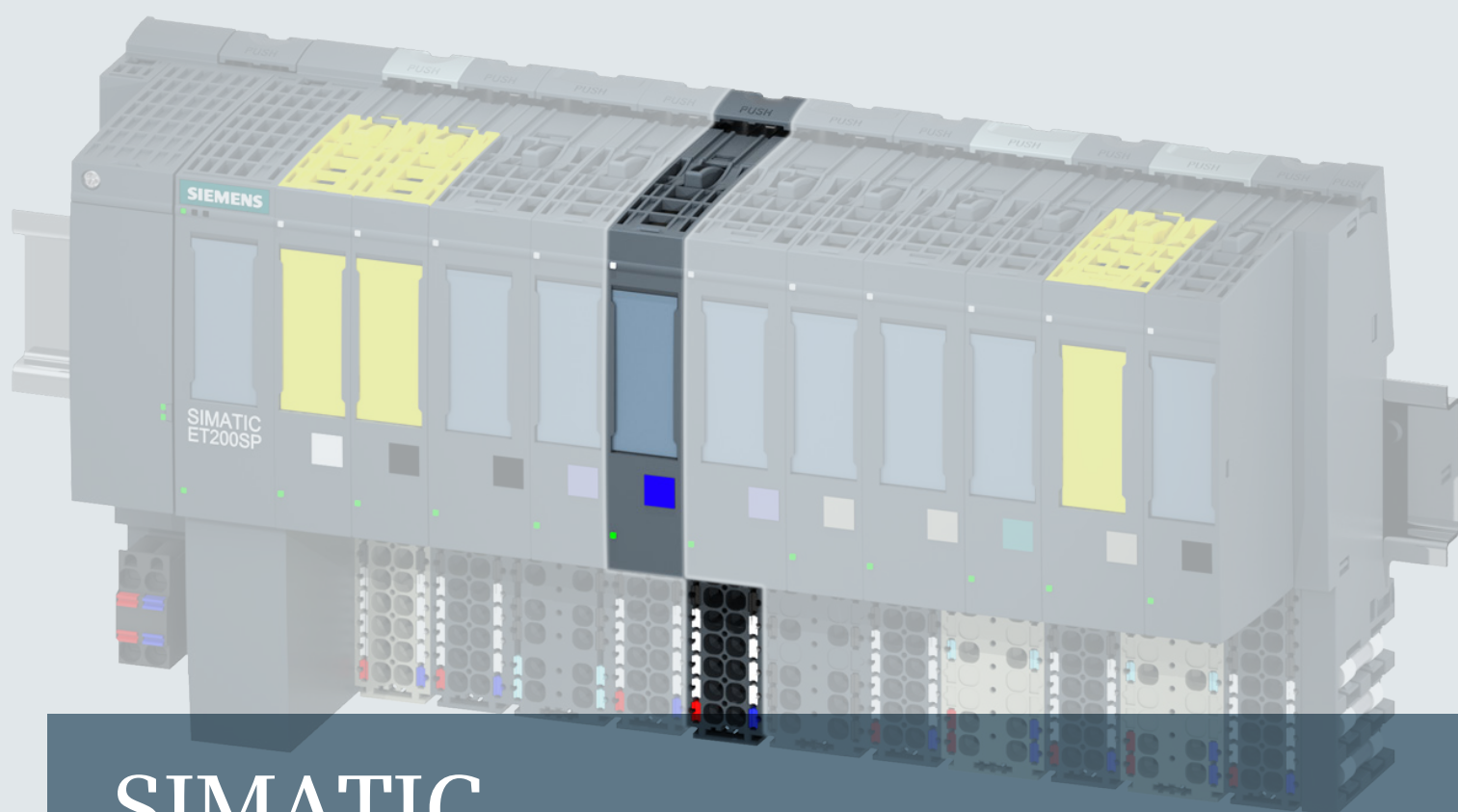


SIEMENS



SIMATIC

ET 200SP

Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)

Manual

Edition

02/2014

Answers for industry.

