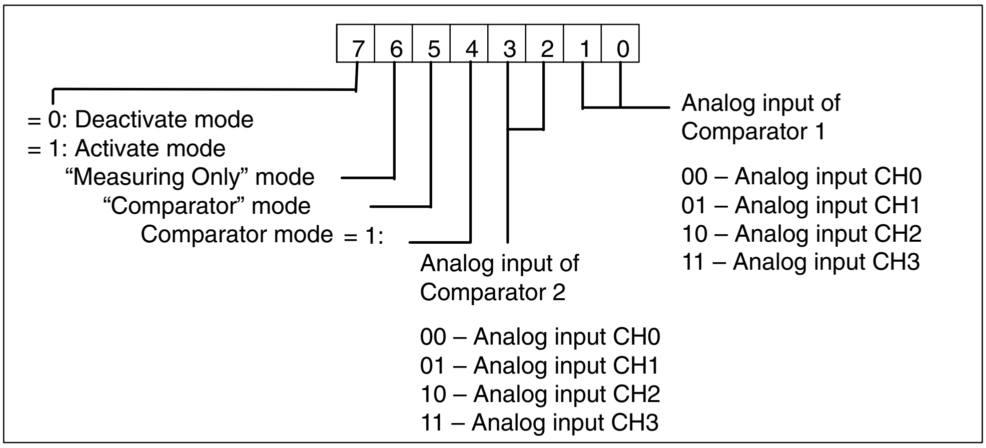

Fig. 5-7 Meaning of bits in the "dynamic measuring cycle control" byte (Comparator)

The "Dynamic Measuring Cycle Control" byte has several functions.

- Activation of "Measuring Only" mode
- Activation of "Comparator" mode
- Allocation of comparator

Note

To ensure compatibility with older module versions, the SM 335 has two comparator modes.

Comparator mode is set via bit 4:
Bit 4 = 0: mode 0 (Comparators 1 and 2 work on only one measuring channel; this mode should only be set to ensure compatibility with older module versions)

Bit 4 = 1: mode 1 (Comparators 1 and 2 work on different or the same measuring channels – see Figure 5-7, bit 3 to bit 0.

With comparator mode 0, the bit allocation (bit 3 to bit 0) shown in Figure 5-7 changes as follows:

- 0001 – Analog input CH0
- 0010 – Analog input CH1
- 0100 – Analog input CH2
- 1000 – Analog input CH3

Comparator check byte (DS1, byte 12)

The Comparator check byte provides an additional means of checking the comparator. The Comparator check byte has the following format:

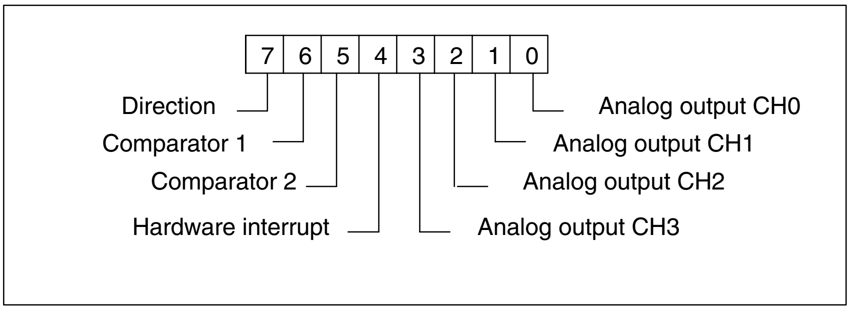

Fig. 5-8 Comparator check byte for “Comparator” mode

Direction (DS1, bit 12.7)

When bit 7 in the Comparator check byte is set to ’0’, the analog values are compared in ascending order (as in Figure 5-8).
If bit 7 is set to ’1’, they are compared in descending order.

Hardware interrupt (DS1, bit 12.4)

If bit 4 in the Comparator check byte is set to '1', the SM 335 generates a hardware interrupt at the reversing point.

Analog output (DS1, bit 12.3 to 12.0)

Use bits 0 to 3 of the Comparator check byte (DS1, byte 12 – see Figure 5-8) to specify the analog outputs, to which the analog values designated in DS1 (bytes 0 to 5 in Table 5-2) are to be forwarded.

- Bit i = '1': Specified value is output
- Bit i = 0: Old analog value is retained

You may set as many as three bits. The analog values are output until a new value is forwarded to the output.

