SIEMENS

Equipment Manual

SIMATIC

S7-1500 / ET 200MP

Analog Input Module AI 8xHART HF
(6ES7531-7TF00-0AB0)

Edition 05/2023

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05/2023
A5E51346434-AA

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.

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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.

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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.

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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.

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Introduction

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Purpose of the documentation

This Equipment Manual supplements the System Manual System Manual S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/59191792).
Functions that relate in general to the systems are described in these system manuals.
The information provided in this manual and in the system/function manuals supports you in commissioning the systems.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 automation system, as well as for interface modules of the ET 200MP distributed I/O system.
Please also observe notes marked as follows:

NOTE

A note contains important information regarding the product described in the documentation or its handling, or draws special attention to a section of the documentation.

1.1 S7-1500/ET 200MP Documentation Guide

1.1.1 S7-1500 / ET 200MP Documentation Guide

The documentation for the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require. Changes and supplements to the manuals are documented in a Product Information.
You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems.
The STEP 7 online help supports you in the configuration and programming.
Examples:

- Getting Started S7-1500
- S7-1500/ET 200MP System Manual
- Online help TIA Portal

Device information

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

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules
- Equipment Manuals Power Supply Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC S7-1500 and ET 200MPsystems.
Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manual Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.
You can find the latest Product Information on the S7-1500 and ET 200MP systems on the Internet (https://support.industry.siemens.com/cs/de/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.
You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/86140384)

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.
You can find the comparison list on the Internet
(https://support.industry.siemens.com/cs/ww/en/view/86630375).

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.
The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in SIOS:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in SIOS and how to use SIOS on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

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

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.
You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).
As successor of the SIMATIC Selection Tools , it assembles the configuration editors for automation technology already familiar into a single tool.
With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.
You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.
The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

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

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- The "Network analysis" offers a quick overview of the PROFINET topology. It is possible to make simple parameter changes (for example, to the names and IP addresses of the devices). In addition, a quick and convenient comparison of the real configuration with a reference system is also possible.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

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

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet:
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

Security information 2

2.1 Open Source Software

Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109805059).

2.2 Security information

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

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

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

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

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Product overview

3

3.1 Properties

Article number

6ES7531-7TF00-0AB0

View of the module

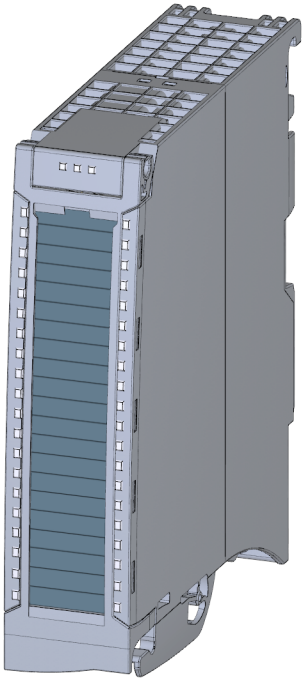

Figure 3-1 View of the AI 8xHART HF module

Properties

The module has the following technical properties:

- 2 potential groups for 4 channels
- HART communication (Rev. 5 to Rev. 7)
- Up to 8 HART variables directly in the input address area
- A multiHART area in the input/output area
- Sensor supply: Yes
- Current measurement type can be set per channel
  - 0 - 20 mA
  - ±20 mA
  - 4 - 20 mA
  - 4 - 20 mA with HART
- Interference frequency suppression: 10/50/60/400 Hz
- Electrical isolation
  - from backplane bus
  - in groups of 4 channels
- Resolution 16 bits including sign
- Operational limit (0 - 60 C): 0.1%
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two low and two high limits per channel)

The module supports the following functions:

Table 3-1 Version dependencies of the module functions

Function	Firmware version of the module	Configuration software	
		STEP 7 (TIA Portal) as of V17 HSP 0383 and V18 HSP 0383	GSD file in STEP 7 (TIA Portal) as of V17 HSP 0383 and V18 HSP 0383
HART communication (Rev. 5 to Rev. 7)	V1.0.0 or higher	X	X
Firmware update	V1.0.0 or higher	X	X
Identification data I&M0 to I&M3	V1.0.0 or higher	X	X
Configuration in RUN	V1.0.0 or higher	X	X
Value status	V1.0.0 or higher	X	X
Up to 8 HART variables directly in the input address area	V1.0.0 or higher	X	X
A multiHART area in the input/output area	V1.0.0 or higher	X	X
Module internal Shared Input (MSI)	V1.0.0 or higher	X (PROFINET IO only)	X (PROFINET IO only)
Configurable submodules / submodules for Shared Device	V1.0.0 or higher	X (PROFINET IO only)	X (PROFINET IO only)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Shield bracket
- Shield clamp
- Power supply element
- Labeling strips
- U connector
- Universal front cover

Other components

The following component can be ordered separately:
Front connector, including potential bridges and cable ties
You can find additional information on accessories in the S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/de/view/59191792/en) system manual.

Connecting

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4.1 Wiring and block diagrams

In this section you will find the schematic circuit diagram of the module and various connection options.
You can find information on wiring the front connector, establishing the cable shield, etc., in the S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/59191792) System Manual, section "Wiring".

NOTE

- You may use and combine the different wiring options for all channels.
- Do not insert the potential bridges included with the front connector.

Abbreviations used

Meaning of the abbreviations used in the following figures:

I_n+/I_n-	Current input channel n (current only)
L+	Supply voltage connection
M	Ground connection

Terminal assignment for the power supply element

The power supply element is inserted into the front connector and serves the shield connection and the use of the sensor supply. Wire the supply voltage to terminals 41 (L+) and 44 (M).
Use terminals 42 (L+) and 43 (M) to loop the potential through to the next module.

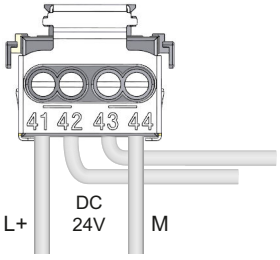
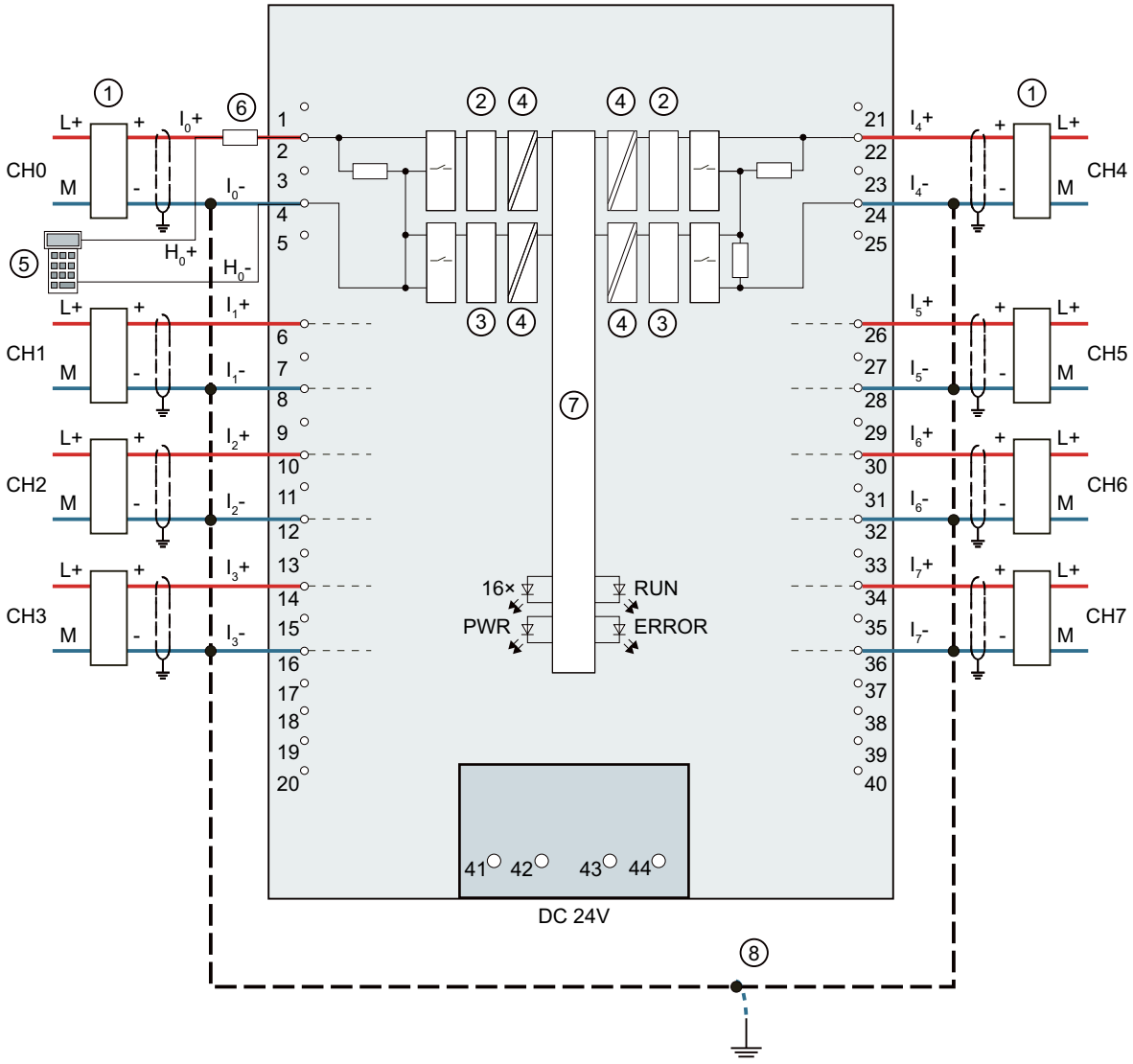


Figure 4-1 Power supply element wiring

Block diagram and terminal assignment for 4-wire transducer for current measurement

The example in the following figure shows the pin assignment for current measurement with 4-wire transducers.

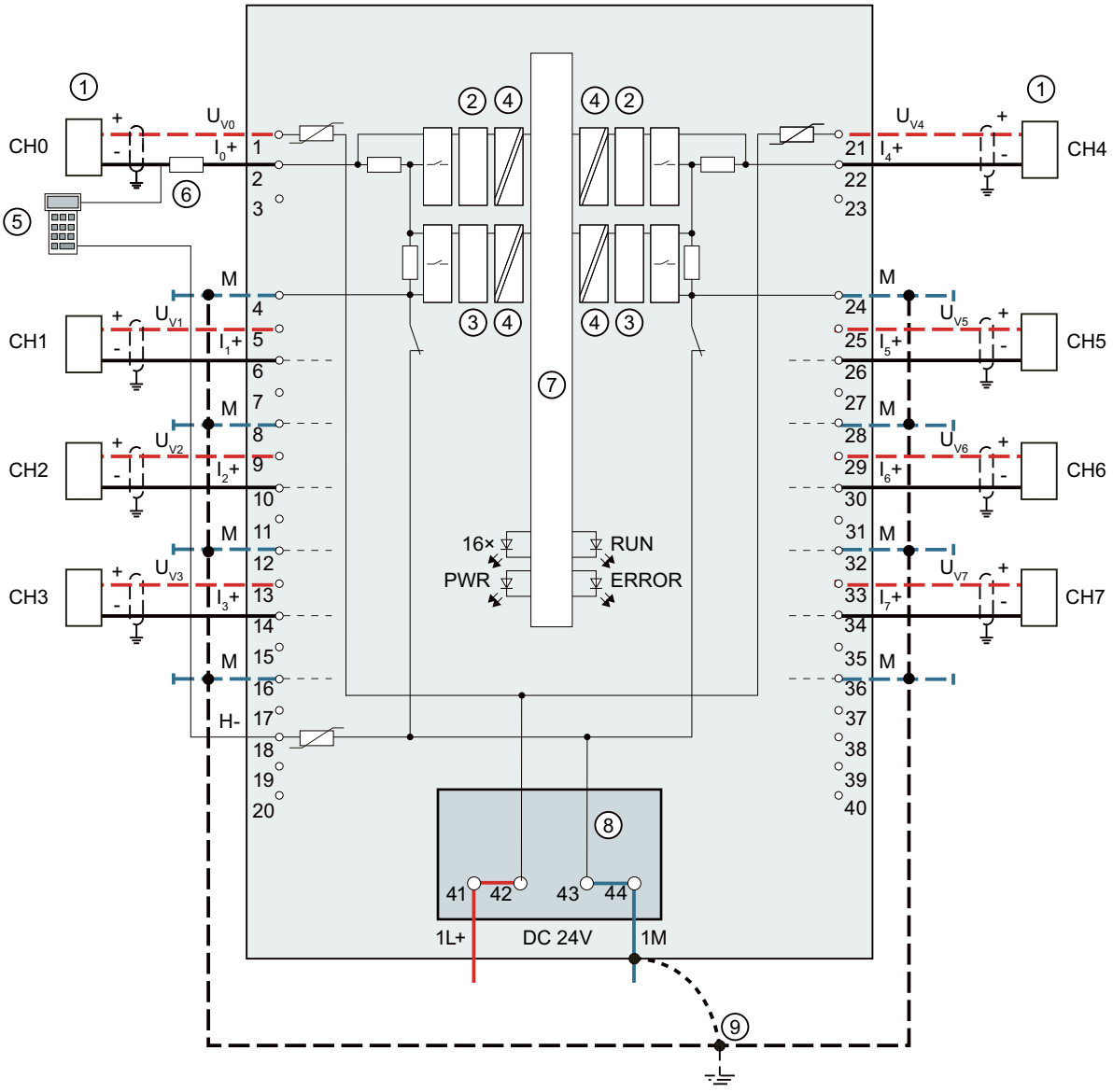


①	Connector 4-wire transducer	⑦	Backplane bus interface
②	HART interface	⑧	Equipotential bonding cable (optional)
③	Analog-to-Digital Converter (ADC)	CHx	8x channel or 8x channel status (green/red)
④	Electrical isolation	RUN	Status display LED (green)
⑤	HART Handheld	ERROR	Error display LED (red)
⑥	180 Ω resistance for circuit of handheld device	PWR	LED for power supply (green)

Figure 4-2 Schematic circuit diagram and terminal assignment for 4-wire transducer

Schematic circuit diagram and terminal assignment for 2-wire transducer for current measurement

The following figure shows an example of the terminal assignment for current measurement with a 2-wire transducer.



①	Connector 2-wire transducer	⑧	Supply voltage via power supply element
②	HART interface	⑨	Equipotential bonding cable (optional)
③	Analog-to-Digital Converter (ADC)	CHx	8x channel or 8x channel status (green/red)
④	Electrical isolation	RUN	Status display LED (green)
⑤	HART Handheld	ERROR	Error display LED (red)
⑥	180 Ω resistance for circuit of handheld device	PWR	LED for power supply (green)
⑦	Backplane bus interface		

Figure 4-3 Schematic circuit diagram and terminal assignment for 2-wire transducer

NOTE

Use of the internal switch to 1M

If you use the internal switch to 1M, the current flow occurs only after you have configured the module. If current flow is needed at all times, e.g. for commissioning without IM/CPU, wire the optional connection of the channels (terminal 4, terminal 8, etc.) to 1M.

HART functions

5

5.1 Use of HART

Definition

"HART" stands for "Highway Addressable Remote Transducer".
The HART functionality allows you to use the AI 8xHART HF analog input module to additionally exchange data with the connected field devices. The HART protocol is generally accepted as a 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. You can find detailed information about HART in the HART specification.

Advantages of HART

Use of the AI 8xHART HF analog input module offers you the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- Additional digital communication using the HART protocol
- Numerous field devices with HART functions are in use
- The option to use HART is integrated into the S7 system by means of the AI 8xHART HF analog input module

Use in the system

The AI 8xHART HF analog input module is used in the central I/O and in the distributed configuration that is connected to PROFIBUS DP or PROFINET IO.
You can connect a field device to any channel: The AI 8xHART HF analog input module operates as a HART master, monodrop. The field devices operate as HART devices.

