

SIMATIC

ET 200SP Analog Output Module AQ 4xI HART HF

Equipment Manual

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Legal information

Warning notice system

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

 DANGER
indicates that death or severe personal injury will result if proper precautions are not taken.
 WARNING
indicates that death or severe personal injury may result if proper precautions are not taken.
 CAUTION
indicates that minor personal injury can result if proper precautions are not taken.
NOTICE
indicates that property damage can result if proper precautions are not taken.

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

Qualified Personnel

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

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Note the following:

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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.

Preface

Validity of the documentation

This documentation describes the analog output module AQ 4xI HART HF, article number 6ES7135-6TD00-0CA1.

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 in this documentation and in the system/function manuals enables you to commission the system.

Conventions

The following terms are used synonymously in this documentation:

Term	Synonyms	Notes
AQ 4xI HART HF	AQ 4xI HART; Analog output module AQ 4xI HART	Unless otherwise specified, applies to the product analog output module AQ 4xI HART HF, article number 6ES7135-6TD00-0CA1.
Actuator	Field device	The following applies in this documentation: The field devices connected to the analog output module are actuators. The field devices connected to an input module, on the other hand, are sensors.

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.

Security information

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<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 customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
<https://www.siemens.com/industrialsecurity>.

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Documentation guide

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 output module AQ 4xI HART HF

The following table lists additional documentation that you require for using the analog output module.

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

2.1 Properties

Article number

6ES7135-6TD00-0CA1

View of the module

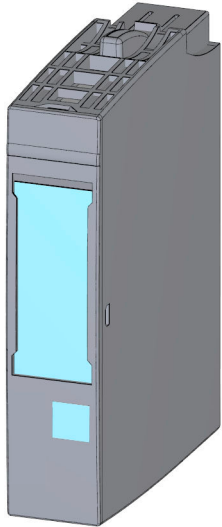


Figure 2-1 View of the AQ 4xI HART HF module

Properties

The module has the following technical properties:

- Analog output module with 4 outputs
- Current output in output ranges 0 to 20 mA, 4 to 20 mA and 4 to 20 mA HART
- Resolution 16 bits including sign
- Channel-specific configurable diagnostics

The module supports the following functions:

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

2.1 Properties

- 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/GSDML 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 (<https://support.industry.siemens.com/cs/ww/en/view/91696622>) system manual.

Wiring up

3.1 Connection and block diagram

The AQ 4xI HART HF analog module can be used with all BaseUnits of the type A0 or A1.

You connect the final controlling elements to the BaseUnit of the analog module. The infeed of the supply voltage on the light BaseUnit of the associated potential group supplies the module and the final controlling elements.

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.

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

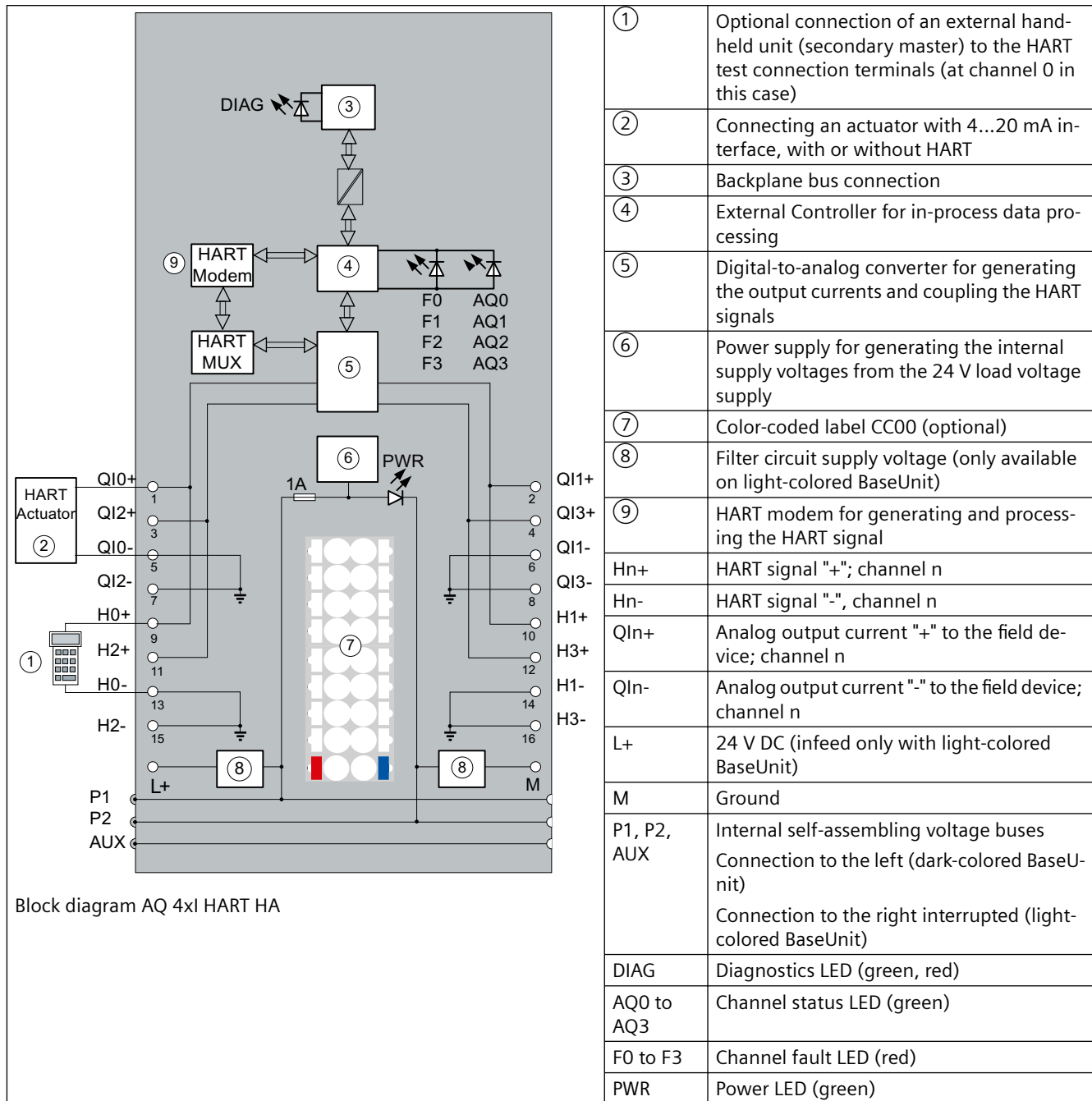
You can find information regarding selection of the suitable BaseUnit in system manual ET 200SP distributed I/O system (<http://support.automation.siemens.com/WW/view/en/58649293>) and in the equipment manual ET 200SP BaseUnits (<http://support.automation.siemens.com/WW/view/en/59753521>).

