Manual

HIMax®

X-AO 16 01

Analog Output Module

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HI 801 110 D, Rev. 10.02 (2002)	German original document
HI 801 111 E, Rev. 10.02.00 (2002)	English translation of the German original document

Table of Contents

1 Introduction

This manual describes the technical characteristics of the module and its use. It provides information on how to install, start up and configure the module in SILworX.

1.1 Structure and Use of This Manual

The content of this manual is part of the hardware description of the HIMax programmable electronic system.

This manual contains the following main chapters:

- Introduction
- Safety
- Product description
- Start-up
- Operation
- Maintenance
- Decommissioning
- Transport
- Disposal

Additionally, the following documents must be taken into account:

Document	Content	Document no.
HIMax system manual	Hardware description of the HIMax system	HI 801 001 E
HIMax safety manual	Safety functions of the HIMax system	HI 801 003 E
HIMax maintenance manual	Description of significant operational and maintenance actions.	HI 801 171 E
Communication manual	Description of safeethernet communication and of the available protocols.	HI 801 101 E
Automation security manual	Description of automation security aspects related to the HIMA systems.	HI 801 373 E
SILworX first steps manual	Introduction to SILworX	HI 801 103 E
SILworX online help (OLH)	Instructions on how to use SILworX	---

Table 1: Additional Applicable Manuals

The current manuals can be obtained upon request by sending an e-mail to: documentation@hima.com. Registered customers can download the product documentation from the HIMA Extranet.

1.2 Target Audience

This document is aimed at the planners, design engineers, programmers and the persons authorized to start up, operate and maintain the automation systems. Specialized knowledge of safety-related automation systems is required.

1.3 Writing Conventions

To ensure improved readability and comprehensibility, the following writing conventions are used in this document:

Bold	To highlight important parts. Names of buttons, menu functions and tabs that can be clicked and used in the programming tool.
Italics	Parameters and system variables, references.
`Courier`	Literal user inputs.
RUN	Operating states are designated by capitals.
Chapter 1.2.3	Cross-references are hyperlinks even if they are not specially marked. In the electronic document (PDF): When the mouse pointer hovers over a hyperlink, it changes its shape. Click the hyperlink to jump to the corresponding position.

Safety notices and operating tips are specially marked.

1.3.1 Safety Notices

Safety notices must be strictly observed to ensure the lowest possible risk.

The safety notices are represented as described below.

- Signal word: warning, caution, notice.
- Type and source of risk.
- Consequences arising from non-observance.
- Risk prevention.

The signal words have the following meanings:

- Warning indicates hazardous situations which, if not avoided, could result in death or serious injury.
- Caution indicates hazardous situation which, if not avoided, could result in minor or moderate injury.
- Notice indicates a hazardous situation which, if not avoided, could result in property damage.

⚠ SIGNAL WORD

Type and source of risk!

Consequences arising from non-observance.

Risk prevention.

NOTICE

Type and source of damage!

Damage prevention.

1.3.2 Operating Tips

Additional information is structured as presented in the following example:

i The text giving additional information is located here.

Useful tips and tricks appear as follows:

TIP The tip text is located here.

2 Safety

All safety information, notes and instructions specified in this document must be strictly observed. The product may only be used if all guidelines and safety instructions are adhered to.

The product is operated with SELV or PELV. No imminent risk results from the product itself. Use in the Ex zone is only permitted if additional measures are taken.

2.1 Intended Use

HIMax components are designed for assembling safety-related controller systems.

When using the components in the HIMax system, comply with the following general requirements.

2.1.1 Environmental Requirements

All the environmental requirements specified in this manual must be observed when operating the HIMax system. The environmental requirements are listed in the product data.

2.1.2 ESD Protective Measures

Only personnel with knowledge of ESD protective measures may modify or extend the system or replace components.

NOTICE

Damage to the HIMax system due to electrostatic discharge!

