

SIEMENS

SIMATIC

ET 200M distributed I/O device HART analog modules

Equipment Manual

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6ES7331-7TF01-0AB0
6ES7332-8TF01-0AB0

Legal information

Warning notice system

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

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

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

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

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

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

Qualified Personnel

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

Proper use of Siemens products

Note the following:

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

Trademarks

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Disclaimer of Liability

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

Preface

Purpose of this manual

The information in this manual will enable you to commission the HART analog modules of the ET 200M distributed I/O device.

Basic knowledge required

This manual requires general knowledge of automation engineering.

Scope of the manual

This manual is valid for the specified components of the ET 200M distributed I/O device.

This manual contains a description of the components that was valid at the time the manual was published. We reserve the right to include product information with information updates with new components and components with a new product version.

Changes/comments compared to the previous version

Adaptations of the safety warnings, the latest markings and approvals.

Validity of the information on the components

NOTICE
Markings and approvals In the manual, you can find the markings and approvals which are generally possible or planned in the system. The marking or approval that is printed on the HART analog modules of the ET 200M system continues to be exclusively valid.

Safety information

NOTICE
Risk of injury Read the manual before use to avoid injury.

 **WARNING**

Explosion hazard

If the electric circuit is live, the following must be observed:

- Do not disconnect the ET 200M HART analog modules in a flammable or combustible atmosphere.
- Do not open the ET 200M HART analog modules in a flammable or combustible atmosphere.

 **WARNING**

Area of application

The ET 200M HART analog modules are intended for use only in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC environments or non-hazardous locations.

 **WARNING**

Ambient conditions

The ET 200M HART analog modules may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.

 **WARNING**

Enclosure and cables

The ET 200M HART analog modules are intended for installation in an enclosure/control cabinet. The internal operating temperature of the enclosure/control cabinet corresponds to the maximum permissible ambient temperature of the module. Cables must be used whose maximum permissible operating temperature is at least 30 °C above the maximum permissible ambient temperature.

 **WARNING**

Ambient temperature of the device

The temperature of the device housing can be higher than 70 °C if the ET 200M HART analog modules are operated at an ambient temperature of more than 50 °C. The device must therefore be installed so that it is only accessible to service technicians or users who are aware of the reason for the restricted access and the necessary safety measures at an ambient temperature of over 50 °C.

<p>! WARNING</p> <p>Safety functional extra low voltage</p> <p>Ensure that the supply and input voltages of the I/O system are generated safely separately $U_{rated} = 24 \text{ V DC} \pm 20\%$ (_).</p> <p>Power supply according to the following standards:</p> <ul style="list-style-type: none"> • IEC/UL 61010-2-201 This safety functional extra-low voltage with the required protection is referred to as SELV (Safety Extra Low Voltage) / PELV (Protective Extra Low Voltage). <p>or</p> <ul style="list-style-type: none"> • NEC Class 2, as in National Electrical Code (r) (ANSI / NFPA 70) <p>If the device is connected to a redundant power supply (two separate power supplies), both power supplies must meet these requirements.</p>
--

<p>NOTICE</p> <p>Removal and replacement</p> <p>If you replace components, compliance with Class I, DIV. 2 can become invalid. Replacing components may affect the usability of the device.</p>

Approvals

The SIMATIC ET 200M product series meets 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.

For details on approvals and standards, refer to the manual SIMATIC S7-300 Automation System, Module Data (<http://support.automation.siemens.com/WW/view/en/8859629>) in the chapter "Standards and Approvals".

CE marking

The SIMATIC ET 200M product series meets the requirements and protection targets of the following EU Directives:

- Low-Voltage Directive
- EMC Directive
- Explosion Protection Directive

The EC Declaration of Conformity can be downloaded from the Internet (keyword "Declaration of conformity").

Low-Voltage Directive

2014/35/EU "Electrical equipment designed for use within certain voltage limits" (Low Voltage Directive) According to the requirements of IEC 61131-2, the components of the distributed I/O system ET 200M have been tested in compliance with the low voltage directive.

EMC Directive

2014/30/EU "Electromagnetic Compatibility" (EMC Directive) Use in the industrial sector SIMATIC products are designed for industrial applications.

Area of application	Requirements for interference emission	Requirements for interference immunity
Industry	EN 61000-6-4	EN 61000-6-2

Use in residential areas

Note

The ET 200M HART analog modules are intended for use in industrial areas. If used in residential areas, they may interfere with radio/TV reception.

If you use the ET 200M HART analog modules in residential areas, you must ensure compliance with EN 61000-6-3 regarding the emission of radio frequency interference.

Suitable measures to achieve limit class B for radio frequency interference include:

- Installation of the ET 200M HART analog modules in grounded control cabinets/switch boxes
- Use of interference filters in the supply lines

Explosion protection

ATEX approval for the 6ES7332-8TF01-0AB0 module:

	DEKRA 20ATEX0069X
Standards	EN 60079-0
	EN 60079-7
Identification	II3G Ex ec IIC T4 Gc
The certificate is valid for the "DEKRA 20ATEX0069X" products listed in the certificate.	

Note**Special conditions**

1. The ET 200M HART analog modules may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The ET 200M HART analog modules must be installed in a suitable enclosure which provides a degree of protection of at least IP54 in accordance with EN 60079-7, considering the ambient conditions of use.
3. Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient interference voltages.

IECEX approval for the 6ES7332-8TF01-0AB0 module:

	IECEX DEK 20.0033X
Standards	EN 60079-0
	EN 60079-7
Identification	Ex ec IIC T4 Gc
The certificate is valid for the "IECEX DEK 20.0033X" products listed in the certificate.	

Note**Special conditions**

1. The ET 200M HART analog modules may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The ET 200M HART analog modules must be installed in a suitable enclosure which provides a degree of protection of at least IP54 in accordance with EN 60079-7, considering the ambient conditions of use.
3. Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient interference voltages.

ATEX approval for the 6ES7331-7TF01-0AB0 module:

	DEKRA 14ATEX0105X
Standards	EN 60079-0
	EN 60079-15
Identification	II3G Ex nA IIC T4 Gc
The certificate is valid for the products listed in the "DEKRA 14ATEX0105 X" certificate (https://support.industry.siemens.com/cs/document/109483305 (https://support.industry.siemens.com/cs/us/en/view/109483305)).	

Note

Special conditions

1. The ET 200M HART analog modules may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The ET 200M HART analog modules must be installed in a suitable enclosure which provides a degree of protection of at least IP54 in accordance with EN 60079-15, considering the ambient conditions of use.
3. Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient interference voltages.

IECEx approval for the 6ES7331-7TF01-0AB0 module:

	IECEx DEK 14.0081X
Standards	EN 60079-0
	EN 60079-15
Identification	Ex nA IIC T4 Gc
The certificate is valid for the products listed in the "EEx DEK 14.0081X" certificate (https://support.industry.siemens.com/cs/ww/en/view/109483303 (https://support.industry.siemens.com/cs/us/en/view/109483303)).	

Note

Special conditions

1. The ET 200M HART analog modules may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The ET 200M HART analog modules must be installed in a suitable enclosure which provides a degree of protection of at least IP54 in accordance with EN 60079-15, considering the ambient conditions of use.
3. Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient interference voltages.

CCC approval for the 6ES7332-8TF01-0AB0 and 6ES7331-7TF01-0AB0 modules:



According to GB 3836.8 (Explosive gas atmospheres - Part 8: Device protection through type of protection "n")
 GB 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements)
 Ex nA IIC T4 Gc

C-Tick mark

The SIMATIC ET 200M product series meets the requirements of the standard AS/NZS 2064 (Australia and New Zealand).

Standards

The SIMATIC ET 200M product series meets the requirements and criteria of the IEC 61131-2.

Guide

To give you quick access to specific information, the manual contains the following access aids:

- You will find a table of contents and a list of all tables included in the manual at the beginning of the manual.
- The glossary lists all important terms.
- You can find the most important locations in our documents by using our index.

Position in the overall information structure

In addition to this manual, you need the manual for the DP master you are using.

Recycling and disposal

The ET 200M is ecologically compatible, and thus suitable for recycling. For ecologically compatible recycling and disposal of your old device, contact a certificated disposal service for electronic scrap.

Additional support

If you have any questions relating to the products described in this manual, and do not find the answers in this documentation, please contact your Siemens partner at our local offices.

You can find your contact person on the Internet (<http://www.automation.siemens.com/partner/>).

The guide to the technical documents for the various SIMATIC products and systems is available on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).

The online catalog and the ordering system are available on the Internet (<http://www.siemens.com/automation/mall>).

Training center

We offer a range of relevant courses to help you to get started with the ET 200M and the SIMATIC S7 automation system. Please contact your local training center or the central training center in D-90327 Nuremberg.

You will find further information on the Internet (<http://www.siemens.com/sitrain>).

Technical Support

You can reach the Technical Support for all the Industry Automation products via the Web form Internet (<http://www.siemens.com/automation/support-request>) for the Support Request.

You can find additional information on our Technical Support on the Internet (<http://www.siemens.com/automation/service>).

Service & Support on the Internet

In addition to our documentation, we offer a comprehensive online knowledge base on the Internet (<http://www.siemens.com/automation/service&support>).

There you will find:

- the newsletter containing the latest information on your products.
- the latest documents via our search function in Service & Support.
- a forum for global information exchange by users and specialists.
- Your local Industry Automation representative via our contact person database.
- Information on field service, repairs, spare parts and much more.

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System connection

1.1 Overview of the HART analog modules

Overview

The following SIMATIC S7 HART analog modules are described in this chapter:

- SM 331; AI 8 x 0/4...20mA HART (HART analog input module),
order number: 6ES7331-7TF01-0AB0
- SM 332; AO 8 x 0/4...20mA HART (HART analog output module),
order number: 6ES7332-8TF01-0AB0

This manual provides you with the knowledge you required to use the modules as a HART interface:

- An introduction to HART to make it easier to get started with this technology
- A guide to commissioning and operation using an example configuration
- HART-specific parameter assignment and diagnostics
- Technical specifications for the HART analog modules

1.2 ET 200M with HART analog modules

Basic properties

You can operate the HART analog modules as part of the distributed I/O ET 200M with the interface modules:

- as of IM153-2BA00 or as of IM153-2BB00 as link to PROFIBUS DP.
- as of IM153-4BA00 as link to PROFINET IO.

In this application the ET 200M is the HART master for HART devices (intelligent field devices). The IM153-2 directs the commands (for example, parameter assignment) that come from the HART client (for example, PDM or programmed via the data record interface of the HART analog modules) through the HART analog module to the intelligent field devices. The reply comes back the same way. In the figure below, the gray line represents the communication path in an application with PROFIBUS DP.

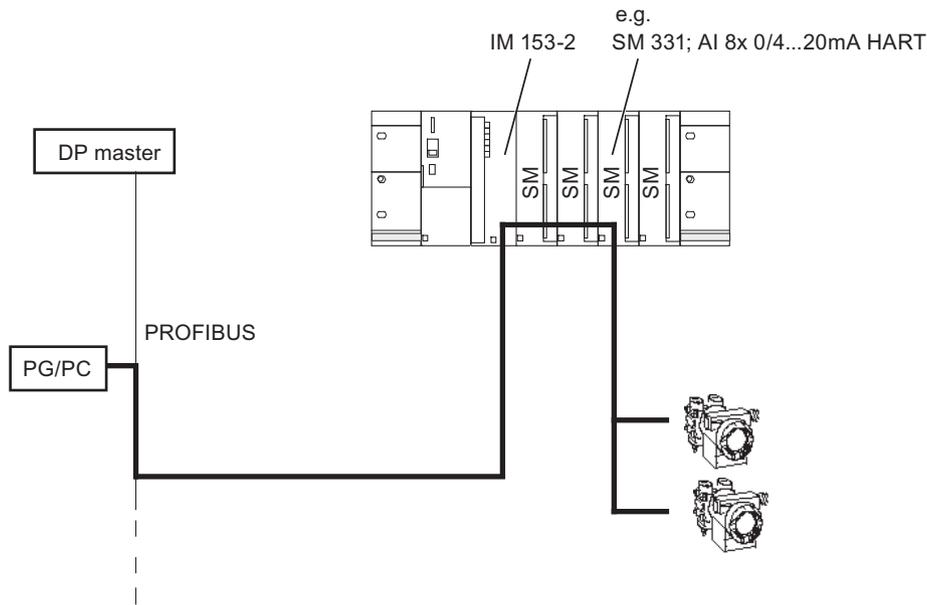


Figure 1-1 Forwarding parameter assignment data with an IM153-2 and HART analog modules

Use with PROFIBUS DP

If you operate the HART analog modules with the PROFIBUS DP interface modules, you can configure the field devices with PDM as of V6.0 + SP3. See section Configuring (Page 36).

All examples listed in this manual refer to the use of modules with PROFIBUS DP interface modules.

Use with PROFINET IO

The use of HART analog modules with PROFINET IO is possible:

- as of STEP 7 V5.4, SP2 and HSP 119 as of V2.2.
- with the latest GSDML file of IM153-4BA00 as of V2.25.

In the event of integration using the GSDML file, HART analog modules are available with 0, 4 or 8 HART auxiliary variables each and will be permanently assigned to the respective address space.

However, you cannot configure HART field devices using PROFINET IO. You cannot use PDM to assign the field device parameters or for a user calibration of the HART analog modules.

See also

For general information on the SIMATIC S7 modules, see the device manual Automation System SIMATIC S7-300 Module Data on the Internet (<http://support.automation.siemens.com/WWW/view/en/8859629>). The general information on analog modules provided there is not repeated in this manual.

You can find more information on ET 200M in the SIMATIC manual Distributed I/O Device ET 200M on the Internet. (<http://support.automation.siemens.com/WWW/view/en/1142798>)

Product Overview

2.1 Fundamental information on the use of HART analog modules

Overview

The following figure shows where you can use the HART analog modules in the system:

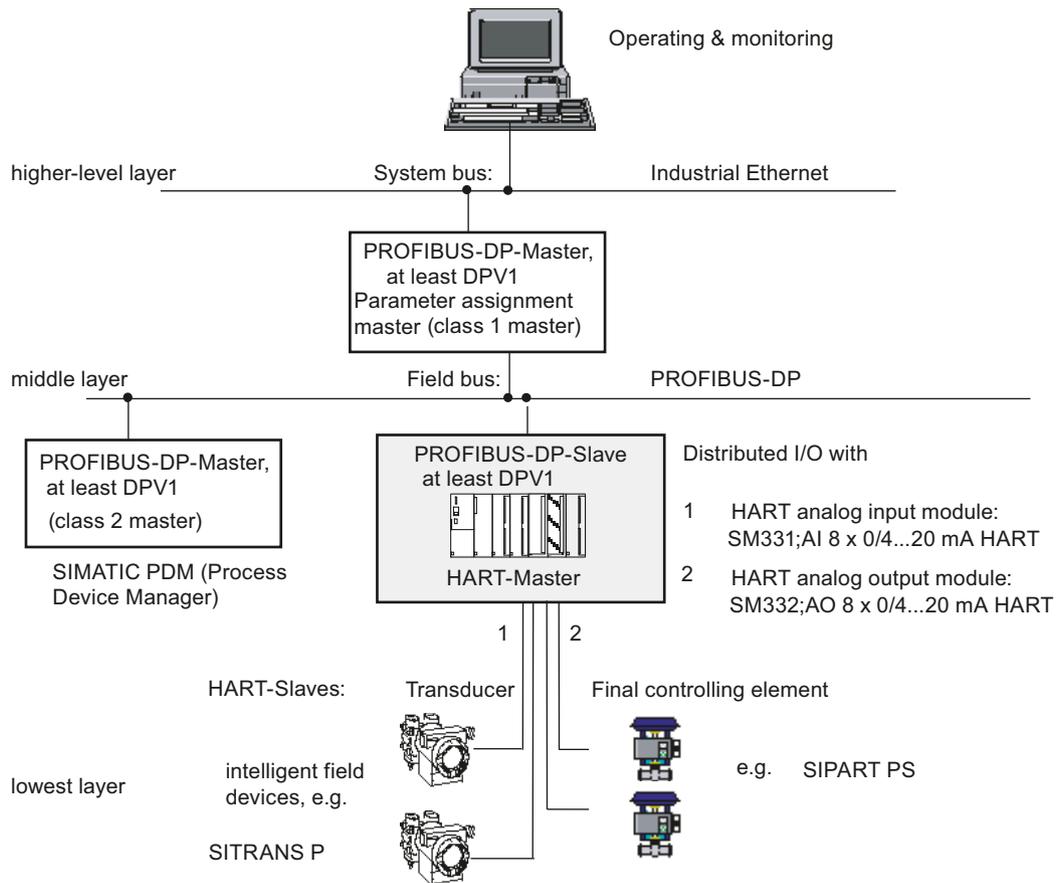


Figure 2-1 Location of HART analog modules in the distributed system

Use in the system

The HART analog modules are used in the distributed I/O connected to the PROFIBUS-DP (see the figure above).

You can connect a field device to each channel of a HART analog module: The module works as the HART master, monodrop; the field devices work as HART devices.

Different SW applications can send or receive data via a HART analog module. They can be compared to clients for which the HART analog module is the server.

2.2 Firmware update via HW Config

Introduction

Based on compatible feature enhancements, you can upgrade the HART modules to the latest firmware version.

The most recent firmware versions are available from your Siemens representative or from the Internet (<http://www.siemens.com/automation/service&support>).

The firmware cannot be updated if the module is in a redundant state.

Requirements

- STEP 7 V 5.4, Service Pack 3 or higher
- The 24 VDC power supply must be connected for the firmware update of the HART analog output module.
- The HART analog module is not being used redundantly during the firmware update.

Updating firmware

1. Select the HART module in HW Config.
2. Select the PLC > Update Firmware menu command.
3. Use the "Browse" button to select the path to the firmware files (*.upd).
4. Click the "Run" button.
 - The module performs the firmware update.

You can find additional information in the STEP 7 Online Help.

Note

It is not permitted to download a firmware version lower than V 3.0.0 to a module with a version \geq V 3.0.0. This will cause the module to malfunction. The module is then considered faulty and must be sent to the manufacturer for repair.

Note

- During the firmware update, OB 83 (Insert/remove module interrupt) and OB 85 (program execution error) are called. If the diagnostic interrupt of the module is enabled, OB 82 is also called during the firmware update. Make sure that the OBs are programmed accordingly.
 - If the SF LED on the module is flashing, the firmware update experienced an error and must be repeated. In this case, the bootloader version Ex.x.x is displayed in the online diagnostics.
-

Labeling the firmware

After the firmware update, you must identify the firmware version on the module.

2.3 Connecting transducers and loads

2.3.1 Connecting current sensors or transducers to analog inputs

Introduction

You can connect current sensors or transducers to the analog input modules.

Lines for analog signals

In the following figures the required connecting lines for the potential connection of the analog input module and the sensors are not shown.

Therefore, please note the generally applicable information on connecting sensors in the *Manual Automation System SIMATIC S7-300 Module Data* on the Internet (<http://support.automation.siemens.com/WW/view/en/8859629>)

Abbreviations used in the following figure

The following abbreviations are used in the figures below:

I	Transducer current
L+	Power supply 24 V DC
M+	Measuring line (positive)
M-	Measuring line (negative)
M	Grounding terminal
MU	transducer
U_{ISO}	Potential difference between M 0- to M 7- and the ground terminal of the IM 153
U_M	Voltage at shunt
U_V	Transducer supply

Sensor Supply Voltage

The 2-wire sensor is wired to a short-circuit-proof supply voltage at the terminals of the analog input module.

The 2-wire transducer then converts the measured value to a current. The 2-wire transducers must be isolated measured-value transmitters.

The figure below shows the connection of current sensors as 2-wire transducers to the analog input module SM 331; AI 8 x 0/4...20mA HART.

The short-circuit-protected transducer supply of the module is activated and jumpering carried out on the analog input via jumper 10-11. U_{ISO} is therefore inapplicable in the case of 2-wire transducers.

Through the use of L+, M to provide a common supply to the transducers, the permitted potential difference between the channels is canceled.

2.3 Connecting transducers and loads

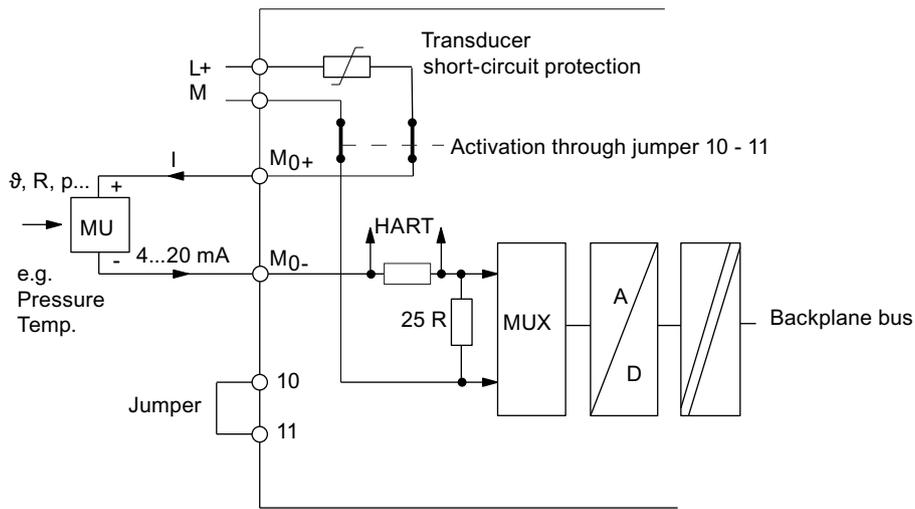


Figure 2-2 Connection of 2-wire transducers to a HART-AI

The following figure shows how to connect a 4-wire transducer (4...20mA) to a module configured for a 2-wire transducer (4...20mA).