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



Note

Parallel connection of the outputs to increase the power is not permitted.

Each actuator must be connected separately to the corresponding terminals (QIn+ and QIn-) (no common cable routing).

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.

3.1 Connection and block diagram

HART function

Definition

"HART" stands for "Highway Addressable Remote Transducer". The HART protocol is a standardized communication protocol for communication with the suitable field devices over a bus system.

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 AQ 4xI HART analog module provides you the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- The AQ 4xI HART analog module is an interface between the S7 system and HART devices
- Communication using the HART protocol
- Communication to field devices with HART functions

Use in the system

The AQ 4xI HART analog module is used in the distributed I/O that is connected to PROFIBUS-DP or PROFINET IO.

You can connect a HART field device to any channel:

- The AQ 4xI HART analog module operates as a HART master, monodrop;
- the HART 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.

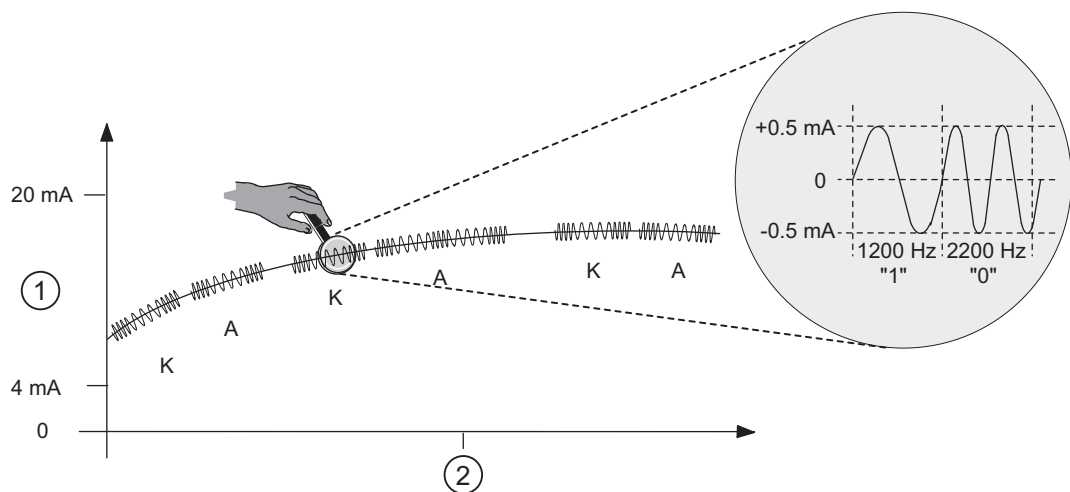


Figure 4-1 The HART signal

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

HART communication

The AQ 4xI HART analog module processes the HART communication in multiplex mode, i.e. one channel after the other. 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. For each channel, commands are always sent time about with any pending external HART commands that are received over the command interface of the module, see section "HART communication interface (Page 24)".

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.)
9	For field devices starting from HART Rev. 7, read up to four pre-defined dynamic variables (primary variable, secondary variable, 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

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.

Table 4-3 Structure of the HART protocol

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK
Key:							
PREAMBLE:	Bytes (0xFF) for synchronizing.					5 to 20 bytes depending on parameter assignment	
STRT:	Start character (start delimiter)					1 byte	
ADDR:	Addresses of the field device					1 byte; short address or 5 bytes; long address	
COM:	HART command number					1 byte	
BCNT:	Byte count, number of bytes to follow without checksum					1 byte	
STATUS:	HART device status. Only present for a response frame. see following tables "Structure of HART device status"					1st and 2nd status bytes	
DATA:	Transferred user data / parameters, quantity depending on command					0 ... 230 bytes	
CHK:	Checksum					1 byte	

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 64).

HART replies always contain data. Together with a HART response, the HART device status (1st and 2nd status bytes) is sent. Always evaluate the HART device status. If no error is pending, the HART response is correct.

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

Table 4-4 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 4-5 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 AQ 4xI HART analog module supports processing 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 24)

Note

- During the time a HART channel of the AQ 4xI 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 AQ 4xI 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 to 20 mA
Connection of the field device to the analog module AQ 4xI HART
- **HART system integration:**
The analog module takes on the function of a "master" by receiving commands from the HART configuration tool or programmed from an S7 user program, for example, forwarding them to the smart field device and returning the responses. The interface of the analog module represents data records that are transferred via the ET 200SP I/O bus. The data records must be created and interpreted by the client.
- **HART parameter assignment tool "Client":**
You can assign the HART parameters using an external hand-held operating device (HART Hand-held) or a HART configuration tool (PDM). Both assume the function of a "client". The parameter assignment tool affects the entire analog module; the HART handheld is connected in parallel to the field device. See pin assignment "HART test connections (terminals 9 to 16)" in the section "Connection and block diagram (Page 13)". PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.