Comparator 1 and Comparator 2 (DS1, Bit 12.6 to 12.5)

Comparator bits 1 and 2 are used to activated Comparators 1 and 2 (see Table 5-3).

Table 5-3 Controlling the comparator via check bits 1 and 2

Bit 6	Bit 5	Comparator performance
1	1	Activate Comparators 1 and 2 in series
0	1	Activate Comparator 2
1	0	Activate Comparator 1
0	0	Exit "Comparator" mode immediately

Comparator 2 measured value

The measured value of Comparator 2 can be taken from the local data of the OB 40. (Byte 10 and byte 11, see Subsection 3.4.1, Table 3-17)

5.3 “Measuring Only” mode

Deactivating outputs

In “Measuring Only” mode, the SM 335 measures only the analog inputs in the free cycle and does not update the analog outputs.
The analog outputs retain their old analog value for a period of 40 to 60 ms.

- When measuring at one analog input: 60 ms
- When measuring at 2 to 4 analog inputs: 40 ms.

Note

- While the SM 335 is measuring, the watchdog is not active.
  This makes it impossible to detect any internal module fault.
- Interrupts are not generated in this mode (no diagnostics or hardware interrupts).
- A new analog value is output after the time expires.

Purpose

You can use “Measuring Only” mode to read values from an analog input in rapid succession and thus obtain, for a short time, the most current analog values ($T_A < 0.5$ ms). After the time expires, the SM 335 returns to the previously parameterized operating mode.

5.3.1 Switching to “Measuring Only” mode

Restrictions

The parameters for “Measuring Only” mode can be passed to the SM 335 only with system function 55 WR_PARA. All parameters must be passed simultaneously.

Data Record 1

The SM 335’s dynamic parameters for “Measuring Only” mode are forwarded in data record 1.

Note

The parameters, which you transfer in data record 1 in order to switch to “Measuring Only” mode, must be identical with the parameters you transferred for Free Cycle or Conditional Cycle mode, with the exception of byte 11.

Table 5-4 SM 335 data record 1 for “Measuring Only” mode

Byte	Content
0	As in Table 3-11
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	Dynamic Measuring Cycle Control
12	As in Table 3-11
13	

Dynamic Measuring Cycle Control (DS1, byte 11)

Byte 11 “Dynamic Measuring Cycle Control” serves three purposes:

- Activation of “Measuring Only” mode
- Activation of “Comparator” mode
- Disabling/enabling analog inputs

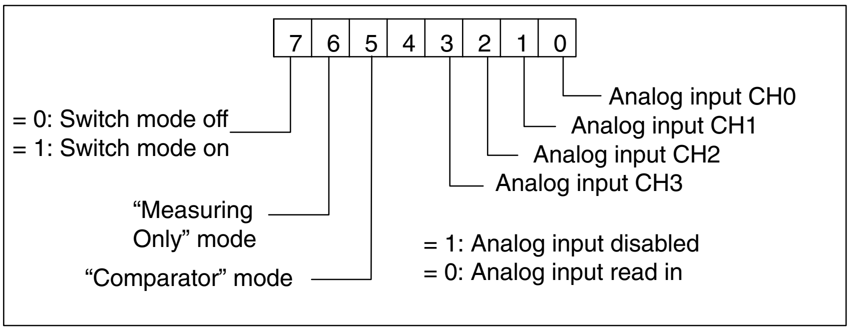

Fig. 5-9 Meaning of the bits in the “dynamic measuring cycle control” byte (Measuring Only)

Activating the mode

In order to activate “Measuring Only” mode, set bit 7 and 6 to ’1’.
Bits 5 and 4 must be set to ’0’.

Dynamic disabling of analog inputs

Bits 0 to 3 are used to disable the associated analog input. The default for bits 0 to 3 is ’0’. Setting a bit to ’1’ disables the associated input. If you disable three analog inputs, it is possible to attain a measuring cycle time < 0.5 ms.

Detecting and Correcting Faults 6

Principle

The SM 335 can detect faults at inputs and outputs.
You can respond to the faults according to the methods of the SIMATIC S7-300.

In this chapter

We deal with the following topics in this chapter

6.1 Principle of diagnostics

LED

When an error or fault occurs on an SM 335, the SF LED on both the CPU and the SM 335 lights up.
(Diagnostics must be enabled.)