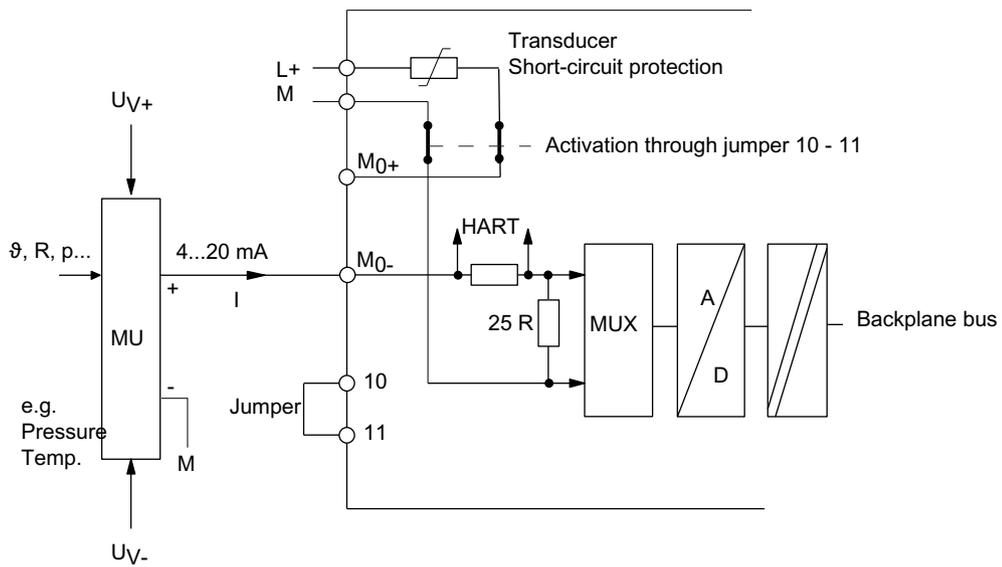


Figure 2-3 Connection of a 4-wire transducer (4...20mA) to a module configured for a 2-wire transducer (4...20mA)

Four-wire measuring transducers have a separate power supply.

The figure below shows the connection of current sensors as 4-wire transducers with external transducer supply to the analog input module SM 331; AI 8 x 0/4...20mA HART.

Remove jumper 10-11; parameter assignment in STEP 7 as "4DMU".

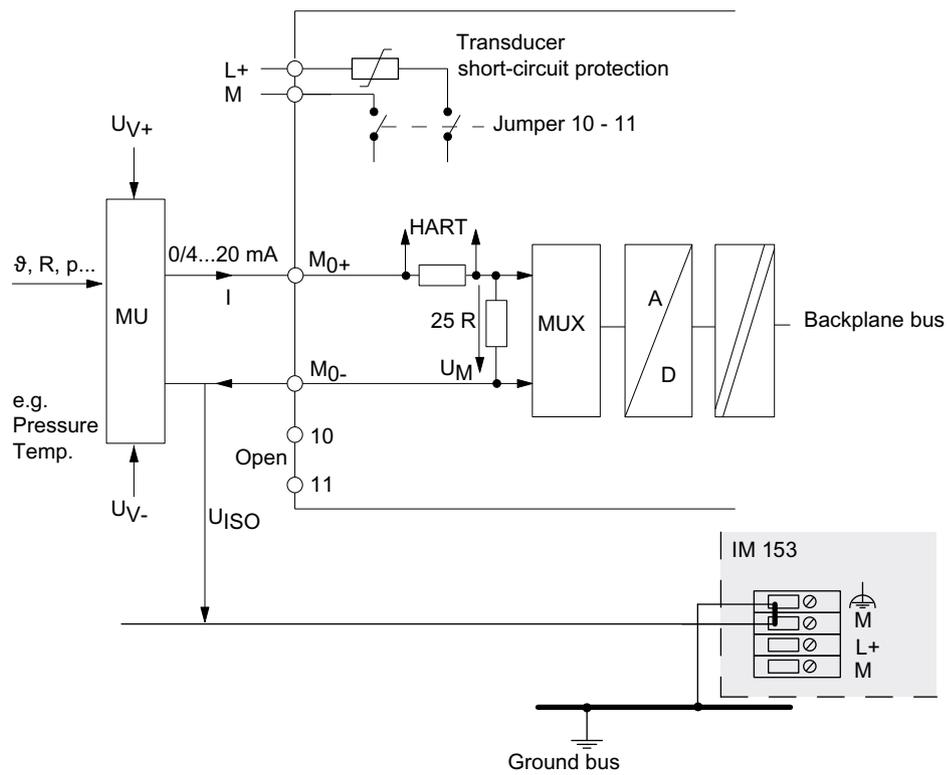


Figure 2-4 Connection of 4-wire transducers to a HART-AI

The following figure shows how to connect a 2-wire transducer (4...20mA) to a module configured for a 4-wire transducer (4...20mA).

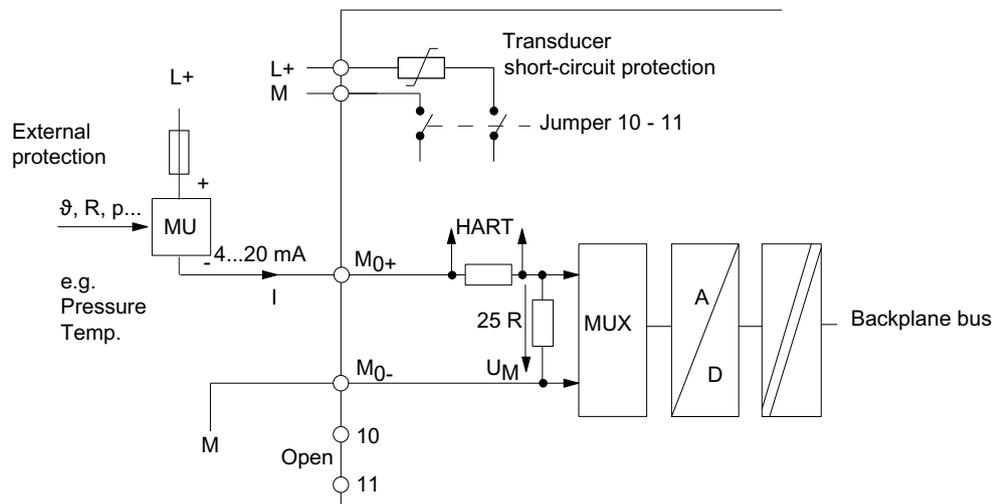


Figure 2-5 Connection of a 2-wire transducer (4...20mA) to a module configured for a 4-wire transducer (4...20mA)

See also

Internet S7-300 Module Data (<http://support.automation.siemens.com/WW/view/en/7215812>)

2.3.2 Connection of loads or actuators to analog outputs

Introduction

With the analog output modules you can supply loads and actuators with current.

Lines for analog signals

In the following figure the required connecting lines for the potential connection of the analog output module are not shown.

Please note the generally applicable information on connecting loads/actuators in the manual Automation System SIMATIC S7-300 Module Data on the Internet (<http://support.automation.siemens.com/WW/view/en/8859629>).

Abbreviations used in the following figure

The following abbreviations are used in the figure below:

CHx +	Positive analog terminal (output current)
CHx -	Negative analog terminal (reference potential)
M_{ANA}	Reference potential of the analog circuit
R L	Load impedance
L+	Power supply 24 V DC
M	Grounding terminal
$M_{external}$	Reference potential of the load circuit
$M_{internal}$	Reference potential of the control circuit (ground terminal of the IM 153) and the backplane bus
U_{ISO}	Potential difference between M_{ANA} and the ground terminal of the IM 153
Mx+/-	Measuring line (positive / negative)

Connecting Loads to Current Outputs

You must connect loads to CHx + and the reference point of the analog circuit CHx - of a current output.

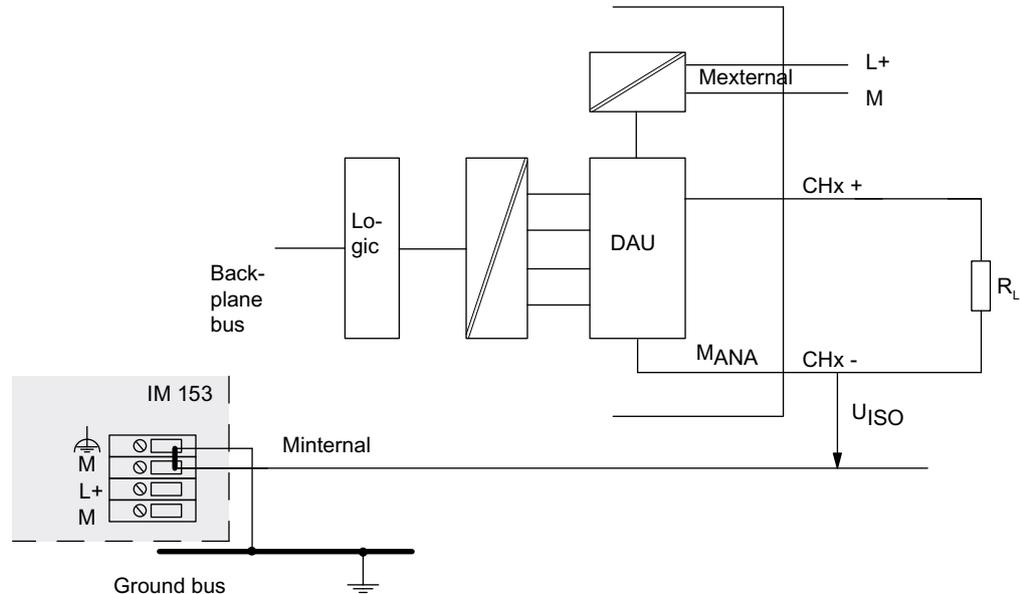


Figure 2-6 Connection of loads to a current output of a HART-AO

2.4 Connecting sensors/actuators in redundant mode

Introduction

Redundant mode is only possible in distributed use. In redundant mode, duplicate HART modules are available and are configured and operated redundantly.

Redundant mode is possible for the HART analog input and output modules. The HART modules have the "Primary Master" and "Secondary Master" parameters for this purpose. This parameter assignment is used to enable simultaneous HART communication to a field device by means of both modules. The module with the lower address is always the "Primary Master".

HART-Fast-Mode is not possible in redundant mode.

Additional information

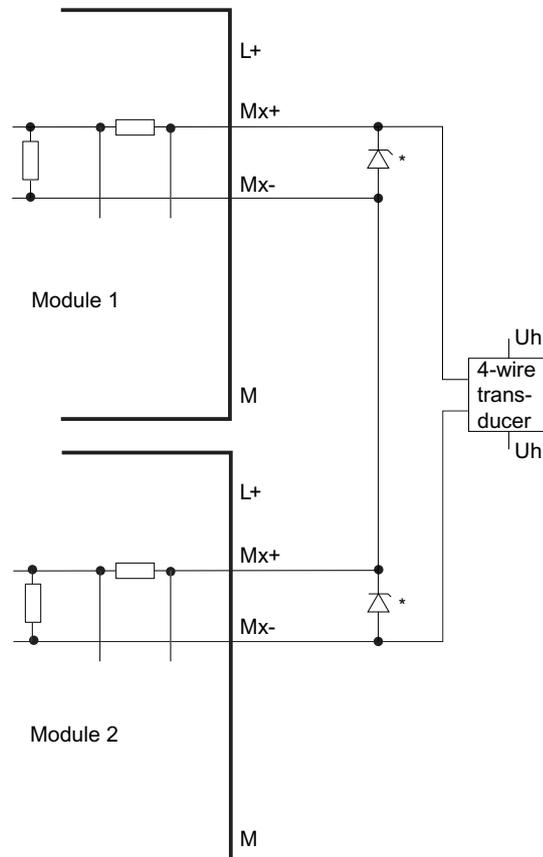
You can find additional information on the subject of redundancy in the Automation System S7-400H Fault-Tolerant Systems manual on the Internet (<http://support.automation.siemens.com/WW/view/en/1186523>)

Notes on modules in redundant use

- In redundant mode, additional HART masters, such as handheld, cannot be connected.
- HART-Fast-Mode is not possible in redundant mode.
- User calibration is not possible in redundant mode.
- In redundant mode, the substitute value behavior of the current outputs is set automatically to "zero current and zero voltage" (OCV). However, if the CPU is in STOP mode, a current of around 115 μ A is still output for each channel.
- When HART analog modules are operated in redundant mode, a 2-wire transducer must be connected as a 4-wire transducer and configured as a 4-wire transducer in the HW Config (see Figure Connection of 2-wire transducer). Terminals 10 and 11 on the front panel connector must not be connected. Note the manufacturer-specific features when configuring the field devices.
- In redundant mode, the voltage drop on both modules must be observed. To ensure a sufficient voltage supply for the transducer, the voltage drop on both modules and the voltage drop on the wiring and on the transducer must be observed (series connection). With a sensor current of 22 mA, a voltage drop of approximately 3.3 V occurs on each module. If you are using the circuit with Zener diodes shown below and you replace the modules, note that the voltage drop on the removed module is the Zener voltage (5.1 V) and the voltage drop on the inserted module is 3.3 V.
- Hardware interrupts are not supported by the blocks in the "RedLib" library. If you would like to use hardware interrupts, you must implement the evaluation at the user level. You can find additional information in the STEP 7 Online Help.

Connection of a 4-wire transducer to the HART analog module SM 331

The following figure shows the connection of a 4-wire transducer in redundant mode.

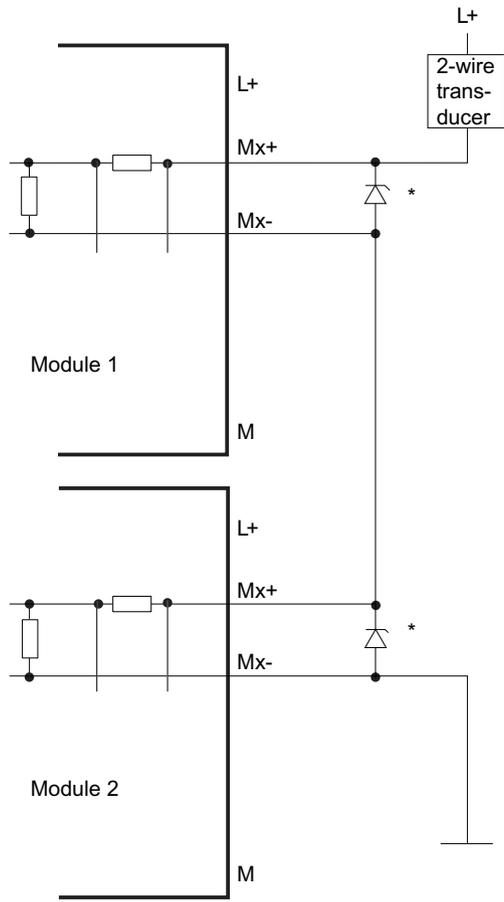


* Zener diode 5.1 V (e.g., BZX85C5V1), only required if a module is removed and the system should continue running.

Figure 2-7 Connection of a 4-wire transducer to the SM 331

Connection of a 2-wire transducer to the HART analog module SM 331

The following figure shows the connection of a 2-wire transducer in redundant mode.



* Zener diode 5.1 V (for example BZX85C5V1), only required if a module is removed and the system is to continue running.

Figure 2-8 Connection of a 2-wire transducer to the SM 331

Connection of an actuator to the HART analog output module SM 332

The discrepancy analysis parameter must be available for the HART analog output module.

The following figure shows the connection of an actuator in redundant mode.

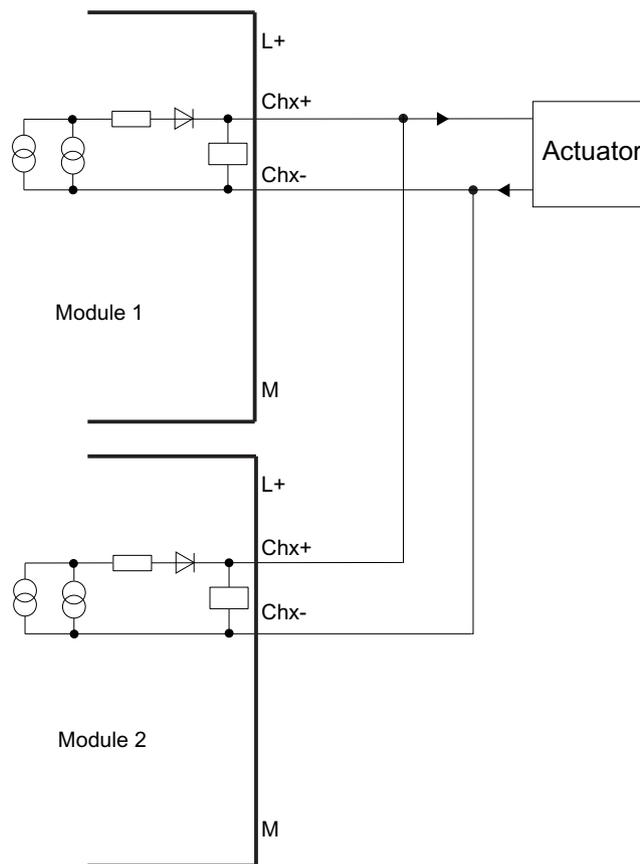


Figure 2-9 Connection of an actuator to the SM 332

Analog output signals

HART analog output modules with current outputs (4 to 20 mA) can be operated redundantly. The value to be output is divided by 2 in the user program or in the "RedLib" redundancy blocks, and each of the two modules outputs its half of the value. If one of the modules fails, the failure is detected and the remaining module outputs the full value.

Note

With this procedure, the output value drops briefly to half, and after the reaction in the program the output value is raised to the correct value.

2.5 Basic features of the HART analog modules

Overview

"HART" stands for Highway Addressable Remote Transducer. HART is a registered trademark of the HART Communication Foundation.

HART analog modules are analog modules that can carry out HART communication in addition to their analog value. HART analog modules can be used as HART interfaces for HART field devices. HART field devices can thus be parameterized or diagnostic statuses can be read out through the modules.

2.6 Introduction to HART

2.6.1 Use of HART

Introduction

This chapter provides an introduction to HART from the user's point of view:

- Definition of HART
- Benefits of HART analog modules
- Typical applications of HART

Definition

HART functionality allows you to use the analog modules with additional digital communication options. The HART protocol has become the de facto standard protocol for communication with intelligent field devices: HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol.

Benefits of HART

The use of HART analog modules offers you the following benefits:

- Pin-compatible with analog modules: Current loop 4 - 20 mA
- Additional digital communication using the HART protocol
- Low power requirements
- Numerous field devices with HART functions are in use
- The HART analog modules allow HART to be used in the S7 system

Typical applications

The following applications are typical for HART:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices

2.6.2 How HART works

Introduction

The HART protocol describes the physical form of the transfer: transfer procedures, message structure, data formats and commands.

HART signal

The figure below shows the analog signal with the modulated HART signal (FSK method), which consists of sine waves of 1200 Hz and 2200 Hz and has a mean value of 0. It can be filtered out using an input filter so that the original analog signal is available again.

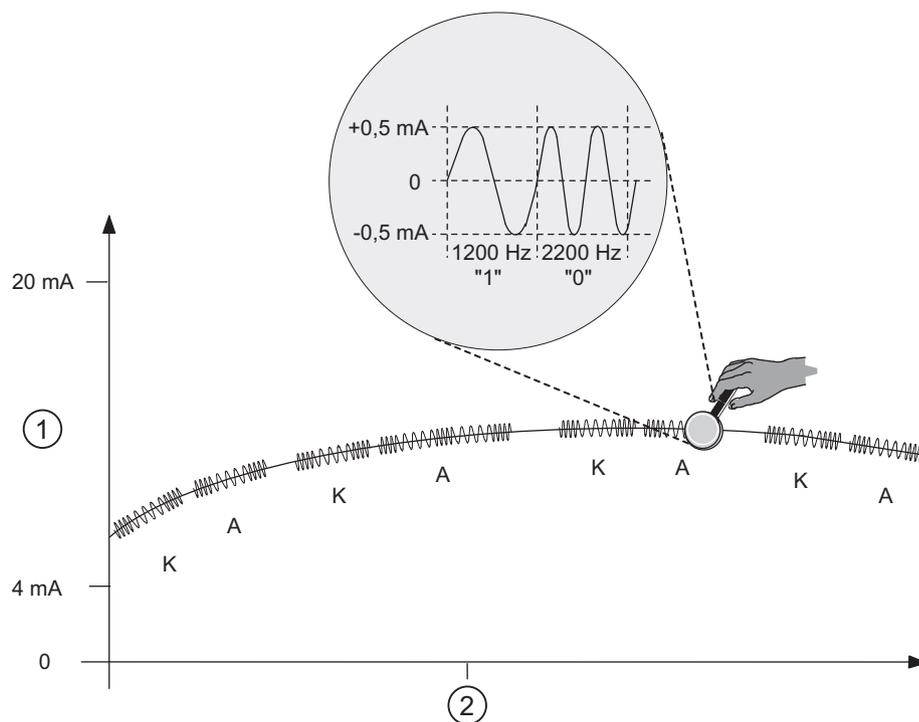


Figure 2-10 The HART signal

- ① Analog signal
- ② Time (seconds)
- K Command
- A Reply

HART commands and parameters

The assigned parameter properties of the HART field devices (HART parameters) can be set with HART commands and read out by means of HART replies. The HART commands and their parameters are divided into three groups with the following properties:

- Universal
- General usage
- device-specific

Universal commands must be supported by all manufacturers of HART field devices and common practice commands should be supported. There are also commands specific to the device that apply only to the particular field device.

HART communication can be controlled by only one client per channel. See Chapter HART communication records (Page 83).

Examples of HART parameters

The following table shows the HART parameters of the various groups:

Table 2-1 Examples of HART parameters

Parameter group	Parameters of the HART field device
Universal	Measured value or manipulated variable (primary variable), manufacturer name, measuring point tag or ID for positioner, further measured values or manipulated variables
General usage	Measuring range, filter time, alarm parameters (message, alarm and warning limits), output range
device-specific	Special diagnostic information

Examples of HART commands

The following two tables show examples of HART commands:

Table 2-2 Examples of universal commands

Command	Function
0	Read manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Read manufacturer and device type
1	Read primary variable and unit
2	Read current and percentage of the range, digitally as floating-point number (IEEE 754)
3	Read up to four predefined dynamic variables (primary variable, secondary variable, etc.)
13, 18	Read or write measuring point tag, description and date (data included in transmission)

Table 2-3 Examples of universal commands

Command	Function
36	Sets the upper limit of the range
37	Sets the lower limit of the range
41	Carries out the device self-test
43	Sets the primary variable to zero

Data and status

HART commands are often sent without data, since they serve to initiate processing. HART replies always contain data. Status information (HART status bytes) is always sent together with a HART reply. You should evaluate these to make sure the reply is correct.