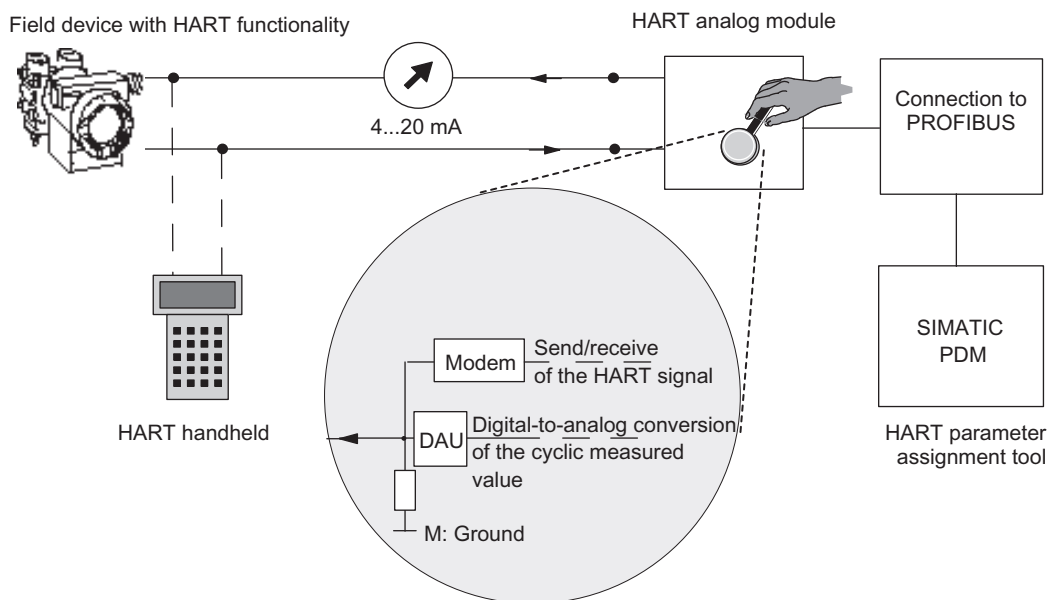


Figure 4-2 System environment for the use of HART

Error management

The two HART status bytes (HART device status) that are transferred with each field device response contain error statements about HART communication, HART command and device status.

These statements are evaluated by the analog module and provided in the system via S7 diagnostics messages.

Configuration/commissioning

You can configure the 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 output and the use of the HART variables in the input address space of the module.

You can configure one field device per channel. The configuration/parameter assignment of the connected field device is then carried out from this configured field device using PDM or the EDD for the ET 200SP.

The analog module can also be configured via a GSD file, both for PROFIBUS DP and PROFINET IO. However, in this case and with the TIA Portal, 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 HART 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 "Diagnostics alarms (Page 44)". 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.

4.3 HART communication interface

Data records

The HART commands are sent over data records to the connected field device as "external HART jobs" from the client (e.g. PDM or the STEP 7 user program). 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 analog module AQ 4xI HART does not support client management.

Each client/channel is allocated fixed data records:

Table 4-6 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. If this condition is not fulfilled, 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 a set SHC bit is sent to the module, this channel is reserved for 2 seconds for HART commands. That is, if the module detects a HART command with SHC bit set for a channel, the complete HART interface of the analog module is reserved for this channel for approximately 2 seconds. There is no processing of internal HART requests, and there is no HART command processing for all other channels of the analog module during this time.

Each time a HART command with a set SHC bit is sent, the analog module reserves this channel again for another 2 seconds for HART commands. If a HART command without SHC bit set is detected for this channel or if no other command for this channel occurs within 2 seconds after the previous HART command, the analog module returns to "normal" HART operation. This means all HART channels are processed again.

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 62).

In addition, a maximum of 4 HART variables can be configured directly in the input address space of the AQ 4xI 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 Parameter assignment and structure of the HART mapping parameters (Page 59). This allows you to easily work with process 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. When configuring, you select these from the four HART variables provided by each channel:

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

When HART mode is enabled, the analog module cyclically reads the variables provided by the connected field devices independently and makes them available in the configured input address space. You specify during parameter assignment which variables are supplied by a field device.

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 analog module are based on 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)	Note
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
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)	Note
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"	
88 _H ...8B _H	"More device variable state 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

5.1 Parameters of AQ 4xI HART

You define the functioning of the Q 4xI HART analog module via parameters.

The parameters are subdivided into:

- Channel/ 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 57).

5.1.1 Channel/technology parameters

Parameters of AQ 4xI HART

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	Configura- tion in RUN	Effective range with configura- tion software, e.g. STEP 7 (TIA Portal)	
				GSD file ¹⁾ PRO- FINET IO	GSD file ¹⁾ PROFIBUS DP
Diagnostics No supply voltage L+	• 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⁾
Diagnostics, Wire break	• Disable • Enable	Disable	Yes	Channel	Module ²⁾

5.1 Parameters of AQ 4xI HART

Parameter	Value range	Default	Configura- tion in RUN	Effective range with configura- tion software, e.g. STEP 7 (TIA Portal)	
				GSD file ¹⁾ PRO- FINET IO	GSD file ¹⁾ PROFIBUS DP
Diagnostics, Short-circuit	- Disable - Enable	Disable	Yes	Channel	Module ²⁾
Diagnostics HART	- Disable - Enable	Disable	Yes	Channel	Module ²⁾
Output type/range	- Disabled - Current 0..20 mA - Current 4..20 mA - Current 4..20 mA HART	Current 4..20 mA HART	Yes	Channel	Channel
Reaction to CPU STOP	- Switch off - Keep last value - Output substitute value	Switch off	Yes	Channel	Module ²⁾
Substitute value	The value range depends on the set output range. The substitute value must be in the nominal range or in the over-range/underrange.	0	Yes	Channel	Channel
Number of HART preamble bytes	0 ³⁾ ; 5...20; 255	5	Yes	Channel	Cannot be changed ²⁾
Number of HART repetitions	0...10	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⁾ GSD file/GSDML file

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, configuration is performed via data record 245. If necessary, you can set these parameters via data record 128 as described in the "GSD file PROFINET IO" column (see table above).