SIEMENS

SIMATIC

ET 200SP

Analog output module

AQ 2xU/I HF

(6ES7135-6HB00-0CA1)

Manual

Preface

Guide to documentation

1

Product overview

2

Wiring

3

Parameters/address space

4

Interrupts/diagnostics alarms

5

Technical specifications

6

Parameter data record

A

Representation of analog
values

B

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.

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

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

Qualified Personnel

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

Proper use of Siemens products

Note the following:

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

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

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

Preface

Purpose of the documentation

This device manual complements 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.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (<http://www.siemens.com/industrialsecurity>).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (<http://support.automation.siemens.com>).

Table of contents

	Preface	3
1	Guide to documentation	5
2	Product overview	7
	2.1 Properties	7
3	Wiring	9
	3.1 Pin assignment.....	9
	3.2 Block diagram	10
4	Parameters/address space	11
	4.1 Output type and output ranges	11
	4.2 Parameters.....	12
	4.3 Explanation of parameters	14
	4.4 Address space	15
5	Interrupts/diagnostics alarms.....	16
	5.1 Status and error displays	16
	5.2 Interrupts	18
	5.3 Diagnostics alarms.....	19
6	Technical specifications	20
A	Parameter data record	24
	A.1 Dependencies when configuring with GSD file	24
	A.2 Parameter assignment and structure of parameter data record	25
B	Representation of analog values	29
	B.1 Representation of output ranges.....	30
	B.2 Representation of analog values in the voltage output ranges.....	31
	B.3 Representation of analog values in the current output ranges	32

Guide to documentation

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP distributed I/O system consists of a system manual, function manuals and product manuals.

The STEP 7 information system (online help) also supports you during the configuration and programming of your automation system.

Overview of documentation for analog output module AQ 2×U/I HF

The following table shows additional documentation that you need when using the AQ 2×U/I HF analog output module.

Table 1- 1 Documentation for the analog output module AQ 2×U/I HF

Topic	Documentation	Key contents
System description	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Wiring • Commissioning
Designing interference-free controllers	Function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog value processing	Function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, installation technology) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Diagnostics evaluation of hardware/software

Topic	Documentation	Key contents
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications
Amendments and special features of the ET 200SP distributed I/O system	Product information on documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864)	Current information not yet documented in the system manuals, function manuals, or product manuals.

SIMATIC manuals

All current manuals for SIMATIC products are available to download free of charge on the Internet (<http://www.siemens.com/simatic-tech-doku-portal>).

Product overview

2.1 Properties

Article number

6ES7135-6HB00-0CA1

View of the module

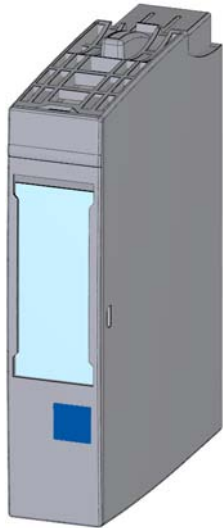


Figure 2-1 View of the module AQ 2xU/I HF

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
- Resolution: Up to 16 bits including sign
- Voltage output can be set for each channel
- Current output can be set for each channel
- Configurable diagnostics for each channel

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Calibration in runtime
- Isochronous mode (PROFINET IO only)
- Value status (PROFINET IO only)

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

Accessories

The following accessories must be ordered separately:

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

See also

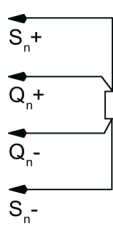
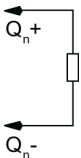
For more information on accessories, refer to the system manual ET 200SP distributed I/O system (<http://support.automation.siemens.com/WW/view/en/58649293>).

Wiring

3.1 Pin assignment

General pin assignment

Table 3- 1 Pin assignment for AQ 2×U/I HF

Pin assignment for AQ 2×U/I HF (6ES7135-6HB00-0CA1)						
Terminal	Assign- ment	Terminal	Assign- ment	Notes	BaseUnits ¹	Color identification label
1	Q ₀ +	2	Q ₁ +	- Q_n+: Analog output voltage/current (positive), channel n - Q_n-: Analog output voltage/current negative, channel n - S_n+: Sensor line positive, channel n - S_n-: Sensor line negative, channel n - RES: Reserved; not connected	A0, A1	–
3	RES	4	RES			
5	Q ₀ -	6	Q ₁ -			
7	RES	8	RES			
9	S ₀ +	10	S ₁ +			
11	RES	12	RES			
13	S ₀ -	14	S ₁ -			
15	RES	16	RES			
L+	24 VDC	M	M			
Voltage 2-wire connection 				Voltage 4-wire 		Current 

¹ Usable BaseUnit types, can be identified by the last two digits of the article number. See also "ET 200SP distributed I/O system" system manual.