- **When performing the work, make sure that the workspace is free of static, and wear a grounding strap.**
- **If not used, ensure that the components are protected from electrostatic discharge, e.g., by storing them in their packaging.**

2.2 Residual Risk

No imminent risk results from a HIMA system itself.

Residual risk may result from:

- Faults related to engineering.
- Faults in the user program.
- Faults related to the wiring.

2.3 Safety Precautions

Observe all local safety requirements and use the protective equipment required on site.

2.4 Emergency Information

A HIMA system is a part of the safety equipment of an overall system. If the controller fails, the system enters the safe state.

In case of emergency, no action that may prevent the HIMA system from operating safely is permitted.

3 Product Description

The X-AO 16 01 analog output module is intended for use in the programmable electronic system (PES) HIMax.

The module is equipped with 16 analog outputs that have a nominal range of 4…20 mA.

i If two modules are redundantly wired, only 8 odd outputs are available, see Chapter 3.4.

The analog outputs are suitable for connecting to ohmic, inductive and capacitive loads in accordance with EN 61131-2.

The module is interference-free, in particular with respect to EMC, electrical safety, communication to the X-SB and X-CPU modules, and the user program.

Module and connector boards are mechanically coded, see Chapter 3.6.1. Coding prevents installation of unsuitable I/O modules.

The module can be inserted into any of the base plate slots with the exception of the slots reserved for system bus modules. Refer to the system manual (HI 801 001 E) for details.

The module has been certified by the TÜV for safety-related applications up to SIL 3 (IEC 61508, IEC 61511, IEC 62061 and EN 50156) as well as Cat. 4 and PL e (EN ISO 13849-1).

The certificates and the EU type test certificate are available on the HIMA website.

3.1 Safety Function

The module ensures its safety function using one extra safety switch for each channel pair that is opened if a fault occurs.

The safety function is performed in accordance with SIL 3.

3.1.1 Response in the Event of a Fault

If the safety-related processor system of the module detects a module fault, the module adopts the safe state after a maximum of 16 ms and all the outputs are de-energized in accordance with the 'de-energize to trip principle'. If a channel fault occurs, only the two channels of the affected channel group are switched off.

The module activates the *Error* LED on the front plate.

3.2 Scope of Delivery

To operate, the module must be installed on a matching connector board. If a field termination assembly (FTA) is used, a system cable is required to connect the connector board to the FTA. Connector boards, system cables and FTAs are not included within the scope of delivery.

The connector boards are described in Chapter 3.7, the system cables are described in Chapter 3.8. The FTAs are described in separate manuals.

3.3 Type Label

The type label specifies the following important details:

- Product name
- Mark of conformity
- Bar code (2D or 1D code)
- Part number (Part-No.)
- Hardware revision index (HW-Rev.)

- Operating system revision index (OS-Rev.)
- Supply voltage (Power)
- Ex specifications (if applicable)
- Production year (Prod-Year:)

Figure 1: Sample Type Label

3.4 Structure

The module is equipped with 16 analog current outputs (0/4…20 mA) that are galvanically separated from the supply voltage and the remaining channel pairs. The analog current value is set by a D/A converter, measured by two independent, internal measuring devices and functionally tested.