³⁾ 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.

Note**Unused channels**

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.
A disabled channel always returns the output value 0 mA.

See also

Parameter assignment and structure of the channel/technology parameters (Page 57)

5.1.2 Explanation of the channel/technology parameters

Output type/range

The analog module has the following output ranges:

Table 5-2 Output range

Type of output	Output range	Resolution
Disabled	-	-
Current	0 to 20 mA	16-bit including sign
Current	4 to 20 mA	16-bit including sign
Current	4 to 20 mA HART	16-bit including sign

An overview of the output range, overflow and overrange etc. can be found in the appendix "Analog value display (Page 70)".

Settling time dependent on the activation of HART communication

You can find the settling time without HART communication (x ms) in section "Technical specifications of the AQ 4xI HART (Page 47)".

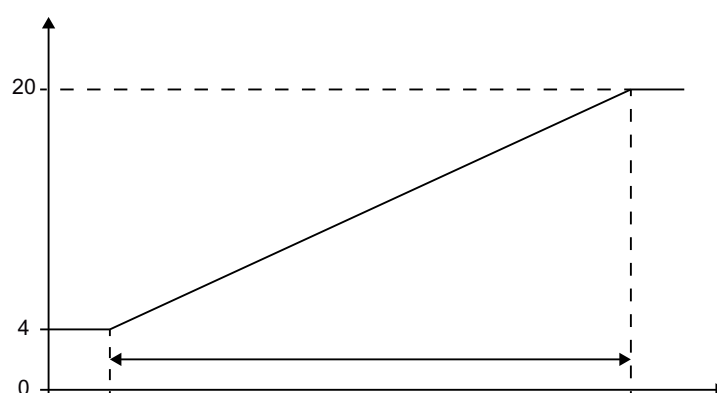


Figure 5-1 Example diagram of settling time without HART communication

If HART communication is activated for the output range, the settling time of the output values can vary (max: 50 ms).

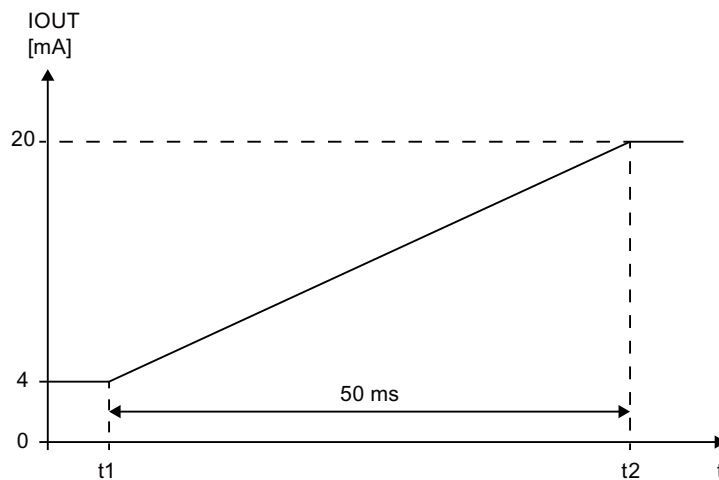


Figure 5-2 Example diagram of settling time with HART communication

Diagnostics no supply voltage L+

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

Diagnostics, Wire break

Enabling of the diagnostics if the analog module does not detect any current flow.

Monitoring is effective from an output current of $\geq 240 \mu\text{A}$.

If the output current drops below $240 \mu\text{A}$ when the "Wire break" diagnostics message is pending, the diagnostic message cannot be canceled until the output current is set above $240 \mu\text{A}$ again and the error has been eliminated.

Diagnostics, Short-circuit

Short-circuit detection is possible for all current output ranges (short-circuit of output QI_{n+} to QI_{n-}).

Monitoring is effective from an output current of at least 1 mA .

The diagnostics short-circuit applies from a connected load of $< 20 \Omega$. From a load of $> 30 \Omega$ the short-circuit is reported as outgoing again.

Diagnostics overflow

Enable diagnostics.

- The event is signaled when the output value violates the overrange.
- The current output is limited to the end of the overrange if the overrange is violated.

Diagnostics underflow

Enable diagnostics.

- The event is signaled when the output value violates the underrange.

Diagnostics HART

Enable the following diagnostics:

- HART frame-specific monitoring
- Status information provided by the connected field device in the HART frame (HART device status).

Number of HART repetitions

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

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. This means the other channels are processed less frequently.

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 to synchronize the frames.

Reaction to CPU STOP

Determines the reaction of the analog module to CPU STOP or to failure of communication between the interface module and CPU.

Substitute value

The substitute value is output by the module at CPU STOP if you set the "Reaction to CPU STOP" parameter to "Substitute value".

The substitute value must not exceed the overrange and must not fall below the underrange.

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 mode, faulty HART frames affect the other channels when the number of HART repetitions is high. This means 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>)).

5.1.3 HART mapping parameters

A maximum of 4 HART variables can be configured (mapped) to the address space of the module with the HART mapping parameters.

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 allocated (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 Parameter assignment and structure of the HART mapping parameters (Page 59).