Example of HART programming

For the HART channel 0, the command 01 is to be sent in Transparent Message Format to the HART device with the address "98 CF 38 84 F0". A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the ET 200M is 512 (200H).
- The record is stored in DB80: starting at address 0.0, length 11 bytes.
- In this example, DB80 (request record for channel 0) consists of 11 bytes.

Table 2-4 FC80: Writing of the record to DB80 with SFC 58

STL	Explanation
U E 4.0	
FP M 101.0	
= M 104.0	
m2: CALL SFC 58	
REQ :=M104.0	Write request
IOID :=B#16#54	Address range ID
LADDR :=W#16#200	Module address of the HART-AI
RECNUM :=B#16#50	Data record number 80
RECORD :=P#DB80.DBX0.0 BYTE 11	Data record with length of 11 bytes (must correspond to the exact length that is to be transferred)
RET_VAL :=MW93	RET_VAL of SFC 58 (OK/error/...)
BUSY :=M51.0	Write operation not yet completed
U M 51.0	
SPB m2	
BE	

2.6 Introduction to HART

Table 2-5 DB80: Transparent Message Format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent Message Format. 40 = Transparent Message Format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Check sum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

As of firmware version V3.0.0, a HART command can also be sent in Compact Message Format. In this case, the data that is to be transferred via the DB 80 is reduced to 4 bytes.

Table 2-6 DB80: Compact Message Format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact Message Format. 60 = Compact Message Format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	01	Command (CMD)
3	00	Length in bytes

You can find out when the reply was received by cyclically reading record DS81 for HART channel 0. The response is always supplied in Transparent Message Format.

Table 2-7 FC81: Reading of the reply to DB81 with SFC 59

STL	Explanation
m3: CALL SFC 59	
REQ :=1	Read request
IOID :=B#16#54	Address range ID
LADDR :=W#16#200	Module address of the HART-AI
RECNUM :=B#16#51	Data record number 81
RECORD :=P#DB81.DBX0.0 BYTE 75	Data record

STL	Explanation
RET_VAL :=MW100	RET_VAL of SFC 59 (OK/error/...)
BUSY :=M49.1	Read operation not yet completed
U M 49.1	
SPB m3	
BE	

The program part UM 49.1 to SPB m3 is only required if reading is to occur synchronously.

As long as "0x03" is in byte 0 of DB81, the reply has not been received from the field device. As soon as bit 2 = 1 is set in byte 0, there is positive reply data available from the field device that you can evaluate.

If the reply data is incorrect, see the tables "HART group fault displays in reply byte 1 (extended response control)" and "HART protocol errors in reply byte 2 for a reply from the field device to the module (error code)" in this manual.

HART-Fast-Mode

SM 331 and SM 332 offer HART-Fast-Mode as of firmware version V3.0.0. Requirement:

- The module must be configured as V3.x.
- The HART-Fast-Mode is enabled via the configuration.
- The module is not being operated redundantly.

With an enabled HART-Fast-Mode, the module supports the processing of HART commands as a SHC sequence (Successive HART Command).

This means, if the module detects a HART command with set SHC bit on a channel, then the entire HART command processing is reserved on the HART module for this channel for approximately 2 seconds. HART command processing does not take place on any of the other module channels during this period.

Each time a HART command with set SHC bit is detected, the module once again reserves the HART command processing for this channel for a further 2 seconds. If a HART command without a set SHC bit is detected for this channel, or if not further command for this channel occurs within 2 seconds after the previous HART command, the module returns to "normal" HART command processing. Meaning that all the HART channels are processed as before.

Note

- While a HART channel of the module is processing an SHC sequence, i.e. the entire HART processing of the module is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
 - HART commands for other channels are not processed and are acknowledged correspondingly.
-

As of V6.0 SP5, the PDM supports the processing of HART commands with SHC sequence. To do this, you must also enable in the PDM "HART RIO SHC mode" in the "Communication" tab under "Tools -> Settings".

2.6.3 Use of HART

System environment for the use of HART

You require the following system environment (see the figure below) in order to use an intelligent field device with HART functionality:

- Current loop 4 - 20 mA
- HART parameter assignment tool:
You can set the HART parameters either by using an external hand-held operating device (HART Handheld) or a HART parameter assignment tool (PDM). The parameter assignment tool goes through the HART analog module whereas the HART Handheld is connected parallel to the field device. PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*. The latter is available in the form of an optional package.
- HART system connection:
The HART analog module takes on the role of a master by receiving the commands from the HART parameter assignment tool, forwarding them to the intelligent field device and sending back the replies. The interface of the HART analog module is formed by records transferred over the I/O bus. The records must be created or interpreted by the HART parameter assignment tool.
The analog values are entered in the process image of the inputs and outputs in 16-bit format.
- IM153-2 interface module for the HART parameter assignment tool:
DP interface module offering both master class 1 functionality and master class 2 functionality.

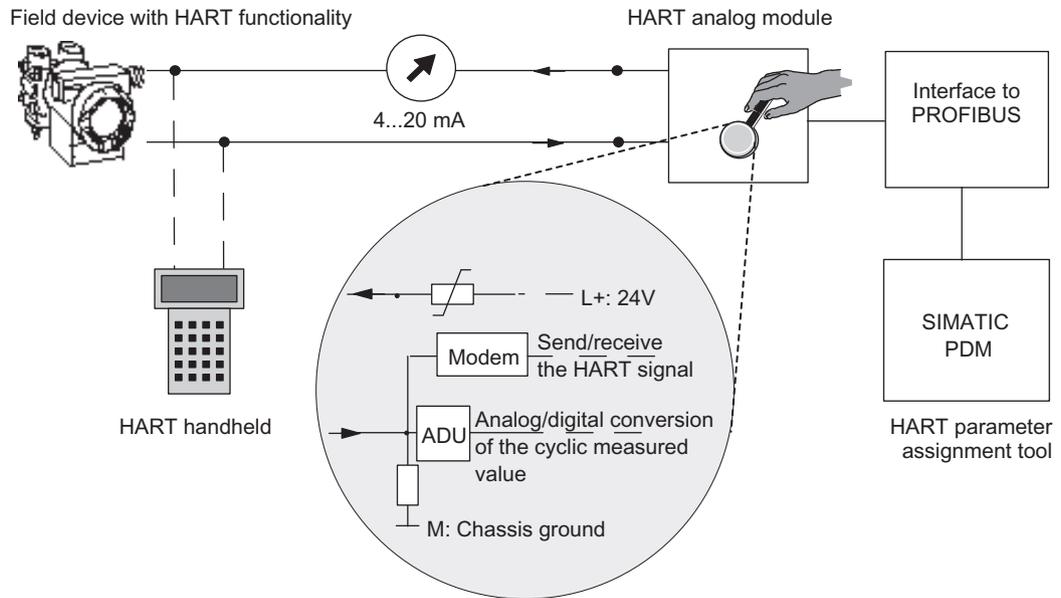


Figure 2-11 System environment for the use of HART

Error management

The two HART status bytes transferred with every reply of the field device contain error information on the HART communication, the HART command and the device status. (See "HART communication records".)

See also

HART communication records (Page 83)

Instructions for configuration, commissioning and operation

3

3.1 Example configuration

Use in the system

Using an example configuration you are shown how to commission a HART analog module with the connected field devices and what you have to take into consideration during operation. You will find more information on the operation of the field devices in the SIMATIC PDM help system.

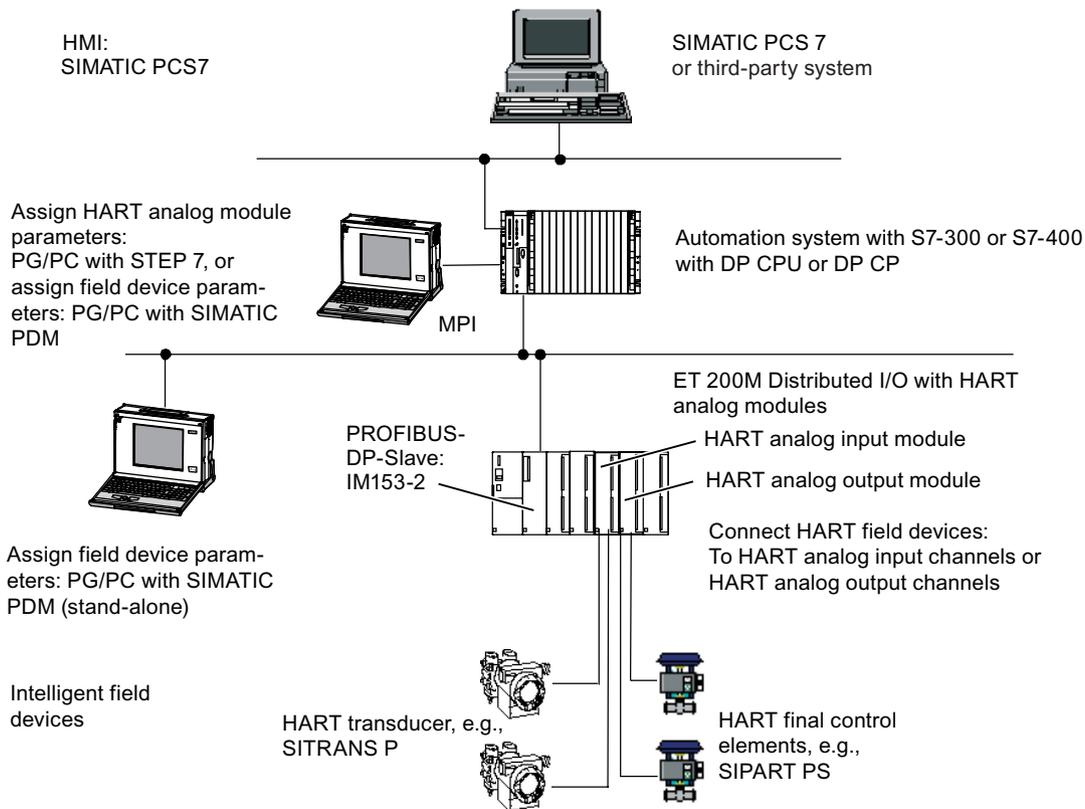


Figure 3-1 Using the HART analog module in an example configuration

3.2 Configuring

3.2.1 Configuring the HART analog module and field devices

Overview

You configure the HART analog modules

- In the SIMATIC S7 system with *STEP 7* as of V5.4, SP3 and in the HSP 0119 V2.0 for the module "AI/AO 8x16 Bit HART, V3.x".
- Using the current GSD file of the IM153-2BA02-0XB0.

You calibrate the HART analog modules

- Using SIMATIC PDM V6.0, SP3 + HF2, see Chapter Calibration (Page 93).

You parameterize the field devices

- With SIMATIC PDM V 6.0 Service Pack 3 or higher and the EDD for ET 200M modules V 1.1.8 or higher.
If you have configured the module as of V3.x, you need the EDD for ET 200M modules as of V1.1.10.

You use the HART-Fast-Mode

- With SIMATIC PDM as of V6.0 + SP5.

3.2.2 Configuring the HART analog modules with a GSD file

Configuration with a GSD file

You can use the current GSD file of the IM 153-2BA02-0XA0 to configure the modules as follows:

1. Insert the HART analog module in the desired slot.
2. Parameterize the diagnostics functionality by double-clicking the module.
3. Create a DB, for example the DB128. The contents of the DB must include the dynamic parameters of the parameter data record 1, see Chapter Parameter records (Page 73) for the AI-HART or for AO-HART.
4. Set up the appropriate DB for the parameter records 131 - 138 of the HART channels, see Chapter Parameter records of the HART channels (Page 88). You could use, for example, the DB 131-138.
5. In a startup OB (OB 100), write the DBs to records 128 and 131 to 138. Not until all records have been received is the module configured.

Example for the writing of DB128 with SFC 58 "WR_REC" for the AI-HART

The following assumptions are made:

- The module address of the ET 200M is 512 (200_H).
- The parameter record is stored in DB128: starting at address 0.0, length 46 bytes.
- The configured data will be transferred as DR128.

STL	Explanation
m1: CALL SFC 58	
REQ :=1	Write request
IOID :=B#16#54	Address range ID
LADDR :=W#16#200	Module address of the HART-AI
RECNUM :=B#16#80	Data record number 128
RECORD :=P#DB128.DBX0.0 BYTE 46	Data record
RET_VAL :=MW92	RET_VAL of SFC 58 (OK/error/...)
BUSY :=M50.0	Write operation not yet completed
U M 50.0	
SPB m1	
BE	

The program part U M 50.0 to SPB m1 is only required if reading is to occur synchronously.

To write DBs 131 to 138, proceed as follows. Note that parameter records 131 to 138 of the HART channels have a length of 8 bytes.

3.2.3 Configuring HART variables**Introduction**

Numerous HART field devices make available additional measured quantities (e.g. sensor temperature). These can be read out if they are set accordingly in the field device configuration in the PDM. Using the HART variables it is possible to adopt the set measured values directly from the field device into the I/O area of your automation system.

Regardless of the number of configured channels, a maximum of 8 HART variables can be assigned for HART modules, and no more than 4 HART variables per channel. You assign the HART variables to a channel in the properties dialog for the module.

Requirement

As of IM 153-2, 6ES7153-2BA02-0AB0 and STEP7 V5.4, SP 3

3.2 Configuring

Address assignment

The HART module occupies 16 input/output bytes. If you configure HART variables, the module occupies an additional 5 bytes for each HART variable.

If you use all 8 HART variables, the HART input module occupies a total of 56 input/output bytes (16 bytes + 8 x 5 bytes = 56 bytes).

The "None" configuration occupies no additional input bytes.

Configuration of HART variables

You assign the HART variables in STEP 7 HW Config.

You can configure up to 4 HART variables for a channel

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary)

If you want to assign the HART variable later in the user program, use the CiR parameter. CiR is a placeholder that reserves the address space for a HART variable. You must configure the HART variables you are not using with the "None" parameter.

Example of a configuration of HART variables

The following figure shows an example for the configuration of HART variables.

Properties - AI8 x 16Bit HART					
General	Addresses	Identification	Inputs	HART Variables	Redundancy
Variable 1	<input type="text" value="Channel 2 PV"/>			Address 144	
Variable 2	<input type="text" value="Channel 4 QV"/>			Address 149	
Variable 3	<input type="text"/>	<input type="text" value="None"/>		Address 154	
Variable 4	<input type="text" value="No"/>	<input type="text" value="Channel 0 PV (Primary Variable)"/>		Address 159	
Variable 5	<input type="text" value="No"/>	<input type="text" value="Channel 0 SV (Secondary Variable)"/>		Address	
Variable 6	<input type="text" value="No"/>	<input type="text" value="Channel 0 TV (Tertiary Variable)"/>		Address	
Variable 7	<input type="text" value="No"/>	<input type="text" value="Channel 0 QV (Quaternary Variable)"/>		Address	
Variable 8	<input type="text" value="No"/>	<input type="text" value="Channel 1 PV (Primary Variable)"/>		Address	

<input type="text" value="Channel 1 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 1 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 1 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 2 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 2 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 2 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 2 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 3 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 3 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 3 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 3 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 4 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 4 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 4 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 4 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 5 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 5 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 5 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 5 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 6 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 6 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 6 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 6 QV (Quaternary Variable)"/>	Address
<input type="text" value="Channel 7 PV (Primary Variable)"/>	Address
<input type="text" value="Channel 7 SV (Secondary Variable)"/>	Address
<input type="text" value="Channel 7 TV (Tertiary Variable)"/>	Address
<input type="text" value="Channel 7 QV (Quaternary Variable)"/>	Address
<input type="text" value="CIR"/>	Address

Figure 3-2 Example of a configuration of HART variables

Configuration of HART variables

The HART variables are structured as follows:

4 bytes of HART data	1 byte QC
----------------------	-----------

Structure of the "Quality-Code" byte

The Quality-Code (QC) can assume the following values:

Quality-Code (QC)	Meaning
0x4C or 0	Initialization: 0 value of IM and 4C of module
0x18	Communication cancelled / no communication
0x0C	Fault in HART device
0x47	HART device is busy
0x84	OK "Configuration changed"
0x80	OK

Reassign HART variables in RUN mode

You can reconfigure HART variables in RUN mode in S7-400 automation systems with CiR capability and also in S7-400H systems.

Requirement: HART variable must already be configured in HW Config as PV, SV, TV, QV, or CiR.

3.3 Commissioning the HART analog module and field devices

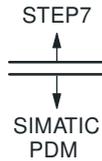
Start-up

Commission the HART analog modules with STEP 7 and the connected intelligent field devices with the SIMATIC PDM parameter assignment tool.

Procedure for commissioning

1. Connect the HART analog module to the ET 200M distributed I/O device. Configure and parameterize the associated station in SIMATIC Manager with *STEP 7*:
To do this, double-click the "Hardware" icon.
2. Select from the PROFIBUS catalog the ET 200M distributed I/O device with one of the permissible IM153 modules and connect it to the PROFIBUS (note the DP slave address).
3. Insert the HART analog module in the desired slot, and parameterize the module:
To do this, double-click the HART analog module in the selected slot.
4. Insert the HART field devices in the corresponding channels.
5. Load the configuration for the station that also contains the parameter assignment for the HART analog module in the automation system.

6. To assign parameters for the field devices, open the SIMATIC PDM:
To do this, double-click the HART field device configured on the channel.



7. Now you can use the SIMATIC PDM parameter assignment tool to assign parameters to the field devices:
SIMATIC PDM provides you with a device- specific parameter assignment interface - depending on the type of field device connected. You must have installed the EDD of the field device, the IM 153, and the HART analog module beforehand.
When SIMATIC PDM as of V6.0 SP3 is installed, the EDD for the IM 153 and the HART modules is also installed.
You need to have already installed the EDD as of V1.1.10 in order to operate a V3.x configured module.
To do this, double-click the field device in *HW Config* or choose >Start >SIMATIC >SIMATIC PDM >Manage Device Catalog.

Modifying parameters of the field devices

Note that the field devices report any parameter modification to the HART analog module as a configuration change. This leads to a diagnostic interrupt in the automation system, if it is enabled. During commissioning it is better if you disable the diagnostic interrupt when you assign parameters to the HART analog module. A diagnostic interrupt can also be triggered, if enabled, during parameter modification with the handheld.

Special features for use of SIMATIC PDM as Secondary Master

If you have only configured one single channel of a module as HART channel and access the field device with SIMATIC PDM via a HART modem (COM as well as USB modem), it may occur that the computer on which SIMATIC PDM is running can no longer establish communication with the field device. This occurs when the computers capacity is full.

Remedy

- Use a handheld (HART Communicator) as secondary master; this uses existing time gaps in the HART protocol for the secondary master.
- Address the field device with SIMATIC PDM via PROFIBUS DP. This module transfers these commands as primary master to the field device.

See also

Overview of the parameters of the HART analog modules (Page 45)

3.4 Operation phase of the HART analog module and field devices

Operation phase

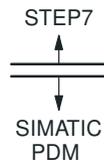
In the operation phase you have to distinguish between the cyclic provision of user data, acyclic HART operation and cyclic HART communication.

- The cyclic user data consists of analog currents by means of which the measured value or control value is transferred. You receive this from the automation system (PROFIBUS-DP master class 1): The user data range, the input range for the HART analog input module and the input and output range for the HART analog output module are available for this.
- You exercise acyclic control for the diagnostics and parameter modification of the field devices by means of the SIMATIC PDM parameter assignment tool (on PROFIBUS DP master class 2) or by using a HART handheld with HART commands and HART replies.

You can set up communication to the field device by means of cyclic DS writing/reading in the *STEP 7* program.

Procedure in the operation phase

1. Switch the automation system to "RUN" mode: User data is transferred via PROFIBUS-DP.
2. You can evaluate the user data cyclically in your user program.



3. You can use the SIMATIC PDM parameter assignment tool to carry out diagnostics and parameter modification of the field devices:
To do this, double-click the HART field device configured on the channel.

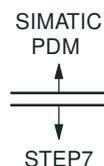
Access to field devices

The HART analog module generally accepts parameter modification for field devices. Access rights can only be assigned using the parameter assignment tool.

Modifying parameters of the field devices

To modify the parameters of the field devices connected to the HART analog modules, proceed as follows:

- To modify the parameters of a field device, enter a HART command using the SIMATIC PDM parameter assignment tool.



Status information

After you have modified the parameters of a HART field device, the corresponding bit is set in the device status of the connected field device (= HART status byte). This should be viewed as an indication rather than an error and is reset by the module. For more information, see "HART status bytes". Before you can access the field device again, the diagnostic interrupt triggered (if enabled) must be acknowledged by the automation system (OB 82).

See also

Diagnostics of the HART analog modules (Page 49)

How HART works (Page 27)

Parameters of the HART analog modules

4.1 Overview of the parameters of the HART analog modules

Overview

The following tables contain the parameters of the HART analog input module and the parameters of the HART analog output module. The tables show which parameters can be set for the module as a whole or for an individual channel. You will find general information on parameter assignment in the description of the SIMATIC analog modules in the Manual *Automation System SIMATIC S7-300 Module Data*.