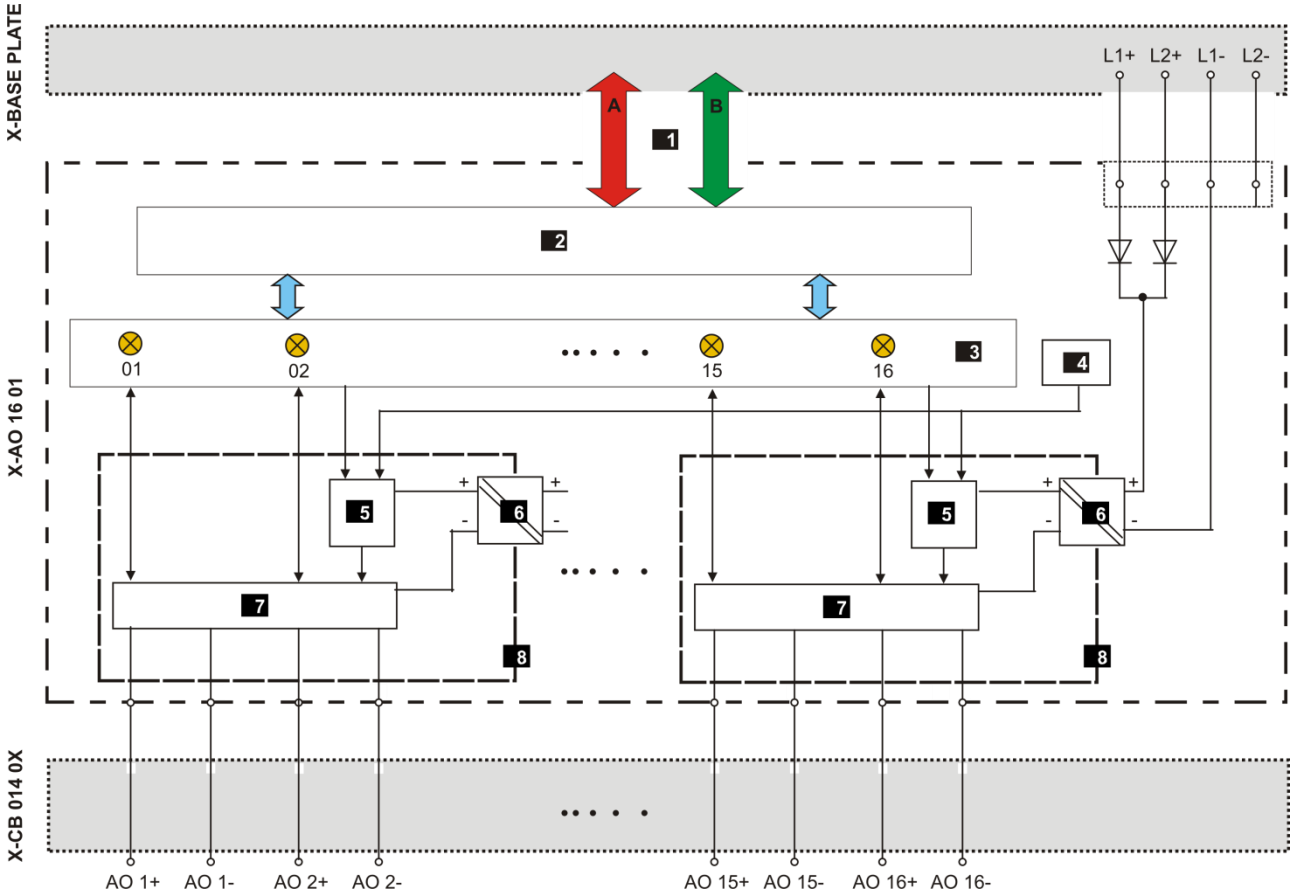
If two modules are redundantly wired, only 8 odd outputs (AO1, AO3…AO15) are available. The even outputs (AO2, AO4…AO16) are not used.

The module automatically performs a diagnosis for open-circuits (OC), which can be evaluated in the user program, see Chapter 4.3.

The 1oo2 processor system within the I/O module controls and monitors the I/O level. The data and states of the I/O module are provided to the processor modules via the redundant system bus. The system bus has a redundant structure for reasons of availability. Redundancy is only ensured if both system bus modules are inserted in the base plates and configured in SILworX.

3.4.1 Block Diagram

The following block diagram illustrates the structure of the module.