Note

The first BaseUnit of a station must be a light-colored BaseUnit. Keep this in mind also during the configuration.

See also

ET 200SP distributed I/O system
<http://support.automation.siemens.com/WW/view/en/58649293>

3.2 Block diagram

Block diagram

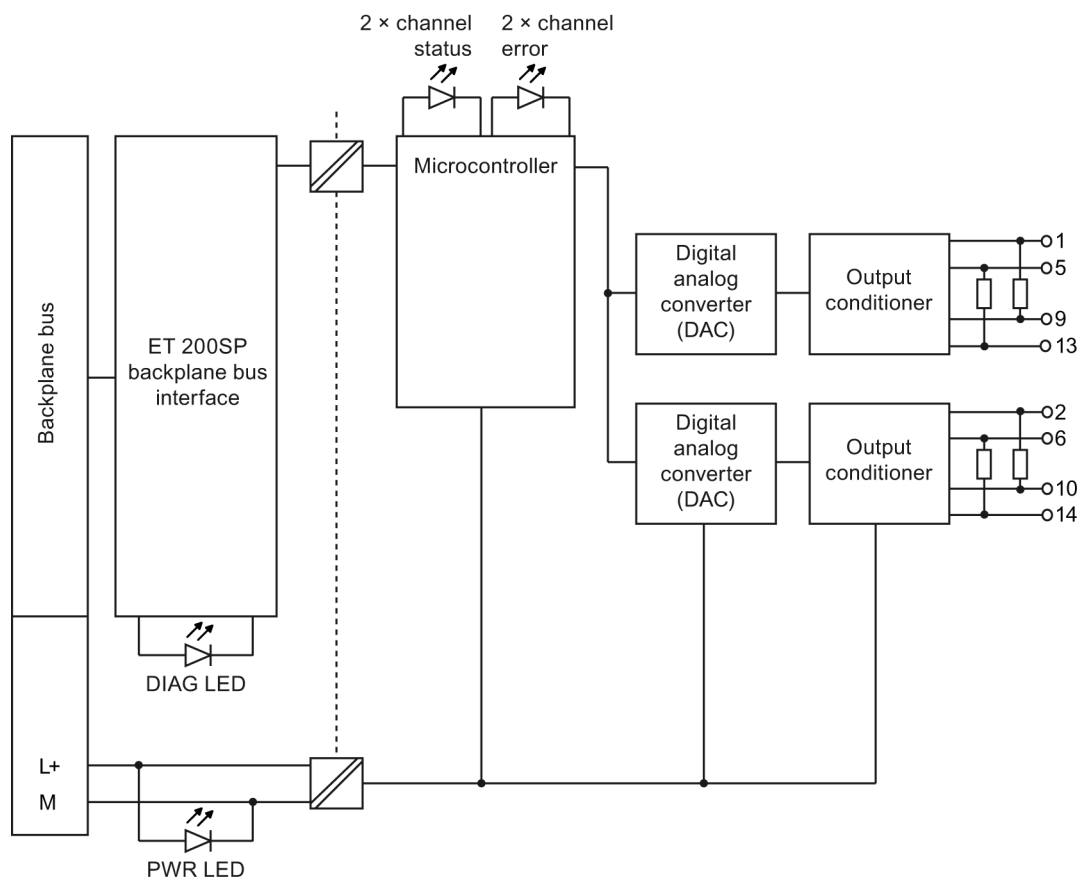


Figure 3-1 Block diagram of AQ 2xU/I HF

Parameters/address space

4.1 Output type and output ranges

The following table shows the output type and the respective output ranges.