4.2 Parameters of the analog input module SM 331; AI 8 x 0/4...20mA HART

Table 4-1 Parameters of the analog input module SM 331; AI 8 x 0/4...20mA HART

Parameters	Value range	Default	Type of parameter	Effective range
Basic settings				
Approvals				
• Diagnostic interrupt	Yes/no	No	Dynamic	Module
• Hardware interrupt when limit exceeded	Yes/no	No		
• HART-Fast-Mode	Yes/no	No	Dynamic	Module
Diagnostics				
• Group diagnostics - Analog	yes/no	No	Static	Channel
• Wire break check	Yes/no	No		
• HART group diagnostics	Yes/no	No	Static	Channel
Smoothing	None Weak Medium Strong	None	Dynamic	Channel
Measurement				
• Measuring type	Deactivated 4DMU (4-wire transducer) 2DMU (2-wire transducer)	4DMU (4-wire transducer)	Dynamic	Module

4.2 Parameters of the analog input module SM 331; AI 8 x 0/4...20mA HART

Parameters	Value range	Default	Type of parameter	Effective range
• Measuring range	Deactivated 0...20mA (only possible with 4DMU), 4...20mA ± 20 mA (only possible with 4DMU)	4...20 mA	Dynamic	Channel
• Interference frequency suppression	60 Hz; 50 Hz; 10 Hz; corresponds to integration time of 16.6 ms; 20 ms; 100 ms	50 Hz	Dynamic	Channel
Hardware interrupt trigger				
• Upper limit value	0...20mA -3.52 mA to 23.52 mA (from -4864 to 32511)*	-	Dynamic	Channel
	4...20 mA 1.185 mA to 22.81 mA (from -4864 to 32511)	-		
	± 20 mA -23.52 mA to 23.52 mA (from -32512 to 32511)*	-		
• Lower limit value	0...20mA -3.52 mA to 23.52 mA (from -4864 to 32511)*	-	dynamic	Channel
	4...20 mA 1.185 mA to 22.81 mA (from -4864 to 32511)	-		
	± 20 mA -23.52 mA to 23.52 mA (from -32512 to 32511)*	-		
HART				

4.3 Parameters of the analog output module SM 332; AO 8 x 0/4...20mA HART

Parameters	Value range	Default	Type of parameter	Effective range
• HART function	Yes (only possible with the measuring range 4...20 mA) / No	Yes	Dynamic	Channel
• Repetitions	0-255	10		

* Values in parentheses can be set by means of dynamic parameter assignment with SFC

4.3 Parameters of the analog output module SM 332; AO 8 x 0/4...20mA HART

Table 4-2 Parameters of the analog output module SM 332; AO 8 x 0/4...20mA HART

Parameters	Value range	Default	Type of parameter	Effective range
Basic settings				
Release				
Diagnostic interrupt	Yes/no	No	Dynamic	Module
HART-Fast-Mode	Yes/no	No	Dynamic	Module
Diagnostics				
• Group diagnostics	Yes/no	No	Static	Channel
• Short-circuit test	Yes/no	No	Static	Channel
• HART group diagnostics	Yes/no	No	Static	Channel
• Discrepancy analysis**	Yes/no	No	Static	Channel
Reaction to IM153-Stop***		4 mA SV		
• Outputs have no current or voltage (OCV)				Channel
• Keep last value (KLV)				Channel
• Set substitution value (SSV)	0/4...20 mA (-6912...32511)*	0 or 4 mA SV	Dynamic	Channel
Output				
Output type	Deactivated I (current, 2-wire)	I (current, 2-wire)	Dynamic	Channel
Output range	Deactivated 4...20 mA 0...20 mA	4...20 mA	Dynamic	Channel
HART				

4.3 Parameters of the analog output module SM 332; AO 8 x 0/4...20mA HART

Parameters	Value range	Default	Type of parameter	Effective range
• HART function	Yes No	Yes	Dynamic	Channel
• Repetitions	0-255	10		
<p>* Values in parentheses can be set by means of dynamic parameter assignment with SFC ** Only when operating an S7-400H automation system *** See Section "Special features for fail-safe behavior" in Chapter "HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)</p>				

Diagnostics and interrupts of the HART analog modules

5

5.1 Diagnostics of the HART analog modules

Overview of diagnostics

If errors occur during commissioning or the operation phase, the diagnostic messages enable you to identify the cause. The general diagnostic behavior of the HART analog module corresponds to that of the SIMATIC S7 analog modules.

Module information in the diagnostic buffer

The HART modules have a diagnostic buffer. Diagnostic events are stored in the diagnostic buffer in their order of occurrence. The first entry contains the most recent event. The number of entries in the diagnostic buffer is 9. Outgoing events are not saved in the diagnostic buffer of the HART modules. The diagnostic buffer is deleted every time you turn on the module. Diagnostic events include:

- Faults on a module
- Faults in the process wiring
- Error during firmware update
- Firmware update successful
- Actuator/sensor is not supported
- Calibration has been successfully completed

The HART modules do not have their own clock. If the PROFIBUS-DP interface module has a clock and time-of-day synchronization is enabled, a time stamp will be entered for each diagnostic buffer event. The accuracy of the time stamp corresponds to a synchronization interval of the PROFIBUS-DP interface module (for example, 10 s).

Diagnostic messages to which parameters can and cannot be assigned

We distinguish between diagnostic messages to which parameters can be assigned and those to which they cannot be assigned.

You only obtain parameterizable diagnostics messages if you have enabled diagnostics at the relevant parameters. Assign the parameters in the "Diagnostics" parameter block in *STEP 7*.

The analog module always provides non-parameterizable diagnostics messages, irrespective of the enable state of diagnostics functions.

Reactions to a diagnostics message in STEP 7

Every diagnostic message initiates the following actions:

- The diagnostic message is entered into the diagnostics of the analog module.
- The error LED on the analog module is lit.
- When "Enable Diagnostic Interrupt" is set in STEP 7, the system triggers a diagnostic interrupt and calls the OB 82 in the CPU.

Reading out diagnostic messages

You can read detailed diagnostics messages in the user program using SFCs.

Viewing the cause of error

You can view the cause of the error in the module diagnostics data in STEP 7 (refer to the STEP 7 Online Help).

Diagnostics message in the measured value of analog input modules

All analog input modules return the measured value 7FFF_H as a reaction to errors, irrespective of parameter settings. This measured value indicates either overflow, error, or a disabled channel.

Diagnostics message using the SF LED

Any analog module that can be diagnosed indicates errors with its SF LED (group fault LED). The SF LED lights up as soon as the analog module has generated a diagnostics message. It goes out after all errors are resolved.

"Analog" diagnostic messages

Table 5-1 "Analog" diagnostic messages

Diagnostics message	LED	Effective range of diagnostics	parameters can be assigned
External load voltage missing	SF	Module	no
Configuration / parameter error	SF	Channel	no
Wire break	SF	Channel	yes (only with SM 331)
Underflow (only with 331 and if no wire break check is enabled)	SF	Channel	yes
Overflow (only with 331)	SF	Channel	yes
Short-circuit to M (only with 332)	SF	Channel	yes

Note

The detection of errors that are indicated in parameterizable diagnostic messages requires appropriate parameter assignment of the analog module in STEP 7.

Causes of error and troubleshooting for "analog" diagnostic messages

Table 5-2 Diagnostics messages of analog input modules, causes of error and troubleshooting

Diagnostics message	Possible cause of error	To correct or avoid error
external load voltage missing	No load voltage L+ in the module	Provide L+ supply
Configuration / parameter error	faulty parameters transferred to module	Modify the module parameters*
Wire break	Resistance of transducer circuit too high	use a different type of sensor or modify the wiring, for example, using a larger conductor cross-section.
	Break in the line between the module and sensor	Connect line
	Channel not switched (open)	Disable channel ("Measuring type" parameter) Wire the channel
Underflow	Input value below underflow range, fault possibly caused by: wrong measuring range setting	set parameters for a different measuring range
	the sensor could be connected the wrong way in the measuring range 4 to 20 mA	Check connection terminals
Overflow	Input value exceeds overflow range	set parameters for a different measuring range
Short circuit	Output overload	Eliminate overload
	Short circuit of output	Eliminate the short-circuit

* When configuring a V3.x module, update the firmware to version V3.0.0.

"HART" diagnostic messages

Table 5-3 Additional diagnostic messages of the analog input module SM 331; AI 8 x 0/4...20mA HART and the analog output module SM 332; AO 8 x 0/4...20mA HART

Diagnostics message	LED	Effective range of diagnostics	parameters can be assigned
HART communication error	SF	Channel	Yes
Primary value outside of limits			
Non-primary variable outside the limits			
HART analog output current saturated			
HART analog output current defined			
HART further status available			
Maintenance request			
HART parameter modification reported by connected field device			
HART group fault			

Causes of error and troubleshooting with "HART" diagnostic messages

The following table contains the possible causes of the faults described in the additional diagnostic messages and the action to take.

Table 5-4 Additional diagnostic messages, the possible causes and the action to take

Diagnostics message	Possible cause of the diagnosis/ fault	Remedies
HART communication error	<ul style="list-style-type: none"> • HART field device not responding • Timing error 	<ul style="list-style-type: none"> • Check the process wiring • Correct the parameter assignment. • Set an output current of ≥ 4 mA • Increase number of assigned repetitions • Analog input: Connect a capacitor of approximately 150 nF in parallel to the transducer

Diagnostics message	Possible cause of the diagnosis/ fault	Remedies
Primary value outside of limits	<ul style="list-style-type: none"> • Incorrect parameters in the HART device • HART device has simulation, and simulation is set to "Primary variable outside the limits" • Incorrect measuring point • Primary variable parameterized outside the limits 	<ul style="list-style-type: none"> • Check the parameter assignment of the HART device • Correct simulation • Check whether the correct sensor is connected
Non-primary variable outside the limits	<ul style="list-style-type: none"> • Incorrect parameters in the HART device • HART device has simulation, and simulation is set to "Non-primary variable outside the limits" • Incorrect measuring point • Primary variable parameterized outside the limits 	
HART analog output current saturated	<ul style="list-style-type: none"> • Incorrect parameters in the HART device • HART device has simulation, and the measured value set for the simulation is too high • Incorrect measuring point • Primary variable parameterized outside the limits 	
HART analog output current defined	<ul style="list-style-type: none"> • Incorrect parameters in the HART device • HART device has simulation, and the measured value set for the simulation is too high • Incorrect measuring point • Primary variable parameterized outside the limits 	
Further HART status available (deleted after 3 seconds)	<ul style="list-style-type: none"> • HART device supplies further status. 	<ul style="list-style-type: none"> • Read out status and correct, if necessary
Maintenance request	There is a maintenance requirement	Maintain device
HART parameter modification reported by connected field device	The identifier for the parameter modification of the HART field device was set in the HART device status (= HART status bytes).	If no diagnostic interrupt is to be triggered at parameter modification, the diagnostic interrupt must not be enabled.
HART group fault	Communication and command errors in HART operation that affect the connected HART field devices.	For detailed information analyze the reply record of the corresponding client or the diagnostic data record.

HART status bytes

Each HART command is followed by a HART reply that contains data and two status bytes. The status bytes provide information on

- Device status of the connected field device (e.g. parameter modification)
- Communication error during transmission between the HART analog module and the connected field device
- Command error in the interpretation of the HART command through the connected field device (warning rather than error message).

The HART status bytes are accepted unchanged in the HART reply record. Their meaning is described in the HART technical specification.

See also

HART communication records (Page 83)

Diagnostic records (Page 78)

5.2 Interrupts of the HART analog modules

Overview of the interrupts

The general interrupt behavior of the HART analog modules corresponds to that of the SIMATIC S7 analog modules. You can enable or disable all the interrupts by parameter assignment.

See also

Overview of the parameters of the HART analog modules (Page 45)

HART analog modules

6.1 HART analog input module SM 331; AI 8 x 0/4...20mA HART (6ES7331-7TF01-0AB0)

Order number

6ES7331-7TF01-0AB0

Properties

- 8 inputs and 8 outputs (for supplying of 2-wire transducers)
- Resolution of 15 bits + sign (regardless of integration time)
- Measuring type selectable for each module (HW parameters can be assigned through a jumper on terminals 10 and 11):
 - 2-wire transducer current
 - 4-wire transducer current
 - Channel deactivated
- Any measuring range selection per channel
 - 0 ... 20 mA / ± 20 mA (without HART usage)
 - 4 ... 20 mA (with/without HART)
- Channel-by-channel parameter assignment through parameter record 1 or 128 or HART data records 131-138
- Parameters can be assigned for diagnostics (per channel) and diagnostic interrupt (across whole module)
 - Group diagnostics
 - Additional wire break check
 - Diagnostic interrupt
- Parameters can be assigned for process interrupt per module
- Electrical isolation
 - Channels only electrically isolated for 4-wire transducer to load voltage L+
 - Channels electrically isolated from IM153
- The module parameters can be reassigned dynamically channel by channel in RUN mode (CiR-capable)
- Configuring HART variables
- Redundant mode

- Firmware update possible
 - Support of:
 - HART fast mode*
 - User calibration*
- * The module must be configured as V3.x.

Analog values and resolution

For the representation of the analog values for analog input channels generally and in the current measuring ranges ± 20 mA, 0 to 20 mA, and 4 to 20 mA, in particular, see the corresponding tables in the Automation System SIMATIC S7-300 Module Data (<http://support.automation.siemens.com/WW/view/en/8859629>) manual.

The resolution of the input value in the case of the HART analog input module is 15 bits + sign.

Table 6-1 Measuring ranges of the analog input module SM 331; AI 8 x 0/4...20mA HART

Selected measuring type	Measuring range
2-wire transducer	4 to 20 mA
4-wire transducer	0 to 20 mA 4 to 20 mA ± 20 mA

Smoothing

Using smoothing

A reliable analog signal is made available for further processing by smoothing analog values.

Smoothing of analog values is appropriate for fast measured value changes.

Parameters

The measured values are smoothed by means of digital filters. Smoothing is achieved by the module calculating a mean value based on a defined number of converted (digitized) analog values.

You assign smoothing in four different levels (none, weak, medium, or strong). The level determines the number of analog signals used to form the mean value.

The stronger the smoothing, the more stable is the smoothed analog value and the longer it takes for the smoothed analog signal to be applied after a step response.

Default settings

The measuring type 4DMU is the default setting. There are also default settings for interference frequency suppression, diagnostics, interrupts. The HART analog module uses these settings when no parameter modification is carried out in STEP 7.

Wire break check

Wire break identification is not possible for the current ranges 0 to 20 mA and ± 20 mA.

For the current range from 4 to 20 mA, provided the wire break check is enabled, the undershooting of the input current of $I \leq 1.185$ mA is interpreted as a wire break. If enabled, a diagnostic interrupt is triggered.

The HART analog input module also interprets it as a wire break when a 4-wire transducer supplies a 4 to 20 mA signal and this is short-circuited, because the input current of $I \leq 1.185$ mA is undershot here too.

If the wire break check is enabled there is no underflow detection.

Removal and insertion

The HART analog modules support the function "Replace modules during operation". However, the evaluation of the removal and insertion interrupts is only possible on an S7/M7-400 CPU master and an active backplane bus in the ET 200M.

Terminal diagram

The figure below is the terminal diagram of the analog input module SM 331; AI 8 x 0/4...20 mA HART. You will find detailed technical specifications on the following pages.

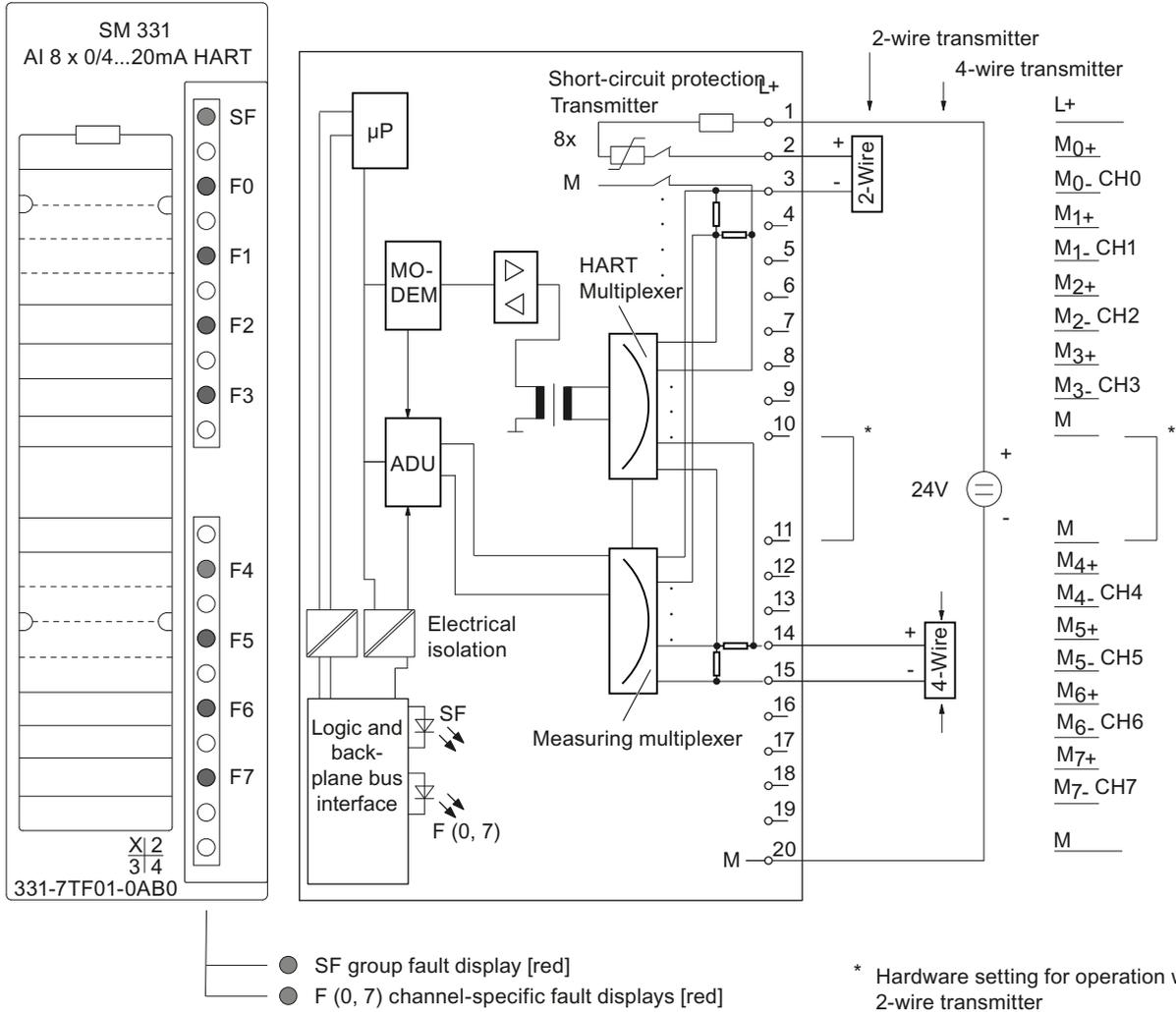


Figure 6-1 Module view and schematic circuit diagram of the SM 331; AI 8 x 0/4...20mA HART

Note

When using 2-wire transducers you have to place a jumper between the reserved terminals 10 and 11.

Technical specifications of the SM 331; AI 8 x 0/4...20 mA HART

Table 6-2 Technical specifications of the SM 331; AI 8 x 0/4...20 mA HART

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	40 x 125 x 117
Weight	Approx. 205 g
Module-specific data	
Number of inputs	8
Number of supply outputs	8
Shielded cable length	Max. 800 m
MTBF	48 years
Temperature range	
• Horizontal installation	0 °C to 60 °C
• vertical installation	0 °C to 40 °C
Voltages, currents, potentials	
Rated load voltage L +	24 VDC
• Polarity reversal protection	Yes
Power supply of the 2-wire transducers	
• Short-circuit-proof	Yes Short-circuit current approx. 40 to 60 mA
Electrical isolation	
• Between the channels and backplane bus	Yes
• Between the channels	No
• Between the channels and load voltage L+	For 2-wire transducer: no 4-wire transducer: Yes
• Between the backplane bus and load voltage L+	Yes
• Permissible potential difference	
• Between the channels and backplane bus (U_{ISO})	75 VDC 60 VAC
• Between the channels and load voltage L+	For 4-wire transducer: 75 VDC 60 VAC
• Between the channels	Permissible common-mode voltage in the case of 4-wire transducer: 60 VAC
• Between the backplane bus and load voltage L+	75 VDC 60 VAC
Insulation tested	
• Channels to backplane bus and load voltage L+	With 500 VDC
• Backplane bus to load voltage L+	With 500 VDC
• Between the channels	No

Technical specifications			
Current consumption			
• From backplane bus	Max. 120 mA		
• From load voltage L + (supply current of all connected transducers)	Typically 20 mA per transducer		
Power loss of the module	Approx. 1.5 W		
Analog value generation			
Measurement principle	SIGMA-DELTA		
Integration time/ interference frequency suppression (per channel)	60 Hz	50 Hz	10 Hz
• parameters can be assigned	Yes	Yes	Yes
• Integration time in ms	16,6	20	100
• Basic conversion time including inte- gration time in ms (per channel)	55	65	305
• Basic execution time of the module, in ms (all channels enabled)	440	520	2440
• Resolution in bits + sign (including overshoot range)	15 + sign	15 + sign	15 + sign
• Smoothing of the measured values	Yes, parameterizable in 4 levels:		
	Step:	Time constant:	
	None	1 x cycle time ***	
	Weak	4 x cycle time ***	
	Medium	32 x cycle time ***	
	Strong	64 x cycle time ***	
Interference suppression, error limits			
Interference voltage suppression for $f = n \times (f_1 \pm 1 \%)$, ($f_1 =$ interference frequency)			
• Common-mode interference (only possible with 4-wire transducers ($U_{cm} < 60$ VAC)	> 100 dB		
• Seriesmode interference (peak value of disturbance < rated input range)	> 40 dB		
Crosstalk attenuation between the inputs ($U_{ISO} < 60$ V)	> 70 dB		
Operating error	$\pm 0,15 \%$		
Intrinsic error	$\pm 0,1 \%$		
Temperature error (referred to input range)	$\pm 0.001\%/K$		
Linearity error (referred to input range)	$\pm 0,01 \%$		
Repeatability (in steady-state condition at 25 °C, referred to in- put range)	$\pm 0,1 \%$		
Influence of a HART signal superimposed on the input signal relative to the input range (in addition to the intrinsic error) *			
Integration time error			
• 16.6 ms	$\pm 0,05\%$		
• 20 ms	$\pm 0,04\%$		

6.2 HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)

Technical specifications		
• 100 ms	± 0,02%	
Status, interrupts, diagnostics		
Interrupts		
• Limit alarm	parameters can be assigned	
• Diagnostic interrupt	parameters can be assigned	
Diagnostic functions		
• Group error display	Red "SF" LED	
• Channel error display	Red LED (F) per channel	
• Diagnostic information readable	Possible	
HART communication		
• Monodrop/multidrop operation	Monodrop only	
• Primary/secondary master	Primary master only **	
Characteristic data of the transducer supply		
• Output voltage for transducer and cable with 22 mA transducer current (measured resistance on module already taken into account)	≥ 18 V (at U _N = 24 V)	
Sensor selection data		
Input ranges (rated values/input resistance)		
• Current	0 to 20 mA 4 to 20 mA ± 20 mA	140 Ω 140 Ω 140 Ω
Maximum input current for current input (destruction limit)	40 mA	
Connection of the sensors		
• for current measurement		
As 2-wire transducer (supply through module)	Possible	
as 4-wire transducer	Possible	
* With HART usage, an integration time of 100 ms is recommended. Parameter assignment of a smoothing step also improves the analog signal behavior.		
** In redundant mode, the module with the higher address is the secondary master.		
*** Cycle time = basic conversion time per channel x number of enabled channels		

See also

Overview of the parameters of the HART analog modules (Page 45)

6.2 HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)

Order number

6ES7332-8TF01-0AB0

Properties

- 8 outputs (current)
 - Resolution:
 - 15 bits (0..20mA)
 - 15 bits (+ sign) (4..20mA)
 - Output type selectable per channel:
 - Current output with HART
 - Current without HART
 - Channel deactivated
 - Selection of any output range per channel
 - 0...20 mA (with HART)
 - 4...20 mA (with HART)
 - Channel-by-channel parameter assignment through parameter data record 1 or 128 or HART data records 131-138
 - Diagnostics (per channel) and diagnostic interrupt (across whole module) configurable
 - Group diagnostics
 - Diagnostic interrupt
 - Electrical isolation
 - Channels electrically isolated from IM153 and load voltage L+
 - Readback capability of the analog outputs
 - The module parameters can be reassigned dynamically channel by channel in RUN mode (CiR-capable)
 - Configuring HART variables
 - Redundant mode
 - Discrepancy analysis for use in the S7-400 H automation system
 - Firmware update possible
 - Support of:
 - HART fast mode*
 - User calibration*
- * The module must be configured as V3.x.