Parameters

Table 5-3 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PRO-FIBUS DP
Variable 0	Channel	0...3	0	Yes	0
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary
Variable 1	Channel	0...3	0	Yes	1
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary

Parameter		Value range	Default	Configuration in RUN	With GSD file PRO-FIBUS DP
Variable 2	Chan-nel	0...3	0	Yes	2
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary
Variable 3	Chan-nel	0...3	0	Yes	3
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary

5.1 Parameters of AQ 4xI HART

Configuring/address space

6.1 Configuring

You can configure the AQ 4xI HART analog output module

- in TIA Portal as of V15.1 (HSP0283), otherwise as of TIA Portal V16
- With STEP 7 V5.6 + 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 ("AQ 4xI HART")
- Without value status, with HART variables ("AQ 4xI HART, 4 variables")
- With value status, without HART variables ("AQ 4xI HART, QI")
- With value status, with HART variables ("AQ 4xI HART, 4 variables, QI")

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

With STEP 7 configuration (TIA Portal or HW Config), the configuration occurs 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 V15.1
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 V15.1
The module can be configured as an open controller.
 - The module cannot be used behind fail-safe controllers.

6.2 Address space

The following tables shows the mapping of the address space of the AQ 4xI HART analog output module for a configuration **with** value status (Quality Information, QI) and **with** HART variables.

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QAQn" stands for value status (QI) of the analog output n
- "QC" stands for Quality Code

Address space

The following tables show the allocation of the address space of the I/O module.

- The addresses for the value status are only available if the value status has been enabled or configured.
- The addresses for the HART variables are only available if the HART variables have been configured or parameterized.

Evaluating the value status

If you enable the value status for the analog output module, an additional byte is occupied in the input address space. This additional byte offsets the HART range by one byte. 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.

There is one bit value status for each analog output in the input address space.

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Generally, the value status is set to "good" if the analog value can be output without errors. The value status is set to "bad" in the following cases:

- The analog value cannot be output due to an error.
- The analog output is deactivated.
- The substitute value is output at the analog output.

Evaluating HART variables

If you have configured (mapped) HART variables for the analog output 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 26) .

The assigned HART variables are automatically updated by the I/O module and can be used directly in the user program.

Input area

If the HART variables are configured or parameterized, then HART variables begin directly after the value status, i.e. from IB x + 1.

IB x +	Meaning							
0 *	-	-	-	-	QAQ3	QAQ2	QAQ1	QAQ0
1	HART range							
:								
:								

* This additional byte offsets the HART range by one byte.

The structure of the HART range is dependent on the configuration:

- With the configuration with 4 variables, the range is 20 bytes long and always contains 4 HART variables, each with 4 bytes value and a byte quality code.

Table 6-1 HART range: Configuration

IB x +	HART range	
1 : 4	Value	Configured HART variable 0
5	QC	
6 : 9	Value	Configured HART variable 1
10	QC	
: : :		
16 : 19	Value	Configured HART variable 3
20	QC	

Output range

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)
4...5	Analog value of analog output 2 (AQ2)
6...7	Analog value of analog output 3 (AQ3)

Interrupts/diagnostics alarms

7.1 Status and error displays

LED displays

The following figure shows the status and error displays of the AQ 4xI HART analog output module.

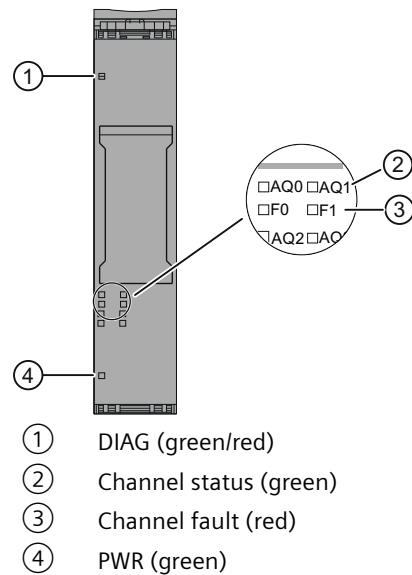


Figure 7-1 LED displays

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 44).

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

7.1 Status and error displays

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

System response (channel LED, error LED and PWR LED switch off briefly).

If all the grounds of the channels are drawn simultaneously (e.g. common ground wiring), the channel LED, the error LED and the PWR LED switch off briefly.

7.2 Interrupts

The AQ 4xI HART analog output module supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt for the following events:

- Channel/component temporarily unavailable
- Short-circuit
- Wire break
- Low limit violated
- High limit violated
- No supply voltage L+
- HART communication error or HART field device error
- Overtemperature
- Parameter assignment 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 processing during this time	- Restart firmware update - Wait for firmware update
Short-circuit	1 _H	Short-circuit of cable to the actuator or impedance too low	- Correct process wiring - Check connected final controlling element
Overtemperature	5 _H	- Ambient temperature is too high - Total current of the analog outputs too high - Short-circuit of one or more analog outputs	- Check wiring - Check the ambient condition
Wire break	6 _H	- Wire break between the module and actuator - Channel not connected (open)	- Connect the cable - Disable diagnostics
High limit violated	7 _H	The analog value is above the over-range.	Correct the output value
Low limit violated	8 _H	The analog value is below the under-range.	Correct the output value
Parameter assignment error	10 _H	Incorrect parameter assignment	Correct the parameter assignment
No supply voltage	11 _H	No or insufficient supply voltage L+	- Check wiring of the supply voltage L+ on the BaseUnit - Check BaseUnit type
HART communication error	141 _H	- HART field device is not responding - Timing error - HART field device did not understand the command that was sent (1st status byte)	- Check the process wiring - Correct the parameter assignment - Set current ≥ 4 mA - Increase the number of assigned repetitions