Table 4- 1 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA	16 bit including sign
	0 to 20 mA	15 bit
	4 to 20 mA	14 bit
Voltage	± 10 V	16 bit including sign
	± 5 V	15 bit including sign
	0 to 10 V	15 bit
	1 to 5 V	13 bit

You can find the tables of output ranges and overflow, overload, etc. in the section Representation of analog values (Page 30) and in the function manual Analog value processing (<http://support.automation.siemens.com/WW/view/en/67989094>).

4.2 Parameters

Parameters of the AQ 2xU/I HF

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

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

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of parameter data record (Page 25).

The following parameter settings are possible:

Table 4- 2 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP ³
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground ¹	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow ³	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Underflow ³	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break ²	• Disable • Enable	Disable	Yes	Channel	Channel
Output type/range	• Deactivated • Voltage ± 10 V • Voltage ± 5 V • Voltage 0..10 V • Voltage 1..5 V • Current ± 20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	Yes	Channel	Channel

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP ³
Reaction to CPU STOP ³	- Turn off - Keep last value - Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various measuring ranges, see device manual AQ 2xU/I HF, Substitute values → Codes for substitute value table	0	Yes	Channel	Channel
Potential group	- Use potential group of the left module - Enable new potential group	Use potential group of the left module	No	Module	Module

¹ No diagnostics detection between -0.5 and +0.5 V (no short-circuit detection)

² No diagnostics detection between -3 and +3 mA (no wire break detection)

³ Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 8 bytes.

Note

Unused channels

"Deactivate" the unused outputs in the parameter assignment.

A deactivated output always returns the value "no current or voltage".

4.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

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

Diagnostics: Underflow

Enabling of the diagnostics when the output value falls below the underrange or reaches the minimum output value or underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

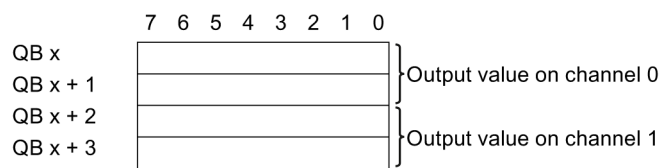
Specifies that a BaseUnit with incoming voltage supply is located on this slot (see system manual ET 200SP distributed I/O system (<http://support.automation.siemens.com/WW/view/en/58649293>)).

4.4 Address space

Address space of the analog output module AQ 2xU/I HF

The following figure shows the assignment of the address space for the AQ 2xU/I HF with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)



Assignment in the process image input (PII)

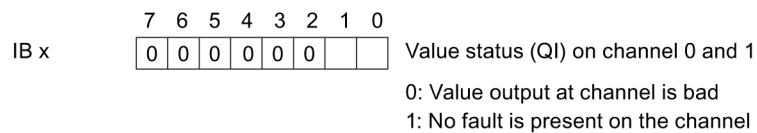


Figure 4-1 Address space of the analog output module AQ 2xU/I HF

Configuration options of the AQ 2xU/I HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The wiring, the value created on the channel, or similar is incorrect.

Interrupts/diagnostics alarms

5.1 Status and error displays

LED displays

The figure below shows the LED displays of the AQ 2xU/I HF.

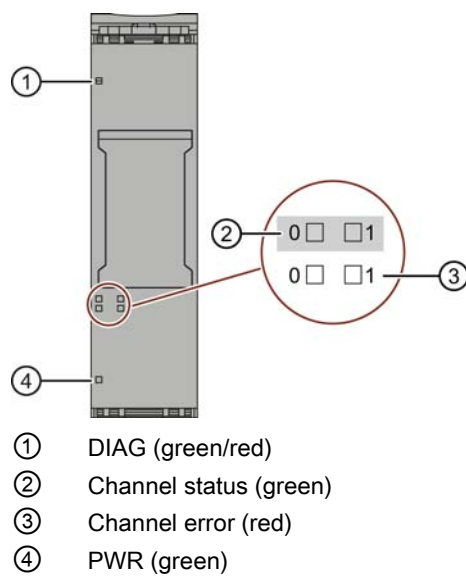


Figure 5-1 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

Table 5- 1 Error display of the DIAG LED

DIAG LED	Meaning
 Off	Backplane bus supply of the ET 200SP not OK
 Flashes	Module parameters not assigned
 On	Module parameters assigned and no module diagnostics
 Flashes	Module parameters assigned and module diagnostics

