SIEMENS

SIMATIC

ET 200SP
Analog Input Module AI 4xI 2-wire 4…20mA HART

Equipment Manual

04/2020
A5E35098013-AD

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Preface

Validity of the documentation

This manual describes the analog input module AI 4xI 2-wire 4…20mA HART, article number 6ES7134-6TD00-0CA1.

It supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Table of contents

Tables

Figures

Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics relating to your automation system.

The complete documentation for the ET 200SP system consists of the system manual, function manuals, and manuals for the individual devices.

The STEP 7 information system (online help) also supports you in configuring and programming your automation system.

Overview of documentation for analog input module AI 4xI 2-wire 4…20mA HART

The following table lists further documentation that you will need when using analog input module AI 4xI 2-wire 4…20mA HART.

Table 1-1 Documentation

Topic	Documentation	Most important contents
System description	System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
Analog value processing	Function Manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, assembly system) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications

SIMATIC manuals

The latest manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7134-6TD00-0CA1

View of the module

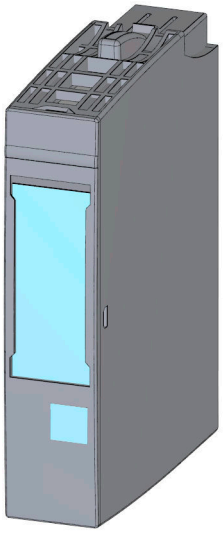


Figure 2-1 View of the AI 4xI 2-wire 4…20mA HART module

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measurement type current for 2-wire HART transducer
- Input range 4 mA to 20 mA
- Resolution 16 bits including sign
- Configurable diagnostics per channel

The module supports the following functions:

- HART communication (Rev. 5 to Rev. 7)
- Firmware update
- I&M identification data

- Configuration in RUN
- Value status (PROFINET IO only)
- Up to four HART variables directly in the input address space

You can configure the module with STEP 7 in the TIA Portal as well as with HW Config and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Connection and block diagram

The AI 4xI 2-wire 4…20mA HART analog module can be used with all A0 or A1-type BaseUnits.

You connect the transducers to the BaseUnit of the analog module. The infeed of the supply voltage at the light BaseUnit of the associated potential group supplies the module and the transducers connected to the encoder supply voltages.

A new potential group always begins with a light BaseUnit.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

An overview of the BaseUnits that you can use with the analog module can be found in Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864)

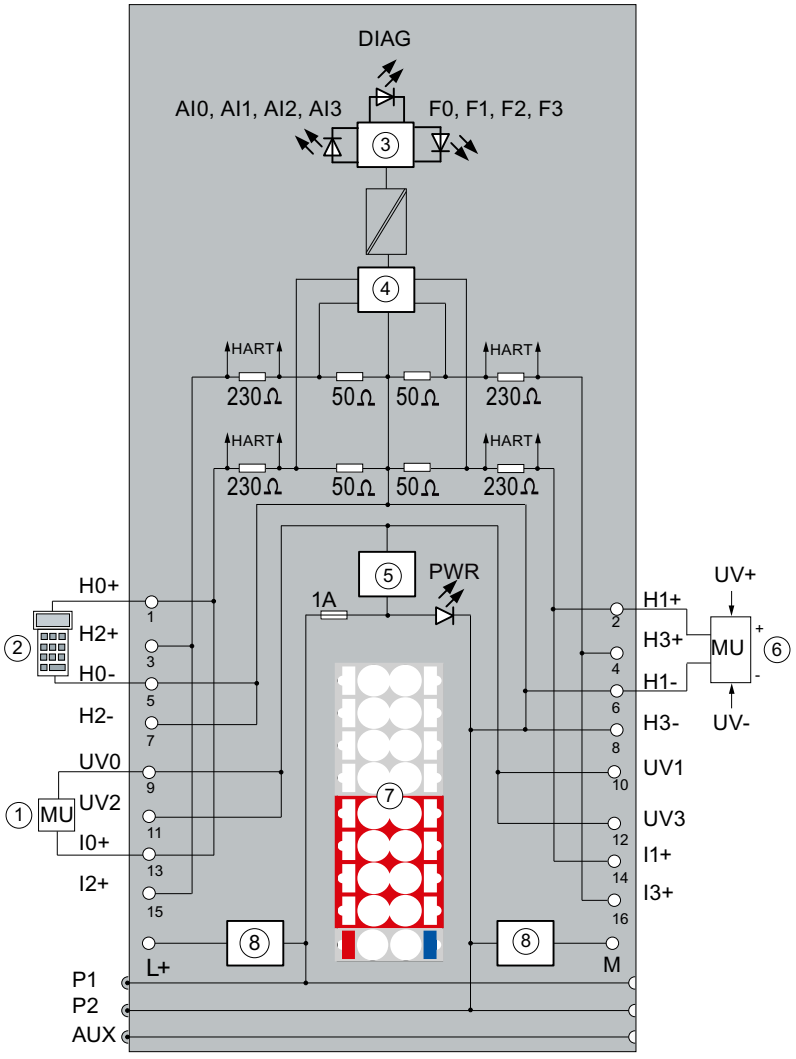
Information regarding selection of the suitable BaseUnit can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521).

Information regarding wiring of the BaseUnit, creating the cable shield, etc., can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) in the section "Connecting".

Note

The first BaseUnit of a station must be a light BaseUnit. Also keep this in mind during the configuration.

General terminal assignment



Block diagram AI 4xI 2-wire 4…20mA HART

①	Connection of a 2-wire transducer, at channel 0 in this case
②	Optional connection of an external hand-held (secondary master) to the HART test connection terminal (at channel 0 in this case)
③	Backplane bus connection
④	Analog-digital converter (ADC)
⑤	Current limitation
⑥	Non-isolated 4-wire connection to the HART test connection terminal (at channel 1 in this case)
⑦	Color-coded label CC03 (optional)
⑧	Filter circuit supply voltage (only available on light-colored BaseUnit)
Hn+	HART signal "+", channel n
Hn-	HART signal "-", channel n
UVn	Supply voltage channel n
In+	Input signal "+" channel n
L+	24 V DC (infeed only with light-colored BaseUnit)
M	Ground
P1,P2, AUX	Internal self-assembling voltage buses Connection to the left (dark-colored BaseUnit) Connection to the right interrupted (light-colored BaseUnit)
DIAG	Diagnostics LED (green, red)
AI0 to AI3	Channel status LED (green)
F0 to F3	Channel fault LED (red)
PWR	Power LED (green)

Supply voltage L+/M

Connect supply voltage (24V DC) to terminals L+ and M. An internal protective circuit protects the analog module from reverse polarity. The analog module monitors the connection of the supply voltage.