Analog values and resolution

For the representation of the analog values for analog output channels generally and in the current output ranges 0 to 20 mA and 4 to 20 mA in particular, see the corresponding tables in the Automation System SIMATIC S7-300 Module Data (<http://support.automation.siemens.com/WW/view/en/8859629>) manual.

6.2 HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)

The resolution of the output value in the case of the HART analog output module is 15 bits (+ sign).

Table 6-3 Output ranges of the analog output module SM 332; AO 8 x 0/4...20mA HART

Output type	Output range
Current	0 to 20 mA 4 to 20 mA

Default settings

The output type HART is the default setting. There are also default settings for substitute value, diagnostics, interrupts. The HART analog output module uses these settings when no parameter modification is carried out in STEP 7.

Wire break check

Wire break detection is possible for the current output ranges 0/4 to 20 mA; if enabled, a diagnostic interrupt is triggered.

Condition: A minimum output current of $\geq 250 \mu\text{A}$ must be set.

If the output current drops under $250 \mu\text{A}$ when the "Wire break" diagnostic message is pending, the diagnostic message cannot be canceled until the output current is set above $250 \mu\text{A}$ again and the error has been eliminated.

Short-circuit test

Short-circuit detection is possible for the current output ranges 0/4 to 20 mA.

Condition: A minimum output current of 4 mA must be set. Short-circuit detection applies when a load of $< 30 \Omega$ is connected.

Discrepancy analysis

In the discrepancy analysis, the current output by the channel is read back and compared to the current to be output. If the values differ (deviation $> 5\%$), the module behavior is faulty. The module signals "Readback error".

Requirement:

- The module is used redundantly (in IM 153-2BA02). You can specify the two modules that are to be operated redundantly in the "Redundancy" tab.
- Group diagnostics is enabled

Special features for fail-safe behavior

If the HART analog output module is connected to a CPU 4xx as a distributed module, the fail-safe behavior depends on the following configuration:

- Module is configured as 6ES7332-**8TF01**-0AB0: The outputs are **not** reset during the mode transition from STOP to RUN.
- Module is configured as 6ES7332-**8TF00**-0AB0 and the outputs are not in the process image: The outputs are reset during the mode transition from STOP to RUN.

Removal and insertion

The HART analog modules support the function "Replace modules during operation". However, the evaluation of the removal and insertion interrupts is only possible on an S7/M7-400 CPU master and an active backplane bus in the ET 200M.

Operation with standard master

In distributed operation with a standard master the following restrictions must be taken into account:

- Parameter assignment with COM PROFIBUS (GSD or type file required)
- Restricted evaluation in the case of removal and insertion

Effect of a falling load voltage on the diagnostic message

When the 24 V load voltage falls under the permissible rated range (< 20.4 V), if loads > 650 Ω are connected and there are output currents > 20 mA, the output current may be reduced before a diagnostic message is issued.

Readback capability

The analog outputs can be read back in the user data range with a resolution of 8 bits (+ sign). Please note that the read back analog output does not become available until after a conversion time in accordance with the accuracy.

Note

Please note the following on readback capability:

- The range of the readback values does not correspond to the STEP 7 system limits; instead, it indicates the readback value linearly depending on the current output range (see the following table).
 - In the case of deactivated or incorrectly assigned channels, the readback value of the channel is written to the value "7FFF Hex".
 - In the case of a module that is not configured, the absence of a 24 V load voltage or a module fault, all the readback values are written to the value "7FFF Hex".
-

6.2 HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)

Table 6-4 Readback value representation of the HART analog output module

Readback value		Current output range	
Decimal	Hexadecimal	0 to 20 mA	4 to 20 mA
32348	7E80	23.41 - 23.52 mA	22.72 - 22.81 mA
27648	6C00	20.00 mA	20.00 mA
0	0	0 mA	4 mA
- 6912	E500	-	0 mA

Note

Sufficient accuracy of the readback values is ensured only for measured values > 16#0800.

Terminal diagram

The figure below is the terminal diagram of the analog output module SM 332; AO 8 x 0/4...20mA HART. You will find detailed technical specifications of the analog output module on the following pages.

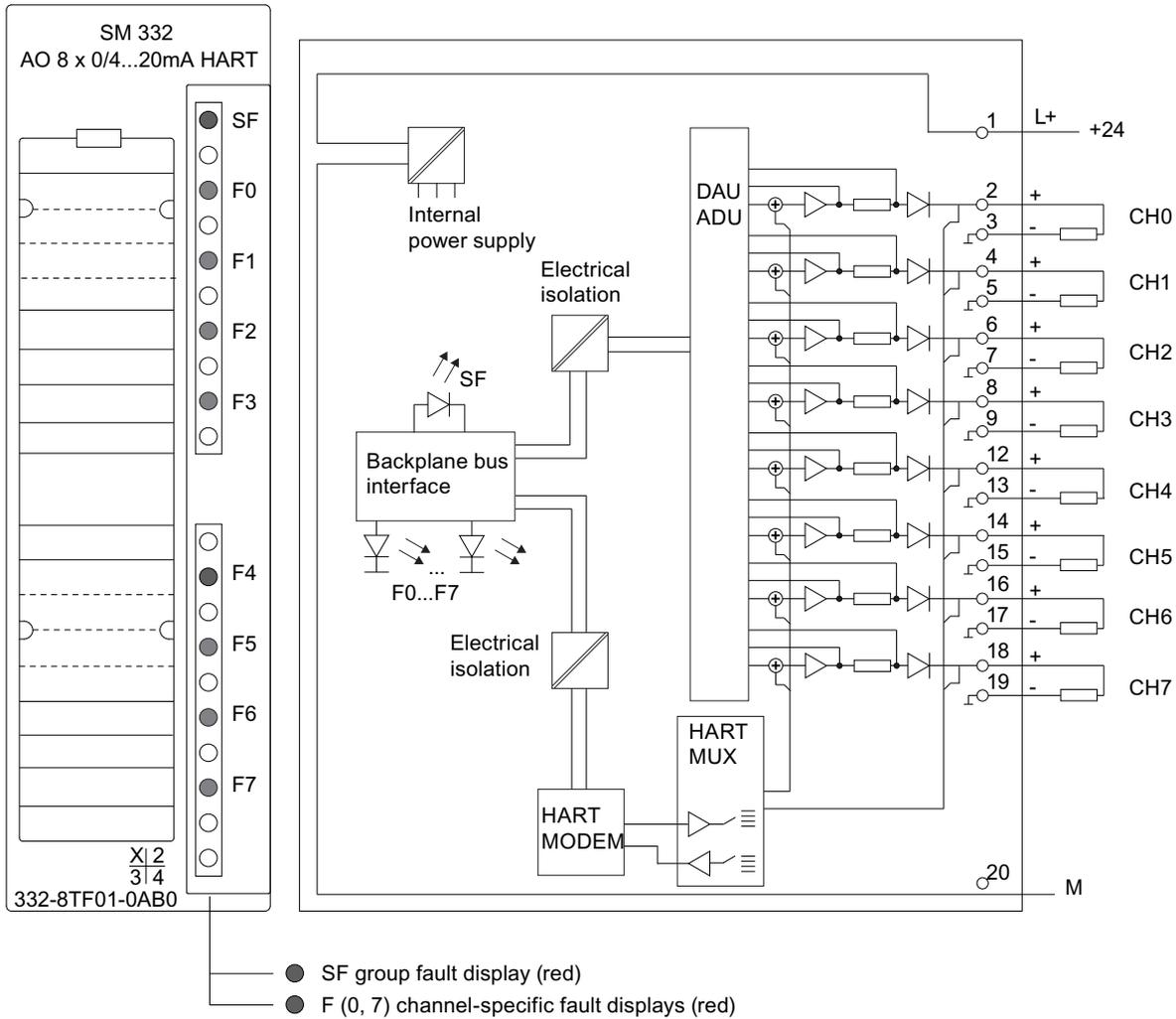


Figure 6-2 Module view and schematic circuit diagram of the SM 332; AO 8 x 0/4...20mA HART

Non-wired output channels

To ensure that non-wired output channels of the analog output module SM 332; AO 8 x 0/4...20mA HART are deenergized, you have to deactivate them. You deactivate an output channel using STEP 7 by means of the "Output" parameter block. Wiring with resistors is not necessary.

Technical specifications of the SM 332; AO 8 x 0/4...20 mA HART data

Table 6-5 Technical specifications of the SM 332; AO 8 x 0/4...20 mA HART

Technical		
Dimensions and weight		
Dimensions W x H x D (mm)	40 x 125 x 117	
Weight	Approx. 220 g	
Module-specific data		
Number of outputs	8	
Shielded cable length	Max. 800 m	
MTBF	33 years	
Temperature range		
<ul style="list-style-type: none"> Horizontal installation Number of outputs that can be used simultaneously (derating) 	0 °C to 60 °C to 40 °C: 8 to 60 °C: 4	
<ul style="list-style-type: none"> Vertical installation Number of outputs that can be used simultaneously 	0 °C to 40 °C 8	
Voltages, currents, potentials		
<ul style="list-style-type: none"> Rated load voltage Polarity reversal protection 	24 VDC Yes	
Electrical isolation		
<ul style="list-style-type: none"> Between the channels and backplane bus Between the channels Between the channels and load voltage L+ Between the backplane bus and load voltage L+ 	Yes No Yes Yes	
Permissible potential difference		
<ul style="list-style-type: none"> Between M_{ANA} and $M_{internal}$ (U_{ISO}) Between M_{ANA} and $M_{external}$ Between $M_{internal}$ and $M_{external}$ Insulation tested with 	75 VDC 60 VAC 75 VDC 60 VAC 75 VDC 60 VAC 500 VDC	
<ul style="list-style-type: none"> Current consumption From backplane bus From load voltage L + (given rated load) Power loss of the module 		Max. 110 mA Max. 350 mA Typically 6.0 W
Analog value generation		
Output value		
<ul style="list-style-type: none"> Resolution (including the overshoot range) Cycle time (all channels) 	15 bits (0...20 mA) 15 bits (+ sign) (4...20 mA) AO mode: 10 ms HART mode: 50 ms	

Technical	
• Settling time	AO mode at different loads: <ul style="list-style-type: none"> • Resistive load: 0.1 ms • Inductive load (10 mH): 0.5 ms HART mode: 40...50 ms
• Input of substitution values	Yes, configurable
Interference suppression, error limits	
Crosstalk attenuation between the outputs	> 70 dB
Operational limit (temperature range, relative to the output range)	± 0,2 %
Intrinsic error limit (operating error limit at 25°C relative to the output range)	± 0,1 %
Temperature error, relative to the output range	± 0.002%/K
Linearity error, relative to the output range	± 0,01 %
Repeatability in transient state at 25 °C, relative to the output range	± 0,05 %
Output ripple at 0 Hz to 50 kHz, relative to the output range	± 0,02 %
Status, interrupts, diagnostics	
Interrupts	
• Diagnostic interrupt	Configurable
Diagnostic functions	Configurable
• Group error display	Red "SF" LED
• Channel error display	Red LED (F) per channel
• Diagnostic information readable	Possible
Monitoring functions	
Readback value	
• Resolution (including the overshoot range)	8 bits (0...20 mA) 8 bits (+ sign) (4...20 mA)
• Cycle time (all channels)	AO mode: 10 ms HART mode: 50 ms
• Operating error limit	± 1 %
• Intrinsic error limit	± 0,8 %
• Wire break as of output value	Yes > 250 µA
• Short circuit	< 30 Ω as of 4 mA
HART communication*	
• Monodrop/multidrop operation	Monodrop only
• Primary/secondary master	Primary master only **
Actuator selection data	
Output ranges (rated values)	
Current	0 to 20 mA 4 to 20 mA
Load impedance (in the nominal range of the output)	

6.2 HART analog output module SM 332; AO 8 x 0/4...20mA HART (6ES7332-8TF01-0AB0)

Technical	
<ul style="list-style-type: none"> At current outputs 	
Resistive load	Max. 750 Ω
Inductive load	Max. 10 mH
Current output	
<ul style="list-style-type: none"> No-load voltage 	Max. 24 V
Destruction limit against voltages applied from outside	
Voltages	Max. + 60 V / - 0.5 V
Connection of actuators	
<ul style="list-style-type: none"> For current output 2-wire connection 	Yes
* HART communication requires an output current of at least 1.17 mA.	
** In redundant mode, the module with the higher address is the secondary master.	

See also

Overview of the parameters of the HART analog modules (Page 45)

Data record interface and user data

7.1 Overview of the data record interface and user data of the HART communication

Introduction

In this chapter you will find the specific data that you require for parameter assignment, diagnostics and HART communication if you go beyond the standard applications of STEP 7 or what to use your own configuration tool for HART communication.

The data made available cyclically (user data) is described at the end of the chapter.

Overview of the data record interface

The HART analog modules use records as input/output interfaces. They are used for the following applications:

- For writing parameters to the module
- For reading the diagnostic data from the module
- For transferring the HART communication data
- For writing the additional parameters for HART

The mapping of the HART commands and HART replies to the PROFIBUS-DP records is based on the *PROFIBUS Profile HART Version 1.0*. You will find more information on the HART protocol in the *PROFIBUS DP HART Profile Application Guidelines*.

You can get the above documentation from PNO (PROFIBUS Nutzer Organisation) on the Internet (<http://www.profibus.com>)

Table 7-1 Additional parameters of the HART analog modules

Data record number	Read/write	Size in bytes	Description
148	Read	25	Directory process data
	DR information (directory record): This data record contains the record numbers (index) of all HART data records and information on numbers and revisions.		
149	read	3	HMD feature parameter process data
	Optional HART functions (HART feature flags): This data record describes which optional HART functions are supported and specifies the maximum data field length of the request/response records.		
131 - 138	Read/write	8	HMD parameter process data
	HART parameter records: These records contain the HART parameters for the module by channel (0 - 7).		
80, 82, 84, 86, 88, 90, 92, 94	Write	240	HART request write process data

7.1 Overview of the data record interface and user data of the HART communication

Data record number	Read/write	Size in bytes	Description
	HART request records to field devices: These records contain by channel (0 - 7) the transfer data for the command from the client to the HART field device.		
81, 83, 85, 87, 89, 91, 93, 95	read	240	HART response read process data
	HART response records from field devices: These records contain by channel (0 - 7) the transfer data for the reply from the HART field device to the client.		

Configuration and parameter assignment with STEP 7

You can configure and parameterize the HART analog modules with STEP 7. The integrated help system helps you do this.

You can integrate certain additional functions for writing parameters and reading diagnostic data in your user program by means of SFCs.

Reading and writing records

:

To read and write records, use the following SFCs / SFBs:

- Read record:
 - SFC 59 "RD_REC".
 - SFB 52 "RDREC"
- Write record:
 - SFB 53 "WRREC".
 - SFC 55 "WR_PARAM" (only for the parameter data record 1).
 - SFC 58 "WR_REC" (not for the parameter data record 1).

For more detailed information on SFCs, refer to the System Software for S7-300/400 System and Standard Functions (<http://support.automation.siemens.com/WW/view/en/1214574>) manual.

Overview of the user data

The HART analog modules have a user data area with the following contents, which are made available for channels 0 to 7 in the same way:

- Current as analog input value or analog output value

Relative addresses are specified in the description of the user data. You obtain the module address that you have to add to it by means of the STEP 7 configuration and parameter assignment application.

The reservation of an output range for the 331-7TF01 is system-related and without significance for the module functionality.

7.2 Data record interface

7.2.1 Parameter records

The figures below show data record 0 for the static parameters and data record 1 for the dynamic parameters for AI-HART and AO-HART.

Structure of the parameter records for the HART analog input

You parameterize the HART channels with parameter records 131 to 138.

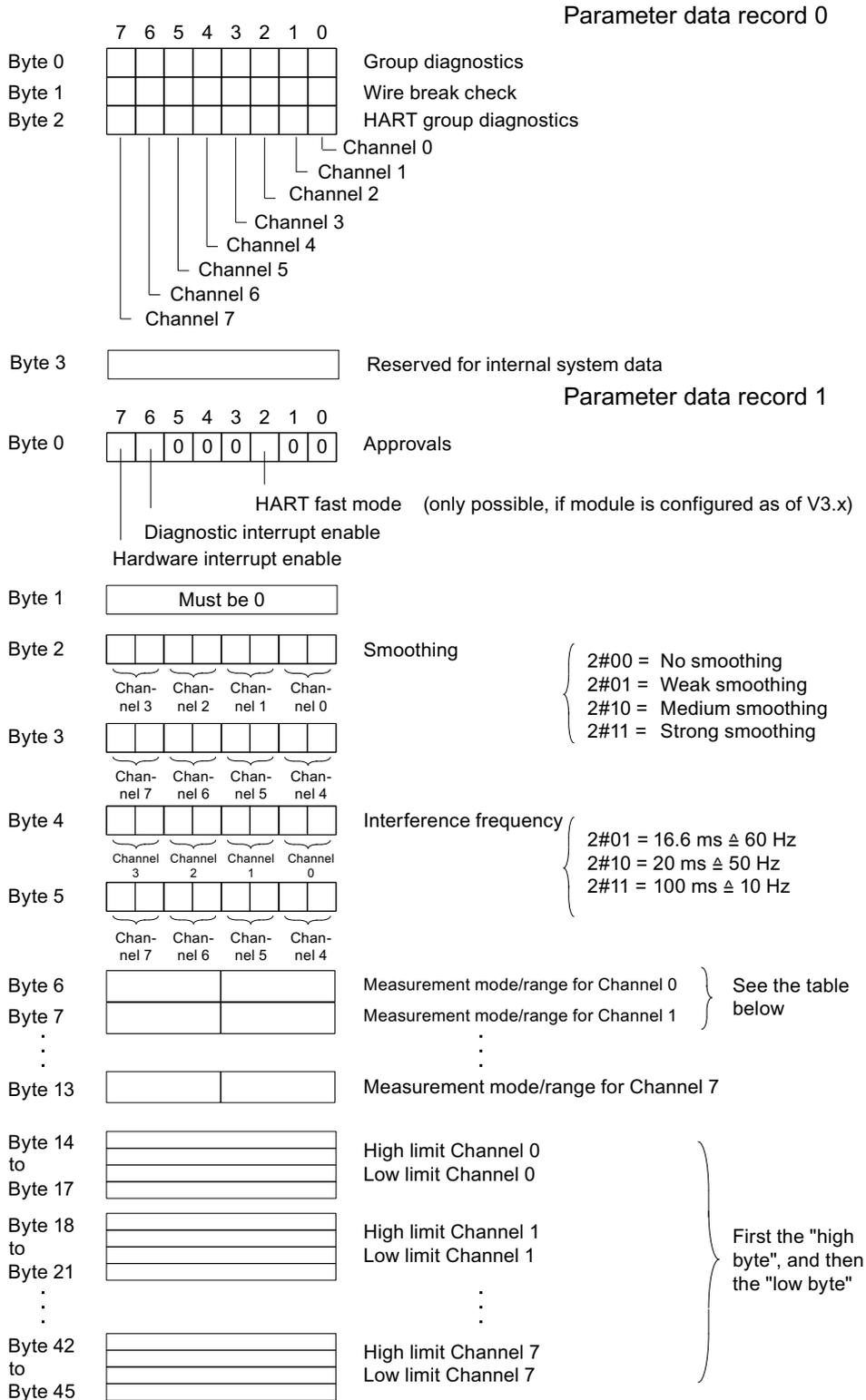


Figure 7-1 Parameters of the HART analog input module

Table 7-2 Codes for the measuring type and measuring range of the HART analog input module

Measuring type	Code	Measuring range	Code
Deactivated	2#0000	Deactivated	2#0000
4-wire transducer	2#0010	0 to 20 mA	2#0010
		4 to 20 mA	2#0011
		± 20 mA	2#0100
2-wire transducer	2#0011	4 to 20 mA	2#0011

Structure of the parameter records for the HART analog output

The figure below shows data record 0 for the static parameters and data record 1 for the dynamic parameters.

You parameterize the HART channels with parameter records 131 to 138.