1 System buses
2 Safety-related processor system
3 Interface
4 Watchdog
5 Safety switch for group of 2
6 Power supply (galvanically separated)
7 Block with D/A and A/D converters
8 Galvanic separation

Figure 2: Module's Block Diagram

3.4.2 Indicators

The following figure shows the front view of the module with the LEDs:

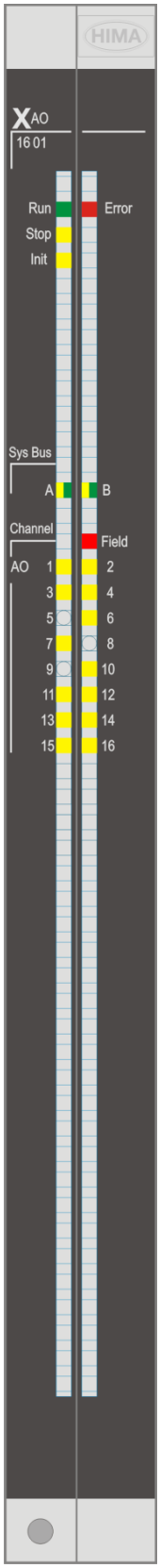


Figure 3: Indicators

The LEDs indicate the operating state of the module.

The LEDs on the module are divided into three groups:

- Module status indicators (Run, Error, Stop, Init)
- System bus indicators (A, B)
- I/O indicators (AO 1…16, Field)

After connecting the supply voltage, an LED test is performed and all the LEDs are lit for at least 2 s. The color of two-color LEDs changes once during the test.

Definition of blinking frequencies

The following table defines the blinking frequencies:

Definition	Blinking frequencies
Blinking1	Long (600 ms) on, long (600 ms) off.
Blinking2	Short (200 ms) on, short (200 ms) off, short (200 ms) on, long (600 ms) off.
Blinking-x	Ethernet communication: Blinking synchronously with data transmission.

Table 2: Blinking Frequencies of the LEDs

Some LEDs can report warnings (On) and faults or errors (Blinking1), see the following tables. The indication of errors or faults has priority over the indication of warnings. Warnings cannot be reported if errors or faults are being signaled.

3.4.3 Module Status Indicators

These LEDs are located on the upper part of the front plate.

LED	Color	Status	Description
Run	Green	On	Module in the RUN state, normal operation.
		Blinking1	Module state STOP / LOADING OS
		Off	Module not in the RUN state, observe the other status LEDs.
Error	Red	On	System warning, for example: ▪ No license for additional functions (e.g., communication protocols), test mode. ▪ Temperature warning
		Blinking1	System error, for example: ▪ Internal module faults detected by self-tests, e.g., hardware or voltage supply faults. ▪ Fault while loading the operating system.
		Off	No faults detected
Stop	Yellow	On	Module state STOP / VALID CONFIGURATION
		Blinking1	The module is in one of the following states: ▪ STOP / INVALID CONFIGURATION ▪ STOP / LOADING OS
		Off	Module not in the STOP state, observe the other status LEDs.
Init	Yellow	On	Module state: INIT
		Blinking1	The module is in one of the following states: ▪ LOCKED ▪ STOP / LOADING OS
		Off	Module is in none of the states described, observe the other status LEDs.

Table 3: Module Status Indicators

3.4.4 System Bus Indicators

The system bus indicator LEDs are labeled *Sys Bus.*

LED	Color	Status	Description
A	Green	On	Physical and logical connection to the system bus module in slot 1.
		Blinking1	No physical connection to the system bus module in slot 1.
	Yellow	Blinking1	The physical connection to the system bus module in slot 1 has been established. No connection to a (redundant) processor module running in system operation.
B	Green	On	Physical and logical connection to the system bus module in slot 2.
		Blinking1	No physical connection to the system bus module in slot 2.
	Yellow	Blinking1	The physical connection to the system bus module in slot 2 has been established. No connection to a (redundant) processor module running in system operation.
A+B	Off	Off	Neither physical nor logical connection to the system bus modules in slot 1 and slot 2.

Table 4: System Bus Indicators

3.4.5 I/O Indicators

The LEDs of the I/O indicators are labeled *Channel*.