HART function

4

Definition

"HART" stands for "Highway Addressable Remote Transducer".

The HART functionality also enables you to use the AI 4xI 2-wire 4…20mA HART analog module to 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

Using the AI 4xI 2-wire 4…20mA HART analog module offers 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 in the S7 system by means of the AI 4xI 2-wire 4… 20mA HART analog module.

Use in the system

The AI 4xI 2-wire 4…20mA HART analog module is used in the distributed I/O connected to PROFIBUS DP or PROFINET IO.

You can connect a field device to any channel: The AI 4xI 2-wire 4…20mA HART analog 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

4.1 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.

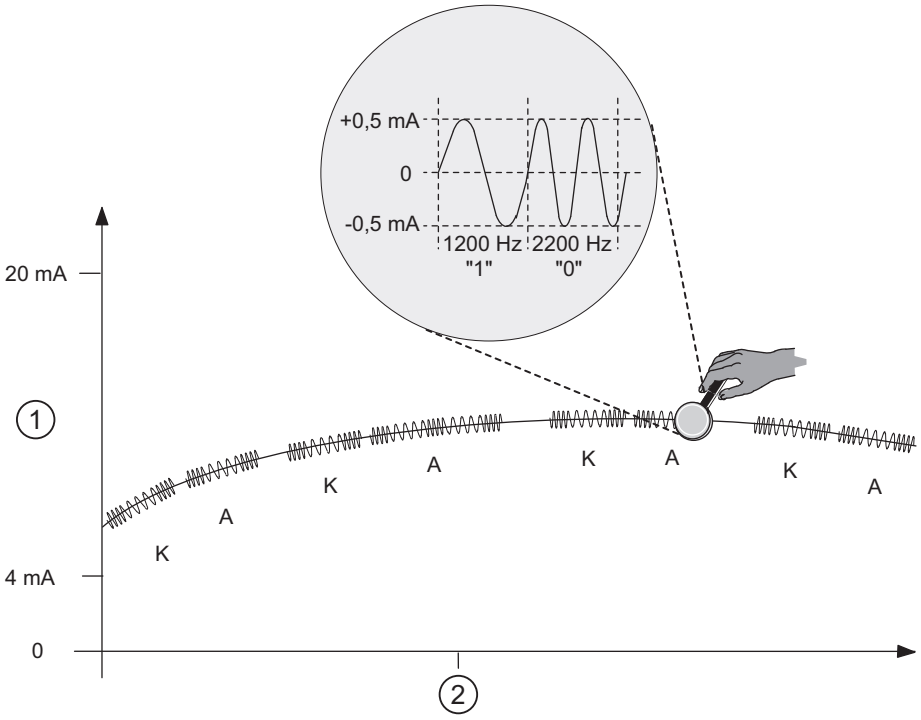


Figure 4-1 The HART signal

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

HART communication

The AI 4xI 2-wire 4…20mA HART analog module processes the HART communication in multiplex mode, i.e., consecutively channel-by-channel. As a result, HART commands of the individual channels influence the speed of the HART processing of the other channels.

When HART mode is enabled, the analog module autonomously sends HART commands to the connected field devices. This takes place alternatingly on a channel-specific basis with any

pending external HART commands that arrive via the command interface of the module, see section 4.3 "HART command interface".

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 4-1 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 4-2 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 (Page 59).

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 4-3 1st status byte

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

Table 4-4 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 4xI 2-wire 4…20mA HART analog module supports the processing of HART commands as a SHC sequence ("Successive HART Command").
That is, if the analog module detects a HART command with SHC bit set 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 22)

Note

- During the time a HART channel of the AI 4xI 2-wire 4…20mA HART analog module is processing an SHC sequence, and thus the complete HART processing of the module is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The AI 4xI 2-wire 4…20mA HART analog module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

4.2 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 transducers to the AI 4xI 2-wire 4…20mA HART analog 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": The configuration tool goes through the AI 4xI 2-wire 4…20mA HART analog module whereas the HART Handheld is connected directly in parallel with the field device. See terminal assignment "HART test connections (terminals 1 to 8)" in the section 3.1 "Terminal assignment".
  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.
- HART system connection:
  The AI 4xI 2-wire 4…20mA HART analog module assumes the function of a "master" by forwarding the commands received from the HART configuration tool or as programmed commands from an S7 user program, for example, to the intelligent field device and sending back the replies. Data records that are transferred via the ET 200SP I/O bus serve as the interface of the AI 4xI 2-wire 4…20mA HART analog module. The data records must be created and interpreted by the client. .

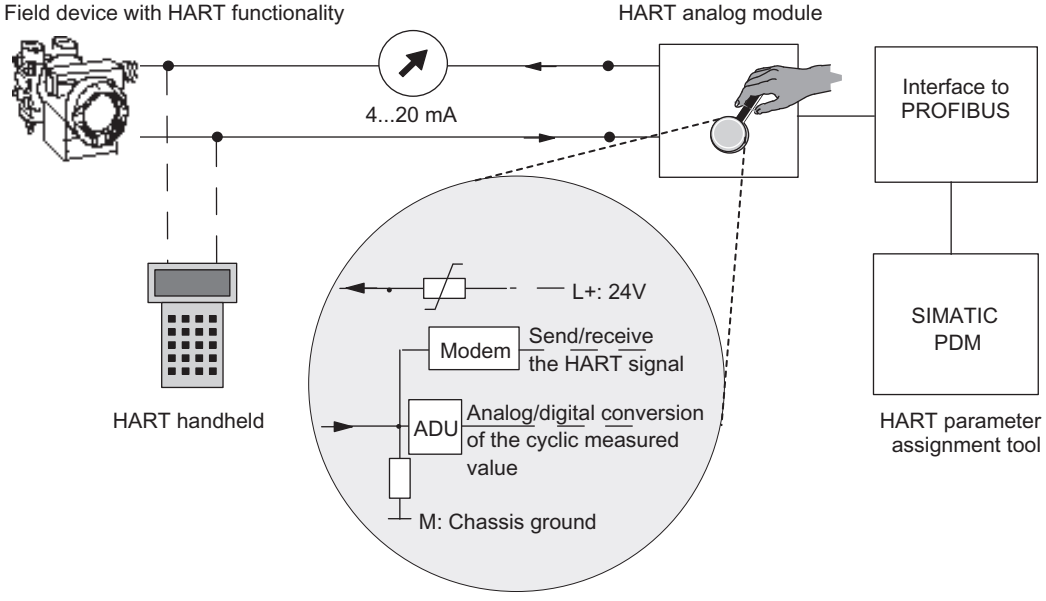


Figure 4-2 System environment for the use of HART

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.
This is evaluated by the AI 4xI 2-wire 4…20mA HART analog module and made available in the system via S7 diagnostic messages.