Table 5- 2 Status display of Channel status/channel error LED

Channel status	Channel error	Meaning
 Off	 Off	Channel deactivated or load voltage L+ missing
 On	 Off	Channel activated and no channel diagnostics
 Off	 On	Channel activated and channel diagnostics
 On	 On	Not permitted (error)

Table 5- 3 Status display of the PWR LED

PWR LED	Meaning
 Off	Supply voltage L+ missing
 On	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 2xU/I HF supports diagnostic error interrupts.

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Overtemperature
- Wire break
- Violation of high limit
- Violation of low limit
- Error
- Parameter assignment error
- Load voltage missing

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

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

Table 5- 4 Diagnostics alarms, their meaning and remedies

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	1F _H	Firmware update is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	–
		The channel is currently being calibrated.	
Short-circuit	1 _H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4 _H	Thermal overload of the I/O module	Correct the process wiring
Wire break	6 _H	Actuator circuit resistance too high	Use a different actuator type or change the wiring, for example, use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	- Deactivate the channel ("Measurement type" parameter) - Connect the channel
Violation of high limit	7 _H	The output value specified by the user program exceeds the overrange.	Correct the output value
Violation of low limit	8 _H	The output value specified by the user program falls below the underrange.	Correct the output value
Error	9 _H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10 _H	The module cannot evaluate parameters for the channel: Module plugged in does not match the configuration. Incorrect parameter assignment.	- Correct the configuration (comparison of preset and actual setup). - Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Load voltage missing	11 _H	Missing or insufficient supply voltage L+	- Check supply voltage L+ on the BaseUnit - Check BaseUnit type

Technical specifications

Technical specifications of AQ 2xU/I HF

	6ES7135-6HB00-0CA1
Product type designation	AQ 2xU/I HF
General information	
Firmware version	V1.0
Usable BaseUnits	BU type A0, A1
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / V5.5 SP4
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Input current	
Current consumption (rated value)	45 mA; no load
Current consumption, max.	90 mA; 2 channels current output 20 mA
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
Address space per module, max.	4 bytes; + 1 byte for QI information

	6ES7135-6HB00-0CA1
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit protection	Yes
Voltage output, short circuit current, max.	45 mA
Cycle time (all channels), min.	750 µs
Output ranges, voltage	
0 to 10 V	Yes; 15 bits
1 to 5 V	Yes; 13 bits
-5 to +5 V	Yes; 15 bits incl. sign
-10 to +10 V	Yes; 16 bits incl. sign
Output ranges, current	
0 to 20 mA	Yes; 15 bits
-20 to +20 mA	Yes; 16 bits incl. sign
4 to 20 mA	Yes; 14 bits
Connecting the actuators	
For voltage output 2-wire connection	Yes
For voltage output 4-wire connection	Yes
For current output 2-wire connection	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Cable length shielded, max.	200 m; 1000 m for current output
Analog value generation	
Settling time	
For resistive load	0.05 ms
For capacitive load	0.05 ms; max. 47 nF and 20 m cable length
For inductive load	0.05 ms
Errors/accuracies	
Output ripple (in relation to output range, bandwidth 0 to 50 kHz), (+/-)	± 0.02%
Linearity error (in relation to output range), (+/-)	± 0.03%
Temperature error (in relation to output range)	± 0.003%
Crosstalk between outputs, max.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	± 0.03%

	6ES7135-6HB00-0CA1
Operational limit in entire temperature range	
Voltage in relation to output range, (+/-)	± 0.2%
Current in relation to output range, (+/-)	± 0.2%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	± 0.1%
Current in relation to output range, (+/-)	± 0.1%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	500 µs
Bus cycle time (TDP), min.	750 µs
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostic error interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; channel-based, only for output type current
Short-circuit	Yes; channel-based, only for output type voltage
Overflow/underflow	Yes
Diagnostics indicator LED	
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic insulation)
Insulation	
Insulation tested with	707 VDC (type test)
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits

(<http://support.automation.siemens.com/WW/view/en/59753521>)

Parameter data record

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics				
		Underflow	Overflow	Wire break	Short-circuit to ground	Missing supply voltage L+
Deactivated	*	*	*	*	*	*
Voltage	±10 V	x	x	–	x	x
	±5 V	x	x	–	x	x
	0 to 10 V	x	x	–	x	x
	1 to 5 V	x	x	–	x	x
Current	±20 mA	x	x	x	–	x
	0 to 20 mA	x	x	x	–	x
	4 to 20 mA	x	x	x	–	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		Underflow / overflow	Wire break	Load voltage L+	Short-circuit to ground
Deactivated	*	*	*	*	*
Voltage	±10 V	x	–	x	x
	±5 V	x	–	x	x
	0 to 10 V	x	–	x	x
	1 to 5 V	x	–	x	x
Current	±20 mA	x	x	x	–
Current (2-wire connection)	0 to 20 mA	x	x	x	–
	4 to 20 mA	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

A.2 Parameter assignment and structure of parameter data record

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

Parameter assignment in the user program

The module parameter settings can be changed in RUN (for example, the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be 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. However, 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.

Structure of data record 128

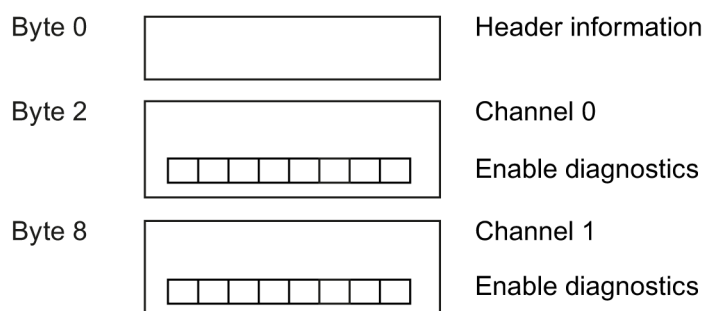


Figure A-1 Structure of data record 128

Header information

The figure below shows the structure of the header information.

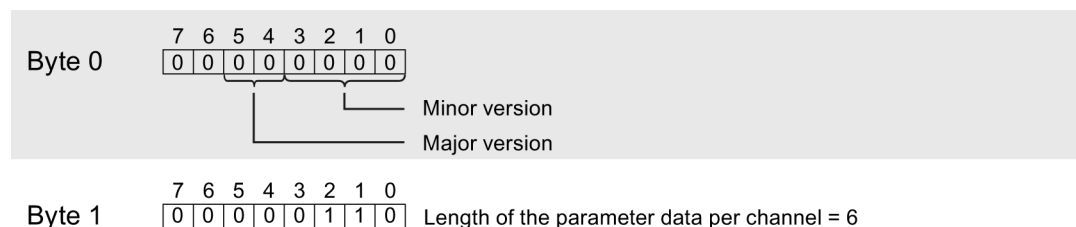


Figure A-2 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 1.

You can activate a parameter by setting the corresponding bit to "1".