LED	Color	Status	Description
AO 1…16	Yellow	On	High level present, current ≥ 4 mA.
		Blinking2	Channel fault, current not equal to setup value.
		Off	Low level present, current < 4 mA.
Field	Red	Blinking2	Field fault on at least one channel or supply (e.g., open-circuit, overcurrent, etc.)
		Off	No field fault displayed.

Table 5: I/O Indicators

3.5 Product Data

General	
Supply voltage	24 VDC, -15…+20 %, rp ≤ 5 % SELV, PELV
Current consumption	600 mA at 24 VDC (outputs switched off) 1.3 mA at 24 VDC (outputs loaded)
Current consumption per channel pair	80 mA
Module cycle time	2 ms
Protection class	Protection class III in accordance with IEC/EN 61131-2
Ambient temperature	0…+60 °C
Transport and storage temperature	-40…+85 °C
Humidity	Max. 95 % relative humidity, non-condensing
Pollution	Pollution degree II in accordance with IEC/EN 60664-1
Installation height	< 2000 m
Degree of protection	IP20
Dimensions (H x W x D) in mm	310 x 29.2 x 230
Weight	Approx. 1.2 kg

Table 6: Product Data

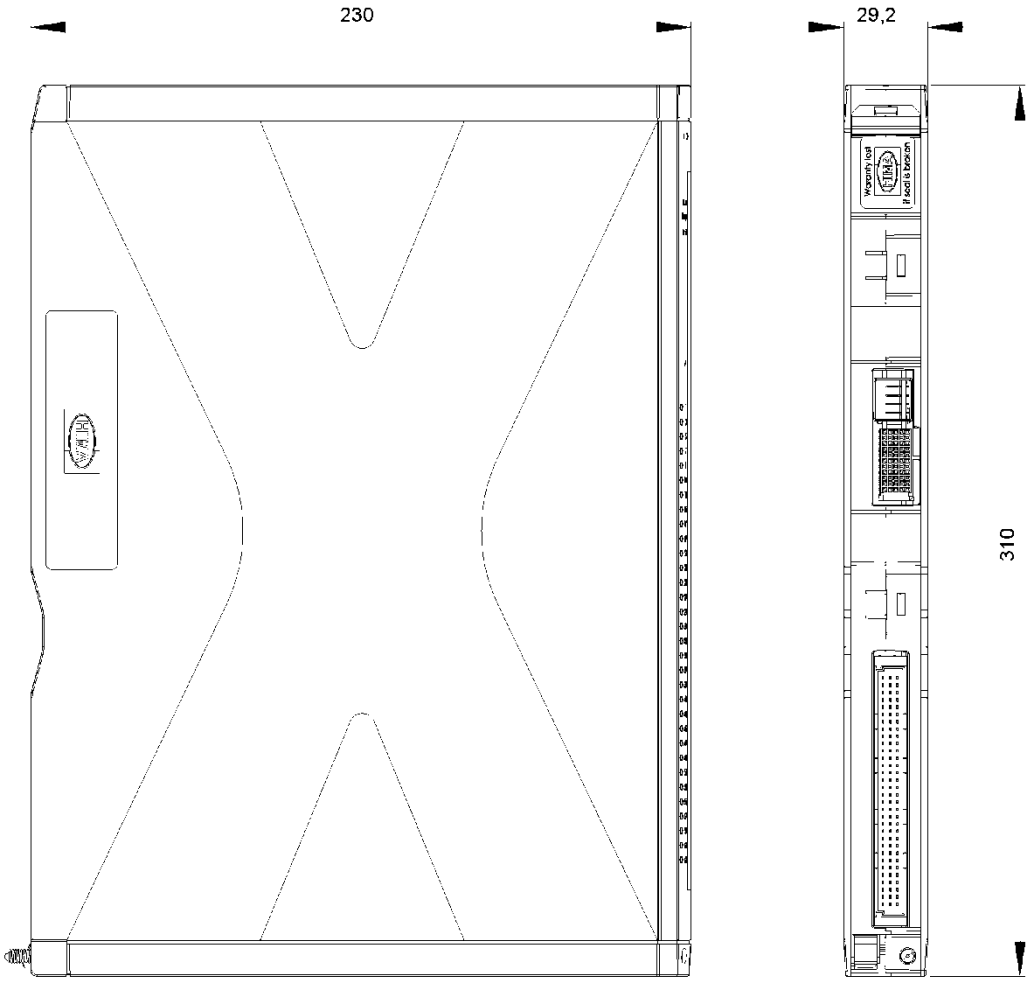


Figure 4: Views

Analog outputs	
Number of analog outputs	16 with 1-channel wiring. 8 with redundant wiring. 2 of these outputs (AO1 and AO2; AO3 and AO4…AO15 and AO16) have a common ground potential. The remaining channel pairs and the supply voltage are galvanically separated.
Nominal range	4…20 mA
Operating range	0…23 mA
Digital resolution	16-bit (10 000 digits in SILworX)
Value of LSB	≤ 2 µA
Ohmic load	Max. 600 Ω
Inductive load	Max. 1 mH
Capacitive load	Max. 100 µF in parallel to the ohmic load
Open-circuit threshold	≥ 18.5 V
Settling time	5 ms
Shutdown time if a fault occurs (transition to the safe state)	16 ms
Metrological accuracy	
Typical metrological accuracy at 25 °C	±0.2 % of full scale
Metrological accuracy across the entire temperature range	±0.5 % of full scale
Temperature coefficient	±0.05 %/K of full scale
Metrological accuracy with active HART communication	±2 % of full scale
Linearity error	±0.1 % of full scale

Table 7: Specifications for the Analog Inputs

3.6 Connector Boards

A connector board connects the module to the field level. Module and connector board together form a functional unit. Insert the connector board into the appropriate slot prior to mounting the module.

The following connector boards are available for the module:

Connector board	Description
X-CB 014 01	Connector board with screw terminals
X-CB 014 02	Redundant connector board with screw terminals
X-CB 014 03	Connector board with cable plug
X-CB 014 04	Redundant connector board with cable plug