Configuration/commissioning

You configure the AI 4xI 2-wire 4…20mA HART analog 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 ET 200SP.

It is also possible to configure the AI 4xI 2-wire 4…20mA HART analog module using a GSD file for PROFIBUS DP and 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 reassigned the parameters of a HART field device, the corresponding bit is set in the device status of the connected field device (in the 2nd status byte).
3. Because of the parameter reassignment of the field device, the HART analog module triggers a diagnostic interrupt "Configuration changed", provided this diagnostic interrupts is enabled. See section 7.3 "Diagnostic alarms". 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.

See also

Connection and block diagram (Page 13)

Diagnostics alarms (Page 39)

4.3 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 4xI 2-wire 4…20mA HART analog module does not support client management.

Each client/channel is allocated fixed data records:

Table 4-5 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

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 is sent to the module with a set SHC bit, then this channel is reserved for HART commands for 2 seconds. This means that no more internal HART commands are sent to the field device with 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.

4.4 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 (Page 57).

In addition, a maximum of 4 HART variables can be configured directly in the input address space of the AI 4xI 2-wire 4…20mA HART analog module. The HART variables are assigned to a channel in the properties dialog of the module. The parameter assignment uses parameter data record 140, see section AUTOHOTSPOT. This makes it easy for you to process measured values directly from the field device as input data in the automation device.

Address assignment

Provided you map HART variables in the input address space of the module by means of the configuration tool or selection of the appropriate configuration, 20 bytes are always additionally 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 enabled, the AI 4xI 2-wire 4…20mA HART analog module autonomously and cyclically reads the variables supplied by the connected field devices and makes them available in the input address space according to 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 4xI 2-wire 4…20mA HART analog module are based on the HART Revision of the utilized field device.

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
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused

Quality code	Meaning (process status)	
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
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	
89_H	"Good" with "Low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "High limit"	
$28_{H...}2B_H$	"Bad"	
$68_{H...}6B_H$	"Poor accuracy"	
$78_{H...}7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
$88_{H...}8B_H$	"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
40_H	Read alternatively via command 3	
00_H	Initialization value from S7 system	

Parameters 5

5.1 Parameters of the AI 4xI 2-wire 4…20mA HART

You specify how the AI 4xI 2-wire 4…20mA HART analog module operates using parameters.

The parameters are subdivided into:

- Channel or technology parameters (data record 128)
  With PROFIBUS DP GSD configuration, there is a reduced configuration via the startup configuration (Prm frame).
- Parameters that define the display of HART variables in the address space of the module; HART mapping parameters (data record 140)

With configuration in the user program, the parameters are transferred to the modules via data records with the "WRREC" instruction; see section Parameter assignment and structure of the channel/technology parameters (Page 51).

5.1.1 Channel/technology parameters

Parameters of the AI 4xI 2-/4-wire ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

Table 5-1 Configurable channel/technology parameters and their default settings

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics encoder supply	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics overflow	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics underflow	• Disable • Enable	Disable	Yes	Channel	Module [2]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics wire break	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics HART	• Disable • Enable	Disable	Yes	Channel	Module [2]
Measuring type/range	• Disabled • Current (2-wire transducer) 4..20 mA • Current (2-wire transducer) 4..20 mA HART	Current (2-wire transducer) 4..20 mA HART	Yes	Channel	Channel
Smoothing	• none • 4-fold (weak) • 16-fold (medium) • 32-fold (strong)	none	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (integration time 16.6 ms) • 50 Hz [1] (integration time 20 ms) • 10 Hz (integration time 100 ms)	50 Hz	Yes	Channel	Module [2]
Current limit for wire break diagnostics	• 1.185 mA • 3.6 mA	1.185 mA	Yes	Channel	Cannot be changed[2]
Number of HART preamble bytes	5…20	5	Yes	Channel	Cannot be changed[2]
Number of HART repetitions	0…255	5	Yes	Channel	Cannot be changed[2]
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	No	Module	Module

[1] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

[2] Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, the parameter assignment uses data record 245. If required, you can assign this parameter using data record 128 as described in the "GSD File PROFINET IO" column (see table above).

Note

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always supplies the analog value $7FFF_H$.

See also

Parameter assignment and structure of the channel/technology parameters (Page 51)

5.1.2 Explanation of the channel/technology parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics encoder supply

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

The short-circuit and underflow diagnostics can be enabled simultaneously. If both diagnostic events occur simultaneously, the short-circuit diagnostics information is output.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics wire break

Enabling of the diagnostics when the module has no current flow at the input or the current flow at the input is below the configured wire break limit.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics information is output.

Diagnostics HART

Enabling of the diagnostics of the HART frame-specific monitoring and the status information supplied by the connected field device in the HART frame (HART device status).

Current limit for wire break diagnostics

You use this to specify the current limit for detecting wire breaks. If the current falls below the configured wire break limit, the measured value is declared invalid and, if wire break diagnostics is enabled, corresponding diagnostics information is generated. When value status is configured, the analog value is marked as invalid.

With a wire break limit of 3.6 mA, the measured value becomes invalid when the current falls below 3.6 mA and is marked as valid again when it rises above 3.8 mA.

There is no hysteresis for a wire break limit of 1.185 mA.