Parameterize diagnostics

Enable the diagnostic interrupt on the SM 335 for an entry to be made in the CPU diagnostic buffer if an error occurs. A diagnostic interrupt is also generated and the diagnostic OB (OB 82) is invoked in the CPU.
See Subsection 3.2.2 for information about how to initialize the SM 335 using HW Config.

You can also enable diagnostics when the parameters are transferred with system function WR_PARA. Descriptions of the SM 335 parameters can be found in Subsection 3.3.2.

Diagnostic buffer

The diagnostic buffer is a buffered memory area in the CPU, which stores the diagnostic events in the order in which they occurred.
For troubleshooting, the user can read out the exact error cause with STEP 7 (target system → module state) from the diagnostic buffer.

Diagnostic OB 82

If you have enabled diagnostic interrupts, the SM 335 generates one. When a diagnostic interrupt is generated, the diagnostic OB (OB 82) is invoked in the CPU. You can program your response to the error/fault which caused the interrupt in this OB.

See Section 6.3 for an example of how to read out the diagnostic data in OB 82.

Diagnostic data format

The SM 335 diagnostic data can be read with system function 59. See Subsection 3.4.2 for information about data formats.

Advantages of a diagnostic interrupt

OB 82 is invoked automatically when diagnostic interrupts are enabled, and makes the module start address available as part of the local data.

Disadvantage of the diagnostic interrupt

The program is interrupted when OB 82 is invoked. If the program contains time-critical sequences, the scan time needed for OB 82 may increase the response time. One way of preventing this is to save only the module start address in OB 82 and evaluate the diagnostic data in OB 1.

6.2 Configuring diagnostics with HW Config

Introduction

Diagnostic messages are programmed with the STEP 7 tool “HW Config” (see also *Programming with STEP 7* Manual).

Enabling diagnostics

The SM 335 can ascertain a variety of diagnostic events for inputs and outputs and forward them to the CPU.

In order for diagnostics to actually be carried out and an entry made in the diagnostic buffer, they must be enabled. The enable applies only to the specified channel group.

The SM 335 generates a diagnostic message for the following events:

Table 6-1 SM 355 diagnostic messages

Diagnostic messages for inputs	Event flagged
Parameter assignment error	Always
No external 24 V auxiliary voltage	Always
Common mode error	Always
Open wire	Only when parameterized
Measuring range violation (underrange)	Only when parameterized
Measuring range violation (overrange)	Only when parameterized
Diagnostic messages for outputs	
Short circuit at output	Always

Open wire

The open-wire test is used to detect an open wire, if any, on the sensor or the sensor cable. The open-wire test is possible in the range 4 to 20 mA and 0 to 10 V. In the 4 to 20 mA, the SM 335 reports an open wire when the current to be measured drops below 1.185 mA.
This triggers a diagnostic message and signal $7FFF_H$.

Measuring range 0 to 10 V

In the input range of 0 to 10 V, the open-wire test differs in that it is executed after completion of A/D conversion of the active analog inputs. The test is executed by outputting brief current pulses of approximately 30 μA to the relevant input. The SM 335 can detect an open wire by analyzing the resulting voltage difference.

In order to ensure that this form of open-wire test will function properly, the capacity of the connecting cable and the sensors must not exceed 10 nF. In general, cables of up to 30 m in length are no problem. The source resistance must not exceed 2.5 Kohms, as otherwise an open wire might be reported erroneously.

This is ensured when, e.g., a linear potentiometer with max. 10 Kohms is connected.
(When the grinder is located at an intermediate point, the partial resistances must be 5 Kohms and the cable connected in parallel, resulting in a resistance of 2.5 Kohms.)

Diagnostic interrupt enable

If the “Diagnostic interrupt” box is checked in HW Config and a diagnostic event occurs, the module generates a diagnostic interrupt.
In addition, certain diagnostics can be switched on and off for specific channels (see Table 6-1).
When the SM 335 generates a diagnostic interrupt, the CPU calls OB 82.

Note

It is possible to parameterize diagnostics monitoring in HW Config (e.g., open wire) while disabling the diagnostic interrupt. If the diagnostics are modified, data record 1 is also modified, and can always be read irrespective of parameter assignment.