7.2 Data record interface

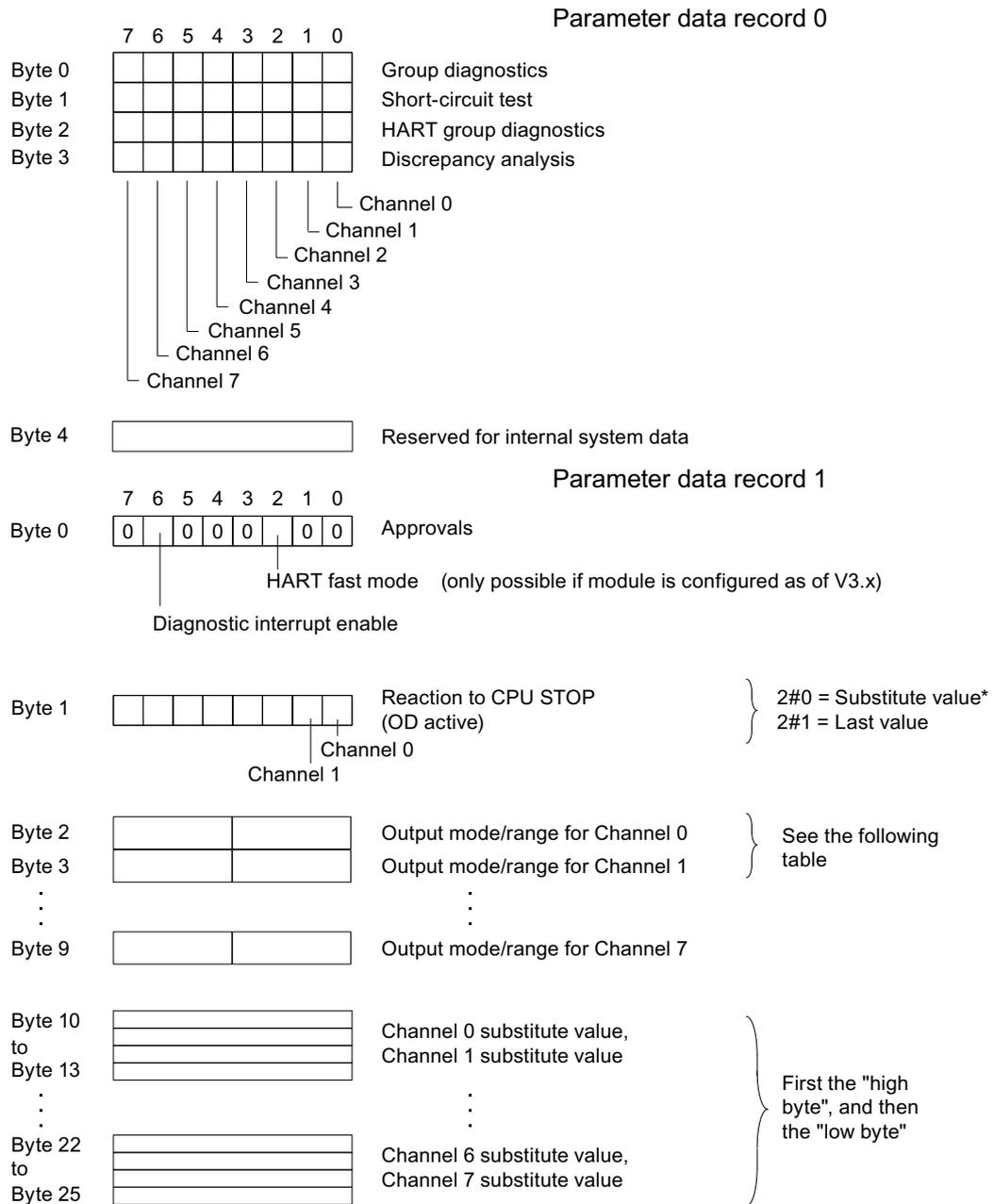


Figure 7-2 Parameters of the HART analog output module

* With a substitute value of -6912 (E500 Hex) the outputs are deenergized.

Table 7-3 Codes for the output type and output range of the HART analog output module

Output type	Code	Output range	Code
Deactivated	2#0000	Deactivated	2#0000
Current (2-wire)	2#0011	0 to 20 mA 4 to 20 mA	2#0010 2#0011

See also

Parameter records of the HART channels (Page 88)

7.2.2 I&M identification data

Properties

I data: Information about the module that generally appears on the module's housing. I data is only read:

- Hardware release status
- Firmware release status
- Serial number

M data: System-dependent information (e.g. plant designation).

M data is created during configuration.

Identification data (I&M) is information stored retentively in a module that helps you

- Troubleshoot a system
- Check the system configuration
- Locate changes to the hardware of a system.

Reading and writing the identification data with STEP 7

System-dependent information is configured in the module's properties dialog.

You obtain information on the module (I data) from the module status dialog. The system-dependent information on the module is displayed here too.

Reading and writing the I&M with SIMATIC PDM

With SIMATIC PDM you can read the parameters and I&M by choosing the **Device > Complete Download to PG/PC** menu command and write them by choosing the **Device > Complete Download to Device** menu command.

Note

The I&M data may only be written when the CPU is in STOP mode!

7.2.3 Diagnostic records

Structure and contents of the diagnostic data

The diagnostic data of a module consists of the data records 0 and 1:

- Data record 0 contains system-specific diagnostic data: 4 bytes that are defined system-wide and are valid for HART analog input and output.
- Data record 1 contains
 - the 4 bytes of diagnostic data of an S7-300 that are also in record 0 **and** further module class-specific diagnostic data.
 - In the case of a module that is not configured as a V3.x module, 20 bytes of module class-specific diagnostic data (channel-specific error) are available in one channel type.
 - A module configured as V3.x supplies two channel types; the first channel type reports the 20 bytes of module class-specific diagnostic data and the second channel type a further 12 bytes of additional diagnostics.

Note

In terms of your diagnostic data records, a module as of firmware version V3.0.0 that is not configured as a V3.x module behaves in a similar manner to a module with firmware version < V3.0.0 and provides only 20 bytes module class-specific diagnostic data in one channel type.

Diagnostic data record DR0/DR1

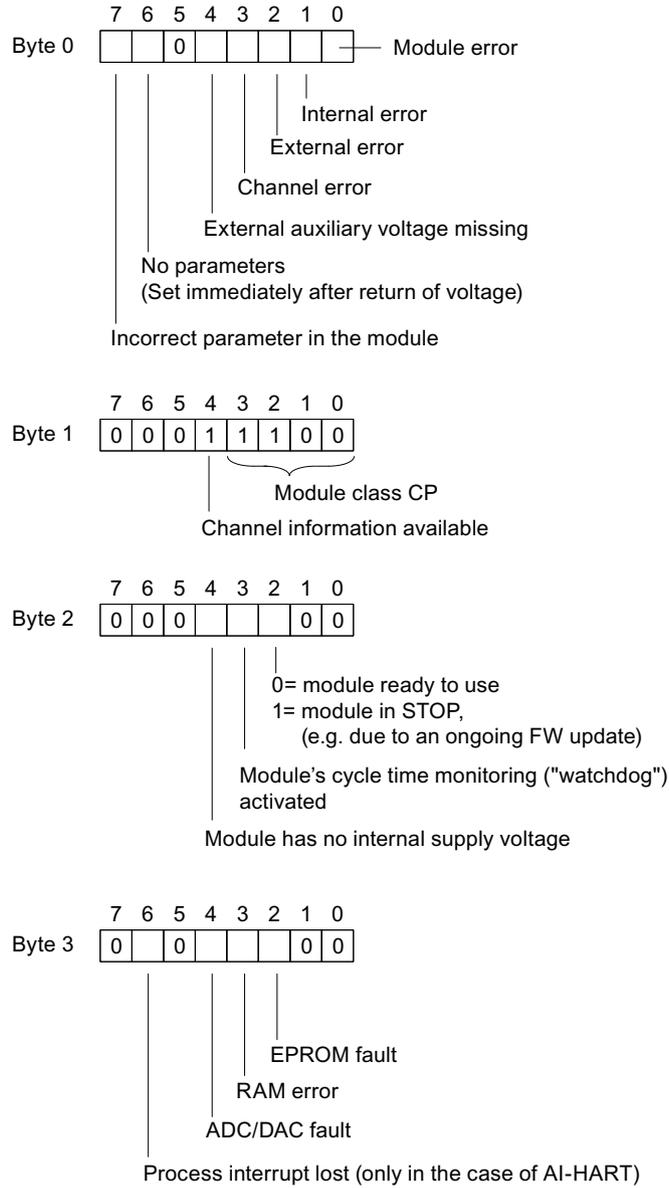


Figure 7-3 Diagnostic data record 0

Diagnostic data record DR1, first channel type

The figure below shows the contents of bytes 4 to 23 of the diagnostic data of the first channel type.

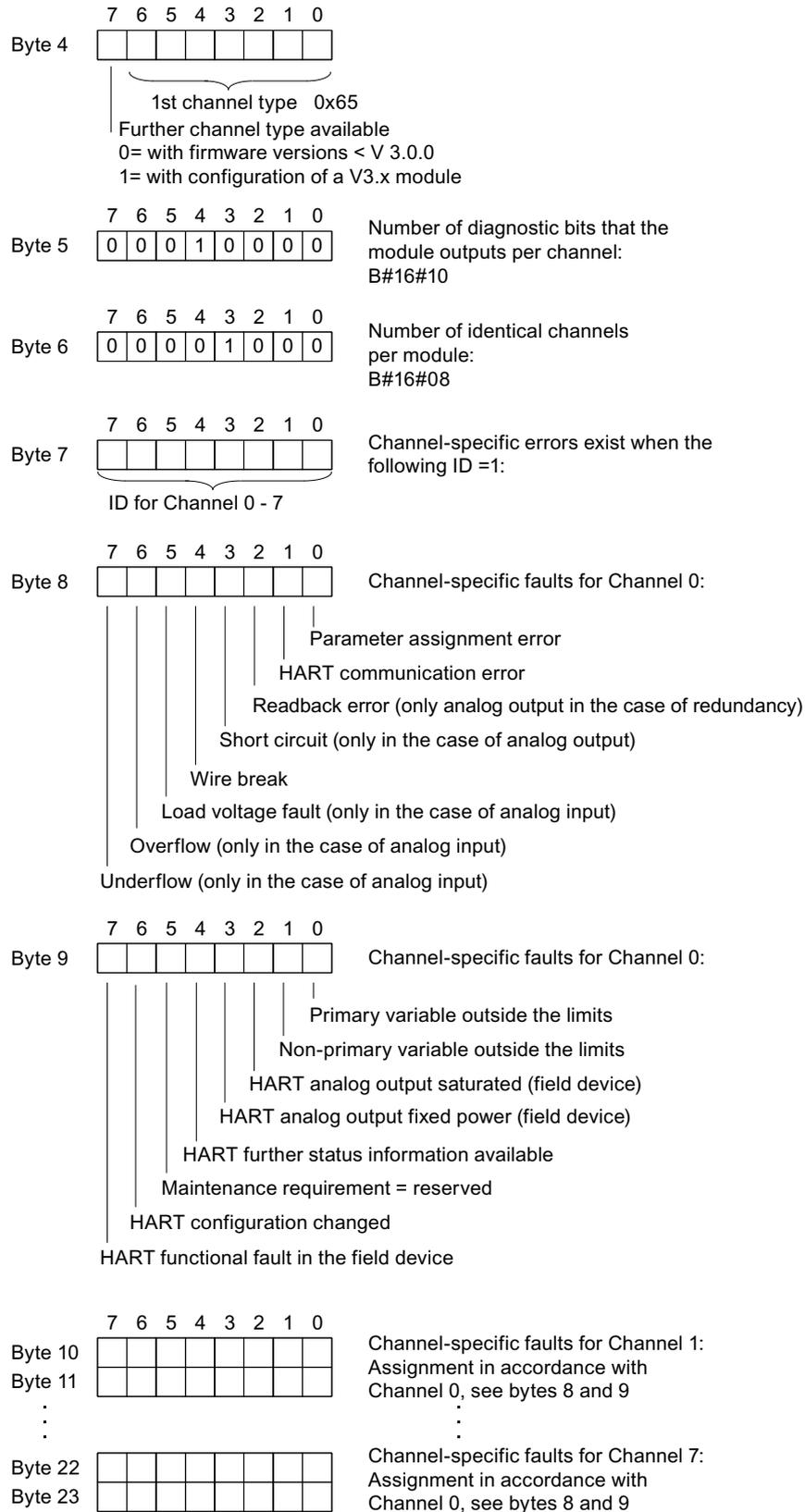


Figure 7-4 Diagnostic data record 1, first channel type

Note

Please note the following on the diagnostic data:

If a HART channel error is set, you receive further information if you read in the status component (= HART status bytes) in the HART reply record for the corresponding client or the diagnostic data record for the corresponding channel with SFC 59.

Diagnostic data record DR1, second channel type

The figure below shows the contents of bytes 24 to 35 of the diagnostic data of the second channel type (only available when configuring a V3.x module).

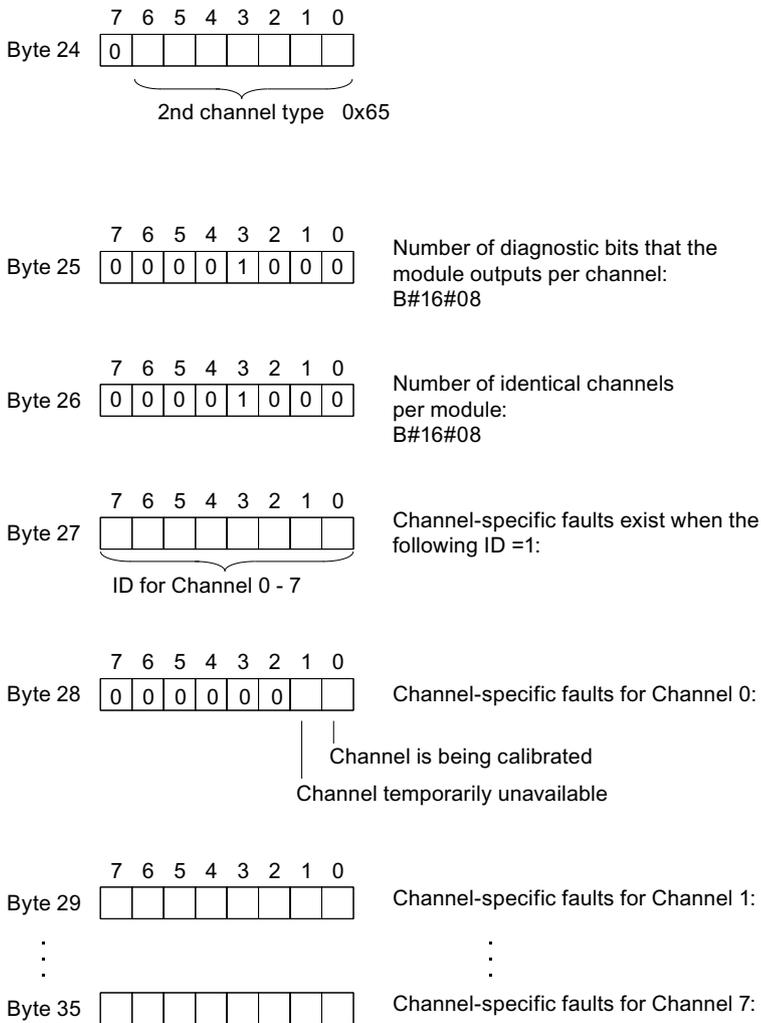


Figure 7-5 Diagnostic data record 1, second channel type

7.2.4 HART communication records

Transfer records

HART communication can be operated only by one client per channel. Each channel has a separate transfer area available. Each transfer area consists of the command and reply data records.

If a channel is operated by several clients, the reply made available by the module cannot be securely allocated to one client. The module does not support client management, refer to data record number 149 (HMD Feature Parameter Process Data) in Chapter Overview of the data record interface and user data of the HART communication (Page 71).

Coordination rules for HART communication

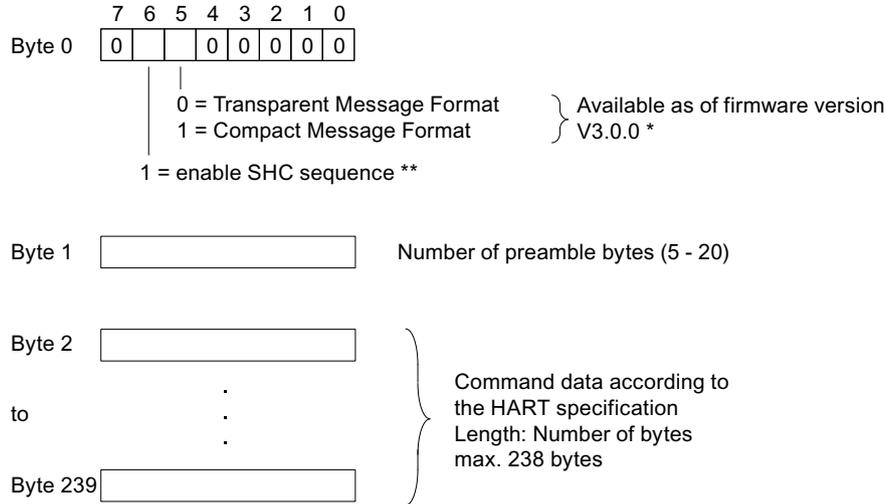
- Fixed record numbers are assigned to each client/channel:

Channel	Client	Data record
0	Command	80
0	Reply	81
1	Command	82
1	Reply	83
2	Command	84
2	Reply	85
3	Command	86
3	Reply	87
4	Command	88
4	Reply	89
5	Command	90
5	Reply	91
6	Command	92
6	Reply	93
7	Command	94
7	Reply	95

- After writing a command record, a client has to read the reply record before writing another command record.
- The client can evaluate the "processing status" in the reply data record: If the processing status is "successful" or "faulty", the record contains current reply data or error displays.
- The record must always be read in its entirety, since after it is first read with a successful or faulty status, the record can be changed by the module.
- The status component in the reply record (= HART status bytes) provides information on whether and which errors have occurred.

Structure of the command record

The figure below shows the command record with which you can write a command to a client's transfer area. The HART analog module sends the command to the connected HART field device.



* As of firmware version V3.0.0, HART commands are processed both in Transparent Message Format as well as in Compact Message Format (see the HART technical specification). The reply data from the module is however always made available in Transparent Message Format. In the case of a firmware version < V3.0.0, bit = 0 must apply.

** Processing a sequence of HART commands as a SHC sequence (Successive Hart Command Mode) will take place only by a module that has been configured as V3.x and with enabled "HART Fast Mode". See section HART Fast Mode in Chapter "Introduction to HART".

Figure 7-6 Command record of the HART analog module

Notes on the command

The same client cannot send another command before reading the reply to the previous command.

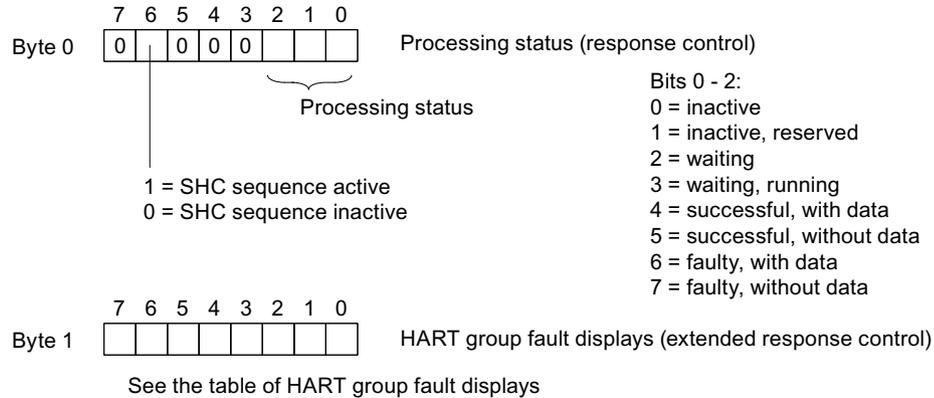
Notes on the reply

When you read the reply record, you have to be sure that a current reply record has arrived:

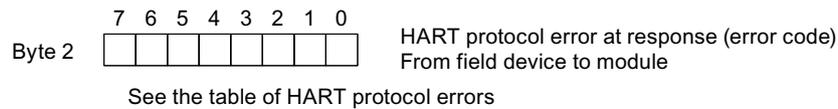
- If the processing status is "successful" or "faulty", the record contains current reply data or error displays.

Structure of the reply record

The figure below shows the structure of the reply record that contains the reply to the previous HART command and error or status.



If communication faulty:



If communication successful:

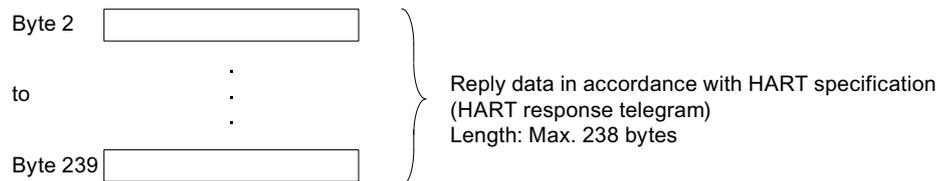


Figure 7-7 Reply record of the HART analog modules

Evaluation of the reply data

If you have a current reply record in front of you, you can carry out the following checks:

- Check that the reply belongs to the command sent.
- You can identify errors by analyzing the group fault displays (see the table below).
- Further error messages are specified in "HART protocol errors in reply" (see table below) and the two HART status bytes.
- In the group fault bytes in the error status the events are set to bits "1".

7.2 Data record interface

Table 7-4 HART group fault displays in reply byte 1 (extended response control)

Bit no.	HART group fault display	Meaning
0	Further status information available	Corresponds to bit 4 in the channel-specific error bytes in diagnostic data record 1 (2nd HART status byte). The HART command 48 provides you with further status information, if required.
1	HART communication error --> HART communication error entry in diagnostic data record 1	Here the field device has identified a communication error on receiving the command. The error information is contained in the 1st HART status byte (in the reply record or diagnostic data record 1) . This is accepted without being changed.
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Always 0	Reserved
4 - 7	HART protocol error for reply --> HART communication error entry in diagnostic data record 1	Error during HART communication from the field device to the module (i.e. there was an error in receiving the reply). 0: Unspecified error 1: HMD error 2: Channel error 3: Command error 4: Query error 5: Reply error 6: Query rejected 7: Profile query rejected 8: Vendor-specific query rejected 9 - 15: Not used You will find information on the cause of the error in reply byte 2. See the table below.