Measuring type/range

The AI 4xI 2-wire 4…20mA HART analog input module has the following measuring ranges:

Table 5-2 Measuring ranges

Measuring type	Measuring range	Resolution
Disabled	-	-
Current (2-wire transducer)	4 to 20 mA	15 bits + sign
Current (2-wire transducer)	4 to 20 mA HART	15 bits + sign

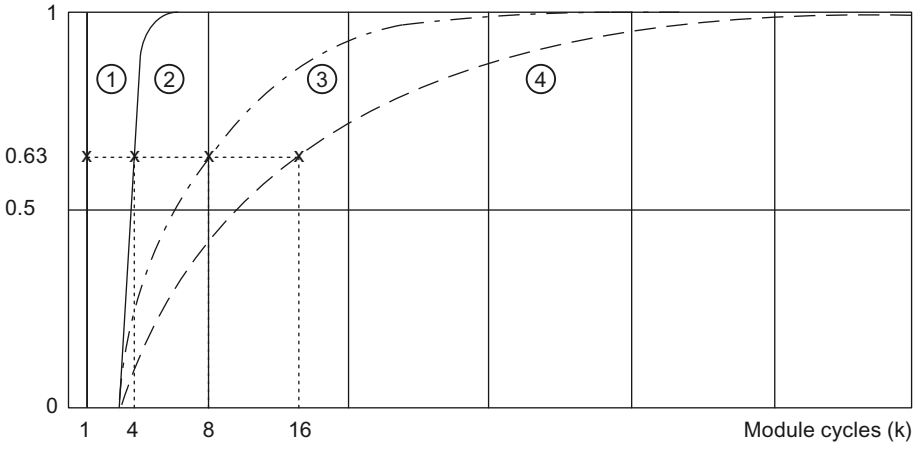
An overview of the measuring range as well as overflow, overrange, etc., can be found in the section Analog value representation (Page 64) and in Analog Value Processing function manual.

Smoothing

The individual measured values are smoothed by filtering. Smoothing can be set in 4 levels.

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

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.



① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 5-1 Smoothing of the analog value

Interference frequency suppression

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

The frequency of the AC supply system may interfere with the measured value, in particular in low voltage ranges. .

Number of HART preamble bytes

Specifies the number of preamble bytes that the module prefixes to each HART frame to be sent (FF_H). These bytes are used for synchronizing the frames.

Number of HART repetitions

Specifies the number of HART frame repetitions. If the analog module receives no response or receives a response with error to a HART frame sent to the field device, the frame is accordingly repeated, i.e., resent to the field device.

Because HART communication of the individual channels uses multiplex operation, faulty HART frames affect the other channels when the number of HART repetitions is high. In other words, the other channels are processed less frequently.

Potential group

Specifies that a BaseUnit with supply voltage infeed is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

See also

Parameters of the AI 4xI 2-wire 4…20mA HART (Page 27)

5.1.3 HART mapping parameters

The HART mapping parameters allow a maximum of 4 HART variables to be configured (mapped) in the address space of the module.

Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all four variables are occupied (20 bytes).

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 AUTOHOTSPOT.

Parameters

Table 5-3 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 0	Channel	0…3	0	Yes	0
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 1	Channel	0…3	0	Yes	1
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 2	Channel	0…3	0	Yes	2
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 3	Channel	0…3	0	Yes	3
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary

Configuring/address space

6

6.1 Configuring

You configure the analog module AI 4xI 2-wire 4…20mA HART

- In the TIA Portal V13.0.1 or higher
- With STEP 7 V5.5 + SP4 or higher (HSP0263)
- Using GSD/GSDML

The GSD files for the ET 200SP Distributed I/O System can be downloaded from the Internet:

- GSDML (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD (http://support.automation.siemens.com/WW/view/en/ 73016883)

Configuration options

The following configurations are possible:

- Without value status and without HART variables ("AI 4xI 2-wire 4…20 mA HART")
- Without value status, with HART variables ("AI 4xI 2-wire 4…20 mA HART, 4 variables")
- With value status and without HART variables ("AI 4xI 2-wire 4…20 mA HART, QI")
- With value status, with HART variables ("AI 4xI 2-wire 4…20 mA HART, 4 variables, QI")

With GSD/GSDML configuration, you must select one of the possible configurations directly.

The configuration for STEP 7 (TIA Portal or HW Config) is made indirectly via the parameters.

Restrictions

- Value status is not available for a PROFIBUS DP station.
- Downstream of a Standard IM (V1.1), the module can be operated only in the "Without value status and without HART variables" configuration.
- TIA Portal:
  - The module behind a standard IM (V1.1) is not available.
  - TIA Portal as of V14.0.1
    The module can be centrally configured on the following CPU:
    - CPU 1510SP-1 (as of V2.1)
    - CPU 1512SP-1 PN (as of V2.1)
  - TIA Portal as of V15.0.0
    The module can be configured as an open controller.
  - The module cannot be used behind fail-safe controllers.

6.2 Address space

The following figure shows the allocation of the address space of the AI 4xI 2-wire 4…20mA HART module for a configuration with value status (Quality Information, QI) and with HART variables.

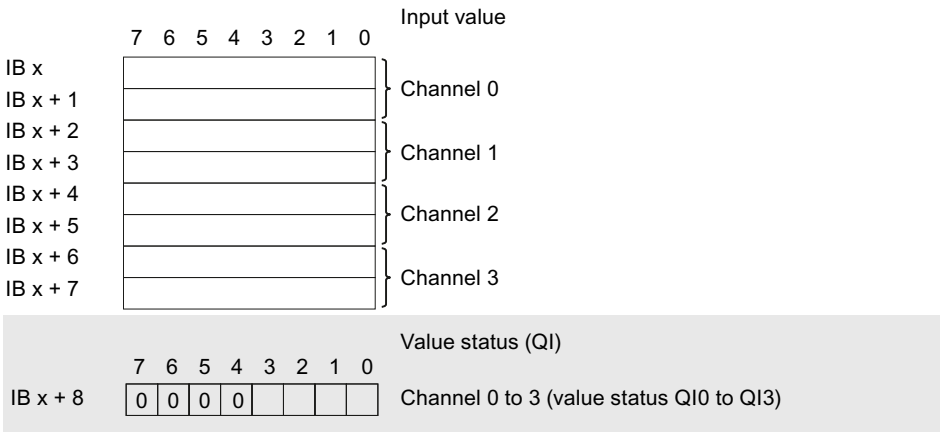
The addresses for the value status are only available if the value status has been enabled or the corresponding configuration has been configured from the GSDML.