Typical applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

5.2 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.

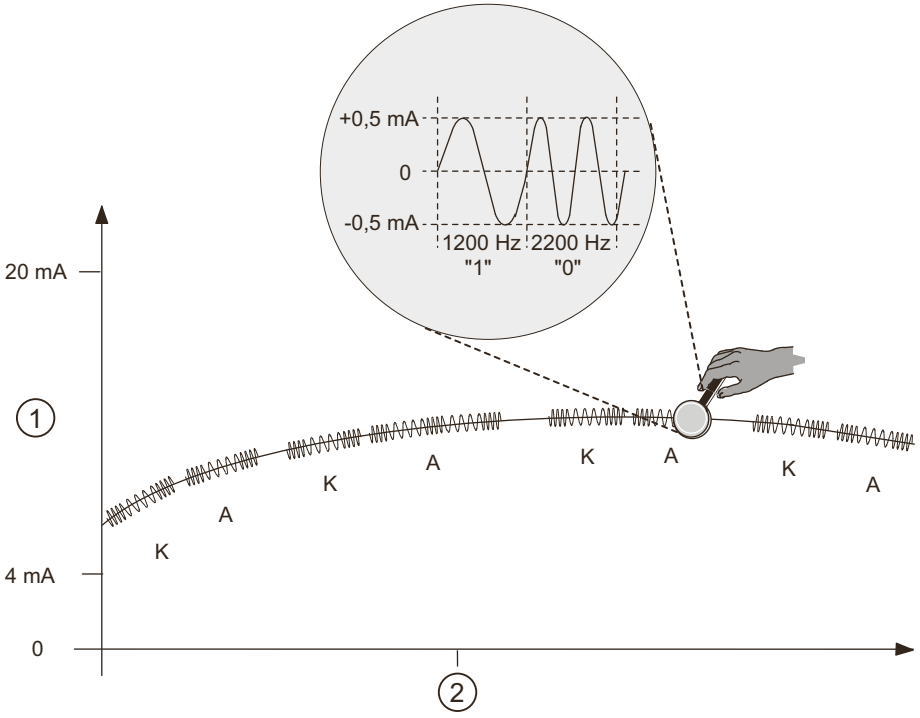


Figure 5-1 The HART signal

①	Analog signal
②	Time (seconds)
K	Command
A	Response

HART communication

The AI 8xHART HF analog input module processes the HART communication in multiplex mode, i.e. channel-by-channel in succession. With this analog input module, two separate HART masters are in use. Consequently, the HART commands of the individual channels 0 to 3 and 4 to 7 influence the speed of the HART processing of channels 0 to 3 and 4 to 7.

When HART mode is enabled, the analog module autonomously sends HART commands to the connected field devices. This always takes place on a channel-specific basis, alternating with any pending external HART commands that arrive via the command interface of the module, see HART communication interface (Page 26).

Commissioning a HART field device

Only HART field devices that are set to the short frame address 0 can be operated. If a HART field device with a different short frame address is connected or a connected field device is reconfigured to a short frame address other than 0 during operation, the module starts a scan of all possible short frame addresses at the next re-establishment of HART communication (command 0 with short frame addresses 1...63). As soon as the connected field device responds, it is converted to the short frame address 0 (HART command 6) by the module. During the scan, the module reports a HART communication error.

HART commands

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

- Universal
- Common practice
- Device-specific

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

Examples of HART commands

The following two tables show examples of HART commands:

Table 5-1 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 output and percent of range, digitally as floating-point number (IEEE 754)
3	Read up to four pre-defined dynamic variables (primary variables, secondary variables, etc.)
13, 18	Read or write tag, descriptor and date (data included in transmission)

Table 5-2 Examples of common practice commands

Command	Function
36	Set upper range value
37	Set lower range value
41	Perform self-test
43	Set the primary variable to zero
109	Switch burst mode on or off

Structure of the HART protocol

Each HART frame sent from the analog module to the connected field device (request frame) and each HART frame from the field device (response frame) has the following basic structure.

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE: Bytes (0xFF) for synchronizing.
5 to 20 bytes depending on parameter assignment

STRT: Start character (start delimiter)

ADDR: Address of the field device (1 byte; short address or 5 bytes; long address)

COM: HART command number

BCNT: Byte count, number of bytes to follow without checksum

STATUS: HART device status (1st and 2nd status byte). Only present for a response frame. For structure of HART device status, see below.

DATA: Transferred user data / parameters, quantity depending on command (0...230 bytes)

CHK: Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface. See section HART request and response data records (DS 80 to DS 95) (Page 75).

HART replies always contain data. Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response. You should evaluate these to make sure the response is correct.

Structure of HART device status (1st and 2nd status bytes).

Table 5-3 1st status byte

When Bit 7 = 1: "Communication error"	
Bit 6 = 1 Bit 5 = 1 Bit 4 = 1 Bit 3 = 1 Bit 2 = 0 Bit 1 = 1 Bit 0 = 0	Parity error Overflow Framing error Checksum error Reserved Overflow in the receive buffer Reserved
When bit 7 = 0: "Specific in line with response frame"	

Table 5-4 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Secondary variable outside the limits
Bit 0 = 1	Primary variable outside the range

HART Fast Mode

The AI 8xHART HF analog input module supports the processing of HART commands as an SHC sequence ("Successive HART Command").
That is, if the analog module detects a HART command with set SHC bit for a channel, the complete HART command processing on the HART analog module is reserved for this channel for approximately 2 s. For all other channels of the analog module, no HART frame processing occurs during this time, see section HART communication interface (Page 26)

NOTE

- During the time a HART channel of the HART module of the AI 8xHART HF analog input module is processing an SHC sequence and, thus, the HART processing of the module is reserved for this channel (channel 0 to 3 and 4 to 7), the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART requests for other channels of the HART module are not processed and are acknowledged accordingly (channel 0 to 3 and 4 to 7).

Burst mode

The AI 8xHART HF analog input module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

5.3 Use of HART

System environment for the use of HART

To use an intelligent field device with HART functionality, you require the following system environment:

- Current loop 4 - 20 mA
  Connection of the transducer to the AI 8xHART HF analog input module
- HART configuration tool "Client":
  You can assign the HART parameters using an external hand-held operating device (HART Handheld) or a HART configuration tool (PDM). Both assume the function of a "client": Whereas the configuration tool reaches through the AI 8xHART HF analog input module, the HART Handheld is connected directly parallel to the field device. See terminal assignment "HART test terminals (terminals 3, 7, 11, 15, 23, 27, 31, 35 to terminal 18)" Wiring and block diagrams (Page 15).
  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.
- HART system connection:
  The AI 8xHART HF analog input module assumes the role of a "master". As such, it receives the commands, e.g. from the HART configuration tool or as programmed commands of an S7 user program, forwards them to the intelligent field device and returns the responses. Data records that are transferred via the S7-1500 I/O bus serve as the interface of the AI 8xHART HF analog input module. The data records must be created and interpreted by the client.

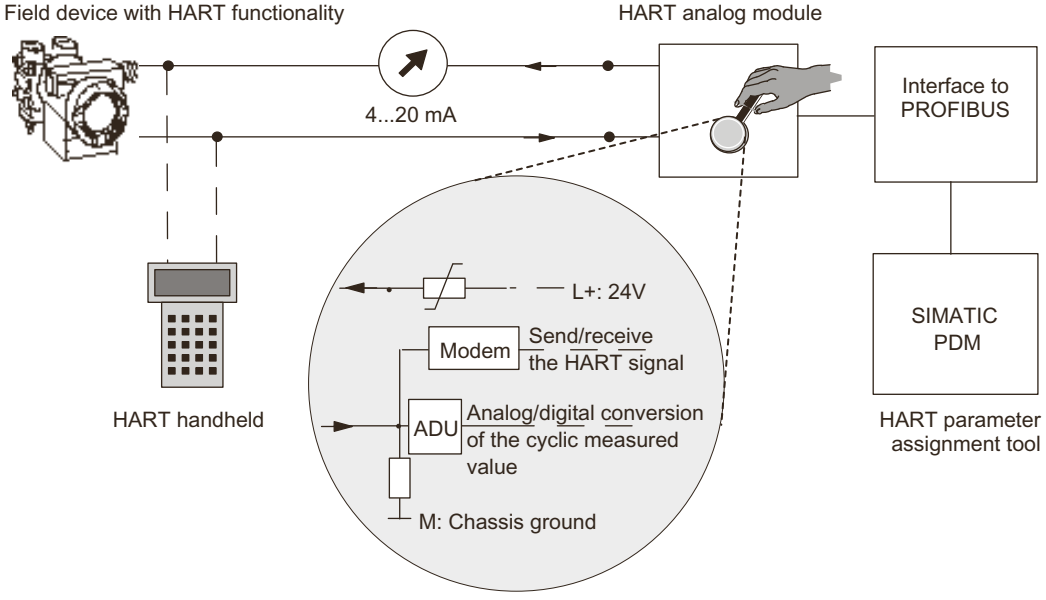


Figure 5-2 System environment for the use of HART

Error management

The two HART status bytes (HART device status) that are transferred with each response of the field device contain error information about the HART communication, HART command and device status.
Among other things, this information is evaluated by the AI 8xHART HF analog input module and made available in the system via the S7 diagnostic alarms.

Configuration/commissioning

You configure the AI 8xHART HF analog input module in the SIMATIC system with STEP 7 or the TIA Portal. You assign parameters for the individual channels with respect to the actual analog value acquisition and the use of HART variables in the input address space of the module.
You can configure one field device per channel. By means of this configured field device, the configuration/parameter assignment of the connected field device is then carried out using PDM or the EDD for the S7-1500/ET 200MP.
The AI 8xHART HF analog input module can also be configured using a GSD file for PROFIBUS DP as well as PROFINET IO. However, in this case, direct configuration / parameter assignment of the connected field devices is not possible.

Parameter reassignment of the field devices

The HART analog module generally accepts parameter reassignments for field devices. Access rights can only be allocated in the configuration tool.
For parameter reassignment of the field devices connected to the HART analog module, proceed as follows:

1. You start the parameter reassignment of a field device using a HART command that you enter using the SIMATIC PDM configuration tool or as a programmed command in the STEP 7 user program.
2. After you have reconfigured a HART field device, the corresponding bit is set in the HART device status of the connected field device (in the 2nd status byte).
3. The reconfiguration of the field device causes the HART analog module to issue a diagnostic interrupt "HART configuration changed", if this is enabled. See Diagnostics alarms (Page 52). This diagnostic interrupt is to be regarded as information and not as an error and is automatically deleted again by the analog module after approximately 1 minute.

A diagnostic interrupt can also be triggered, if enabled, when parameter reassignment is carried out with the hand-held device.

5.4 HART communication interface

Data records

The HART commands are sent as so-called external HART requests from the client (e.g., PDM or the STEP 7 user program) to the connected field device via data records. The response of the field device is made available again in the system via data records.

HART communication may only be handled by one client (e.g., PDM) per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. The AI 8xHART HF analog input module does not support client management.

Each client/channel is allocated fixed data records:

Table 5-5 Structure of the data records

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87
4	88	89
5	90	91
6	92	93
7	94	95

The corresponding data records are transferred to the module with the "WRREC" instruction and read by the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS.

Errors during interpretation of the request data record are signaled in the corresponding response data record. The faulty request can be read back again using the request data record.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error displays.
- The response data record must always be read completely because the analog module may modify the data record after the initial reading with "successful" or "error" status. If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.
- The client may only write a request data record to the module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is disabled. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command with set SHC bit is sent to the module, this channel is reserved for HART commands for 2 seconds. This means that an internal HART command is no longer sent to the field device for this channel.
Each time a HART command with a set SHC bit is sent, the module reserves this channel again for another 2 seconds for HART commands. If a HART command without a set SHC bit is detected for this channel, or if no further command occurs for this channel within 2 seconds after the previous HART command, then command 3 or 9 for reading the HART variables is cyclically sent to the field device for this channel.

5.5 HART variables

Introduction

Numerous HART field devices make available additional measured quantities (e.g. sensor temperature).
A maximum of four HART variables supported by the connected field device can be cyclically read per channel with activated HART functionality. The HART variables are read automatically with HART command 3 (for field devices with HART rev. 5 and 6) or with command 9 (for field devices with HART rev. 7 or later).
These four HART variables per channel are always stored in HART variable data record 121 and can be read at any time. See section HART variable data record (DS 121) (Page 73).
Additionally, a maximum of 8 HART variables can be configured directly in the input address space of the AI 8xHART HF analog input module. The HART variables are assigned to a channel in the properties dialog of the module. Parameters are assigned using parameter data record 140 (see section Parameter assignment and structure of the HART mapping parameters (Page 67)). This enables you to easily process measured values directly from the field device as input data in the automation device.

Evaluating the multiHART area

You can select the multiHART area via the parameter assignment dialog.

The multiHART area occupies 1 byte in the output area (command) and 6 bytes in the input area (1 byte acknowledgment + 5 bytes HART variable).

You can read all HART variables available in the module via the multiHART area. To do this, you must request a HART variable from the module using the command byte in the output area.

The command byte identifies the requested HART variable (HART variable reference):

HART variable reference	
Bit 4...7: Channel number 0...7	Bit 0...3: Variable identification 1 = Primary 2 = Secondary 3 = Tertiary 4 = Quaternary

The command is acknowledged using the acknowledgment byte in the input area. As soon as the HART variable reference requested using the command can be read, the requested HART variable can be evaluated.

The corresponding HART variable is continually updated by the module as long as you leave the command byte of the multiHART area unchanged.

If an invalid HART variable reference is requested, this is also acknowledged accordingly. The value of the corresponding HART variable is then zero, and the quality code is signaled with $0x37_H$ (initialization value from analog module).

Example:
The primary variable is to be read from channel 6.

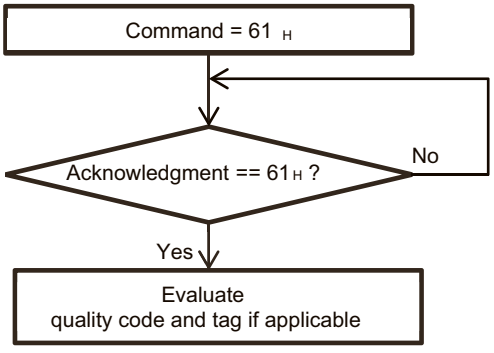


Figure 5-3 Command = 0x61

Address assignment

In as far as you map HART variables in the input address space of the module via parameter assignment or by selecting the corresponding configuration, an additional 40 bytes is always allocated for the HART variables.

Configuration of HART variables

You can configure up to 4 HART variables for each channel

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

When HART mode is active, the AI 8xHART HF analog input module autonomously and cyclically reads the variables provided by the connected field devices and makes them available in the input address space in accordance with the configuration.

Each HART variable consists of a 4-byte value and a quality code byte.

Quality code

The quality code describes the process status of the corresponding HART variable.

Basic structure of the quality code

Bit	7....6	5....2	1...0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the AI 8xHART HF analog input module conform to the HART revision of the field device in use.

Field devices with HART Revision 5 and 6

The quality code is formed exclusively from the 1st and 2nd Status byte (HART device status) of the response frames (HART command 3).

Quality code	Meaning (process status)	
80_H	Value is okay	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting
78_H	Value is uncertain	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range

Quality code	Meaning (process status)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	• After module startup • After incorrect operation of the multiHART interface
00_H	Initialization value from S7 system	

Field devices with HART Revision 7 or higher

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Quality code	Meaning (process status)	
80_H	Value is okay	
$28_{H...}2B_H$	"Bad"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above)
$68_{H...}6B_H$	"Poor accuracy"	
$78_{H...}7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
88_H	"More device variable state available" (additional status information available)	
89_H	"Good" with "Low limit"	
$8A_H$	"Good" with "High limit"	
$8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	• After module startup • After incorrect operation of the multiHART interface
40_H	Read alternatively via command 3	
00_H	Initialization value from S7 system	

Parameter assignment/addressing 6

6.1 Measuring types and ranges

Introduction

The default setting of the module is the current measurement type and a 4 to 20 mA HART measuring range. If you want to use a different measuring range, you must reassign the module parameters with STEP 7.