* $x = 2 + (\text{channel number} \times 6)$; channel number = 0 to 1

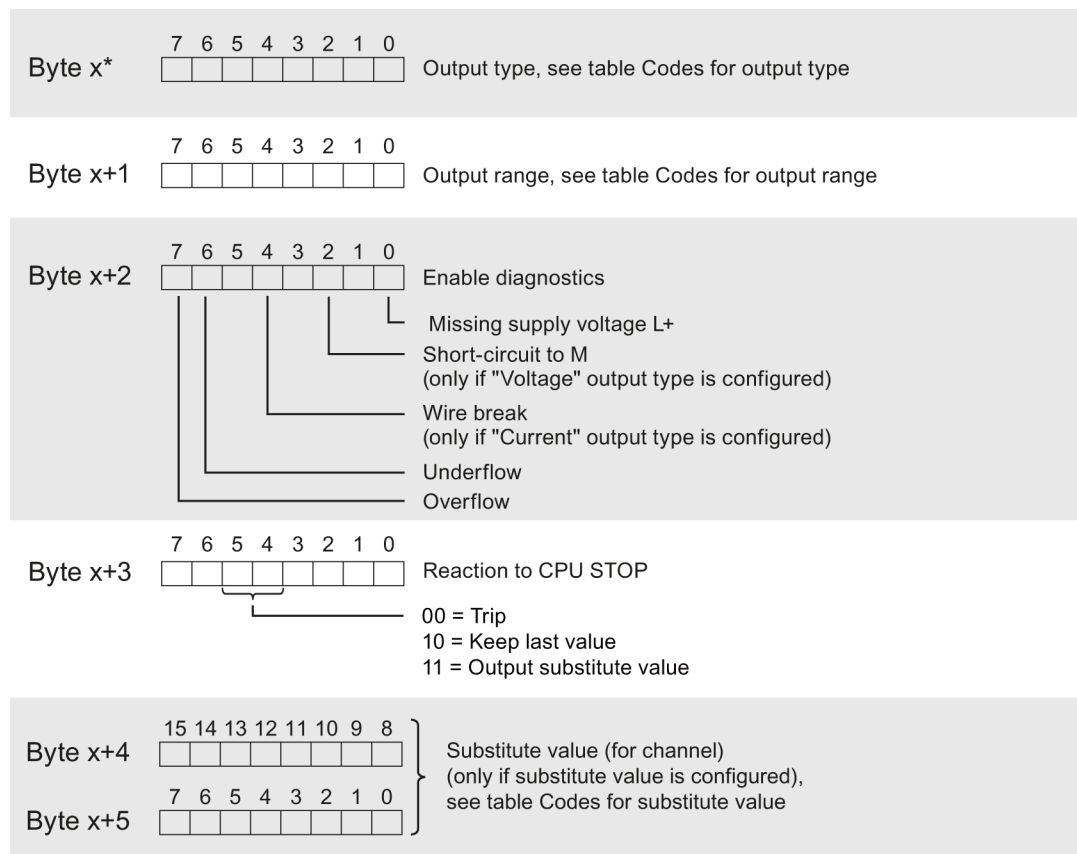


Figure A-3 Structure of byte x to x+5 for channel 0 and 1

Codes for output type

The following table contains the codes for the output types of the analog output module. You must enter these codes in byte x (see previous figure).

Table A- 1 Codes for output type

Output range for voltage	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output range

The following table contains the codes for the output ranges of the analog output module. You must enter these codes in byte x+1 (see previous figure).

Table A- 2 Codes for output range

Output range for voltage	Code
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Output range for current	Code
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute value

The following table contains the codes for the substitute values. You must enter these codes in bytes x+4 and x+5 (see previous figure).

Table A- 3 Codes for substitute value

Output range for voltage and current	Valid substitute value
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511
±20 mA	-29031 to 29030
0 to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Representation of analog values

This appendix describes the analog values for all output ranges supported by the AQ 2xU/I HF analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The resolutions 13, 14, 15, and 16 bit including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table B- 1 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8 _H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4 _H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2 _H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1 _H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

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

Table B- 2 Bipolar output ranges

Dec. value	Output 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	
≥ 32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
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	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table B- 3 Unipolar output ranges

Dec. value	Output 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	
≥ 32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
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	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table B- 4 Voltage output ranges ± 10 V and ± 5 V

Values			Voltage output range		Range
	Dec.	Hex.	± 10 V	± 5 V	
118.515%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 μ V	180.8 μ V	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 μ V	-180.8 μ V	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593%	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* outputs positive maximum value or negative minimum value

Table B- 5 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	Hex.	0 to 10 V	
118.519%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 μ V	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table B- 6 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	Hex.	1 to 5 V	
118.519%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 μ V	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 μ V	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

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

Table B- 7 Current output range ± 20 mA

Values			Current output range	Range
	Dec.	Hex.	± 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	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	Underrange
	-27649	93FF	-20 mA + 723.4 nA	
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

Table B- 8 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		

* outputs positive maximum value or negative minimum value

Table B- 9 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		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value