Diagnostic alarm	Error code	Meaning	Remedy
HART primary variable outside range	142 _H	- Incorrect parameters in the HART field device - HART field device is set to "Primary variable outside of limits" in simulation mode - Primary variable assigned outside the limits	- Check the parameter assignment of the HART device - Correct the simulation - Check if the correct field device is connected
HART output current 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 too high a measured value in simulation mode	
HART fixed analog output current	144 _H	- The output current of the HART field device is fixed: - Incorrect parameters in the HART field device - HART field device is set to too high a measured value in simulation mode	
HART secondary variable outside the limits	149 _H	- Incorrect parameters in the HART field device - HART field device is set to "Non-primary variable outside the limits" in simulation mode - 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
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

Technical specifications

8.1 Technical specifications of the AQ 4xI HART

Technical specifications

Article number	6ES7135-6TD00-0CA1
General information	
Product type designation	AQ 4xI HART HF
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 SP1
• STEP 7 configurable/integrated as of version	V5.6 and higher
• PCS 7 configurable/integrated as of version	V9.0 SP1
• PROFIBUS as of GSD version/GSD revision	V04.02.14
• PROFINET as of GSD version/GSD revision	GSDML V2.34
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 (rated value)	115 mA
Current consumption, max.	125 mA
Power loss	
Power loss, typ.	1.7 W
Address area	
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 outputs	

8.1 Technical specifications of the AQ 4xI HART

Article number	6ES7135-6TD00-0CA1
Number of analog outputs	4
Current output, no-load voltage, max.	28 V
Cycle time (all channels), min.	3 ms
Output ranges, current	
• 0 to 20 mA	Yes; 16 bit incl. sign
• -20 mA to +20 mA	No
• 4 mA to 20 mA	Yes; 16 bit incl. sign
Connection of actuators	
• for current output two-wire connection	Yes
Load impedance (in rated range of output)	
• with current outputs, max.	750 Ω
• with current outputs, inductive load, max.	10 mH
Destruction limits against externally applied voltages and currents	
• Voltages at the outputs	30 V
Cable length	
• shielded, max.	800 m
Settling time	
• for resistive load	2 ms; 750 ohm
• for capacitive load	2 ms
• for inductive load	2 ms
Errors/accuracies	
Output ripple (relative to output range, band-width 0 to 50 kHz), (+/-)	0.02 %
Linearity error (relative to output range), (+/-)	0.03 %
Temperature error (relative to output range), (+/-)	0.003 %/K
Crosstalk between the outputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.03 %
Operational error limit in overall temperature range	
• Current, relative to output range, (+/-)	0.3 %; 0 ... 60 °C: 0.2 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to output range, (+/-)	0.1 %
Protocols	
HART protocol	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes; Module-wise

Article number	6ES7135-6TD00-0CA1
- Wire-break - Short-circuit - Overflow/underflow	Yes; channel by channel Yes Yes; channel by channel
Diagnostics indication LED	
- Monitoring of the supply voltage (PWR-LED) - Channel status display - for channel diagnostics - for module diagnostics	Yes; green PWR LED Yes; Green LED Yes; Red LED Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
- between the channels - between the channels and backplane bus - Between the channels and load voltage L+	No Yes Yes
Permissible potential difference	
between different circuits	60 V DC/30 V AC
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
- horizontal installation, min. - horizontal installation, max. - vertical installation, min. - vertical installation, max.	-30 °C 60 °C -30 °C 50 °C
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>)

8.2 Standards and Approvals

8.2.1 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:
--

- | |
|--|
| <ul style="list-style-type: none">• 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, the suitability for Class I, DIV. 2 becomes 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.

8.2.2

CCC approval



Certificate: 020322310003113

Ex nA IIC T4 Gc

According to the following standards:

- GB 3836.1-2010 (Explosive atmospheres - Part 1: Equipment - General requirements)
- GB 3836.8-2014 (Explosive atmospheres-Part 8: Equipment protection by type of protection "n")

8.2.3

UKCA approval



DEKRA 21UKEX0020 X

Importer UK:

Siemens plc

Manchester M20 2UR

8.2.4 cULus approval



Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA/ CAN 61010-2-201 (Process Control Equipment)

8.2.5 cULus HAZ. LOC. approval



Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA / CAN 61010-2-201 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

8.2.6 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.

8.2.7 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.

8.2.8 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

Appendix

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 34 bytes and contains the channel or technology parameters of all four channels, each 8 bytes per channel.

The parameters are divided into parameters which influence the actual analog value output, diagnostic enables and basic parameters of the 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 63).