The following table shows the measuring types and the respective measuring range.

Measurement type	Measuring range	Analog value representation
2-WMT current (2-wire transducer)	4 to 20 mA HART 4 to 20 mA	See Appendix Representation of analog values in the current measuring ranges (Page 84).
Current 4WMT (4-wire transducer)	4 to 20 mA HART 4 to 20 mA 0 to 20 mA ±20 mA	
Deactivated	-	

The tables of the input ranges, overflow, undershoot range, etc. are available in appendix Representation of input ranges (Page 83).

6.2 Parameters

Parameters of the AI 8xHART HF

The AI 8xHART HF is available for STEP 7 (TIA Portal) V17 and V18 with HSP 0383. In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

You can also assign the module parameters using a GSD file and the configuration software of any provider. The module checks the validity of the configured properties only after the configuration has been downloaded.

When you assign the module parameters in STEP 7, you use various parameters to specify the module properties. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with a S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200MP system
- Distributed operation on PROFIBUS DP in an ET 200MP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment (Page 62).

The following parameter settings for the channels are possible:

Table 6-1 Configurable parameters and their defaults

Parameter	Range of values	Default setting	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog of STEP 7 (TIA Portal) as of V17 and V18 HSP 0383 or the PROFINET IO GSD file	GSD file PROFIBUS DP
Diagnostics					
• No supply voltage L+ [5]	Yes/No	No	Yes	Channel [1]	Module [3]
• Overflow	Yes/No	No	Yes	Channel	Module [3]
• Underflow	Yes/No	No	Yes	Channel	Module [3]
• Wire break	Yes/No (current: 4 mA to 20 mA)	No	Yes	Channel	Module [3]
• Current limit for wire break diagnostics [2]	1.185 mA or 3.6 mA	1.185 mA	Yes	Channel	--- [4]
• HART [6]	Yes/No	No	Yes	Channel	Channel
Measuring					
• Measurement type	See section Measuring types and ranges (Page 31)	2-WMT current	Yes	Channel	Channel
• Measuring range		4..20 mA HART	Yes	Channel	Channel
• Operating mode	Standard Fast Mode	Standard	Yes	Channel	--- [4]
• Interference frequency suppression	400 Hz 60 Hz 50 Hz 10 Hz	50 Hz	Yes	Channel	Module
• Smoothing	None/low/medium/high	None	Yes	Channel	Channel
Hardware interrupt					
• Hardware interrupt high limit 1	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt low limit 1	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt high limit 2	Yes/No	No	Yes	Channel	--- [4]
• Hardware interrupt low limit 2	Yes/No	No	Yes	Channel	--- [4]

Parameter	Range of values	Default setting	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				Integrated in the hardware catalog of STEP 7 (TIA Portal) as of V17 and V18 HSP 0383 or the PROFINET IO GSD file	GSD file PROFIBUS DP
HART					
• HART preamble bytes	5 .. 20	5 .. 20	Yes	Channel	Channel
• HART telegram repetitions	0 .. 255	0 .. 255	Yes	Channel	Channel

1) If you enable diagnostics for multiple channels, you will receive an alarm surge on failure of the supply voltage because each enabled channel will detect this fault.

You can prevent this message burst by assigning the diagnostics function to one channel only.

2) When "Wire break" diagnostics is disabled, the current limit of 1.185 mA applies to the value status. For measured values below 1.185 mA, the value status is always: 0 = fault.

3) You can set the effective range of the diagnostics for each channel in the user program with data records 0 to 7.

4) You can configure the current limit for wire break diagnostics, the "Hardware interrupt" parameter, the "Measuring range adjustment high and low limit" parameters, the hardware interrupt limits and the operating mode in the user program using data records 0 to 7.

5) For 2-wire transducer only

6) For 4 to 20 mA HART only

6.3 Declaration of parameters

Missing supply voltage L+

Enabling of the diagnostics, with missing or too little supply voltage L+.

Overflow

Enabling of the diagnostics if the measured value violates the high limit.

Underflow

Enabling of the diagnostics if the measured value violates the low limit.

Wire break

Enabling of the diagnostics if the module has no current flow or too little current for the measurement at the correspondingly configured input. The "Wire break" diagnostics is only available in the 4 to 20 mA HART measuring range.

Current limit for wire break diagnostics

Threshold for reporting wire breaks. The value can be set to 1.185 mA or 3.6 mA, depending on the sensor used.

HART diagnostics

Enabling of the diagnostics of the HART telegram-specific monitorings and the status information provided by the connected field device in the HART telegram (HART device status).

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

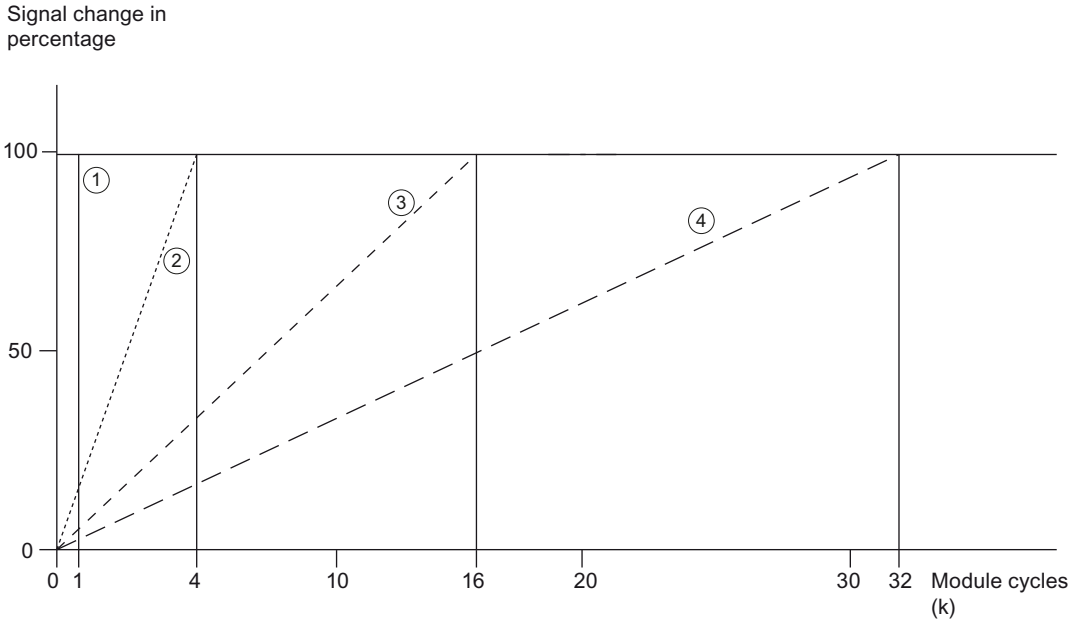
With this parameter, the user specifies the line frequency that is predominant in the plant.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows after how many module cycles the smoothed analog value is almost 100%, depending on the set smoothing. Is valid for each signal change at the analog input.



① None (k = 1)
② Weak (k = 4)
③ Medium (k = 16)
④ Strong (k = 32)

Figure 6-1 Smoothing with AI 8xU/I HF

Hardware interrupt 1 or 2

Enable a hardware interrupt at violation of high limit 1 or 2 or low limit 1 or 2.

Low limit 1 or 2

Specifies the low limit threshold that triggers hardware interrupt 1 or 2.

High limit 1 or 2

Specifies the high limit threshold that triggers hardware interrupt 1 or 2.

Operating mode Fast / Standard

You can use this parameter to determine the operating mode for the module.

- Fast Mode; single integration time with lower interference frequency suppression (shortest integration time 2.5 ms)
- Standard mode; triple integration time with higher interference frequency suppression (shortest integration time 7.5 ms)

HART preamble bytes

With this parameter you define the number of preambles sent.

HART telegram repetitions

Defines the number of HART telegram repetitions. If the AI 8xHART HF receives no response or an incorrect response to a HART telegram sent to the field device, the telegram is repeated accordingly. It is thus sent to the field device again.

6.4 HART mapping parameters

A maximum of 8 HART variables can be configured (mapped) in the address space of the module using the HART mapping parameters.

Each HART variable occupies 5 bytes of input data. As soon as you map at least one HART variable in the input address space, the addresses are allocated for 4 variables (20 bytes) or 8 variables (40 bytes), depending on the configuration.

With PROFIBUS DP GSD configuration with HART variables, the HART variables cannot be directly configured. The four secondary variables are supplied in ascending channel order in the address space of the module.

When required, this can be changed using data record 140; see section Parameter assignment and structure of the HART mapping parameters (Page 67).

Parameters

Table 6-2 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 1	Channel	0...7	0	Yes	0
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
Variable 2	Channel	0...7	0	Yes	1
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 3	Channel	0...7	0	Yes	2
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
Variable 4	Channel	0...7	0	Yes	3
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
The following variables apply only to a configuration with 8 HART variables:					
Variable 5	Channel	0...7	0	Yes	4
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
Variable 6	Channel	0...7	0	Yes	5
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
Variable 7	Channel	0...7	0	Yes	6
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary
Variable 8	Channel	0...7	0	Yes	7
	Type	• Non • Primary • Secondary • Tertiary • Quartenary	Non	Yes	Secondary

6.5 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 8xHART HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file.

When you configure the module by means of the GSD file, the configurations are available under different abbreviations/module names.

The following configurations are possible:

Table 6-3 Configuration options

Configuration	Short designation/ module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)	
		Integrated in the hardware catalog of STEP 7 (TIA Portal) V18 or higher	GSD file in STEP 7 (TIA Portal) V18 or higher or STEP 7 V5.5 SP3 or higher
1 x 8-channel without value status	AI 8xHART HF	X	X
1 x 8-channel with value status	AI 8xHART HF, QI	X	X
1 x 8-channel with value status for module-internal shared input with up to 4 submodules	AI 8xHART HF, MSI	X	X
8 x 1-channel without value status	AI 8xHART HF, S	X (PROFINET IO only)	X (PROFINET IO only)
8 x 1-channel with value status	AI 8xHART HF, S QI	X (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel without value status, HART with 4 variables	AI 8xHART HF, 4 Variablen	X (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel with value status, HART with 4 variables	AI 8xHART HF, QI 4 Variablen	X (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel without value status, HART with 8 variables	AI 8xHART HF, 8 Variablen	X (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel with value status, HART with 8 variables	AI 8xHART HF, QI 8 Variablen	X (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel with value status, HART, multiHART	AI 8xHART HF, QI multiHART	V14 or higher with HSP 0186 (PROFINET IO only)	X (PROFINET IO only)

Address assignment for HART

Each HART variable occupies 5 bytes of input data. As soon as you map at least one HART variable in the input address space, the addresses are allocated for 4 variables (20 bytes) or 8 variables (40 bytes), depending on the configuration.

When the multiHART area is used, an additional 6 bytes of input address space and 1 byte of output address space is allocated.

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 8xHART HF, QI
- AI 8xHART HF, MSI
- AI 8xHART HF, S QI
- AI 8xHART HF, QI 4 variables
- AI 8xHART HF, QI 8 variables
- AI 8xHART HF, QI multiHART

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

6.5.1 Address space 1 x 8-channel with and without value status

Address space for configuration as 1 x 8-channel AI 8xHART HF and AI 8xHART HF QI

The figure below shows the address space assignment for the configuration as 1 x 8-channel module. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IB x" stands, for example, for the module start address input byte x.

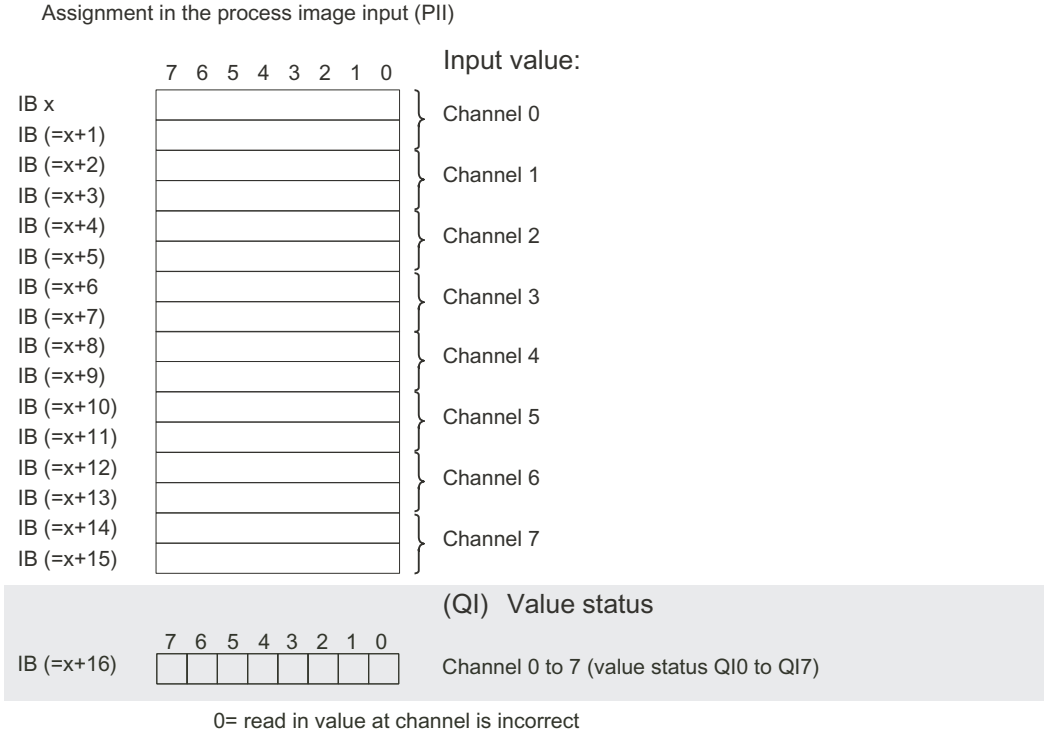


Figure 6-2 Address space for configuration as 1 x 8-channel AI 8xHART HF with value status

6.5.2 Address space 1 x 8-channel with value status for MSI

Address space for configuration as 1 x 8-channel AI 8xHART HF MSI

When configured as 1 x 8-channel module (module-internal shared input, MSI), channels 0 to 7 of the module are copied four times to up to 4 submodules. Channels 0 to 7 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of IO controllers depends on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

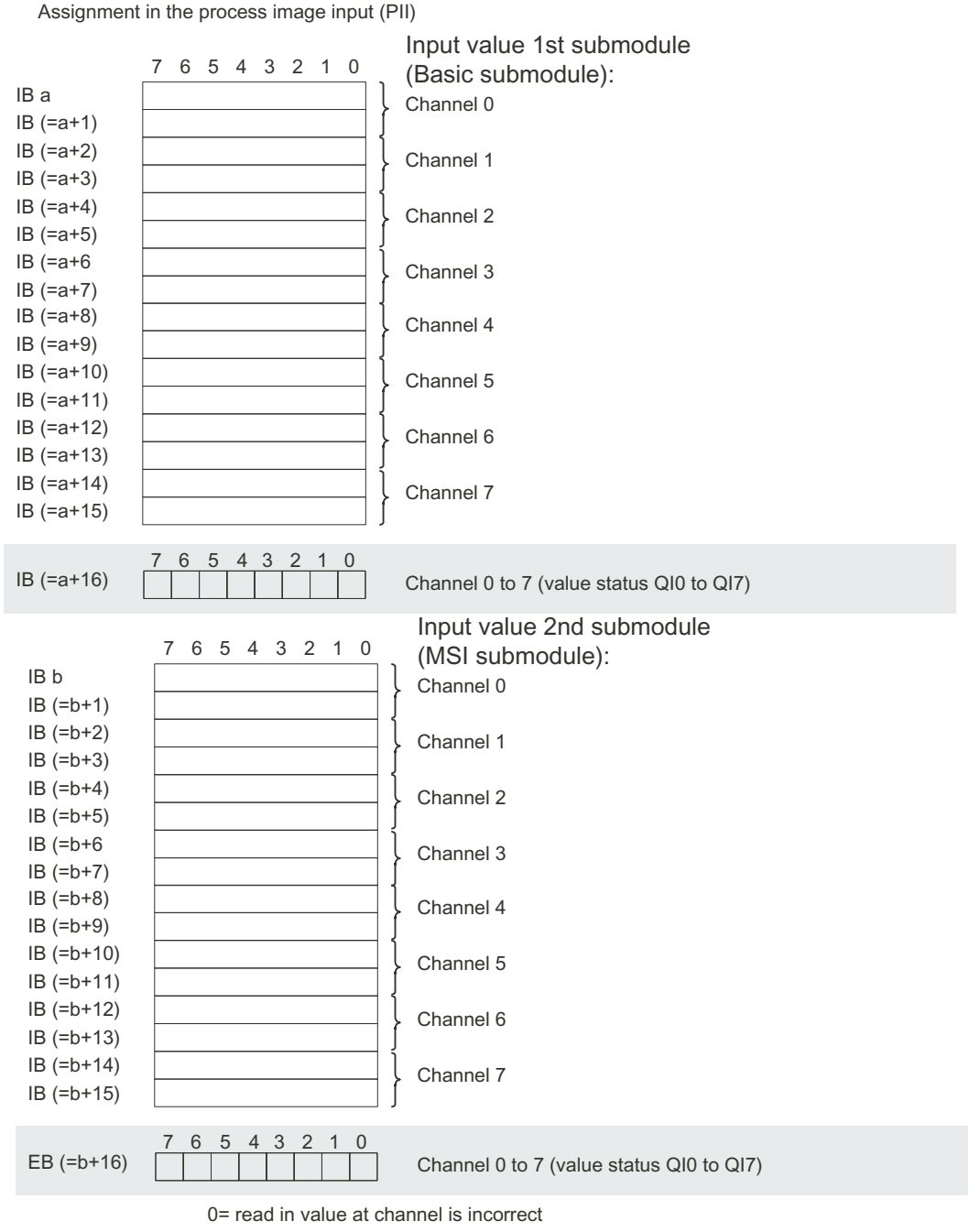


Figure 6-3 Address space for configuration as 1 x 8-channel AI 8xHART HF MSI with value status

The following figure shows the assignment of the address space with submodules 3 and 4.