Table 7-5 HART protocol error in reply byte 2 for the reply from the field device to the module (error code)

Error	HART protocol error in byte 2	Meaning
0	Unspecified error	0: Not specified
1	HMD error	0: Unspecified 1: Internal communication error 2: Parameter assignment error 3: HW error 4: Wait time expired 5: HART timer expired
2	Channel error	0: Unspecified 1: Line error 2: Short circuit 3: Open line 4: Low current output 5: Parameter assignment error
3	Command error	0-127: HART protocol, Bit 7=0

Error	HART protocol error in byte 2	Meaning
4	Query error	HART protocol, Bit 7=1 Bit 0: Reserved Bit 1: Receive buffer overflow Bit 2: Reserved Bit 3: Checksum error Bit 4: Frame error Bit 5: Overflow error Bit 6: Parity error Bit 7: 1
5	Reply error	HART protocol, Bit 7=1 Bit 0: GAP timeout Bit 1: Receive buffer overflow Bit 2: Timeout Bit 3: Checksum error Bit 4: Frame error Bit 5: Overflow error Bit 6: Parity error Bit 7: 1
6	Query rejected	0: Unspecified 1: Short format not supported 2: SHC not supported 3: Impermissible command 4: No resources
7	Profile query rejected	0: Not specified (not supported)
8	Vendor-specific query rejected	0: Not specified (not supported)

7.2.5 Parameter records of the HART channels

Structure of parameter records 131 to 138

The figure below shows the structure of parameter records 131 to 138 for HART channels 0 to 7. The settings apply to the assigned channel:

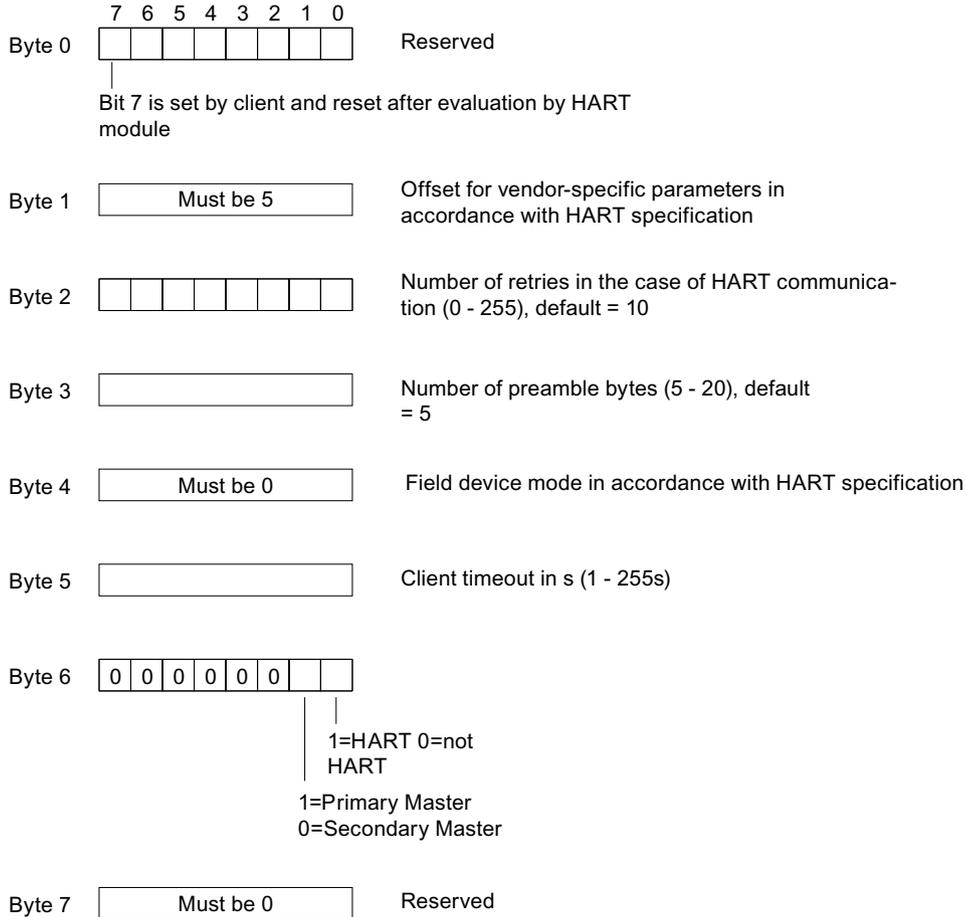


Figure 7-8 Parameter records 131 to 138 of the HART analog modules

Notes on the parameter records of the HART channels

The parameter records contain parameters that you normally do not have to change, since the optimum value is already set.

7.3 User data interface

7.3.1 User data interface, input range (reading)

Structure of the user data

The figure below shows the structure of the input user data area of the HART analog modules. You can read in the data of the user data area (e.g. with L PEW 256) and evaluate it in your user program.

7.3 User data interface

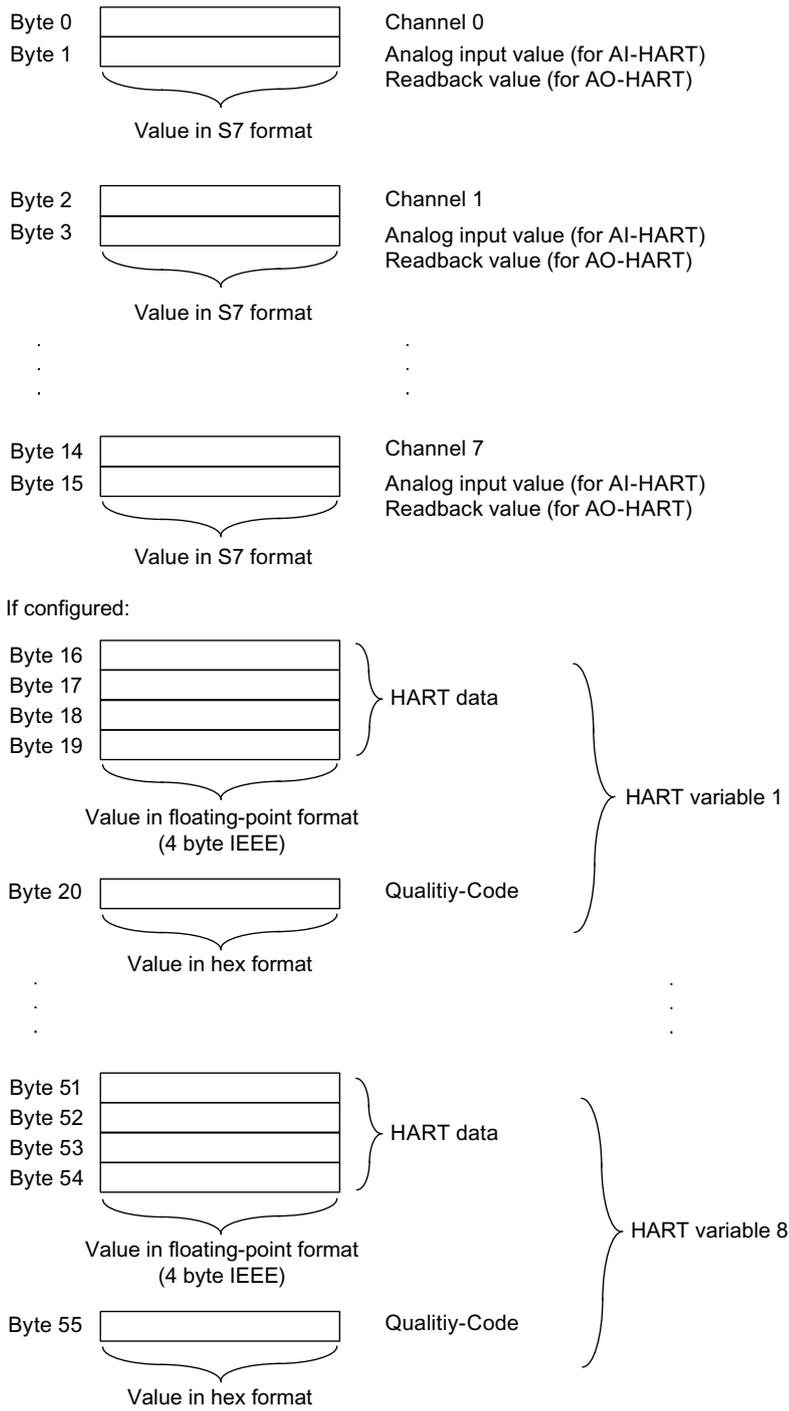


Figure 7-9 Input user data area of the HART analog modules

7.3.2 User data interface, output range (writing)

Structure of the user data

The figure below shows the structure of the output user data area of the HART analog modules. You can transfer the data to the user data area in a permissible format (e.g. with T PAW 256).

Both the analog input as well as the analog output occupy 16 bytes in the output area. In the case of the analog input, writing has no effect.

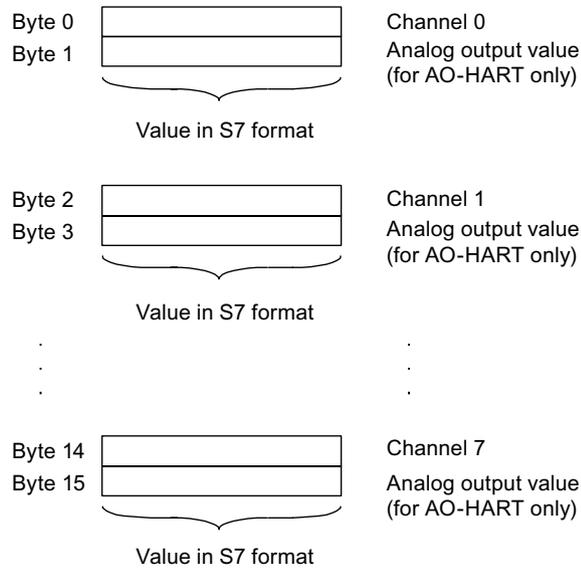


Figure 7-10 Output user data area of the HART analog modules

Calibration

Introduction

The SM 331 and the SM 332 are calibrated prior to delivery and comply with the specified precision. Generally speaking, there is no need to recalibrate the module.

In some systems it can nevertheless be advisable or, due to standardization requirements (e.g. required by specific institutions in the field of food, beverage and tobacco or pharmaceuticals), it can also be necessary to recalibrate the system itself, for example at specified intervals.

Particularly in systems where sensors record or process relatively small voltages or current, it can be practical to perform a recalibration using a calibration set-up inside the system, i.e. including all connected cables. This means you can compensate for any influences from cables and / or temperature.

If you perform an independent recalibration, new calibration values are recorded and saved redundantly on the module. The calibration values recorded in the factory prior to delivery of the module will however not be lost as a result of an independent recalibration. You can always reset to these original calibration values at any time.

Note

The calibration values from each channel are saved redundantly, measuring range-specific, to the module. I.e. they apply only with the measuring range for which the user calibration was carried out.

If a channel, for which the user calibration values are effective, is reconfigured in a different measuring mode, the factory-set calibrated values for this channel and for this measuring range will then become effective.

The user calibration values do remain saved. They are overwritten only when another user calibration of the channel is performed. If, however, the original measuring range is set for this channel without a new user calibration, then the previously recorded user calibration values are effective again.

Requirements

- The module must be configured as a V3.x module.
- Distributed use of the module in conjunction with the PDM ("Process Device Manager") as of V6.0 + SP3 + HF2.
- EDD for ET200M "DP_IOSystem_Siemens_ET200M_Module.Device" as of version V1.1.10.
- The calibration may not be carried out in redundant mode!

8.1 Introduction to the calibration

Introduction to the calibration

The following figures show the steps of a user calibration in SIMATIC PDM V6.0 + SP5. The display may differ from these figures for more recent versions of SIMATIC PDM.

The introduction to the calibration of the module takes place in SIMATIC PDM via <Device => Calibration > for the selected module.

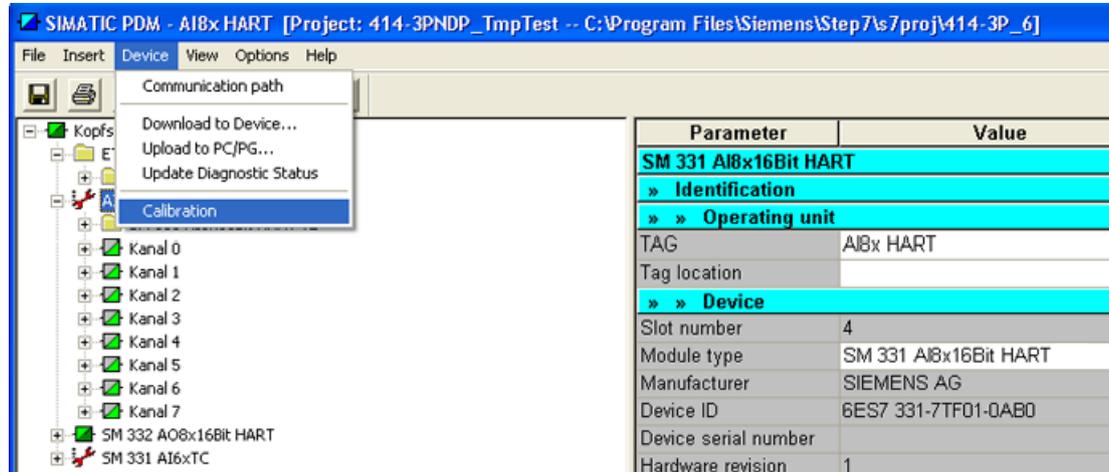


Figure 8-1 Introduction to the calibration

After the calibration function starts, the basic screen for the calibration is displayed. Each time a channel is called, the following general information data and calibration values of the module are immediately read:

General information data:

- Measuring range: Currently configured measuring range of the selected channel
- Date: Date and time of the recording of the displays calibration values
- Calibration: Indicates whether the currently effective calibration values are factory calibration values or user calibration values.

Calibration values:

- Offset: Current effective offset correction of the analog digital converter.
- Gain: Current effective amplification correction of the analog digital converter.

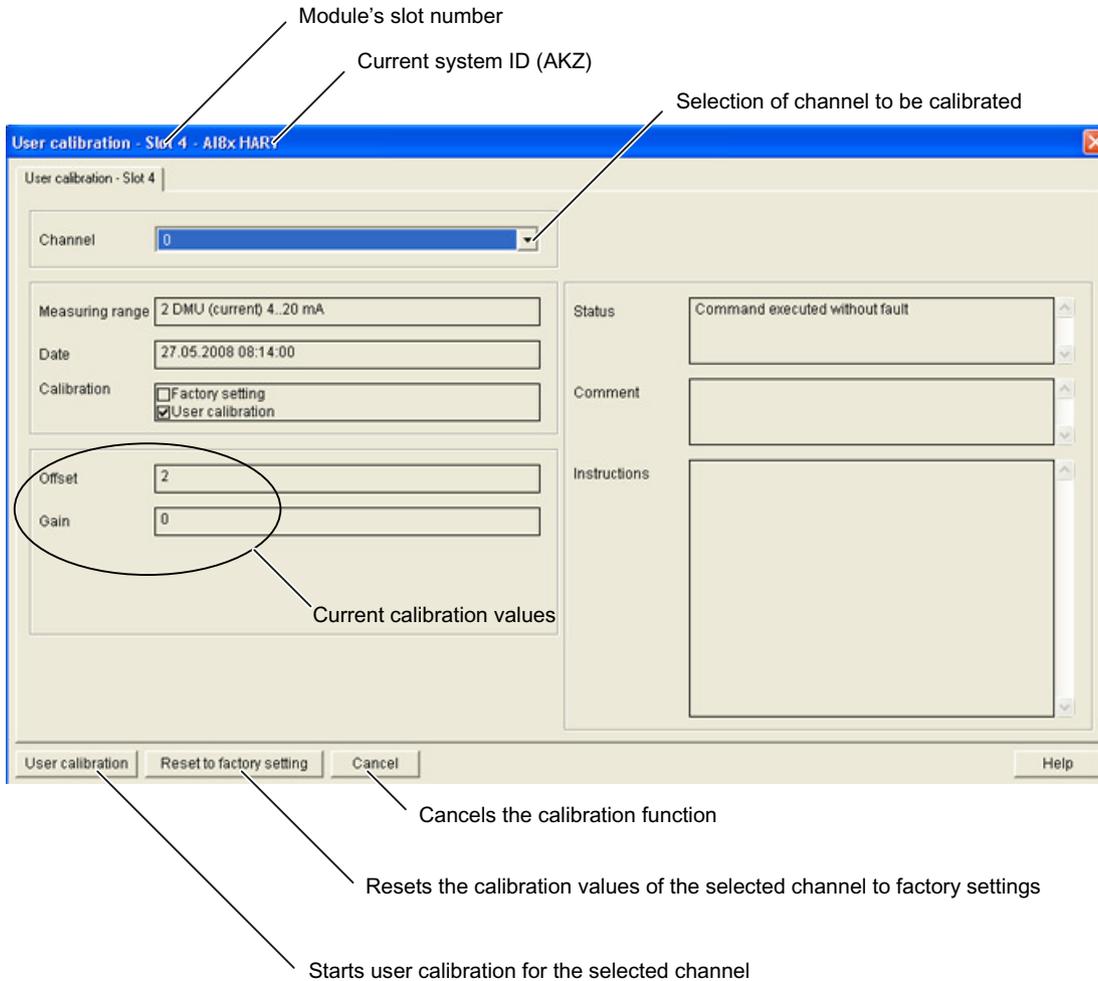


Figure 8-2 Basic screen for the calibration

Options

You now have the option:

- To start a user calibration of the selected channel;
 - "User calibration" button
- To enable the factory-set calibration values of the selected channel;
 - "Restore factory settings" button
- To stop the calibration
 - "Cancel" button

Note

When you reset the current channel to the factory settings, the original, factory-set calibration values for the module become valid again. Possible existing user calibration values of this channel are lost. You cannot restore these user calibration values.

8.2 User calibration

User calibration

Via the "User calibration" button, start a user calibration for the selected channel.

The module must have a 24 V load voltage so that a calibration can be performed for the analog output module 6ES7332-8TF01-0AB0.

During a user calibration, the necessary calibration values of the selected channel are recorded again for the measuring range set for this channel.

You can perform a calibration both in RUN and in STOP of the CPU. Of course, you must note that if the CPU is in RUN for the duration of the module calibration, correct analog values can no longer be supplied or issued.

Note

During a user calibration, all channels of the module can no longer record or issue any new process values. No HART communication is possible.

- Each channel displays this via a respective channel-specific diagnosis in the second channel diagnostic type (see Chapter "Diagnostic data record" (Page 78)).
 - All process input values of the module are set to 0x7FFF ("invalid analog value") until you exit the user calibration.
 - The value for all HART variables remains unchanged until the user calibration is exited.
 - The process output values of all channels of the analog output module 6ES7332-8TF01-0AB0 are not edited during a user calibration. For the channel for which the user calibration is running, calibration-specific analog values are issued from the module. All the remaining channels are switched off. After leaving the user calibration, the process output values that were last transferred to the module are issued again.
-

A calibration of the selected channel is performed via the displayed calibration screen.

A calibration consists of several, individual calibration steps within which the individual calibration values are recorded. You will be guided through all the necessary calibration steps.

- If an error occurs during a calibration, or if the module is reconfigured, then the calibration of the channel is aborted and the last effective calibration value of the channel is again valid. All the calibration values recorded up to now are lost. The module reprocesses the current process values.
- You can abort a calibration that has already been started at any time. After an abort, again the last effective calibration value of the channel becomes valid and any calibration values recorded up to this time are lost. The module reprocesses the current process values.

User calibration for the HART analog input module 6ES7331-7TF01-0AB0

During the course of a user calibration of a HART analog input module, you must supply a current using the appropriate external cabling.

The precision of the supply determines the precision of the calibration.

To ensure that, for example, the module still complies with the specified precision of $\pm 0.1\%$ even after a user calibration, you should specify the current with a precision of at least $\pm 0.05\%$. Imprecise current supplies will result in an incorrect calibration. If necessary, the precision specified in the technical specifications is no longer maintained.

In the case of the terminal numbers shown in the "Instructions", the first terminal shows the positive connection and the second terminal shows the negative connection.

Note

Even if you are using a 2-wire transducer, the module cannot be calibrated with a 2-wire calibrator. You must use a 4-wire calibrator. For the main process for connecting a 4-wire calibrator, refer to figure 2-3 in chapter Connecting current sensors or transducers to analog inputs (Page 17) .

In doing so, note that the polarity of the connections (4...20mA and M) when calibrating must be opposite that shown in Figure 2-3.

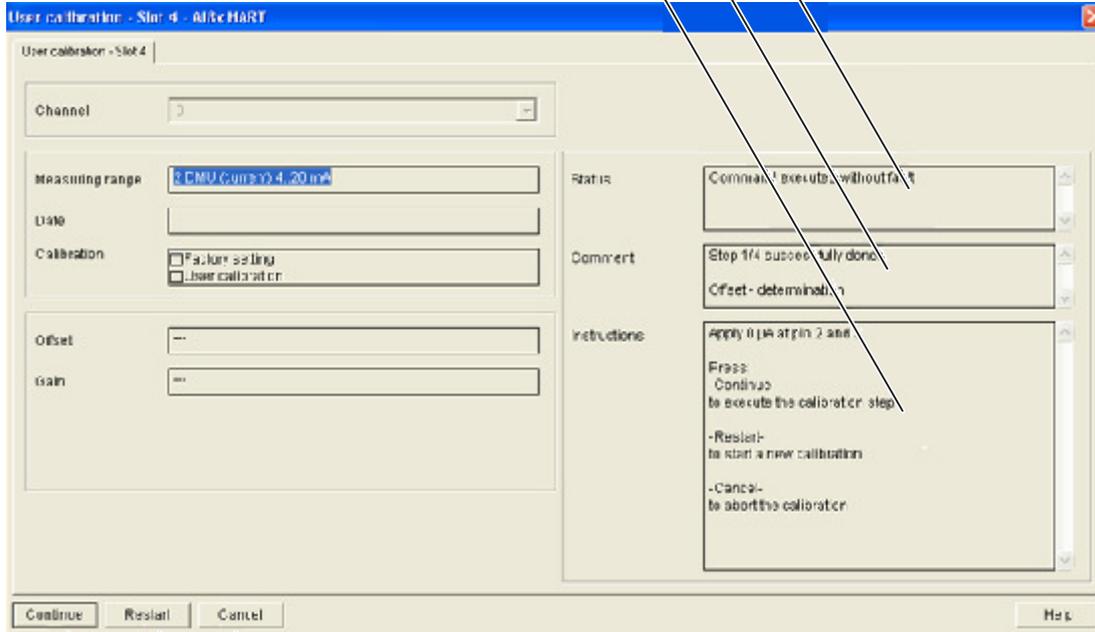
By means of the user calibration you can correct the characteristic curve of the AD converter of max. 5% of the maximum value.