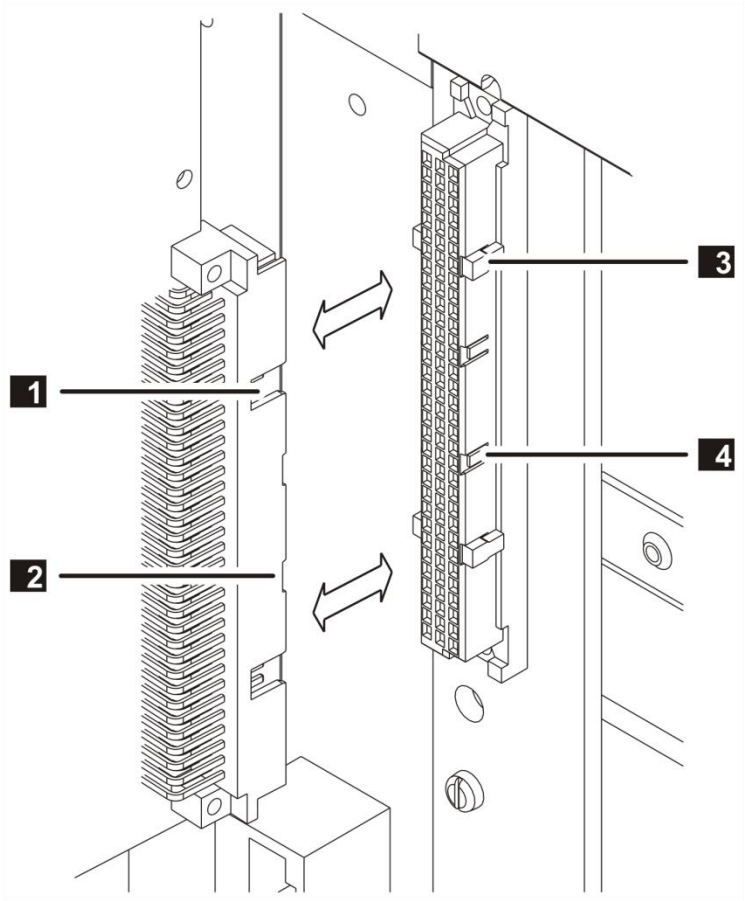
Table 8: Available Connector Boards

3.6.1 Mechanical Coding of Connector Boards

I/O modules and connector boards are mechanically coded starting from hardware revision index (HW-Rev.) 10. Coding avoids installation of improper I/O modules thus preventing negative effects on redundant modules and the field level.
Apart from that, improper equipment has no effect on the HIMax system since only I/O modules properly configured in SILworX can enter the RUN state.