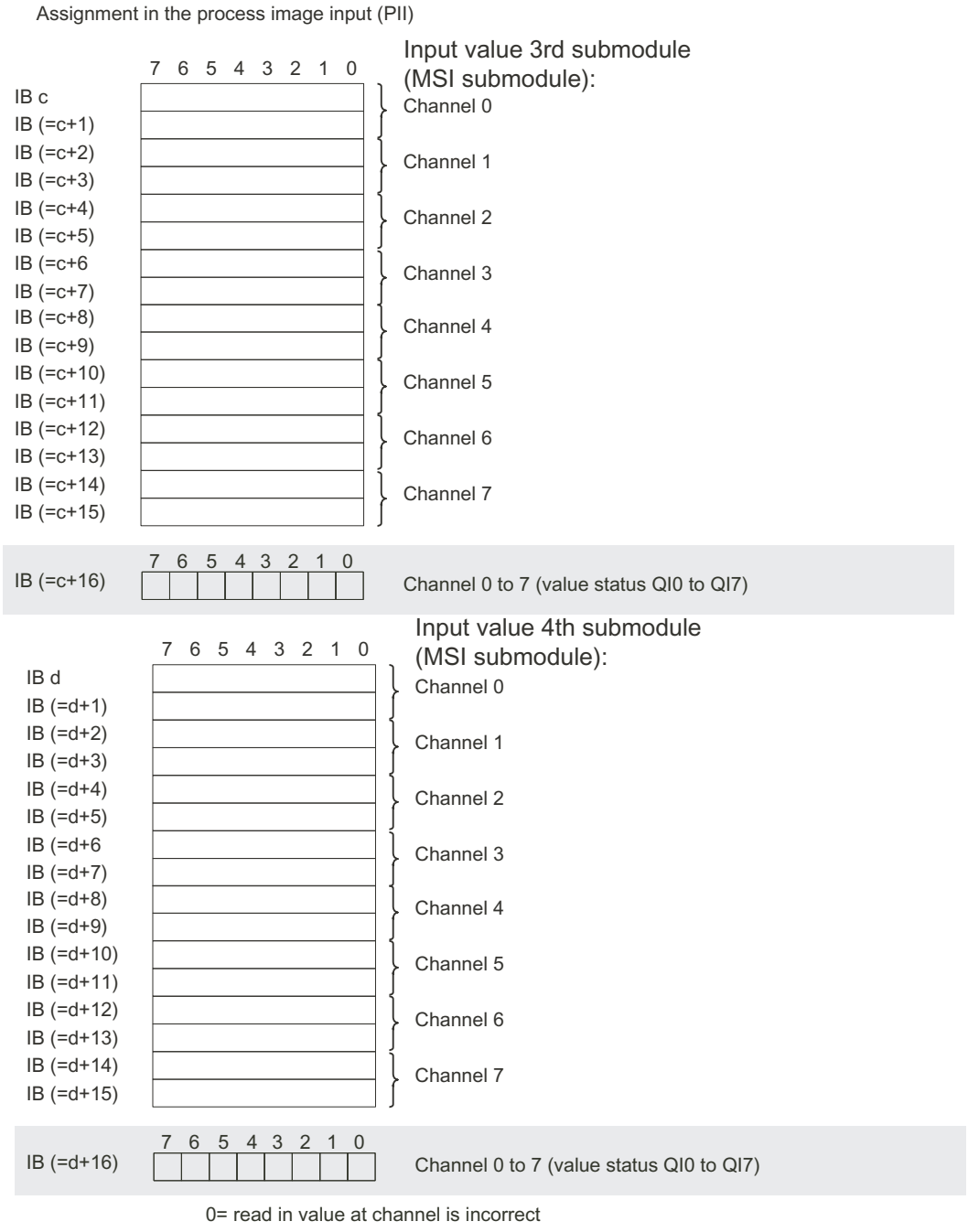


Figure 6-4 Address space for configuration as 1 x 8-channel AI 8xHART HF MSI with value status

Reference

You can find information on the Shared Input/Output (MSI/MSO) functionality in the section "Module-internal shared input/shared output (MSI/MSO)" of the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/de/en/view/49948856/en) Function Manual.

6.5.3 Address space 8 x 1-channel with and without value status

Address space for configuration as 8 x 1-channel AI 8xHART HF S and AI 8xHART HF S QI

When configured as 8 x 1-channel module, the channels of the module are divided into multiple submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Observe the information in the respective equipment manual of the interface module.

In contrast to the 1 x 8-channel module configuration, each of the eight submodules has a freely assignable start address.

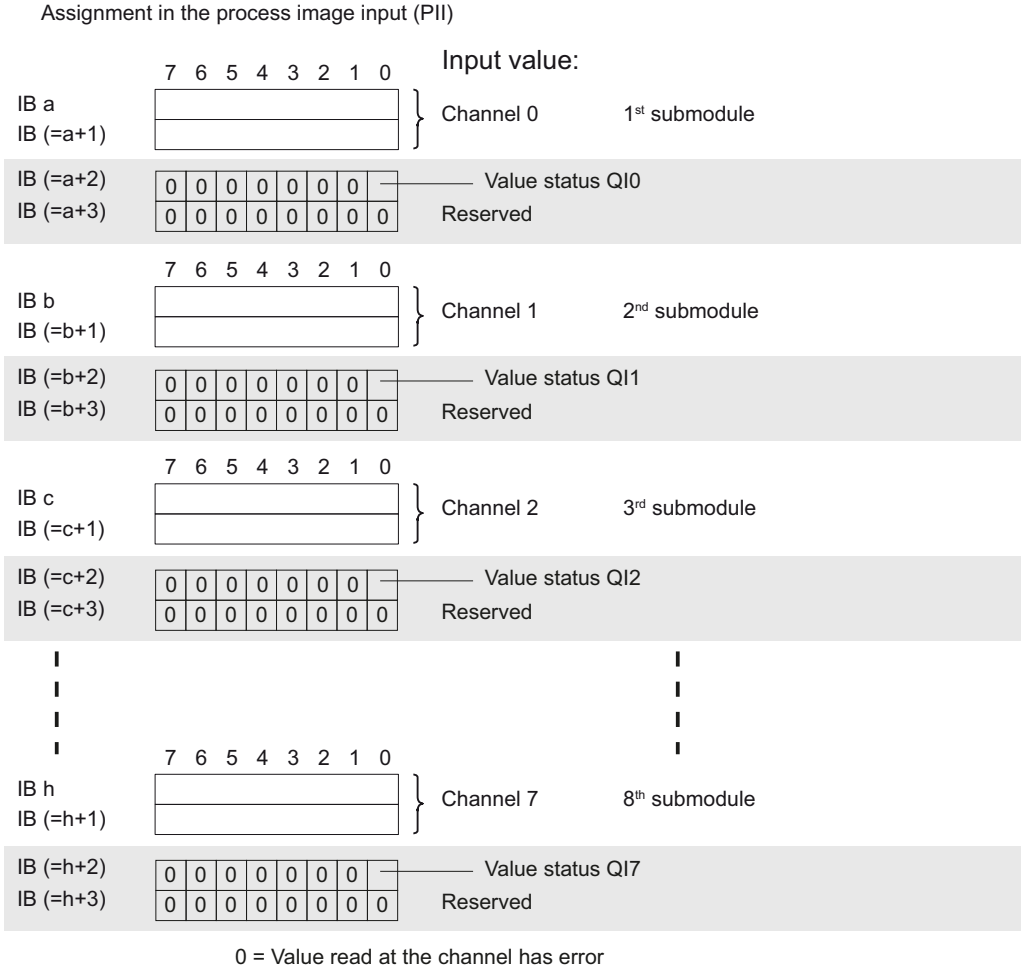


Figure 6-5 Address space for configuration as 8 x 1-channel AI 8xHART HF S QI with value status

6.5.4 Address space 1 x 8-channel with value status and HART with 4 variables

Address space 1 x 8-channel with value status and HART with 4 variables

The figure below shows the address space assignment for the configuration as 1 x 8-channel module with value status. Following are the 4 x HART auxiliary variables.

You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"EB x" stands, for example, for the module start address input byte x.

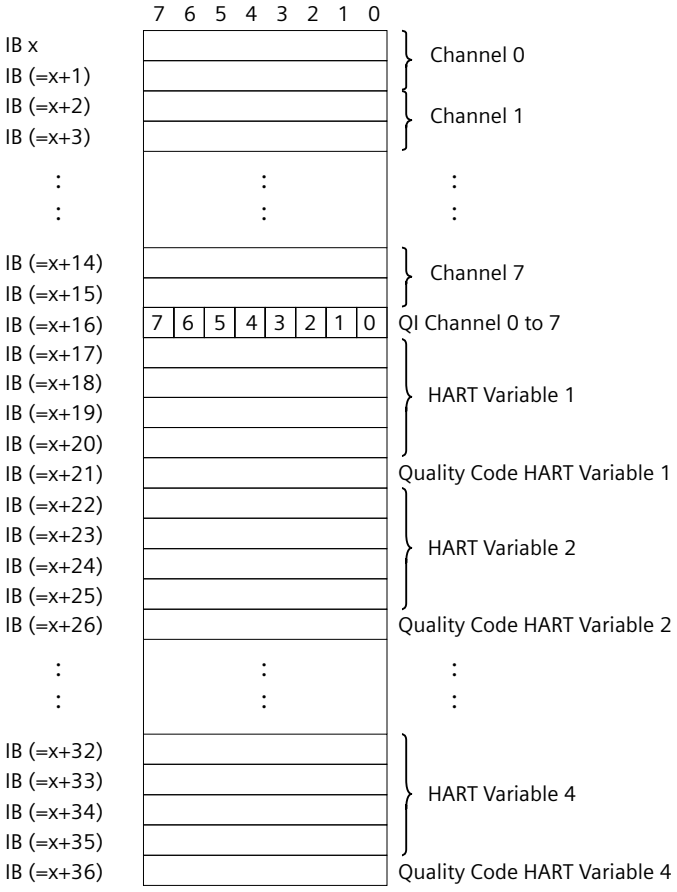


Figure 6-6 Address space for configuration as 1 x 8-channel with value status and HART with 4 variables

6.5.5 Address space 1 x 8-channel without value status and HART with 4 variables

Address space 1 x 8-channel without value status and HART with 4 variables

The figure below shows the address space assignment for configuration as 1 x 8-channel module without value status. Following are the 4 x HART auxiliary variables.

You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"EB x" stands, for example, for the module start address input byte x.

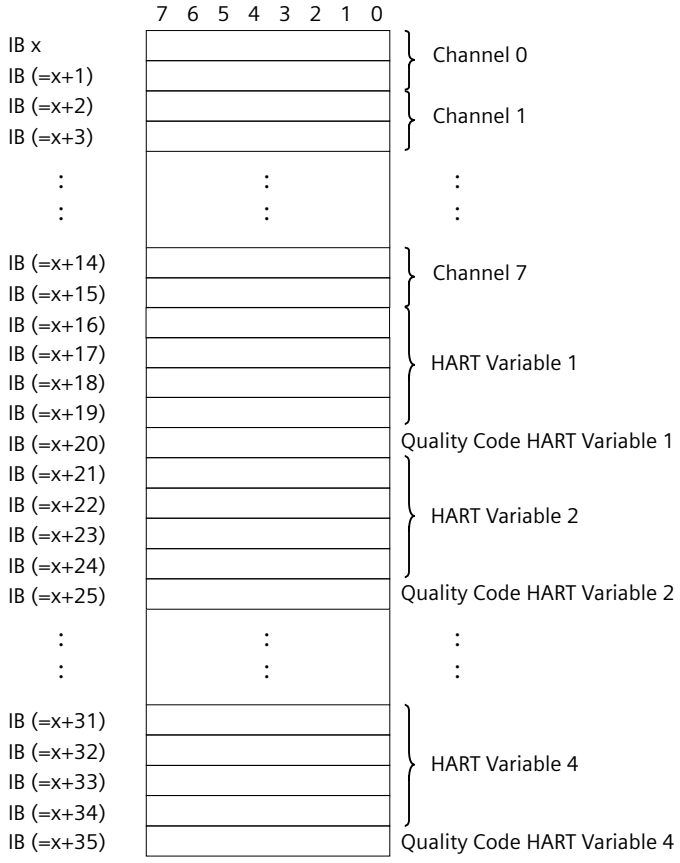


Figure 6-7 Address space for configuration as 1 x 8-channel without value status and HART with 4 variables

6.5.6 Address space 1 x 8-channel with value status and HART with 8 variables

Address space 1 x 8-channel with value status and HART with 8 variables

The figure below shows the address space assignment for the configuration as 1 x 8-channel module with value status. Following are the 8 x HART auxiliary variables.

You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"EB x" stands, for example, for the module start address input byte x.