The addresses for the HART variables are only available if configuration/parameter assignment of the HART variables has been carried out or the corresponding configuration has been configured from the GSD/GSDML.

If the HART variables are configured and there is no value status configuration or parameter assignment, the HART variables begin directly after the analog values, thus starting from IB x + 8.

Table 6-1 Address space of analog input module AI 4xI 2-wire 4…20mA HART

Assignment in the process image input (PII)



IB x+9 …. IB x+12	Value	Configured HART variable 0
IB x+13	Quality code	
IB x+14 …. IB x+17	Value	Configured HART variable 1
IB x+18	Quality code	
IB x+19 …. IB x+22	Value	Configured HART variable 2
IB x+23	Quality code	
IB x+24 …. IB x+27	Value	Configured HART variable 3
IB x+28	Quality code	

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to the corresponding channel. The provide information about the validity of the analog value, namely irrespective of the diagnostics enables.

Bit = 1: There is no error in the analog value or the analog value acquisition of the channel.

Bit = 0: The analog value of the channel cannot be correctly acquired.
The channel is disabled; there is a fault in the wiring or module.

Evaluating HART variables

If you have configured (mapped) HART variables for the analog module, four HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a quality code byte. The quality code describes the validity of the value; see section HART variables (Page 23) .

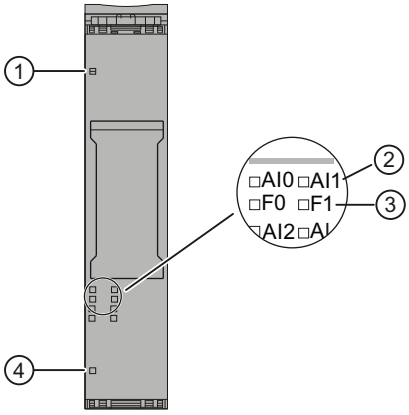
Interrupts/diagnostics alarms

7

7.1 Status and error displays

LED displays

The figure below shows the status and error displays of the AI 4xI 2-wire 4…20mA HART analog input module.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 7-1 LED displays

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostic alarms can be found in the section Diagnostics alarms (Page 39).

Table 7-1 Status display of the channel status/channel fault LEDs

LEDs		Meaning
Channel status	Channel fault	
□ Off	□ Off	Channel disabled or module switched off
■ On	□ Off	Channel enabled and no channel diagnostics present

LEDs		Meaning
Channel status	**Channel fault**	
□ Off	■ On	Channel enabled and channel diagnostics present
■ On	■ On	Channel enabled and **only** HART channel diagnostics present

Table 7-2 DIAG LED error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP is not OK or switched off
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics, at least one error is currently present

Table 7-3 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

7.2 Interrupts

The AI 4xI 2-wire 4…20mA HART analog input module supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt for the following events:

- Channel/component temporarily unavailable
- Short-circuit / Overload of encoder voltage
- Wire break
- Low limit violated

- High limit violated
- Error
- No supply voltage L+
- HART communication error or HART field device error

7.3 Diagnostics alarms

A diagnostic alarm is generated for each detected diagnostic event. The DIAG LED flashes on the module.

There is additionally a channel-specific display of the diagnostics through the corresponding channel fault/channel status LEDs.

The diagnostic alarms can, for example, be read from the diagnostic buffer of the CPU or be displayed in STEP 7 using the Online and Diagnostics view. You can evaluate the error codes with the user program.

Table 7-4 Diagnostic alarms, their meaning and how to deal with them

Diagnostic alarm	Error code	Meaning	Remedy
Channel/component temporarily unavailable	$1F_H$	• Update of the firmware is being performed or has been canceled. The module does not perform any measurements during this time.	
Short-circuit/overload at external encoder supply *	$10E_H$	• Short-circuit of the encoder supply to M • Short-circuit of the input to the encoder supply • Overload of the encoder supply	• Correct the module/encoder tuning
Wire break	6_H	• Impedance of encoder circuit too high. • Wire break between the module and sensor • Channel not connected (open)	• Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section • Connect the cable • Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	• The analog value is above the overrange.	• Correct the module/encoder tuning
Low limit violated	8_H	• The analog value is below the underrange.	• Correct the module/encoder tuning
Error	9_H	• Internal module error occurred.	• Replace module
No supply voltage	11_H	• No or insufficient supply voltage L+	• Check wiring of the supply voltage L + on the BaseUnit • Check BaseUnit type

Diagnostic alarm	Error code	Meaning	Remedy
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 of ≥4 mA • Increase the number of assigned repetitions
HART primary variable outside 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 assigned outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct 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 is set to a fixed value: • 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 secondary 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 assigned outside the limits	
HART - more status available	145_H	• The identifier for "Additional status information available" of the HART field device was set in the HART device status (in the 2nd status byte).	• Read status using HART command 48 and eliminate error/cause, if necessary

Diagnostic alarm	Error code	Meaning	Remedy
HART configuration changed (reset again automatically by the module after approximately 1 minute)	146_H	• The identifier for "Parameter reassignment" of the HART field device was set in the HART device status (in the 2nd status byte).	• If you do not want a diagnostic interrupt to be triggered for parameter reassignment, the diagnostic interrupt must not be enabled.
HART malfunction in field device	147_H	• The field device signals a malfunction in the HART device status (in the 2nd status byte)	• Read status using HART command 48 and eliminate error/cause, if necessary • Replace the field device

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostic information can also be signaled on unaffected channels and/or the measured value can be affected temporarily.

Technical specifications

8

8.1 Standards and Approvals

8.1.1 Currently valid markings and approvals

Introduction

This section contains the technical specifications of the system:

- The standards and test values that the module complies with and fulfills.
- The test criteria according to which the module was tested.

Safety information

⚠ WARNING

Explosion hazard

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

- Do not disconnect the device in a flammable or combustible atmosphere.
- Do not open the enclosure in a flammable or combustible atmosphere.

⚠ WARNING

Area of application

This device is intended for use only in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC environments or non-hazardous locations.

⚠ WARNING

Environmental conditions

The device may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.

⚠ WARNING

Enclosure and cables

The device is intended for installation in an enclosure / control cabinet. The internal operating temperature of the enclosure / control cabinet corresponds to the maximum permissible ambient temperature of the module.

Cables must be used whose maximum permissible operating temperature is at least 30 °C above the maximum permissible ambient temperature.