6.3 Evaluating diagnostic data in OB 82

Method

There are several easy ways to acquire the diagnostic data.
In principle, the procedure is as follows:

1. The SM 335 detects a problem, and generates a diagnostic interrupt on the CPU.
2. The CPU fetches several items of diagnostic data from the SM 335.
3. The CPU calls OB 82 (diagnostic interrupt).

The OB 82 local data contain information about the problem at hand. In addition, the local data provide the module address of the module, which is the subject of the diagnostics.

4. Using the information provided in the OB 82 local data, call system function 59.
5. You can read out data record DR1 using system function 59 “RD_REC” (read record), and also receive the channel-specific diagnostics information (see also Subsection 3.4.2)

Once you have these data, you can respond accordingly in your program.

6.4 SM 335 error tree

Tips for readers

Read the SM 335 error tree as follows: Bit 0 of module diagnostic byte 1 indicates whether an error has occurred.

1. Check to see whether bit 0 in module diagnostic byte 1 is set.
2. If it is, check the bits to which the arrows going out from bit 0 of module diagnostic byte 1 point.
3. If a bit is set, follow the arrows going out from that bit and see which of those bits are set, and so on.
4. See Table 6-2 for a description of the error associated with each bit.

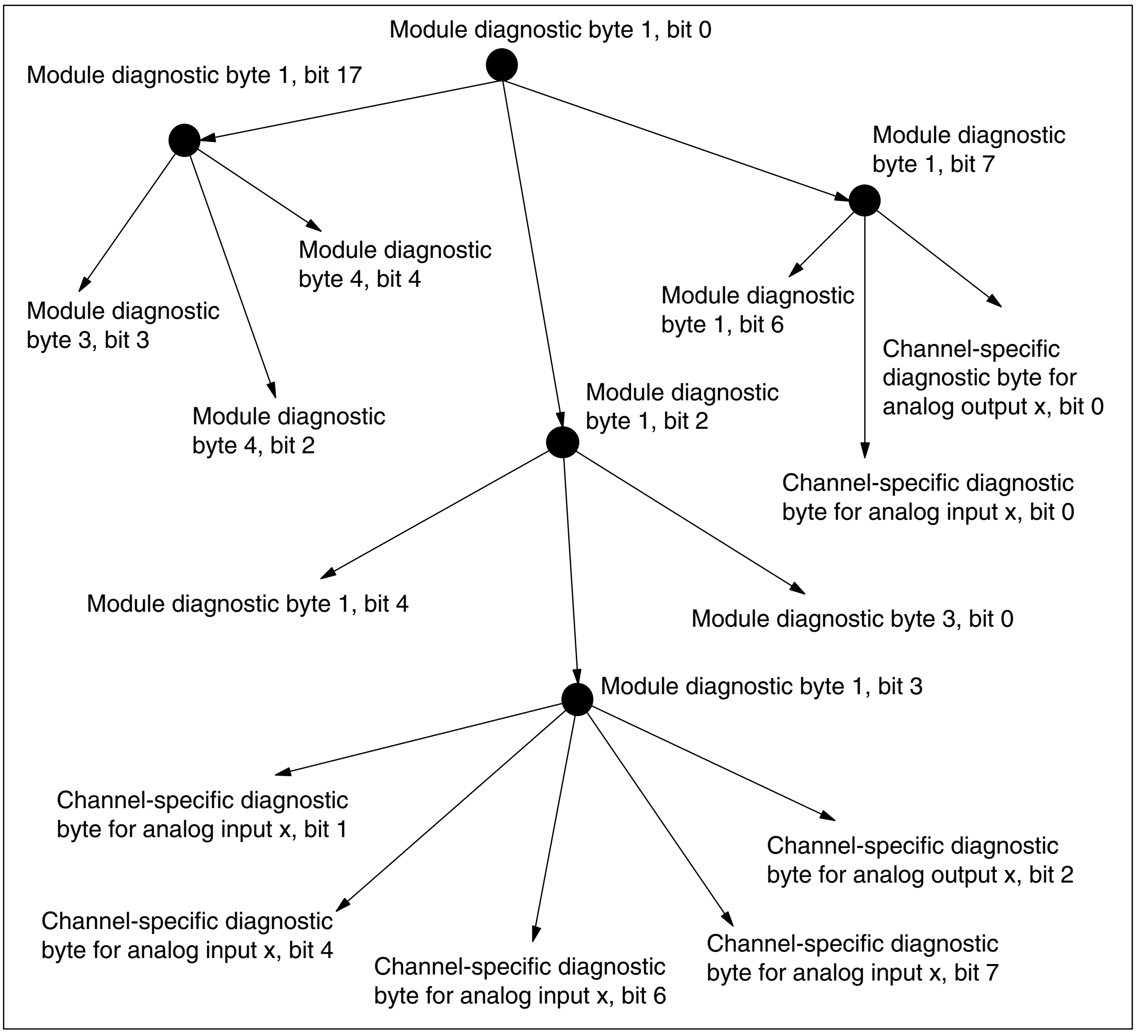

Fig. 6-1 SM 335 error tree

6.5 Troubleshooting

Overview

If you want to evaluate the diagnostic data in your program, Table 6-2 will help you find the error description and corrective measure for the bits set in the diagnostic data.

Table 6-2 Errors and corrective measures for the SM 335

Bits set	Error description	Corrective measure
Module diagnostic byte 1 bit 1 AND Module diagnostic byte 3 bit 3	Internal hardware fault	Module is defective. Make a note of the error description and contact your SIEMENS representative.
Module diagnostic byte 1 bit 1 AND Module diagnostic byte 4 bit 2	Module outputs 0 V; inputs are set to $7FFF_H$, counter value is = $FFFFFF_H$	
Module diagnostic byte 1 bit 1 AND Module diagnostic byte 4 bit 4	DA/AD conversion error The relevant channel is set to $7FFF_H$ or 0 V. Possible causes of error: • No 24 V load voltage or load voltage is less than 10 V • High-frequency interference disturbing the measuring signal • A/D converter is defective	1. Check the load voltage. 2. Check the input signal for high-frequency interference. You might have an EMC problem. 3. Have the module chekked and repaired if necessary.
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 4	No 24 V load voltage or load voltage less than 10 V; input values are set to $7FFF_H$.	Check load voltage.