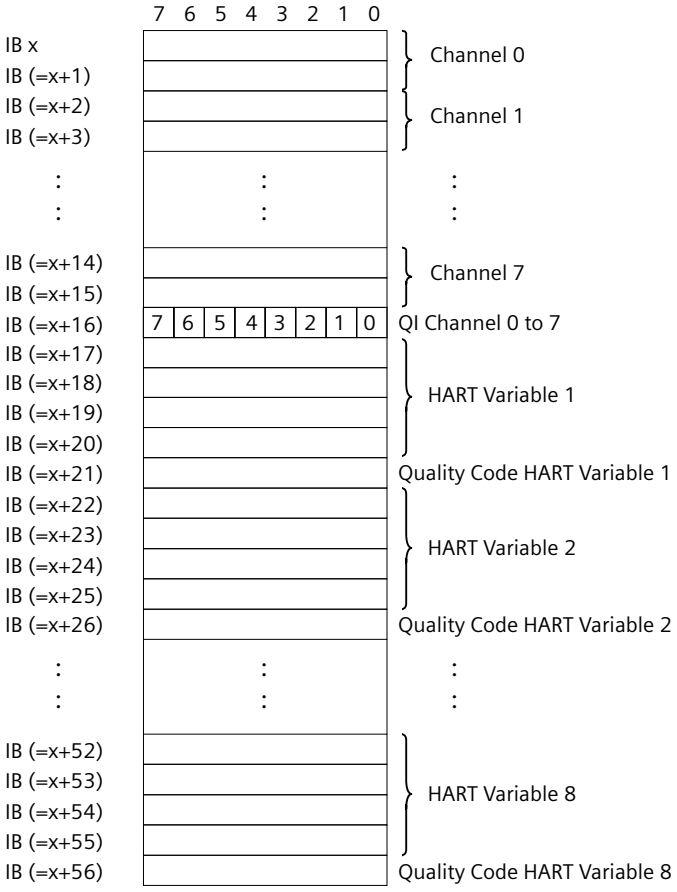


Figure 6-8 Address space for configuration as 1 x 8-channel with value status and HART with 8 variables

6.5.7 Address space 1 x 8-channel without value status and HART with 8 variables

Address space 1 x 8-channel without value status and HART with 8 variables

The figure below shows the address space assignment for configuration as 1 x 8-channel module without value status. Following are the 8 x HART auxiliary variables.

You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"EB x" stands, for example, for the module start address input byte x.

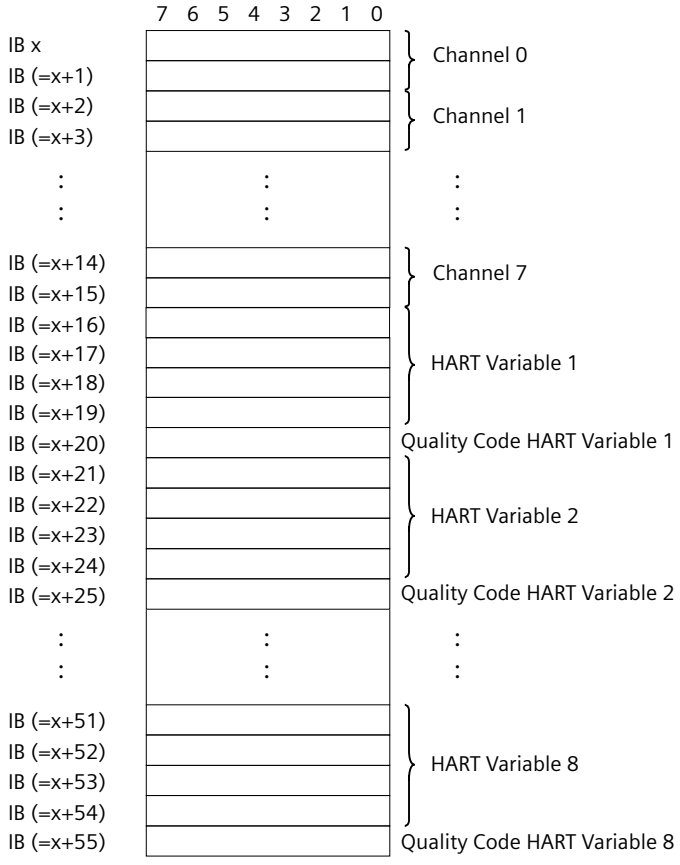


Figure 6-9 Address space for configuration as 1 x 8-channel without value status and HART with 8 variables

6.5.8 Address space 1 x 8-channel with value status and HART and multiHART

Address space 1 x 8-channel with value status and multiHART

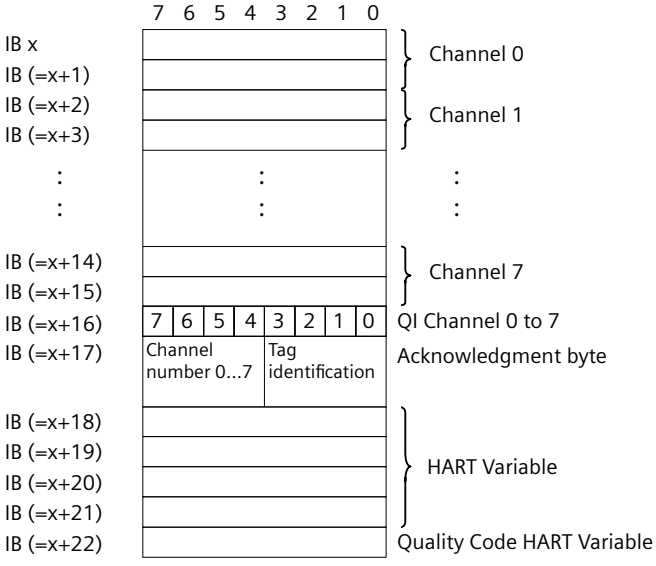
The figure below shows the address space assignment for the configuration as 1 x 8-channel module with value status. Following is the acknowledgment byte and the HART auxiliary variable.

The command byte is at QB x.

You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

"IB x" stands, for example, for the module start address input byte x.

"AB x" stands, for example, for the command byte output byte x.



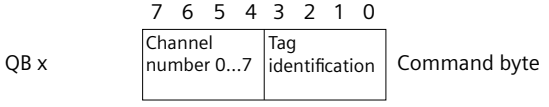


Figure 6-10 Address space for configuration as 1 x 8-channel with value status and multiHART

Interrupts/diagnostic alarms

7

7.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the AI 8xHART HF.

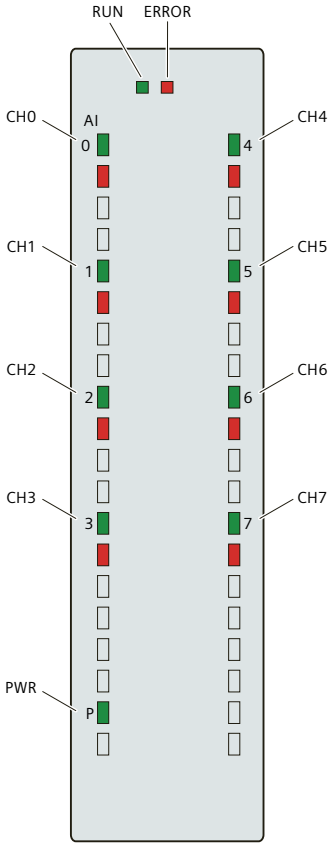


Figure 7-1 LED displays of the AI 8xHART HF module

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 52).

RUN and ERROR LED

Table 7-1 Status and error displays RUN and ERROR

LED		Meaning	Remedy
RUN	**ERROR**		
Off	Off	Voltage missing or too low at backplane bus.	• Switch on the CPU and/or the system power supply modules. • Verify that the U connectors are inserted. • Check whether too many modules are inserted.
Flashes	Off	The module starts and flashes until the valid parameter assignment is set.	---
On	Off	Module is configured.	
On	Flashes	Indicates module errors (at least one error at one channel, e.g., wire break).	Evaluate the diagnostics data and eliminate the error (e.g., wire break).
Flashes	Flashes	Hardware defective.	Replace the module.

PWR LED

Table 7-2 PWR status display

LED PWR	Meaning	Remedy
Off	Supply voltage L+ to module too low or missing	Check supply voltage L+.
On	Supply voltage L+ is present and OK.	---

CHx LED

Table 7-3 Status display of the CHx LED

LED		Meaning
Channel status	**Channel error**	
Off	Off	Channel deactivated or module switched off
On	Off	Channel activated and no channel diagnostics available
Off	On	• Channel activated and channel diagnostics available • Channel diagnostics and HART channel diagnostics available
On	On	Channel activated and **only** HART channel diagnostics available

7.2 Interrupts

The AI 8xHART HF analog input module supports diagnostic and hardware interrupts.
You can find detailed information on the event in the error organization block with the RALRM instruction (read additional interrupt info) and in the STEP 7 online help.

Diagnostic interrupt

The module generates a diagnostic interrupt at the following events:

- Missing supply voltage L+
- Wire break
- Overflow
- Underflow
- Parameter assignment error
- HART communication error or error of the HART field device
  HART diagnostic messages are generated in parallel and additionally in the case of wire break and overflow/underflow.

Hardware interrupt

The module generates a hardware interrupt at the following events:

- Low limit violated 1
- High limit violated 1
- Low limit violated 2
- Violation of high limit 2

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

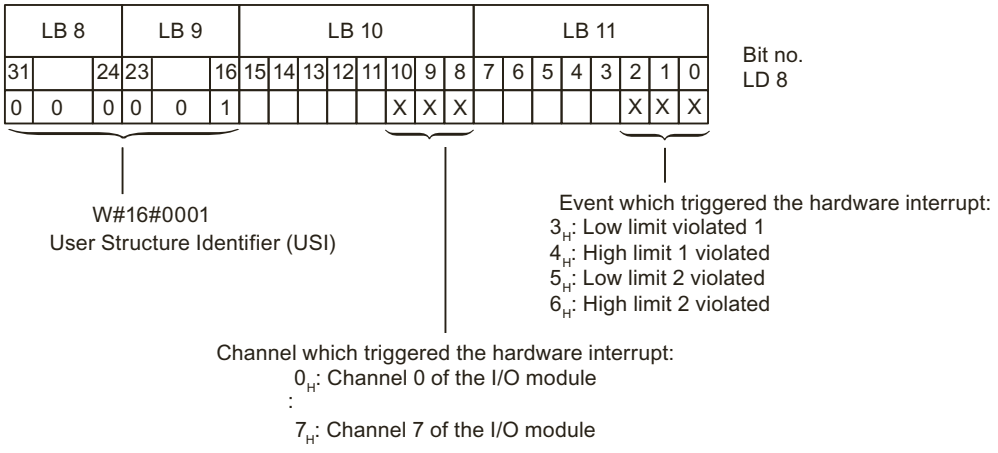


Figure 7-2 OB start information

Reaction when reaching limits 1 and 2 at the same time

If the two high limits 1 and 2 are reached at the same time, the module always signals the hardware interrupt for high limit 1 first. The configured value for high limit 2 is irrelevant. After processing the hardware interrupt for high limit 1, the module triggers the hardware interrupt for high limit 2.

The module has the same reaction when the low limits are reached at the same time. If the two low limits 1 and 2 are reached at the same time, the module always signals the hardware interrupt for low limit 1 first. After processing the hardware interrupt for low limit 1, the module triggers the hardware interrupt for low limit 2.

Structure of the additional interrupt information

Table 7-4 Structure of USI = W#16#0001

Data block name		Contents	Remark	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#n	Number of the event-triggering channel (n = number of module channels -1)	1
It follows the error event that triggered the hardware interrupt.				
	Event	B#16#03	Low limit violated 1	1
		B#16#04	High limit violated 1	
		B#16#05	Low limit violated 2	
		B#16#06	Violation of high limit 2	

7.3 Diagnostics alarms

A diagnostics alarm is generated and the ERROR LED flashes for each diagnostics event on the module. The diagnostics alarms can be read out in the diagnostics buffer of the CPU, for example. You can evaluate the error codes with the user program.

If the module is operated distributed with PROFIBUS DP in an ET 200MP system, you have the option to read out diagnostics data with the instruction RDREC or RD_REC using data record 0 and 1. You can find the structure of the data records on the Internet in GHB Interface module IM 155-5 DP ST (https://support.industry.siemens.com/cs/de/en/view/78324181).

Table 7-5 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Wire break	6_H	Impedance of sensor circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the channel
Overflow	7_H	Measuring range violated	Check the measuring range
Underflow	8_H	Measuring range violated	Check the measuring range

Diagnostics alarm	Error code	Meaning	Remedy
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Supply voltage L+ of the module is missing	Connect supply voltage L+ to module/channel
HART communication error	141_H	• HART field device is not responding • Timing error • HART field device has not understood the sent command (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set output current ≥4 mA • Increase the configured number of repetitions
HART primary variable outside of range	142_H	• Incorrect parameters in the HART field device • HART field device is at "Primary variable outside the limits" in simulation mode • Incorrect measuring point • Primary variable configured outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct measuring transducer is connected
HART output current of the field device saturated	143_H	The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART output current of the field device specified	144_H	The output current of the HART field device has been permanently set: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART auxiliary variable outside the limits	149_H	• Incorrect parameters in the HART field device • HART field device is at "Non-primary variable outside the limits" in simulation mode • Incorrect measuring point • Non-primary variable configured outside the limits	

Diagnostics alarm	Error code	Meaning	Remedy
HART additional status information available	145_H	In the HART device status (in the 2nd status byte), the HART field device identifier for "additional status information available" has been set	Read status using HART command 48 and eliminate error/cause, if necessary
HART configuration changed (automatically reset by the module after approximately 1 minute)	146_H	In the HART device status (in the 2nd status byte), the identifier for "reconfiguration" of the HART field device has been set	If you do not want the reconfiguration to trigger a diagnostic interrupt, the diagnostic interrupt diagnostics must not be enabled.
HART malfunction in the field device	147_H	In the HART device status (in the 2nd status byte), the field device reports a malfunction.	• Read status using HART command 48 and eliminate error/cause, if necessary • Replace the field device

NOTE

HART diagnostics for PROFIBUS IM with GSD file

In the case of PROFIBUS IM with GSD file, the HART diagnostics are represented by "external error".

Diagnostics alarms with value status (QI)

If you configure the module with value status (QI), the module always checks all errors even if the respective diagnostics is not enabled. But the module cancels the inspection as soon as it detects the first error, regardless if the respective diagnostics has been enabled or not. The result may be that enabled diagnostics may not be displayed.

Example: You have enabled "Underflow" diagnostics, but the module detects the previous "Wire break" diagnostics and aborts after this error message. The "Underflow" diagnostics is not detected.

Recommendation: To ensure that all errors are subjected to the diagnostics, select all check boxes under "Diagnostics".

NOTE

HART diagnostics

HART diagnostics are generated in parallel and additionally in the case of wire break and overflow/underflow.