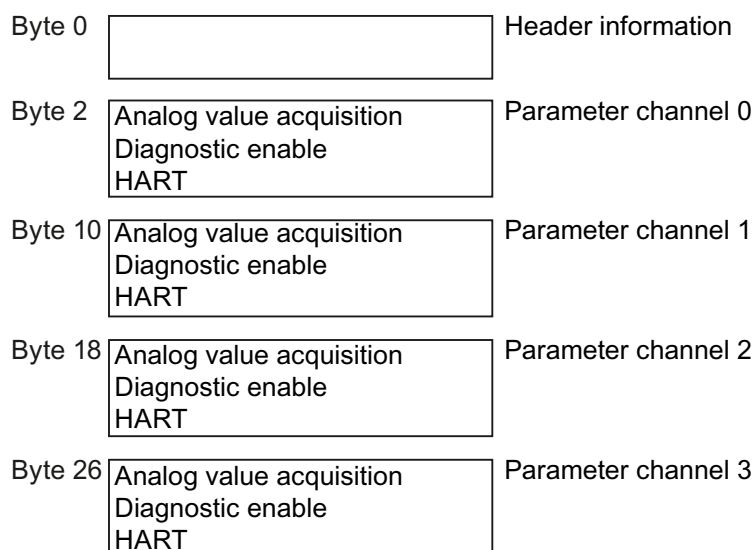


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

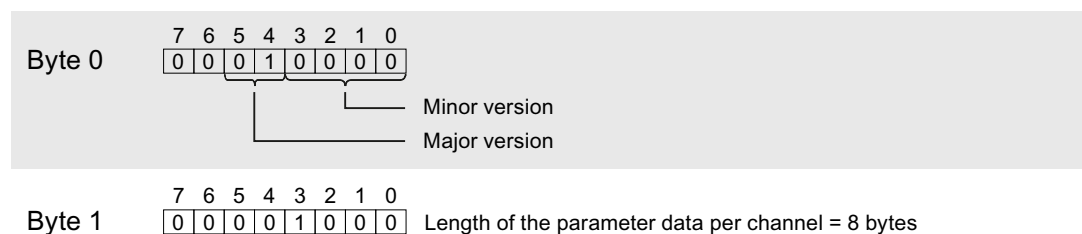
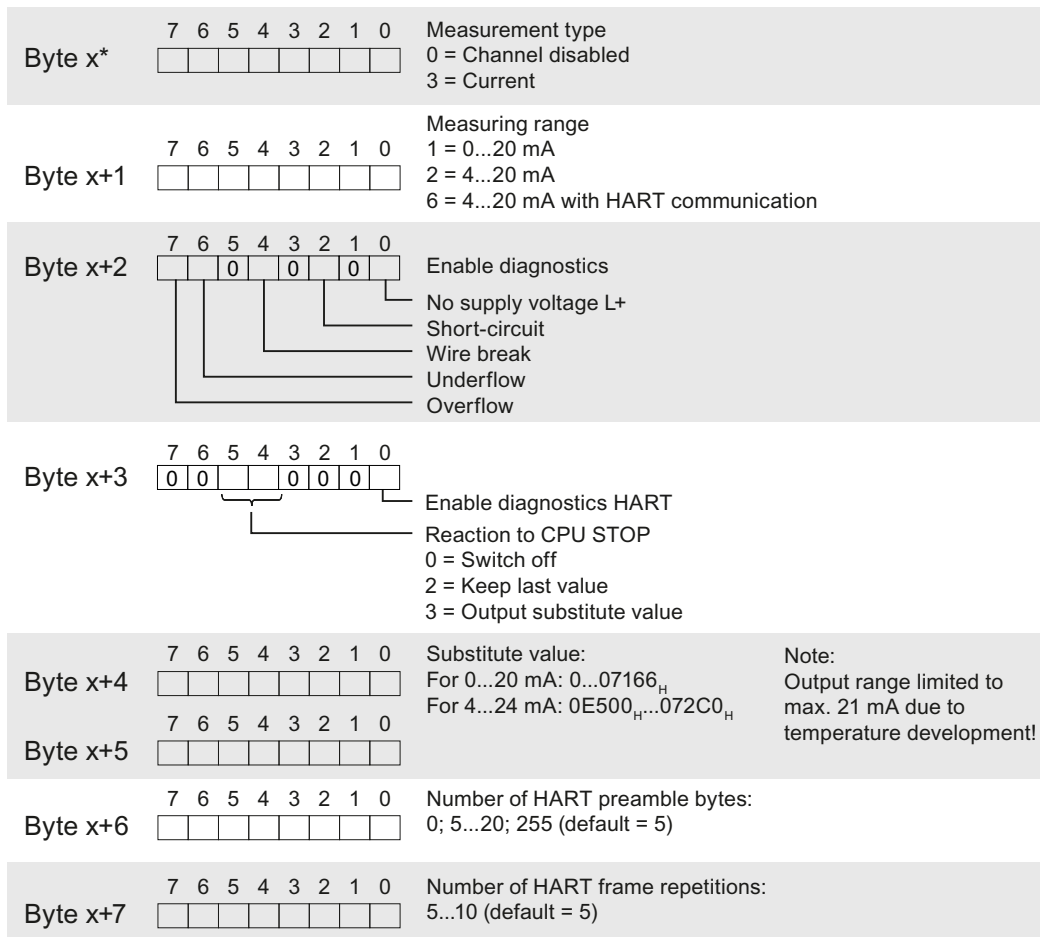


Figure A-2 Header information

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.



* $x = 2 + (\text{channel number} * 8)$; with channel number 0...3

Figure A-3 Structure byte x to x+33 for channels 0 to 3

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

Structure of data record 140

Data record 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 37)".

Header information

The figure below shows the structure of the header information.

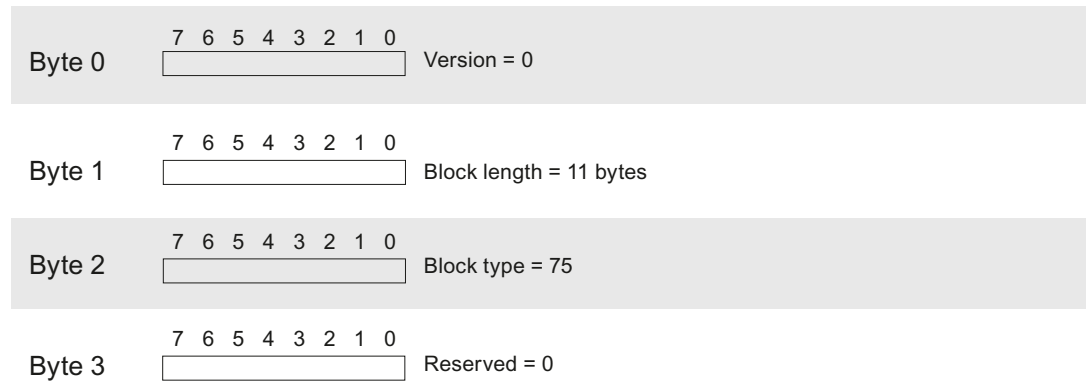
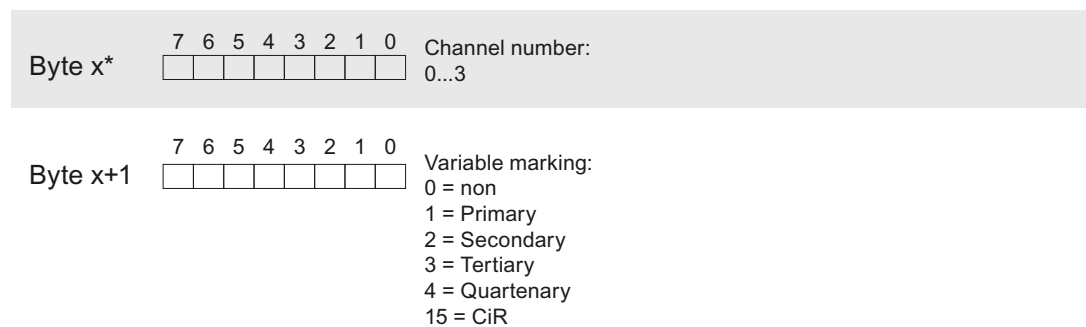