I/O modules and the corresponding connector boards have a mechanical coding in the form of wedges. The coding wedges in the female connector of the connector board match with the male connector recesses of the I/O module plug, see Figure 5.

Coded I/O modules can only be plugged in to the corresponding connector boards.



1 Male connector recess
2 Prepared male connector recess
3 Coding wedge
4 Guideway for coding wedge

Figure 5: Coding Example

Coded I/O modules can be plugged in to uncoded connector boards. Uncoded I/O modules cannot be plugged in to coded connector boards.

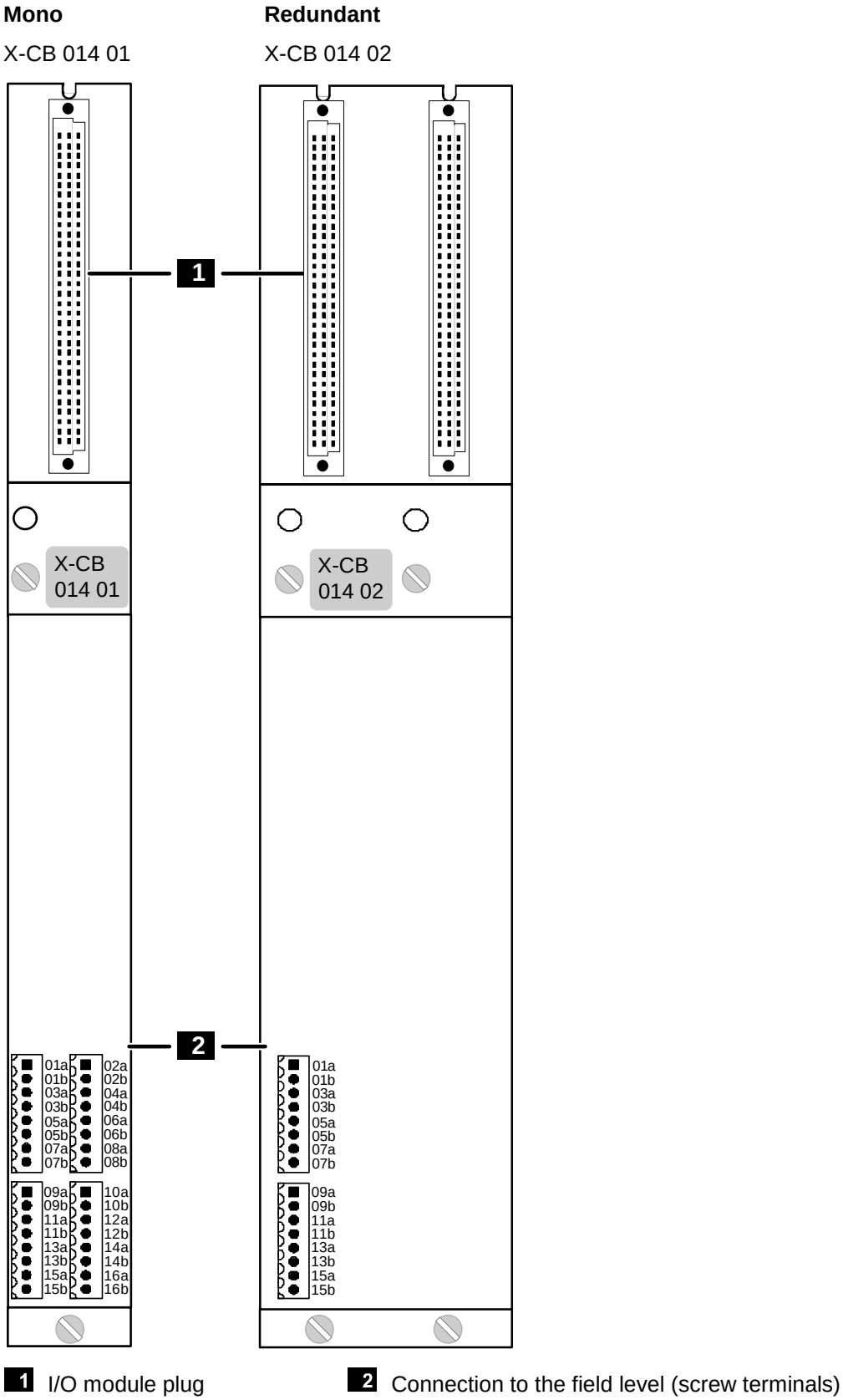
3.6.2 Coding of X-CB 014 0X Connector Boards