⚠ WARNING

Ambient temperature of the device

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

⚠ WARNING

Safety extra-low voltage

The device is designed for operation with safety extra-low voltage (SELV) from a limited power source (LPS).

Power supplies connected to the power supply terminals must comply with the following:

- SELV/LPS (current source with limited power), according to standards IEC 60950-1 / UL 60950-1 / EN 60950-1 / VDE 0805-1
  or
- Power supply for the NEC Class 2 device as described in the National Electrical Code (r) (ANSI / NFPA 70).

If the device is connected to a redundant power supply (two separate power sources), both must meet these requirements.

NOTICE

Removal and replacement

If you replace components, compliance with Class I, DIV 2 can become invalid.

Replacing components may affect the usability of the device.

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

Validity of the information on the components

NOTICE
Markings and approvals
In the documentation, you can find the markings and approvals which are generally possible or planned in the system.
The identification or approval that is printed on the module continues to be exclusively valid.
The currently valid markings and approvals are printed on the component.

8.1.2 ATEX Approval

Table 8-1 ATEX Certification

Type Examination Certificate Number	DEKRA 14ATEX0109 X
Standards	EN 60079-0
	EN 60079-7

ATEX II 3 G Ex ec IIC T4 Gc

Note

Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with EN 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.1.3 IECEx Approval

Table 8-2 IECEx certification

Certificate number	IECEx DEK 14.0063X
Standards	IEC 60079-0
	IEC 60079-7

IECEx Ex ec IIC T4 Gc

Note

Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with IEC 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.1.4 FM Approval

Table 8-3 Factory Mutual Research (FM) Certification

Classification	NI, Class I, Div 2, Groups A, B, C and D
	NI, Class I, Zone 2, Groups IIC
Standards	Class No. 3600
	Class No. 3611
	Class No. 3810
	ANSI/ISA-61010-1
	C22.2 No. 0-10
	C22.2 No. 213-17
	C22.2 No. 1010.1
	CAN/CSA C22.2 No. 0.15-15

8.2 Technical specifications of the AI 4xI 2-wire 4…20mA HART

Technical specifications of the AI 4xI 2-wire 4…20mA HART

Article number	6ES7134-6TD00-0CA1
General information	
Product type designation	AI 4xI 2-wire HART
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC03
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
• STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No
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
Input current	
Current consumption, max.	25 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.65 W; without sensor supply
Address area	

Article number	6ES7134-6TD00-0CA1
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
• Address space per module with HART, max.	28 byte; + 1 byte for QI information
Analog inputs	
Number of analog inputs	4; Differential inputs
• For current measurement	4
permissible input current for current input (destruction limit), max.	50 mA
Input ranges (rated values), currents	
• 0 to 20 mA	No
• -20 mA to +20 mA	No
• 4 mA to 20 mA	Yes; 15 bit + sign
– Input resistance (4 mA to 20 mA)	280 Ω; + approx. 0.35 V diode forward voltage
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; channel by channel
• Interference voltage suppression for interference frequency f1 in Hz	10 / 50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	No
• for current measurement as 2-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	60 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	

Article number	6ES7134-6TD00-0CA1
• Series mode interference (peak value of interference < rated value of input range), min.	60 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; Channel-by-channel, short-circuit of the encoder supply to ground or of an input to the encoder supply
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
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
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.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Appendix A

A.1 Parameter data records

Parameter assignment in the user program

You have the option of reassigning parameters for individual channels of the module and for the mapping of HART variables in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module.

- Channel/technology parameters using data record 128
- The HART mapping using data record 140.

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.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Parameters

Only the values specified in each case in the following are permitted. Values that are not listed are rejected by the analog module.

Each parameter data record is checked by the analog module. If an incorrect parameter is detected, the complete data record is discarded and the parameters of the analog module remain unchanged.

A.1.1 Parameter assignment and structure of the channel/technology parameters

Structure of data record 128

Data record 128 has a length of 42 bytes and contains the channel/technology parameters of all four channels (10 bytes per channel).

The parameters are divided into parameters that influence the actual analog value acquisition, diagnostic enables, and basic parameters of HART communication.

You can use data records 131 to 134 to assign and change additional parameters and HART-specific settings. See section HART-specific settings (Page 58).

Byte 0		Header information
Byte 2	Analog value acquisition Diagnostics enable HART	Channel 0 parameters
Byte 12	Analog value acquisition Diagnostics enable HART	Channel 1 parameters
Byte 22	Analog value acquisition Diagnostics enable HART	Channel 2 parameters
Byte 32	Analog value acquisition Diagnostics enable HART	Channel 3 parameters

Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

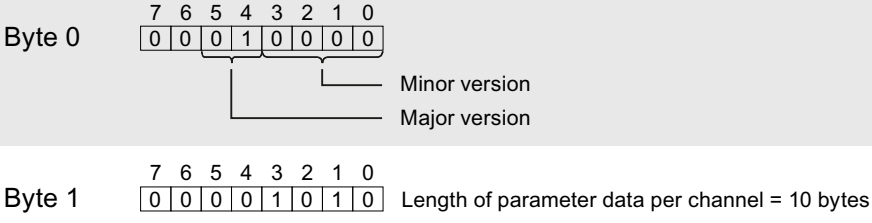
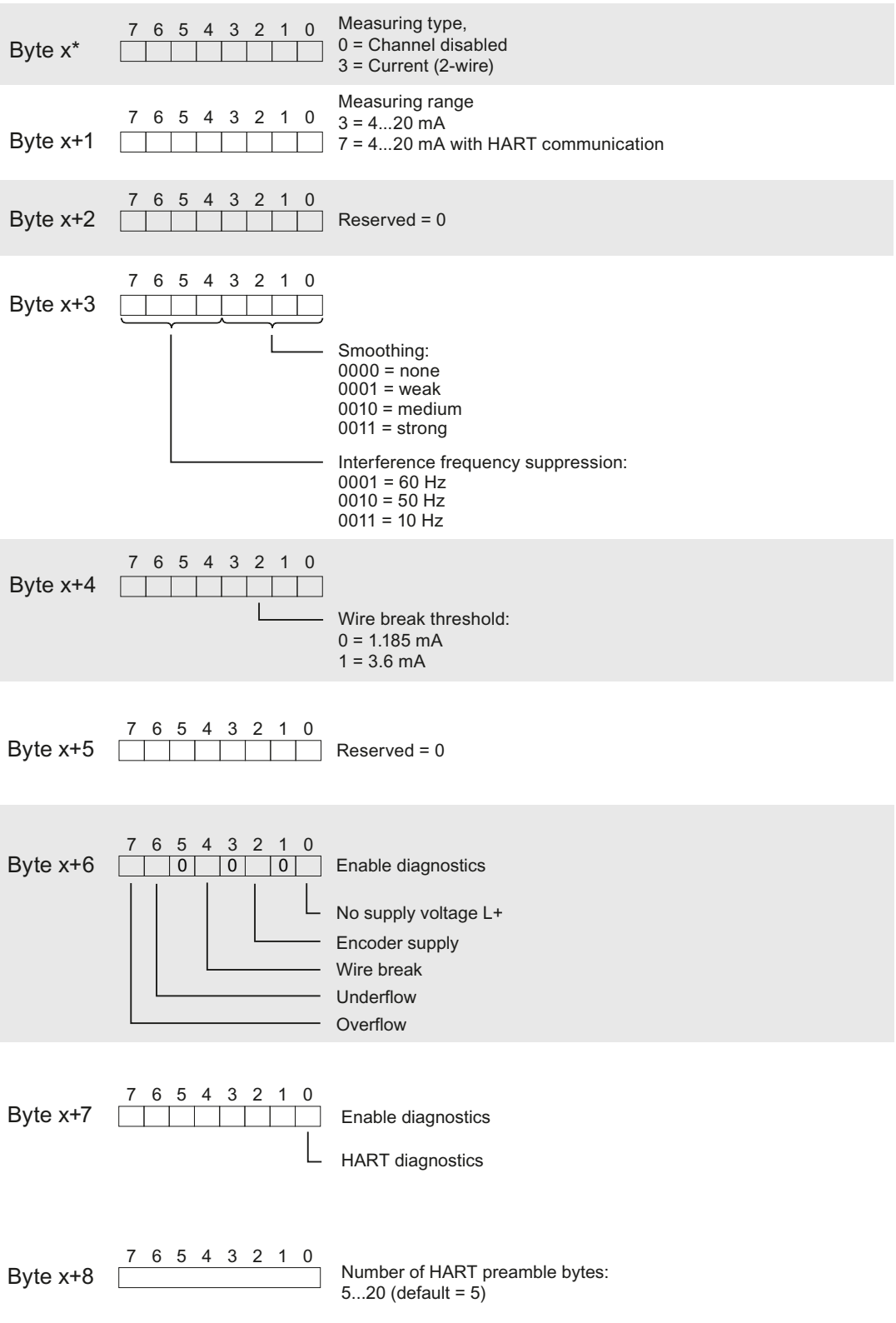


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

All unused bits and the bits or bytes marked with "reserved" must be set to zero.
You enable a parameter by setting the corresponding bit to "1" or the appropriate value.


Byte x*
7 6 5 4 3 2 1 0
Measuring type,
0 = Channel disabled
3 = Current (2-wire)
Byte x+1
7 6 5 4 3 2 1 0
Measuring range
3 = 4...20 mA
7 = 4...20 mA with HART communication
Byte x+2
7 6 5 4 3 2 1 0
Reserved = 0
Byte x+3
7 6 5 4 3 2 1 0
Smoothing:
0000 = none
0001 = weak
0010 = medium
0011 = strong
Interference frequency suppression:
0001 = 60 Hz
0010 = 50 Hz
0011 = 10 Hz
Byte x+4
7 6 5 4 3 2 1 0
Wire break threshold:
0 = 1.185 mA
1 = 3.6 mA
Byte x+5
7 6 5 4 3 2 1 0
Reserved = 0
Byte x+6
7 6 5 4 3 2 1 0
0 0 0
Enable diagnostics
No supply voltage L+
Encoder supply
Wire break
Underflow
Overflow
Byte x+7
7 6 5 4 3 2 1 0
Enable diagnostics
HART diagnostics
Byte x+8
7 6 5 4 3 2 1 0
Number of HART preamble bytes:
5...20 (default = 5)

	7	6	5	4	3	2	1	0	
Byte x+9									Number of HART retries: 0...255, internally limited to maximum 10 (default = 5)

* x = 2 + (channel number * 10); with channel number 0 ….3

Figure A-3 Structure of bytes x to x+39 for channels 0 to 3

A.1.2 Parameter assignment and structure of the HART mapping parameters

Structure of data record 140

Data block 140 has a total length of 12 bytes.

Using the parameters of data record 140, you can configure/map up to four HART variables of the individual channels in the input address space of the module if the corresponding configuration is selected, see "Configuring (Page 33)".

Header information

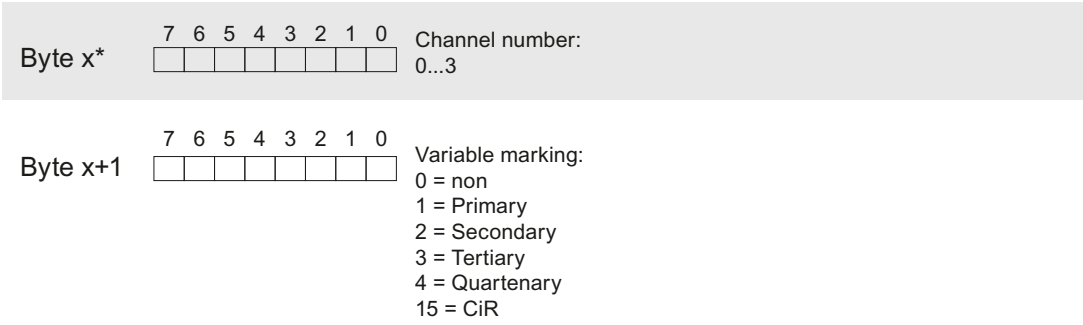
The figure below shows the structure of the header information.

	7	6	5	4	3	2	1	0	
Byte 0									Version = 0
Byte 1									Block length = 11 bytes
Byte 2									Block type = 75
Byte 3									Reserved = 0

Figure A-4 Header information

Parameters

The following figure shows the parameter assignment of the four HART variables 0...3.