Technical specifications

8

8.1 Technical specifications

Technical specifications of the AI 8xHART HF

Article number	6ES7531-7TF00-0AB0
General information	
Product type designation	AI 8xHART HF
HW functional status	From FS01
Firmware version	V1.0.0
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Prioritized startup	No
• Measuring range scalable	No
• Scalable measured values	No
• Adjustment of measuring range	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V17/V18 with HSP 383
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	V1.0 / V5.1
• PROFINET from GSD version/GSD revision	V2.42 / -
Operating mode	
• Oversampling	No
• MSI	Yes
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7531-7TF00-0AB0
Input current	
Current consumption, max.	163 mA
Encoder supply	
24 V encoder supply	
• Short-circuit protection	Yes
• Output current, max.	20 mA; Max. 47 mA per channel for a duration < 10 s
Power	
Power available from the backplane bus	1.15 W
Power loss	
Power loss, typ.	1.8 W
Analog inputs	
Number of analog inputs	8
• For current measurement	8
permissible input current for current input (destruction limit), max.	40 mA
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
– Input resistance (0 to 20 mA)	125 Ω
• -20 mA to +20 mA	Yes
– Input resistance (-20 mA to +20 mA)	125 Ω
• 4 mA to 20 mA	Yes
– Input resistance (4 mA to 20 mA)	125 Ω; plus approx. 17 Ohm when using the switch against M
Cable length	
• shielded, max.	800 m
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	Fast mode: 2.5 / 16.67 / 20 / 100 ms, standard mode: 7.5 / 50 / 60 / 300 ms
• Basic conversion time, including integration time (ms)	Fast Mode: 7 / 22 / 25 / 106 ms; Standard Mode: 12 / 55 / 65 / 308 ms
• Interference voltage suppression for interference frequency f1 in Hz	10 / 50 / 60 / 400 Hz

Article number	6ES7531-7TF00-0AB0
• Basic execution time of the module (all channels released)	channel 0 and 4, 1 and 5, etc. measure in pairs simultaneously. The slower channel of each pair determines the basic execution time of the channel pair. The basic execution time of the module is calculated by adding the basic conversion times of the channel pairs.
Smoothing of measured values	
• parameterizable	Yes
• Step: None	Yes
• Step: low	Yes
• Step: Medium	Yes
• Step: High	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	No
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	820 Ω; at 24 V input voltage
• for current measurement as 4-wire transducer	Yes
• for resistance measurement with two-wire connection	No
• for resistance measurement with three-wire connection	No
• for resistance measurement with four-wire connection	No
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.02 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, max.	-80 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.02 %
note regarding accuracy	at temperatures below 0 °C, the figures for operating error and temperature error are doubled
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.1 %; without HART communication
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.05 %; without HART communication

Article number	6ES7531-7TF00-0AB0
Influence of a HART signal modulated on the input signal in relation to input range	
• error occurred at interference frequency suppression: 400 Hz	0.19 %; in the Standard operating mode, 0.55 % in the Fast operating mode
• error occurred at interference frequency suppression: 60 Hz	0.05 %; in the Standard operating mode, 0.1 % in the Fast operating mode
• error occurred at interference frequency suppression: 50 Hz	0.04 %; in the Standard operating mode, 0.09 % in the Fast operating mode
• error occurred at interference frequency suppression: 10 Hz	0.02 %; in the Standard operating mode, 0.03 % in the Fast operating mode
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	80 dB; in the Standard operating mode, 40 dB in the Fast operating mode
• Common mode voltage, max.	60 V DC/30 V AC
• Common mode interference, min.	80 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; With 4 mA to 20 mA, channel by channel
• Overflow/underflow	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; red LED
Potential separation	
Potential separation analog inputs	
• between the channels	No; however, increased permissible potential difference between the inputs.
• between the channels, in groups of	8
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No

Article number	6ES7531-7TF00-0AB0
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Permissible potential difference	
between different circuits	60 V DC/30 V AC
between the inputs (UCM)	60 V DC/30 V AC
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	40 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	270 g

Dimension drawing

A

A.1 Dimensional drawing

This appendix contains the dimensional drawing of the module installed on a mounting rail and with a shield bracket. Always adhere to the specified dimensions for installations in cabinets, control rooms, etc.

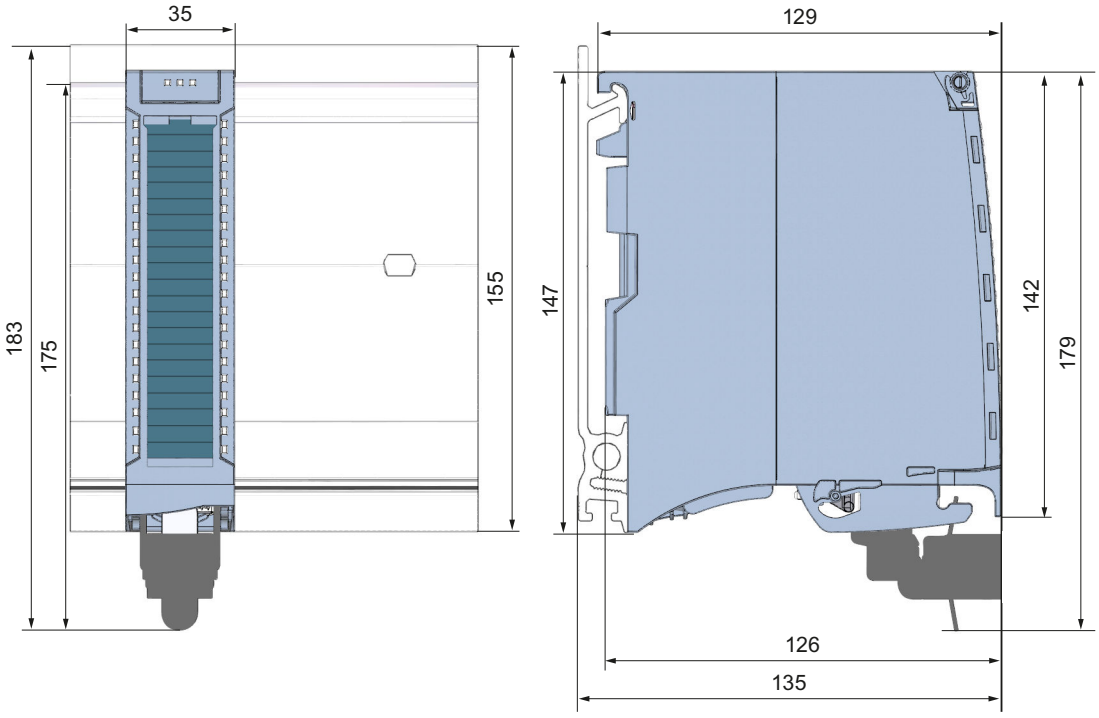


Figure A-1 Dimension drawing of the AI 8xHART HF module

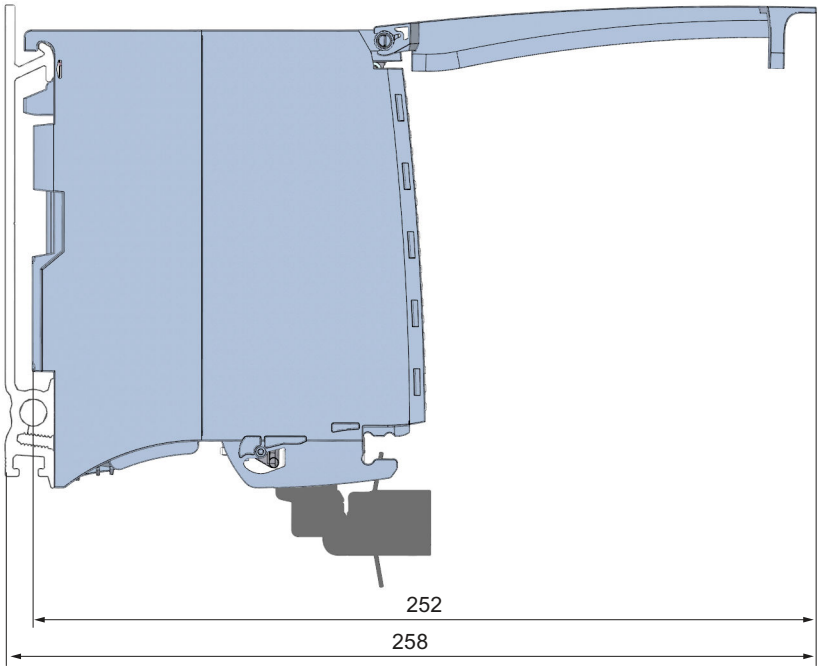


Figure A-2 Dimensional drawing of the AI 8xHART HF module, side view with open front cover

Parameter data records

B

B.1 Parameter assignment

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Dependencies for configuration with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other. The parameters are only checked for plausibility by the module after the transfer to the module.

The following table lists the parameters that depend on one another.

Table B-1 Dependencies of parameters for configuration with GSD file

Device-specific parameters (GSD file)	Dependent parameters
Current limit for wire break	Only for **measurement type** current with **measuring range** 4 to 20 mA.
Wire break	Only for **measurement type** current with **measuring range** 4 to 20 mA.
Hardware interrupt limits	Only if hardware interrupts are enabled.
No supply voltage L+	Only for 2-wire transducer.
HART diagnostics	Only for measuring range 4 to 20 mA HART. [1]
Number of HART preamble bytes	Not used for configuration "Address space 8 x 1-channel with value status".
Number of HART repetitions	

[1] Measuring range 4 to 20 mA HART not for configuration "Address space 8 x 1-channel with value status"

Parameter assignment in the user program

You have the option to configure the module in RUN (e.g. current values of individual channels can be changed in RUN without having an effect on the other channels).

Parameter assignment in RUN

The WRREC instruction is used to transfer the parameters to the module using data records 0 to 7. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

The parameters are only checked for plausibility by the module after the transfer to the module.

Output parameter STATUS

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.
The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Operation of the module behind a PROFIBUS DP interface module

If the module is operated behind a PROFIBUS DP interface module, the parameter data records 0 and 1 are not read back. You obtain the diagnostics data records 0 and 1 with the read back parameter data records 0 and 1. You can find more information on the Internet (https://support.industry.siemens.com/cs/de/en/view/78324181).

Assignment of data record and channel

For the configuration as a 1 x 8-channel module, the parameters are located in data records 0 to 7 and are assigned as follows:

- Data record 0 for channel 0
- Data record 1 for channel 1
- ...
- Data record 6 for channel 6
- Data record 7 for channel 7

For configuration 8 x 1-channel, the module has 8 submodules with one channel each. The parameters for the channel are available in data record 0 and are assigned as follows:

- Data record 0 for channel 0 (submodule 1)
- Data record 0 for channel 1 (submodule 2)
- ...
- Data record 0 for channel 6 (submodule 7)
- Data record 0 for channel 7 (submodule 8)

Address the respective submodule for data record transfer.

See also

Structure of the parameter data records (Page 64)

B.2 Structure of the parameter data records

The figure below shows the structure of data record 0 for channel 0 as an example. The structure is identical for channels 1 to 7. The values in byte 0 and byte 1 are fixed and may not be changed.

Enable a parameter by setting the corresponding bit to "1".

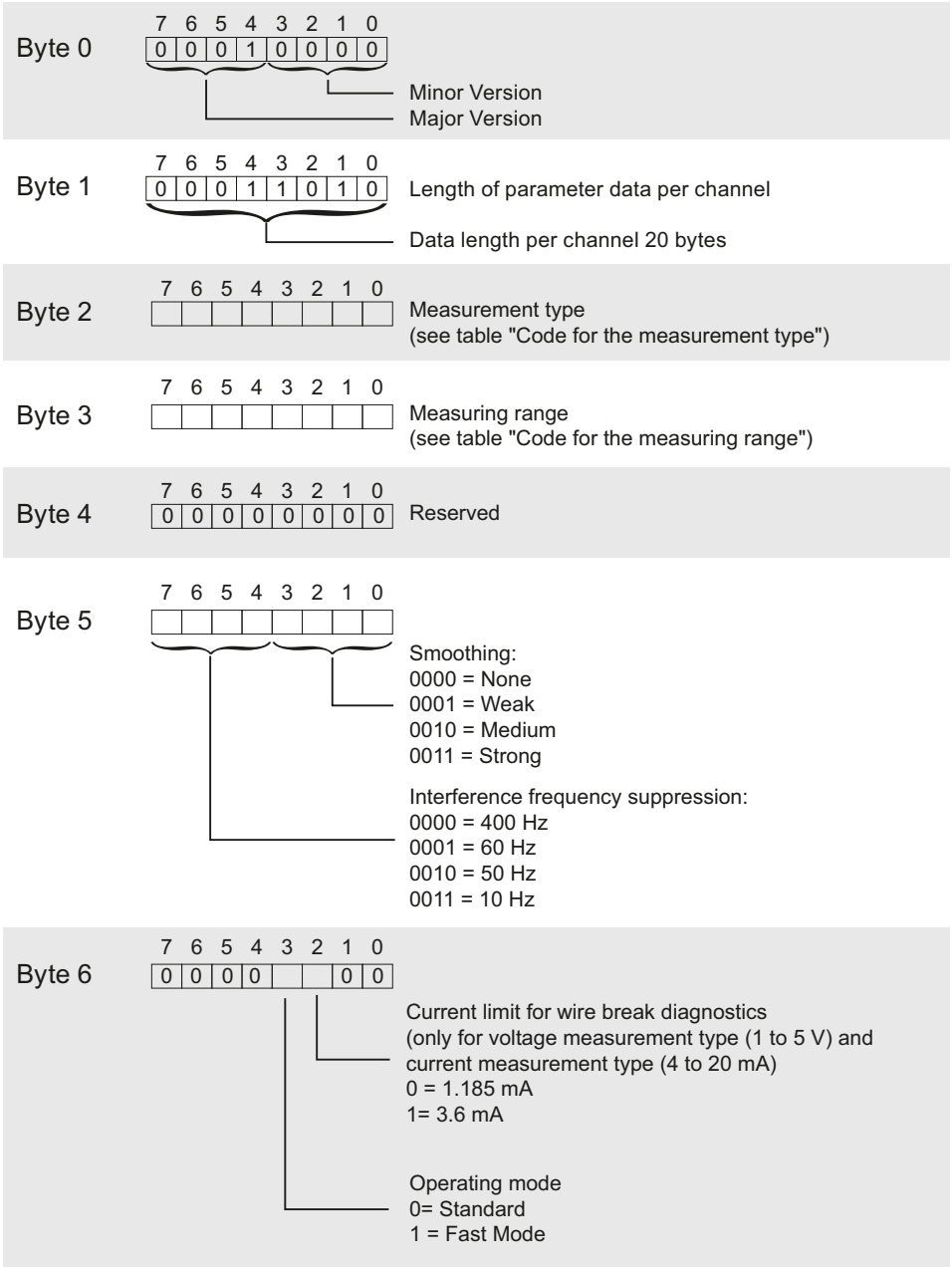
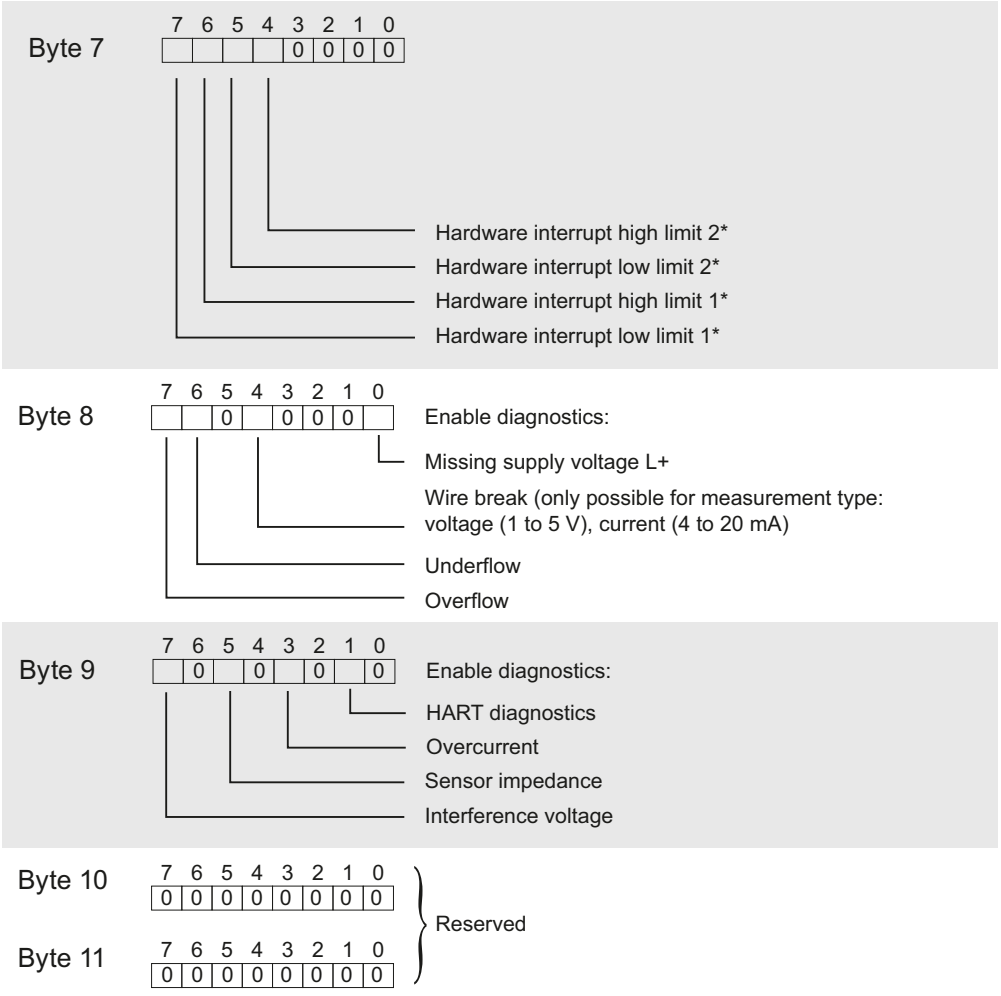
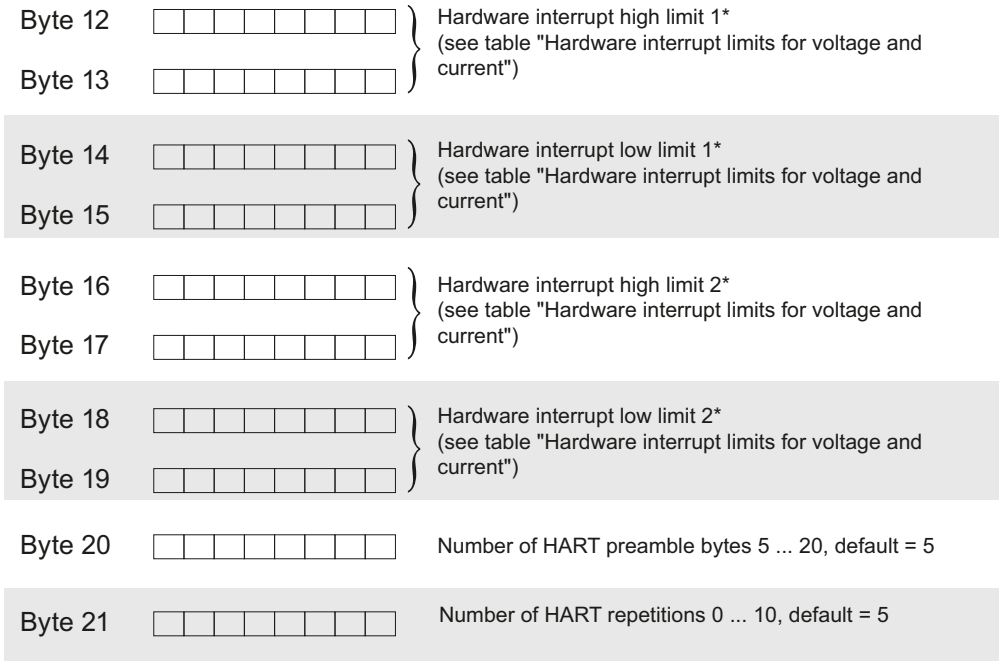