Figure A-4 Header information

Parameters

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



* $x = 4 + (\text{HART variable} * 2)$; with HART variable 0...3

Figure A-5 Parameters

Note

Memory area allocation

- HART variables set to 0 = "non"
If all four HART variables are set to 0 = "non", no memory area for HART variables is reserved/allocated in the input address area.
- HART variable set as not equal to 0
If at least one HART variable is not set to 0, then the complete memory area of the four HART variables in the input address space is always allocated.
All HART variables set to 0 = "non" are automatically preset to 15 = "CiR" (0 = "non" is inadmissible).

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
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)

Byte	Meaning	Comment
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	= 230 (maximum length of the HART request data records)

A.2.3 HART variable data record

The AQ 4xI HART analog module supports a maximum of 4 HART variables per channel. Provided they are supported by the connected field device, these variables are ready cyclically. These 16 HART variables are made available as readable variables in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a quality code byte. See section "HART variables (Page 26); "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	Quaternary (QV)
19	Quality code	

Byte	Meaning
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 the standard parameter assignment (see section "Parameter assignment and structure of the channel/technology parameters (Page 57)").

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 repetitions (0 ... 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	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 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. 1 = Compact format
		Bit 6: 1 = Activate SHC mode Execution of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section "HART communication interface (Page 24)"; SHC sequence.
		Bit 7: 0 = HART request
1	Number of preamble bytes	0.5...20, 255 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 63)).
3...239	Communication data according to HART specification	

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

In case of response error

Byte	Meaning	Comment
0	Response control	See table below: Coding "Response control":
1	HART group error display	See table below: Coding "HART group error display"
2	Protocol error	
3...239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data" see table below: Coding "HART protocol error during response"

In case of response error

Byte	Meaning	Comment
0	Response control	See table below: Coding "Response control":
1	HART group error display	See table below: Coding "HART group error display"
2...239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data" see table below: Coding "HART protocol error during response"

Coding "Response control":

Bits 0-2:	Response Result (processing status):	
	0 = Inactive	4 = Successful, with data
	1 = Inactive (reserved)	5 = Successful, without data
	2 = Waiting	6 = Incorrect, with data
	3 = Waiting, executing	7 = Incorrect, 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)	

A.2.6 Example of HART programming (HART command interface)

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 AQ 4xI 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
<pre> U E 4.0 FP M 101.0 = M 104.0 m2: CALL SFC 58 REQ :=M104.0 IOID :=B#16#54 LADDR :=W#16#200 RECNUM :=B#16#50 RECORD :=P#DB80.DBX0.0 BYTE 11 RET_VAL :=MW93 BUSY :=M51.0 A M 51.0 SPB m2 BE </pre>	Write request Address range identifier Module address Data record number 80 Data record with length 11 bytes (must correspond exactly to the length that is to be transmitted) RET_VAL from SFC 58 (OK/error/...) Write operation is not finished yet

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 (0.05 ... 14,FF)
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 (0.05 ... 14,FF)
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.

FC81: Reading of the response to DB81 with SFC 59

STL	Explanation
<pre> m3: CALL SFC 59 REQ :=1 IOID :=B#16#54 LADDR :=W#16#200 RECNUM :=B#16#51 RECORD :=P#DB81.DBX0.0 BYTE 75 RET_VAL :=MW100 BUSY :=M49.1 A M 49.1 m3 BE </pre>	<pre> Read request Address range identifier Module address for HART AI Data record number 81 Data record RET_VAL from SFC 59 (OK/error/...) Read operation is not finished yet </pre>

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 display

In the following tables, you can find the digitized representation of the unipolar output ranges.

Display of analog value of current output ranges:

- Analog value display in the current output range 0 to 20 mA (Page 70)
- Analog value display in the current output range 4 to 20 mA (Page 70)

A.3.1 Analog value display in the current output range 0 to 20 mA

The following table shows you the decimal and hexadecimal values (codes) in the current output range 0 to 20 mA. The resolution is 16-bit including sign.

Analog value display

Table A-3 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow
-118.519%	-32768	8000		

A.3.2 Analog value display in the current output range 4 to 20 mA

The following table shows you the decimal and hexadecimal values (codes) in the current output range 4 to 20 mA. The resolution is 16-bit including sign.

Analog value display

Table A-4 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29377	72C1		

Values			Current output range	Range
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	4 mA – 578.7 nA	Underrange
-25%	-6912	E500	0 mA	Underflow
	-6913	E4FF	0 mA	
-118.519%	-32768	8000		

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

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