8.2 User calibration

Here, information is provided regarding the current status of the calibration process

Here, information is provided regarding the current calibration step

Here, instructions are provided to perform the current calibration step



Continues the entire calibration function

Resets the current calibration and returns to the basic screen

Confirms the current calibration step and changes to the next calibration step

Figure 8-3 User calibration for the analog input module

User calibration for the HART analog output module: 6ES7332-8TF01-0AB0

During the course of a user calibration of a HART analog output module, you must supply a current using the appropriate external cabling.

The precision of the supply determines the precision of the calibration.

To ensure that, for example, the module still complies with the specified precision of $\pm 0.1\%$ even after a user calibration, you should specify the current with a precision of at least $\pm 0.05\%$.

Imprecise measured values will result in an incorrect calibration. If necessary, the precision specified in the technical specifications is no longer maintained.

In the case of the terminal numbers shown in the "Instructions", the first terminal shows the positive connection and the second terminal shows the negative connection.

By means of the user calibration you can correct the characteristic curve of the AD converter of max. 5% of the maximum value.

Here, information is provided regarding the current status of the calibration process

Here, information is provided regarding the current calibration step

Here, instructions are provided to perform the current calibration step

Figure 8-4 User calibration for the analog output module

Status

Depending on the measuring type set, several calibration steps are necessary to calibrate a channel. The field "Status" displays in each case whether or not the last calibration step was free from error or was performed with errors.

If, during the processing of a calibration step, an error occurs, then the error is displayed here and the calibration of the channel is aborted. All the calibration values recorded so far are deleted. The calibration values that were enabled before the user calibration was launched are retained.

Comments

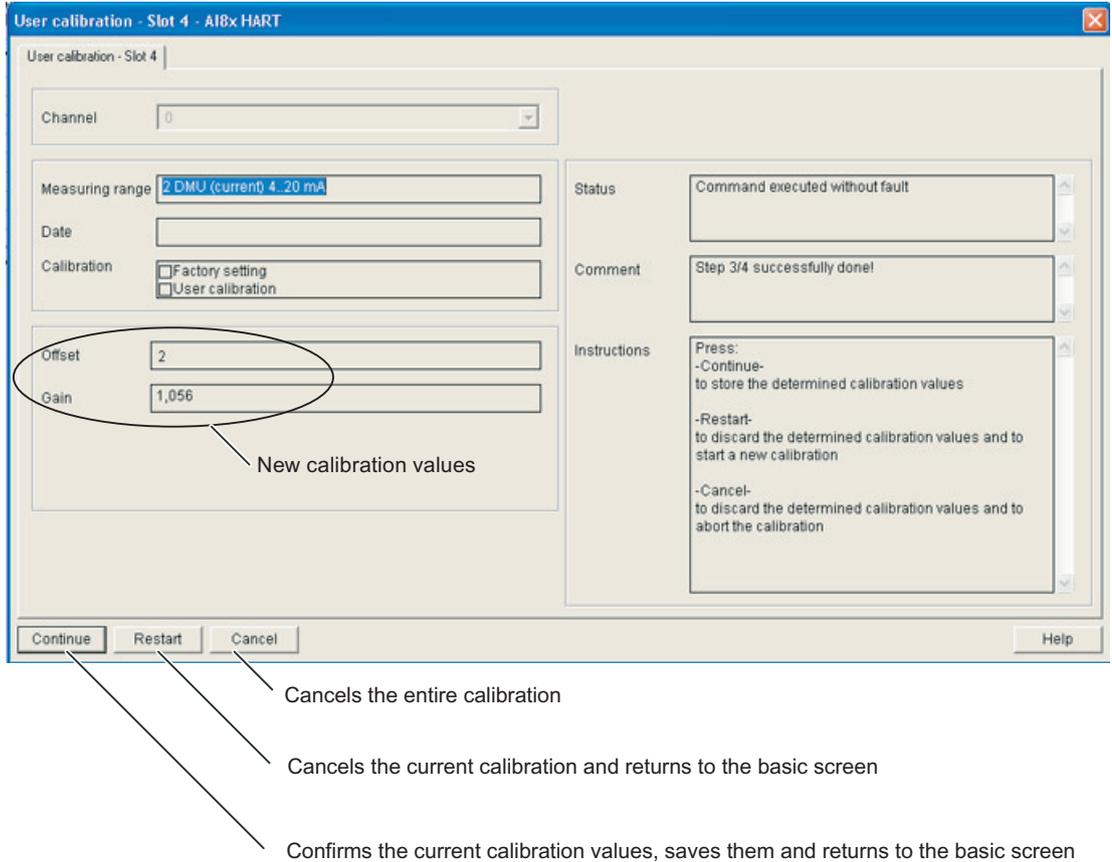
The "Comment" field shows you:

- How many calibration steps you have already performed,
- How many calibration steps are required to complete the calibration and
- Which calibration value the module is currently recording

Instructions

The "Instructions" field contains information about what you have to do in the current calibration step. You must carry out these actions and then confirm them with "Continue". The module then performs all the necessary actions for the current calibration step and then switches to the next calibration step, provided there were no errors.

The last calibration step shows you the new calibration values that were recorded during the course of the calibration.



- Continues the entire calibration
- Continues the current calibration and returns to the basic screen
- Confirms the current calibration values, saves them and returns to the basic screen

Figure 8-5 Ending the calibration

With "Continue" you can now adopt these calibration values as the new calibration values of this channel. The calibration values are saved redundantly and the calibration of the channel is ended.

If you do not want to use the displayed calibration values, then you can either return to the basic screen with "Start again" and start a new calibration or end the calibration entirely by pressing "Cancel".

List of abbreviations

A.1 List of abbreviations

Abbreviations	Explanations
EDD	Electronic Device Description
HF	Hotfix
SHC	Successive HART Command mode
SFB	Standard function block
SP	Service Pack
PDM	Process Device Manager

Glossary

Automation system

An automation system is a programmable logic controller which consists at least of one → CPU, various I/O modules, and operating and monitoring devices.

Backplane bus

The backplane bus is a serial data bus. It supplies power to the modules and is also used by the modules to communicate with each other. Bus connectors interconnect the modules.

The → I/O bus is a component of the backplane bus.

Backplane bus, active

The configuration backplane bus of the distributed I/O → ET 200M consists of active bus modules. This is the prerequisite for a configuration in which hot swapping (removal and insertion during operation) is permitted.

Baud rate

The baud rate is the speed at which data is transmitted. It specifies the number of bits transferred per second (bit rate).

The → ET 200 supports transmission rates from 9.6 kbps to 12 Mbps.

Bus

Shared data transmission path to which all nodes are connected. It has two defined ends.

The → ET 200 is connected to a 2-wire or optical fiber bus system.

Bus node

Device which can send, receive, or amplify data on the → bus (for example, a → DP master, → DP slave, RS 485 repeater, or active hub).

Calibration

Records the connection between the measured value or expected value of the output variable and the associated true or correct value of the measured quantity which is given as an input variable for a considered measuring device with specified conditions.

CELENEC

European committee for electrical standards

Chassis ground

Chassis ground includes all the interconnected inactive parts of equipment that cannot carry a hazardous voltage even in the event of a fault.

CiR

CiR (Configuration in RUN) refers to a system modification during operation. A system modification in RUN mode by means of CiR enables configuration changes to be made in RUN mode in portions of the system with distributed I/O. The process is thereby halted for a brief, assignable time period. The process inputs retain their last value during this time period.

Client

Clients can request services from a → server. A client can be, for example, a program, a central module (CPU) or a station (a PC, for example). Data can be transferred between the client and server via → PROFIBUS-DP, for example, or in a → master-slave relationship. If there are several clients, data transfer between client and server can be coordinated by means of separate transfer areas for each client, for example.

Configuration

Assignment of modules to racks/slots and addresses. A differentiation is made between the actual configuration, i.e. actually inserted modules, and the target configuration. You specify the preset configuration using STEP 7, COM PROFIBUS. The operating system can thus detect any incorrect assembly at startup.

Configuration, centralized

In a centralized configuration, the process I/O devices and central module are located in the same rack or in expansion units in the same or a neighboring cabinet.

Configuration, distributed

In a distributed configuration, the process I/O devices are not located in the same rack as the central module or in the same or a neighboring switch cabinet. They are located in different places and connected to each other by a communication bus..

CPU

Central processing unit = CPU of the S7 automation system with a control and arithmetic unit, memory, operating system, and interface for the programming device.

Diagnostic buffer

The diagnostic buffer is a buffered memory area in the CPU. It stores diagnostic events in the order of their occurrence.

Ground may have a potential other than zero near ground electrodes. The term "reference ground" is frequently used for this.

Diagnostic interrupt

Modules which support diagnostics interrupts report system errors detected to the central → CPU.

In SIMATIC S7/M7: The module triggers a diagnostics interrupt when errors, such as a wire break, are detected or cleared, provided the interrupt function is enabled. The → CPU interrupts execution of the user program or of jobs of a lower priority class in order to execute diagnostic interrupt OB 82.

Diagnostics

The detection, localization, classification, visualization and further evaluation of errors, faults and messages.

Provides monitoring functions which are executed automatically when the system is in RUN mode. This increases plant availability by reducing commissioning times and downtimes.

Distributed I/O devices

Input/output units which are not installed in the central rack but located at some distance from the → CPU, for example:

- ET 200M, ET 200B, ET 200C, ET 200U
- DP/AS-I Link
- Additional → DP slaves of Siemens or other manufacturers

Distributed I/O devices are interconnected with the → DP master via → PROFIBUS-DP.

DP address

Each → bus node must be assigned a unique DP address for → PROFIBUS-DP.

The PC/PG or the ET 200 handheld has the DP address "0".

→ DP masters and → DP slaves are assigned DP addresses from 1 to 125.

DP master

A → master with characteristics to EN 50170, Volume 2, → PROFIBUS is defined as DP master.

DP slave

A → slave operated on → PROFIBUS with → PROFIBUS-DP protocol and with characteristics to EN 50170, Volume 2, → PROFIBUS is defined as DP slave.

DP standard

Bus protocol of the ET 200 distributed I/O system in accordance with EN 50170, Volume 2, → PROFIBUS.

Electronic Device Description (EDD)

Description of the operation and configuration of devices for process and production automation.

Error display

One of the possible reactions of the operating system to → runtime errors. The other possible reactions include: an → error reaction in the user program or the → CPU or IM 153 going into STOP mode.

Error handling with OBs

After the operating system has detected a specific error (e.g. an → access error with STEP 7), it calls a dedicated → organization block (error OB) in which the subsequent behavior of the → CPU can be defined.

Error reaction

Reaction to a runtime error. The operating system can react in the following ways: Transition of the automation system to STOP state, call of an → organization block at which the user can program a specific reaction, or display of the error.

ET 200

The distributed I/O system ET 200 with → PROFIBUS-DP protocol is a → bus system for interconnecting distributed I/O with a → CPU or for interconnecting adequate → DP master. ET 200 features high-speed → reaction times as the system only transfers a low data volume (bytes).

ET 200 is based on EN 50170, Volume 2, → PROFIBUS standard.

ET 200 works on the master-slave principle. The IM 308-C master interface module or the CPU 315-2 DP, for example, can be a → DP master.

→ DP slaves can be represented by distributed I/O ET 200B, ET 200C, ET 200M, and ET 200U, or by DP slaves of Siemens or other manufacturers.

Field

This can be an area of the plant outside the control room where measured values can be obtained through communication or manipulated values can be sent to actuators.

Alternatively, it can be part of a message, for example an address field or command field dedicated to a particular function. The size of the field or other rules for the interpretation of each field are part of the protocol specification.

Field device

A → transducer in the → field which exchanges data with the central unit via communication bus.

FM

Factory Mutual, a US quality assurance system

Frequency shift keying (FSK)

A form of data modulation that is suitable for data transfer over normal cables. Two tone frequencies are used to encode binary "0" and binary "1" in the frequency range 300 - 3000 Hz. With → HART protocol, the FSK signal is transferred via current loop.

FSK

Frequency Shift Keying

Ground

The electrical potential of conductive ground can be pulled down to zero at any point.

Ground may have a potential other than zero near ground electrodes. The term "reference ground" is frequently used for this.

Ground electrode

One or more conductive parts that have very good ground contact.

H system

Fault-tolerant station consisting of at least two CPU modules or two separate devices, e.g., PCs (master / reserve). The user program is processed identically in the master and in the reserve.

Glossary entry

Hardware interrupt

A hardware interrupt is triggered by interrupt-capable S7-300 modules due to a certain event in the process. Process interrupts are reported to the central → CPU. The assigned organization block is then processed according to the priority of this interrupt.

In SIMATIC S7/M7: An operating range is defined by configuring upper and lower limit values, for example. If the process signal (for example, the temperature) of an analog input module leaves this operating range, the module triggers a hardware interrupt, provided the interrupt is enabled. The → CPU interrupts execution of the user program or of jobs of a lower priority class in order to execute process interrupt OB 40.

HART

Highway Addressable Remote Transducer = remotely controlled → transducer which can be addressed by communication functions. HART is a registered trademark of the → HART Communication Foundation.

HART analog modules

Analog modules which are capable of handling → HART communication functions in addition to their analog values. HART analog modules can be implemented as → HART interface for HART field devices.

HART commands

The HART field device works as a HART devices and is controlled by the master by means of HART commands. The master sets the → HART parameters and requests data in the form of → HART response frames.

HART communication

The transfer of data between a master (e.g. HART analog module) and a HART device (→ HART field device) by means of the → HART protocol.

HART Communication Foundation

The HART Communication Foundation (HCF) was set up in 1993 to promote and further develop the HART protocol. The HCF is a non-profit-making organization financed by its members.

HART fast mode

Module mode which enables support from HART commands with SHC (Successive HART Command mode).

HART field device

Smart device with additional → HART-compatible functionality to enable interpretation of the → HART communication functions.

HART handheld

The HART Handheld contains the original programming tool of Fisher-Rosemount LTd. for → HART field devices and is connected directly to the field devices. The HART Handheld is used to configure the → HART parameter.

HART interface

System component which can be used to interconnect a → HART field device. The HART interface represents the master for the field device. As far as the system is concerned, however, the HART interface is a slave that can be supplied by different masters in the system. The → HART parameter assignment tool is a master, for example. Another master is the automation system itself.

HART parameter assignment tool

The HART programming tool is a comfortable means of setting → HART parameters. It may be a → HART handheld or a parameter assignment tool that is integrated in the system (e.g. SIMATIC PDM).

HART parameters

HART parameters are the configurable properties of → HART field devices that can be changed by means of the → HART protocol. The parameters are set using a → HART programming tool.

HART protocol

The → HART protocol represents the industrial standard of enhanced communication with → HART field devices. It contains the → HART commands and → HART response frames.

HART replies

The HART field device transfers data on the request of the master. These data represent measurement results, manipulated values or the values of → HART parameters. The HART response frame always contains status information, namely the → HART status bytes.

HART signal

Analog signal on a current loop from 4 - 20 mA, where the aid of the → FSK procedure, the sinus waves for the → HART protocol, 1200 Hz for the binary "1" and 2200 Hz for the binary "0" can be modulated.

HART status byte

Status information which consists of status bytes 1 and 2 of the → HART response frame in which the HART field device returns → HART communication data, the acknowledgement of → HART commands and its device status.

HART transfer area

Area of data records that is defined for the writing of HART commands and reading of HART replies in HART analog modules. The HART transfer area consists of records. Each → client is assigned a separate data record area which can be used to exchange data with the → server.

HCF

→ HART Communication Foundation

I&M (identification data)

Identification data (I&M) is information stored in a module.

I data: information on the module that generally appears on the modules housing. I data is read-only.

M data: system-specific information such as the installation location and date.
M data is created during configuration and written to the module.

I/O bus

Component of the → S7-300 backplane bus in the → automation system. Tuned to high-speed signal exchange between the IM 153 module(s) and the signal modules. The I/O bus is used to transfer → process data, such as digital input signals of a signal module and system data, such as the → default parameter records of a signal module.

Interrupt

The →CPU operating system supports 10 different priority classes which control execution of the user program. These priority classes include interrupts (e.g. hardware interrupts). When an interrupt is triggered, the operating system automatically calls an assigned OB in which the user can program the desired reaction.

Isolated

Electrically isolated I/O modules are isolated from the → reference potentials of the control and load circuit by means of optocoupler, relay contact or transformer circuits. I/O circuits may be connected to the same source.

Load power supply

Power supply to the signal/function modules and the process I/O devices connected to them.

Master

When a master is in possession of the token, it can send data to other nodes and request data from other nodes (= active node).

→ DP masters, for example, are the 315-2 DP CPU or the IM 308-C interface.

Master class 1

→ master which controls process data traffic and the configuration / diagnostics of the distributed I/O.

Master class 2

→ Master for control/commissioning/configuration tasks (e.g. parameter assignment and diagnostics of the field devices connected to the distributed I/O devices).

Master/slave method

Bus access method in which at least one node is the → DP master and the other nodes are → DP slaves.

Measuring-point tag

Unique identifier of a measuring point. Consists of eight characters. The tag is written to memory of the → HART field device, and can be edited or read by means of → HART commands.

Modem

A modem (MOdulator / DEModulator) is a facility which converts binary digital signals into → FSK signals and vice versa. A modem does not encode data; it simply converts the physical form of the signals.

Module parameters

Module parameters are values with which the behavior of the module can be set. There are two different types of module parameters: static and dynamic.

Monodrop

In a monodrop communication system, a maximum of two devices are connected on the same transmission link (e.g. channel of the HART analog module and → HART field device). The method supports simultaneous use of the → HART protocol and of the analog signal.

The short HART address of the field device is 0.

Multidrop

In a multidrop communication system, up to 15 field devices can be connected to a HART master. Communication is only possible on the basis of the → HART protocol. The analog signal cannot be used in this method.

The short HART address of the field device is between 1 and 15.

Non-isolated

The → reference potentials of non-isolated I/O modules and of the control and load circuit are interconnected electrically.

OB

→ Organization blocks

Organization blocks

Organization blocks form the interface between the operating system of the S7 CPU and the user program. The order in which the user program is processed is defined in the organization blocks.

Parameter assignment (initialization)

The term configuration denotes the programming of module or → field device characteristics.

Parameter assignment tool

A software tool used to set the parameters of an → intelligent field device, for example.

Parameters, dynamic

In contrast to static parameters, dynamic parameters of modules can be changed dynamically by the user program.

Parameters, static

Unlike dynamic parameters, static parameters of modules cannot be changed by the user program. You can only modify these parameters in STEP 7 or COM PROFIBUS.

PLC

→ Automation System

Primary variable

Variable for the primary measured value of a HART analog input module (e.g. pressure). In the case of → HART field devices, other measurements may be implemented (e.g. temperature) whose results are stored in the secondary variable, tertiary variable, etc.. In the case of a HART analog output module, the primary variable contains the manipulated value.

Process image

Special memory area of the → automation system. At the start of the cyclic program the signal states of the input modules are transferred to the process image of the inputs. At the end of the cyclic program the process image of the outputs is transferred as a signal state to the output modules.

PROFIBUS

PROcess Field BUS, a German process and field bus standard defined in the PROFIBUS standard (EN 50170). It specifies functional, electrical, and mechanical properties for a bit-serial field bus system.

Bus system for networking PROFIBUS compatible → automation systems and field devices on cell and field level. PROFIBUS is available with the DP (= Distributed Peripherals), FMS (= Fieldbus Message Specification) or TF (= Technological Functions) protocols.

PROFIBUS-DP

PROFIBUS bus system with the DP protocol. DP stands for the German equivalent of distributed I/O. The ET 200 distributed I/O system is based on EN 50 170, Volume 2, → PROFIBUS standard.

PTB

Physikalisch Technische Bundesanstalt (an official German product certification body)

Reaction time

The reaction time is the average time that elapses between the changing of an input and the associated changing of an output.

RedLib

Blocks for the use of redundant modules → STEP 7 block library

Redundant systems

Redundant systems are characterized by the fact that important automation system components are available more than once (redundant). When a redundant component fails, processing of the program is not interrupted.

Reference potential

Potential from which the voltages of the participating circuits are evaluated and/or measured.

Runtime error

Errors during execution of the user program in the → automation system, i.e. not in the process.

S7-300 backplane bus

Backplane bus for the S7-300 system. This bus can also be used for the → ET 200M distributed I/O. Integration of the active backplane bus is also possible (→ Backplane bus, active)

Server

A server provides a service on request. A client can be, for example, a program, a module, or a station (a PC, for example). Data can be transferred between the → client and server via PROFIBUS-DP, for example, or in a → master-slave relationship.

SFB

Standard function blocks are function blocks made available by SIEMENS to solve complex problems.

A system function block (SFB) is integrated in the CPU operating system and can be called in the STEP 7 user program.

→ System function

SFC

A system function (SFC) is a function that is integrated in the operating system of the CPU and can be called in the STEP 7 user program, when necessary.

Signal module

Signal modules form the interface between the process and the automation system. There are digital input and output modules and analog input and output modules.

Slave

A slave can only exchange data with a master after being requested to do so by the master.

SM

→ Signal module

Smart device

Field device with complex functionality, contains a microprocessor with functions which can be set at the control room using a corresponding → programming tool.

Substitution value

Values output by faulty signal output modules to the process, or used to substitute a process value of a faulty signal input module in the user program. The substitute values can be set by the user (for example, retain old values).

System diagnostics

System diagnostics is the detection, evaluation, and indication of faults/errors which occur within the automation system. Examples of such error/faults are: program errors or failures on modules. System errors can be indicated by LEDs or in STEP 7.

System function

System functions are an integral of the → CPU operating system and can be called in the STEP 7 user program.

Terminating resistor

Resistor for impedance matching on the bus cable. Terminating resistors are required at the ends of cables and segments.

The → ET 200 bus connectors are equipped with switched terminating resistors.

Timeout

If an expected event does not take place within a specified time, this time is referred to as a timeout. The →HART protocol defines timeout intervals for the response of a slave to a master's message and for the waiting time after each transaction.

Transducer

Sensor, measuring transducer, actuator or final control element. A transducer can be implemented by means of a → smart device.

User data

User data is exchanged between a central module and signal module, function module and communication modules via the process image or direct accesses. User data can be digital and analog input/output signals of signal modules or control and status information of function modules.

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