Figure B-1 Structure of data record 0: Bytes 0 to 6



* Activation of hardware interrupts via a data record is only possible if the channel has been assigned a hardware interrupt OB in STEP 7

Figure B-2 Structure of data record 0: Bytes 7 to 11



* High limit must be greater than low limit

Figure B-3 Structure of data record 0: Bytes 12 to 21

B.3 Parameter assignment and structure of the HART mapping parameters

Structure of data record 140

Data record 140 has a total length of 20 bytes (for configuration with 4 variables) or 40 bytes (for configuration with 8 variables).

Using the parameters of data record 140, you can configure/map up to eight HART variables of the individual channels in the input address space of the module, provided that the corresponding configuration has been selected, see "HART mapping parameters (Page 36)".

Header information

The figure below shows the structure of the header information.

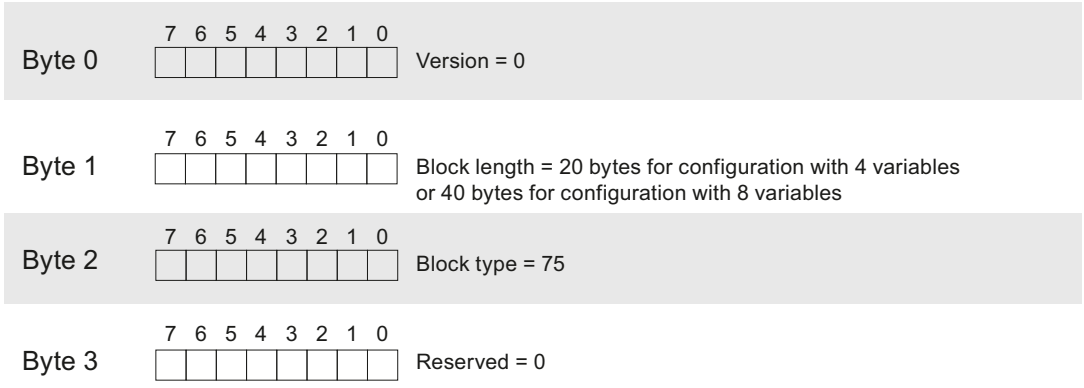
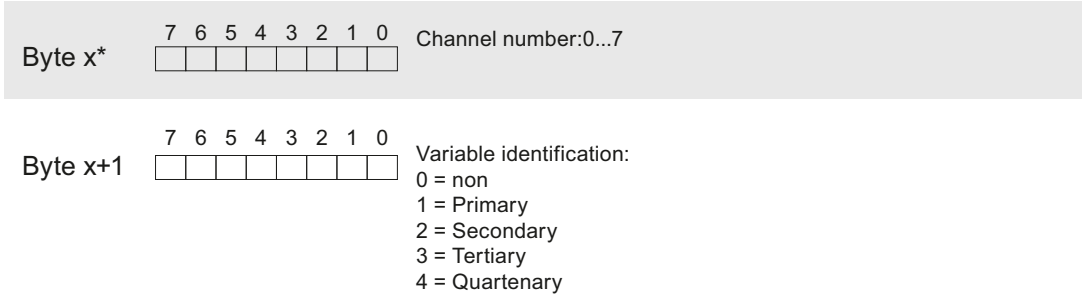


Figure B-4 Header information

Parameters

The following figure shows the parameter assignment of the eight HART variables 1...8.



* x = 4 + (HART variable - 1) * 2; with HART variable 1....8

Figure B-5 Parameters

NOTE

Memory area

Allocation of the memory area based on the configuration of the HART variables:

- You can choose from the following options:
  - None:
    Only analog values 8 words
  - 8 HART:
    8 words (AI) + 5x8 bytes input address area
  - 4 HART:
    8 words (AI) + 5x4 bytes input address area
  - 1 multiHART:
    8 words (AI) + 6 bytes input address area + 1 byte output address area
- At least one HART variable has been configured not equal to 0 = "non":
  The memory area is allocated for 4 or 8 variables depending on the configuration with 4 or 8 HART variables.

B.4 Codes for measurement types/measuring ranges and limits for hardware interrupts

Codes for measuring types

The following table lists all measuring types of the analog input module along with their codes. Enter these codes in byte 2 of the respective data record.

Table B-2 Code for the measuring type

Measurement type	Code
Deactivated	0000 0000
Current 4-wire transducer	0000 0010
Current 2-wire transducer	0000 0011

Codes for measuring ranges

The following table lists all measuring ranges of the analog input module along with their codes. Enter these codes in byte 3 of the respective data record.

Table B-3 Code for the measuring range

Measuring range	Code
Current 4-wire transducer 0 to 20 mA 4 to 20 mA 4 to 20 mA HART ±20 mA	 0000 0010 0000 0011 0000 0111 0000 0100
Current 2-wire transducer 4 to 20 mA 4 to 20 mA HART	 0000 0011 0000 0111

Hardware interrupt limits

The following tables list the valid hardware interrupt limits. The limit values depend on the selected measuring type and range. The values that you can set for hardware interrupts (high/low limit) must not exceed the respective rated measuring range.

You enter the limits in bytes 12 to 19 of the corresponding data record.

Table B-4 Hardware interrupt limits for current

Current		
±20 mA	4 to 20 mA, 0 to 20 mA, 4 to 20 mA with HART	
32510	32510	High limit
-32511	-4863	Low limit

B.5 Error when transferring the data record

Error when transferring the data record

The module always checks all values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data records.

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E0	01	Unspecified error.	-
DF	80	E0	02	Wrong version in the header information.	Correct the version of the parameter blocks.

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	E0	03	Wrong length in the header information	Correct the length of the parameter blocks.
DF	80	E1	00	Unspecified error.	-
DF	80	E1	01	Reserved bit set	Check the parameters of the module.
DF	80	E1	02	Invalid diagnostics enable bit set for operating mode.	Check the parameters of the module.
DF	80	E1	04	Invalid value for hardware interrupt limit.	Check the parameters of the module.
DF	80	E1	05	Invalid coding set for measuring range / measurement type / output range / output type.	Check the parameters of the module.
DF	80	E1	08	Invalid coding set for interference frequency suppression.	Check the parameters of the module.
DF	80	E1	09	Invalid coding for smoothing.	Check the parameters of the module.
DF	80	E1	16	Invalid measurement type / output type.	Check the parameters of the module.
DF	80	E1	17	Invalid measuring range / output range	Check the parameters of the module.
DF	80	E1	32	Invalid value for length of HART preamble	Check the parameters of the module.
DF	80	E1	33	Invalid channel for HART variable	Check the parameters of the module.
DF	80	E1	34	Invalid type (primary, secondary, etc.) for HART variable	Check the parameters of the module.
DF	80	E1	35	Invalid value for HART repetitions	Check the parameters of the module.

HART operating data records

C

C.1 HART operating data records

Reading/writing data in RUN

HART operating data records are transferred to the module with the "WRREC" instruction and read from the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART request Channel 0	240	Yes	Yes
81	HART response Channel 0	240	No	Yes
82	HART request Channel 1	240	Yes	Yes
83	HART response Channel 1	240	No	Yes
84	HART request Channel 2	240	Yes	Yes
85	HART response Channel 2	240	No	Yes
86	HART request Channel 3	240	Yes	Yes
87	HART response Channel 3	240	No	Yes
88	HART request Channel 4	240	Yes	Yes
89	HART response Channel 4	240	No	Yes
90	HART request Channel 5	240	Yes	Yes
91	HART response Channel 5	240	No	Yes
92	HART request Channel 6	240	Yes	Yes
93	HART response Channel 6	240	No	Yes
94	HART request Channel 7	240	Yes	Yes
95	HART response Channel 7	240	No	Yes
121	HART variables	160	No	Yes
131	HART parameters Channel 0	8	Yes	Yes
132	HART parameters Channel 1	8	Yes	Yes
133	HART parameters Channel 2	8	Yes	Yes
134	HART parameters Channel 3	8	Yes	Yes
135	HART parameters Channel 4	8	Yes	Yes
136	HART parameters Channel 5	8	Yes	Yes
137	HART parameters Channel 6	8	Yes	Yes

Data record number	Description	Length (bytes)	Writable	Readable
138	HART parameters Channel 7	8	Yes	Yes
148	HART directory	25	No	Yes
149	HART feature data	3	No	Yes

C.2 HART directory (DS 148)

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 8
5	Write Read Index Offset	= 1 (The response to a request data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82, 84, 86, 88, 90, 92, 94) are always used.

C.3 HART feature data (DS 149)

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit 1 = 1: "Parameter check result is given with a read response" Bit 5 = 1: "compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 230 (maximum length of the HART request data)

C.4 HART variable data record (DS 121)

The AI 8xHART HF analog module supports a maximum of 4 HART variables per channel, which are read cyclically, provided they are supported by the connected field device. Depending on the configuration with 4 or 8 variables, a total of 16 or 32 HART variables, respectively, are made available for reading in the HART variable data record 121.

Each HART variable consists of a 4-byte real value and a quality code byte. See section 4.4.1 "Quality code".

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0...3	Value	Primary Variable (PV)
4	Quality code	
5...8	Value	Secondary Variable (SV)
9	Quality code	
10...13	Value	Tertiary (TV)
14	Quality code	
15...18	Value	Quartenary (QV)
19	Quality code	
Channel 1		
20...39	HART variables same as for Channel 0	
Channel 2		
40...59	HART variables same as for Channel 0	
Channel 3		
60...79	HART variables same as for Channel 0	
Channel 4 (only for configuration with 8 variables)		
80...99	HART variables same as for Channel 0	
Channel 5 (only for configuration with 8 variables)		
100...119	HART variables same as for Channel 0	
Channel 6 (only for configuration with 8 variables)		
120...139	HART variables same as for Channel 0	
Channel 7 (only for configuration with 8 variables)		
140...159	HART variables same as for Channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

C.5 HART-specific settings (DS 131 to DS 138)

HART communication is available using standard parameter assignment (see Parameters (Page 31)).

You can specify additional HART-specific settings on a channel-specific basis using data records 131 to 138.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Every new parameter assignment of the analog module resets the HART-specific settings back to the initial values from the parameter data record (0...7).

Channel	Data record number
0	131
1	132
2	133
3	134
4	135
5	136
6	137
7	138

Structure of the HART-specific settings

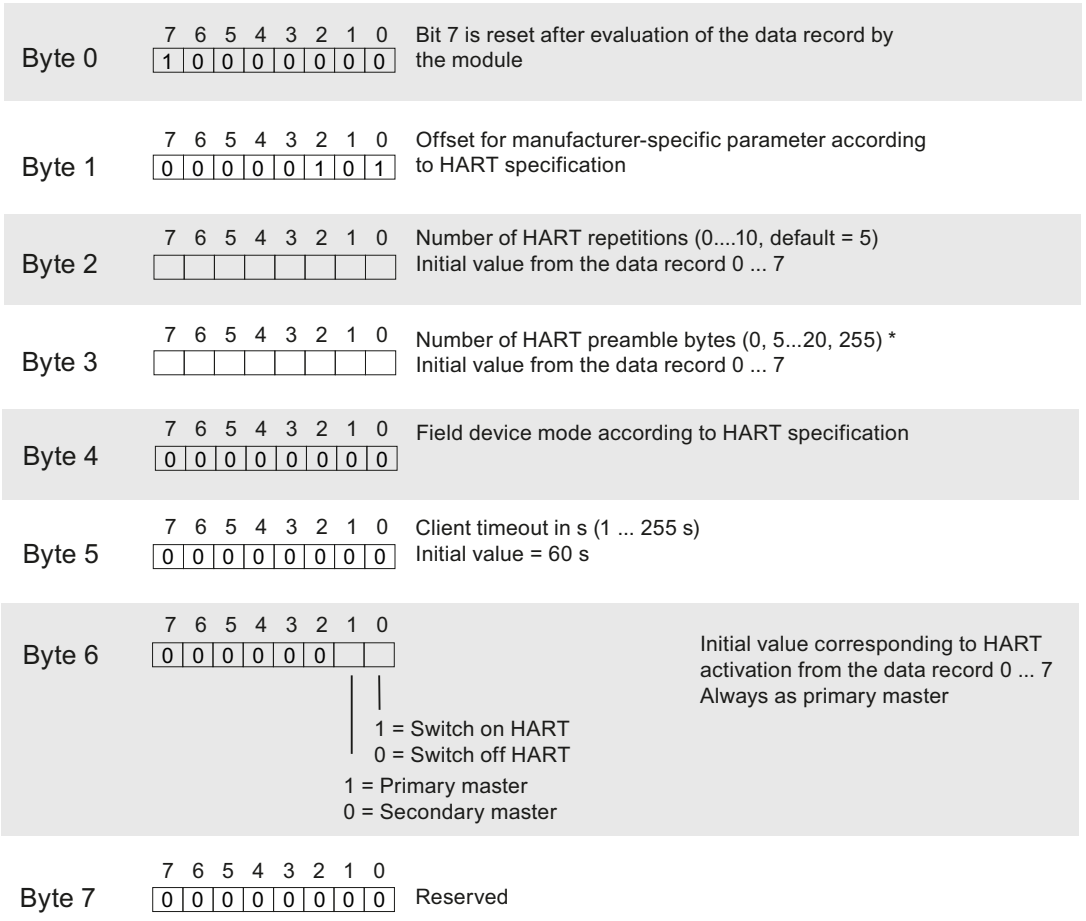


Figure C-1 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes requested by the connected field device are used, but no fewer than 5.
When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

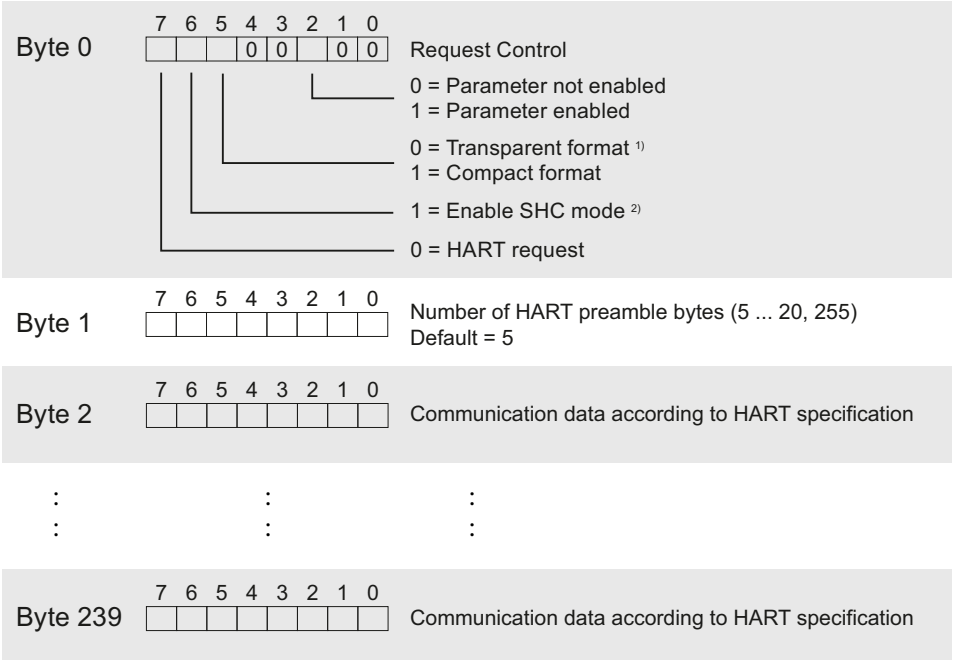
C.6 HART request and response data records (DS 80 to DS 95)

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87
4	88	89

Channel	Data record number	
	Request to the field device	**Response from the field device**
5	90	91
6	92	93
7	94	95

Structure of the request data records 80, 82, 84, 86, 88, 90, 92, 94



1) HART commands are processed by the analog module in transparent message format and in compact message format. However, the response data from the module is always made available in transparent message format.