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 3 AND channel-specific diagnostic byte for analog input x bit 1	Common-mode error on input x	Check the connections at input x.
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 3 AND channel-specific diagnostic byte for analog input x bit 4	Open wire on input x	
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 3 AND channel-specific diagnostic byte for analog input x bit 6	Range violation (high) on input x	The error disappears when the input voltage goes into the nominal range or overrange.
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 3 AND channel-specific diagnostic byte for analog input x bit 7	Range violation (low) on input x	
Module diagnostic byte 1 bit 2 AND Module diagnostic byte 1 bit 3 AND channel-specific diagnostic byte for analog output x bit 2	Ground short on output x	Check the connections at output x.

Table 6-2 Errors and corrective measures for the SM 335, continued

Bits set	Error description	Corrective measure
Module diagnostic byte 1 bit 1 AND Module diagnostic byte 3 bit 0	Measuring range module improperly inserted/not inserted.	Check to make sure that the measuring range module has been inserted correctly, and that the measuring range module setting conforms with the parameters.
Module diagnostic byte 1 bit 7 AND Module diagnostic byte 1 bit 6 (Module diagnostic byte 1 bit 0 = ’0’ !)	Module is not initialized. The SM 335 is using default parameters (no hardware interrupts, no diagnostic interrupts).	Initialize the SM 335 correctly.
Module diagnostic byte 1 bit 2 AND channel-specific diagnostic byte for analog output x bit 0 channel-specific diagnostic byte for analog input x bit 0	Invalid parameters in channel x. When it detects an invalid channel-specific parameter, the SM 335 flags the channel for which the parameter was specified.	Initialize the SM 335 correctly.

List of Abbreviations

A

The abbreviations used in this documentation are listed in alphabetical order in the appendix, along with the corresponding explanations.

Abbreviation	Explanation
AC	Alternating current
ADC	Analog/digital converter
AI	Analog input
AO	Analog output
CPU	Central processing unit
DAC	Digital/analog converter
DB	Data block
DC	Direct current
EMC	Electromagnetic compatibility
EPROM	Erasable programmable read-only memory
KLV	Keep last value
L+	Terminal for 24 V DC supply voltage
M	Ground terminal
M+	Measuring lead (positive)
M–	Measuring lead (negative)
M_{ANA}	Reference potential of the analog measuring cir-cuit
OB	Organization block
OCV	Output have no current or voltage
SF	*Group error* LED
SFB	System function block
SFC	System function
SM	Signal module
U_{CM}	Common mode voltage

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