* x = 4 + (HART variable * 2); with HART variable 0….3

Figure A-5 Parameters

Note

Memory area

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

- All four HART variables are set to 0 = "none":
  No memory area is reserved/allocated for HART variables in the input address range.
- As least one HART variable is set to not equal to 0 = "none":
  The entire memory area always allocated to the four HART variables in the input address space. All remaining HART variables are preset to 15 = "CiR" and 0 = "none" is no longer allowed.

A.2 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

Data record number	Description	Length (bytes)	Writable	Readable
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
121	HART variables	80	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
148	HART directory	17	No	Yes
149	HART feature data	3	No	Yes

A.2.1 HART directory

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	= 4
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) are used.

A.2.2 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit1 = 1: "Parameter check result is given with a read response" Bit5 = 1: "Compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 240 (maximum length of the HART request data records)

A.2.3 HART variable data record

The AI 4xI 2-wire 4…20mA HART analog module supports a maximum of 4 HART variables per channel that are read cyclically, provided this is supported by the connected field device. These 16 HART variables are are made available in a readable manner in 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	

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).

A.2.4 HART-specific settings

The HART communication is available using standard parameter assignment (see section 9.1 "Parameter assignment and structure of the channel/technology parameters").

Additional HART-specific settings can be specified on a channel-specific basis using data records 131 to 134.

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.

Each parameter reassignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

Where there is no supply voltage L+, the module does not assume the HART-specific settings.

Channel	Data record number
0	131
1	132
2	133
3	134

Structure of the HART-specific settings

Byte 0	7 6 5 4 3 2 1 0 Must be 128	Bit 7 is reset after evaluation of data record by module
Byte 1	7 6 5 4 3 2 1 0 Must be 5	Offset for manufacturer-specific parameters according to HART specification
Byte 2	7 6 5 4 3 2 1 0	Number of HART retries (0....255, internally limited to 10) Initial value from parameter data record 128
Byte 3	7 6 5 4 3 2 1 0	Number of HART preamble bytes (0, 5...20, 255) * Initial value from parameter data record 128
Byte 4	7 6 5 4 3 2 1 0 Must be 0	Field device mode according to HART specification
Byte 5	7 6 5 4 3 2 1 0	Client timeout in s (1 ... 255 s) Initial value = 60 s
Byte 6	7 6 5 4 3 2 1 0 0 0 0 0 0 0	Initial value according to HART activation from parameter data record 128 Always as primary master 1 = Enable HART 0 = Disable HART 1 = Primary master 0 = Secondary master
Byte 7	7 6 5 4 3 2 1 0 Must be 0	Reserved

Figure A-6 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes required 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.

A.2.5 HART request and response data records

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

Structure of request data records 80, 82, 84, 86

Byte	Meaning	Comment
0	Request control	
1	Number of preamble bytes	5....20, 255
2…239	Communication data according to HART specification	

Coding "Request control":

Bit 0…1: Reserved = 0
Bit 2: 0 = Parameters are not checked
Bit 3...4: Reserved = 0
Bit 5: 0 = Transparent format *
1 = Compact format
Bit 6: 1 = Enable SHC mode **
Bit 7: 0 = HART Request

* 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.

** Processing of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section 4.3 "HART command interface", SHC sequence.

Note

When "Number of Preamble Bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can re-configure the number of preamble bytes using the parameters and HART-specific settings (see section HART-specific settings (Page 58)).

Structure of response data records 81, 83, 85, 87

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2	Protocol error	
3…239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data"

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2…239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data"

Coding "Response control":

Bits 0-2:	Response result (processing status) 0 = Inactive 1 = Inactive (reserved) 2 = Waiting 3 = Waiting, executing 4 = Successful, with data 5 = Successful, without data 6 = Error, with data 7 = Error, without data
Bit 3:	0 = Burst mode not active;
Bit 4:	0 = Response data come directly from the HART device
Bit 5:	0 = Response data in transparent message format
Bit 6:	0 = SHC mode not active 1 = SHC mode active
Bit 7:	0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.
1	HART communication error	The field device has detected a communication error when receiving the command. The error information can be found in the 1st HART status byte.
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Reserved	Always 0
4…7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

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 fault	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
3	Command error	0-127: HART protocol, Bit 7 = Always 0

HART protocol error during response	Meaning	Explanation
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 "98 CF 38 84 F0".
A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the AI 4xI 2-wire 4…20mA HART analog module is 512 (200_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.

```
STL                                 Explanation
    A I 4.0
    FP M 101.0
    = M 104.0
m2: CALL SFC 58
```

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

Table A-1 DB80: Transparent message format

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

Table A-3 FC81: Reading of the response to DB81 with SFC 59

```
STL                                 Explanation
m3: CALL SFC 59
    REQ :=1                         Read request
    IOID :=B#16#54                  Address range ID
    LADDR :=W#16#200                Module address of the HART-AI
    RECNUM :=B#16#51                Data record number 81
    RECORD :=P#DB81.DBX0.0 BYTE     Data record
75
    RET_VAL :=MW100                 RET_VAL of SFC 59 (OK/error/...)
    BUSY :=M49.1                    Read operation not yet completed
    A M 49.1
    SPB m3
    BE
```

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

As long as "0x03" is in byte 0 of DB81, the 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.

A.3 Analog value representation

Table A-4 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

Representation / Value range

The table below contains the decimal and hexadecimal values (codings) of the possible current measuring ranges.

Table A-5 Current measuring range 4 to 20 mA / 4…20 mA HART

Values		Current measuring range	Range
Dec.	Hex.	4 to 20 mA	
32767	7FFF	> 22.81 mA	Overflow

Values		Current measuring range	Range
32511	7EFF	22.81 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	16 mA	
1	1	4 mA + 578.7 nA	
0	0	4 mA	
-1	FFFF		Underrange
-4864	ED00	1.185 mA	
-32768	8000	< 1.185 mA	Underflow

A.3.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table A-6 Bipolar input ranges

Dec. value	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	Overrange
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	Nominal 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	Underrange
-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 A-7 Unipolar input ranges

Dec. value	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

Dec. value	Measured value in %	Data word																Range
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
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	Nominal 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	Underrange
-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

A.3.2 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 A-8 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal 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		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table A-9 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		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	Overrange
27649	6C01			

Values		Current measuring range		Range
27648	6C00	20 mA	20 mA	Nominal 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			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

A.4 Contact

Range	Contact
Repair Service Facility	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA QM 31 Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447
Manufacturer	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447

Index

I

L

M

O

P

Q

R

S

T

V