2) When a sequence of HART commands in the form of an SHC sequence is processed, this affects all other channels with activated HART. See HART communication interface (Page 26), SHC sequence.

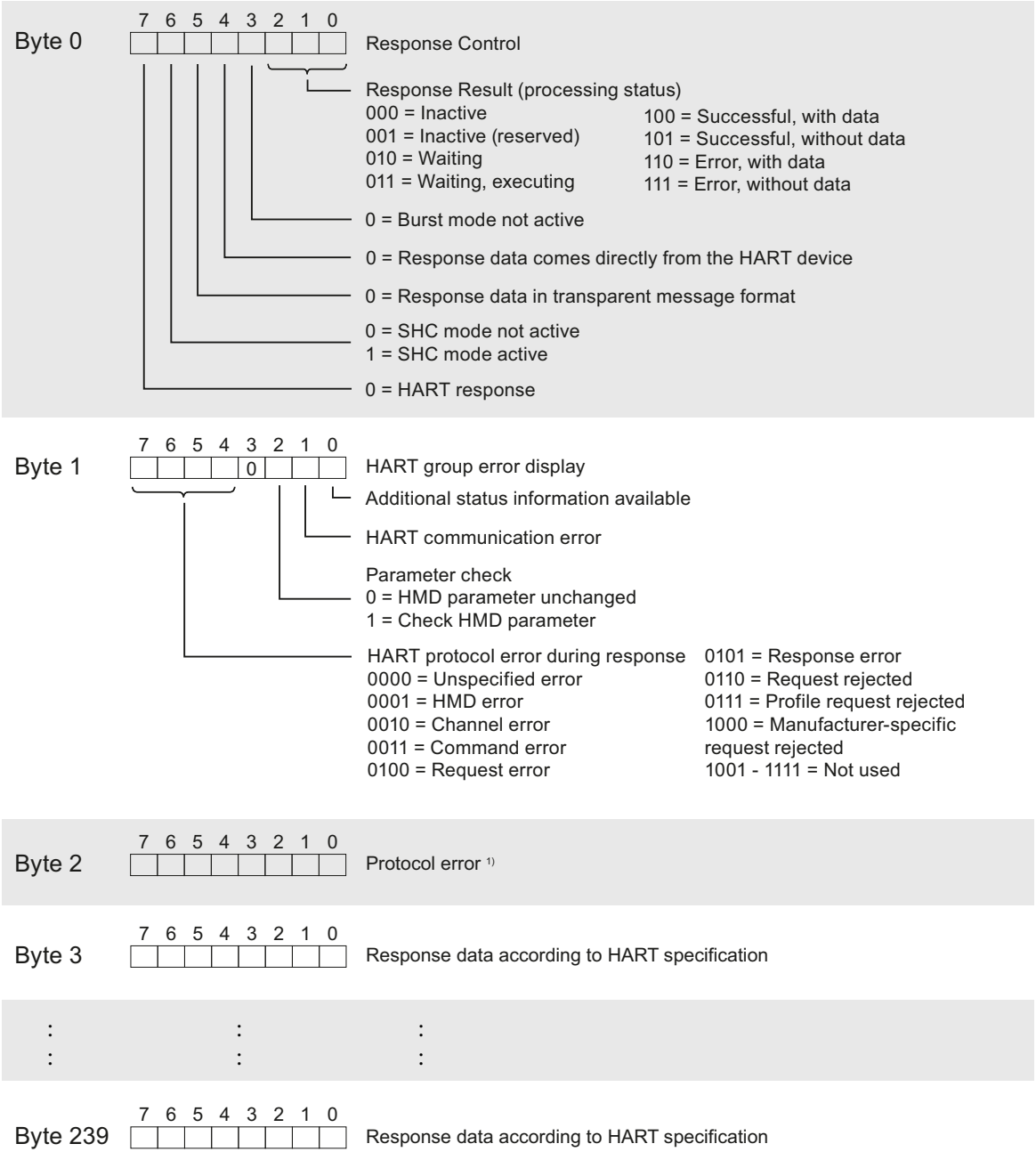
Figure C-2 Request data record

NOTE

When "Number of HART preamble bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can reconfigure the number of preamble bytes using the parameters and HART-specific settings (see section HART-specific settings (DS 131 to DS 138) (Page 74)).

Structure of the response data records 81, 83, 85, 87, 89, 91, 93, 95

In case of response error



1) See table: "HART protocol error during response" coding

Figure C-3 Response data record in case of response error

In case of response error

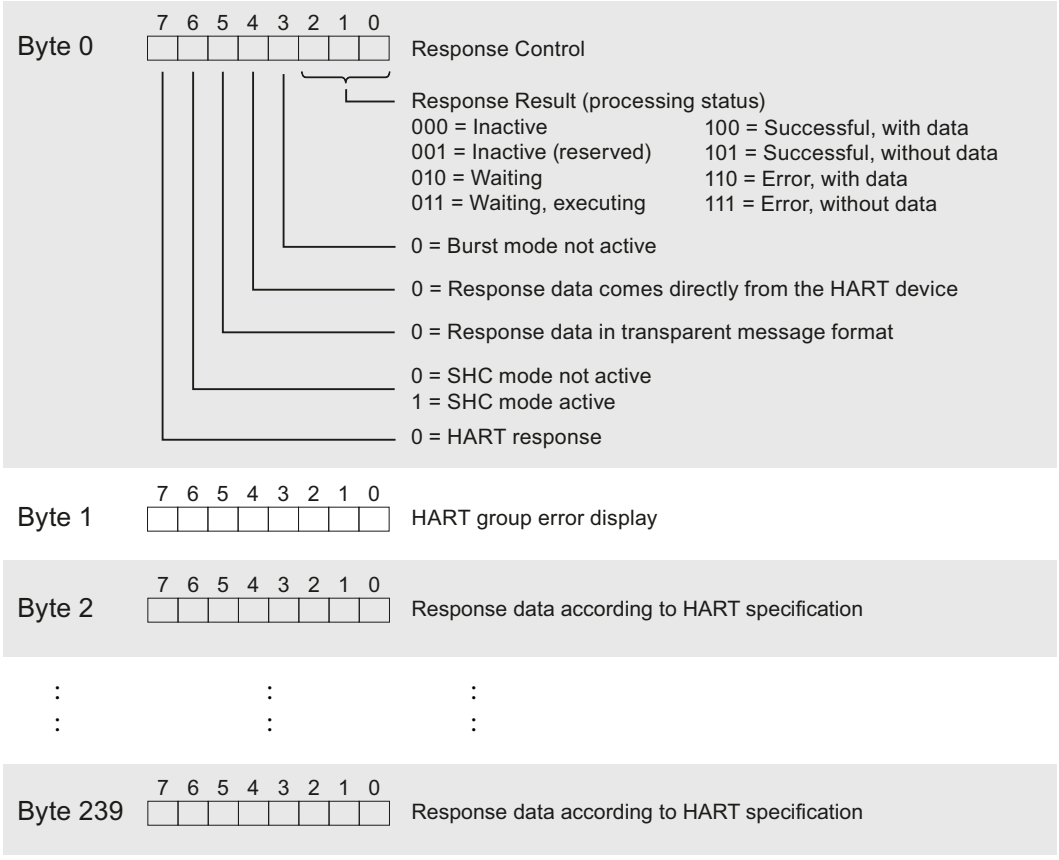


Figure C-4 Response data record in case of response error

Table C-1 "HART protocol error during response" coding

HART protocol error during response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6...127: Reserved 128...255: Manufacturer-specific
2	Channel error	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6...127: Reserved 128...255: Manufacturer-specific

HART protocol error during response	Meaning	Explanation
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 5...127: Reserved 128...255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

Example of HART programming (HART command interface)

For HART channel 0, the command 01 is to be sent in transparent message format to the HART field device with address "2A 2F 00 59 D3".
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 identification number of the hardware component of the AI 8xHART HF analog module is 266 ($10A_H$).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

Symbol	Address	Data type	Comment
T_DS80	I 4.0	Bool	Button of DS80
M_PF_WR	M 104.0	Bool	Positive edges auxiliary flag WRREC
M_WR_Done	M 51.0	Bool	Flag =1 : Data record was transferred
M_WR_Busy	M 51.1	Bool	Flag =1 : Writing has not yet finished

Symbol	Address	Data type	Comment
M_WR_Error	M 51.2	Bool	Flag =1 : An error occurred when writing.
MD_WR_Status	MD 93	DWord	WRREC block status or error information
DB80	DB80	DB80	The data record is stored in DB80:

```
SCL                                 Explanation
"R_TRIG_DB"(CLK:="T_DS80",
Q=>"M_PF_WR");
WHILE "M_PF_WR" DO
"WRREC_DB"(REQ := TRUE,
ID := 266,                          Identification number of the hardware component
INDEX := 80,                        Data record number 80
LEN := 11,                          Data record length 11 bytes
DONE => "M_WR_Done",                Done= True: Data record was transferred
BUSY => "M_WR_Busy",                BUSY= True: Writing has not yet finished
ERROR => "M_WR_Error",              ERROR = True: An error occurred when writing.
STATUS => "MD_WR_Status",           Block status or error information
RECORD := P#DB80.DBX0.0 BYTE 11     Data record with length of 11 bytes (must corres-
                                    pond to the exact length that is to be transferred)
);
IF ("M_WR_Done" OR "M_WR_Error")    Exit loop immediately if data record was trans-
THEN                                ferred or an error occurred.
EXIT;
;
END_IF;
;
END_WHILE;
```

Table C-2 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	2A	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	2F	
5	00	
6	59	
7	D3	

Byte	Initial value (hex)	Comment (Hex)
8	01	Command (CMD)
9	00	Length in bytes
10	0D	Checksum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

A HART command can also be sent in compact message format. In this case, the data that is transferred via DB 80 is reduced to 4 bytes.

Table C-3 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 learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Symbol	Address	Data type	Comment
T_DS81	I 4.1	Bool	Button of DS81
M_PF_RD	M 104.1	Bool	Positive edges auxiliary flag RDREC
M_RD_Done	M 49.0	Bool	Flag = True : New data record was received and is valid
M_RD_Busy	M 49.1	Bool	Flag = True : Reading has not yet finished.
M_RD_Error	M 49.2	Bool	Flag = True : An error occurred when reading
MD_RD_Status	MD 100	DWord	RDREC block status or error information
MW_RD_Len	MW104	Word	The read length of the data record
DB81	DB81	DB81	The read data record is stored in DB81

```
SCL                                 Explanation
"R_TRIG_DB_1"(CLK:="T_DS81",
Q=>"M_PF_RD");
WHILE "M_PF_RD" DO
"RDREC_DB"(REQ:=TRUE,
ID:=266,                            Identification number of the hardware component
INDEX:=81,                          Data record number 81
MLEN:=255,                          Maximum length in bytes of the data record informa-
                                    tion to be read
VALID=>"M_RD_Done",                 New data record was received and is valid
BUSY=>"M_RD_Busy",                  BUSY = True: Reading has not yet finished.
ERROR=>"M_RD_Error",                ERROR = True: An error occurred when reading
STATUS=>"MD_RD_Status",             Block status or error information
```

```
LEN=>"MW_RD_Len",                 Read length of the data record
RECORD:=P#DB81.DBX0.0 BYTE 255    Data record
IF ("M_RD_Done" OR "M_RD_Error")  Exit loop immediately if data record was trans-
THEN                              ferred or an error occurred.
EXIT;
;
END_IF;
;
END_WHILE;
```

As long as "0x03" is in byte 0 of DB81, the response has not been received from the field device. Positive response data that you can evaluate is available from the field device as soon as bit 2 = 1 in byte 0.
If there are errors in the response data, see the "HART group fault display" tables in byte 1 or "HART protocol error during response" in byte 2 of the field device response.

Analog value representation

D

D.1 Representation of analog values

Introduction

This analog values for all measuring ranges supported by the AI 8xHART HF analog module are represented in this appendix.

Measured value resolution

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table D-1 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

D.2 Representation of input ranges

The tables below set out the digitized representation of the input ranges separately for bipolar and unipolar input ranges. The resolution is 16 bits.

Table D-2 Bipolar input ranges

Units	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Undershoot range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table D-3 Unipolar input ranges

Units	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overshoot range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Rated range
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Undershoot range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

D.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table D-4 Current measuring range ±20 mA

Values		Current measuring range	
dec	**hex**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overshoot range
27649	6C01		
27648	6C00	20 mA	Rated range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Undershoot range
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table D-5 Current measuring range 0 to 20 mA, 4 to 20 mA, 4 to 20 mA with HART

Values		Current measuring range		
dec	**hex**	**0 to 20 mA**	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overshoot range

Values		Current measuring range		
27649	6C01			Overshoot range
27648	6C00	20 mA	20 mA	Rated range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Undershoot range
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<- 3.52 mA	< 1.185 mA	Underflow

D.4 Measured values for wire break diagnostic

Measured values on diagnostic event "wire break", dependent on diagnostics enables

Error events initiate a diagnostics entry and trigger a diagnostics interrupt if configured accordingly.

Table D-6 Measured values for wire break diagnostic

Format	Parameter assignment	Measured values		Explanation
S7	• "Wire break" diagnostics enabled • "Overflow/Underflow" diagnostics enabled or disabled ("Wire break" diagnostics takes priority over "Overflow/Underflow" diagnostics)	32767	$7FFF_H$	"Wire break" or "Open circuit" diagnostic alarm
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics enabled	-32767	8000_H	• Measured value after leaving the undershoot range • Diagnostic alarm "Low limit violated"
	• "Wire break" diagnostics disabled • "Overflow/Underflow" diagnostics disabled	-32767	8000_H	Measured value after leaving the undershoot range