The following table specifies the position of the coding wedges on the I/O module plug:

a7	a13	a20	a26	c7	c13	c20	c26
X	X				X	X	

Table 9: Position of Coding Wedges

3.6.3 Connector Boards with Screw Terminals



1 I/O module plug **2** Connection to the field level (screw terminals)

Figure 6: Connector Boards with Screw Terminals

3.6.4 Terminal Assignment for Mono Connector Board with Screw Terminals

Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	01a	AO1+	1	02a	AO2+
2	01b	AO1-	2	02b	AO2-
3	03a	AO3+	3	04a	AO4+
4	03b	AO3-	4	04b	AO4-
5	05a	AO5+	5	06a	AO6+
6	05b	AO5-	6	06b	AO6-
7	07a	AO7+	7	08a	AO8+
8	07b	AO7-	8	08b	AO8-
Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	09a	AO9+	1	10a	AO10+
2	09b	AO9-	2	10b	AO10-
3	11a	AO11+	3	12a	AO12+
4	11b	AO11-	4	12b	AO12-
5	13a	AO13+	5	14a	AO14+
6	13b	AO13-	6	14b	AO14-
7	15a	AO15+	7	16a	AO16+
8	15b	AO15-	8	16b	AO16-

Table 10: Terminal Assignment for Mono Connector Board with Screw Terminals

Cable plugs attached to the connector board pin headers are used to connect to the field level.

The cable plugs feature the following characteristics:

Connection to the field level	
Cable plugs	4 pieces, with 8 poles
Wire cross-section	0.2…1.5 mm^2 (single-wire) 0.2…1.5 mm^2 (finely stranded) 0.2…1.5 mm^2 (with wire end ferrule)
Stripping length	6 mm
Screwdriver	Slotted 0.4 x 2.5 mm
Tightening torque	0.2…0.25 Nm

Table 11: Cable Plug Characteristics

3.6.5 Terminal Assignment for Redundant Connector Board with Screw Terminals

Pin no.	Designation	Signal
1	01a	AO1+
2	01b	AO1-
3	03a	AO3+
4	03b	AO3-
5	05a	AO5+
6	05b	AO5-
7	07a	AO7+
8	07b	AO7-
Pin no.	Designation	Signal
1	09a	AO9+
2	09b	AO9-
3	11a	AO11+
4	11b	AO11-
5	13a	AO13+
6	13b	AO13-
7	15a	AO15+
8	15b	AO15-

Table 12: Terminal Assignment for Redundant Connector Board with Screw Terminals

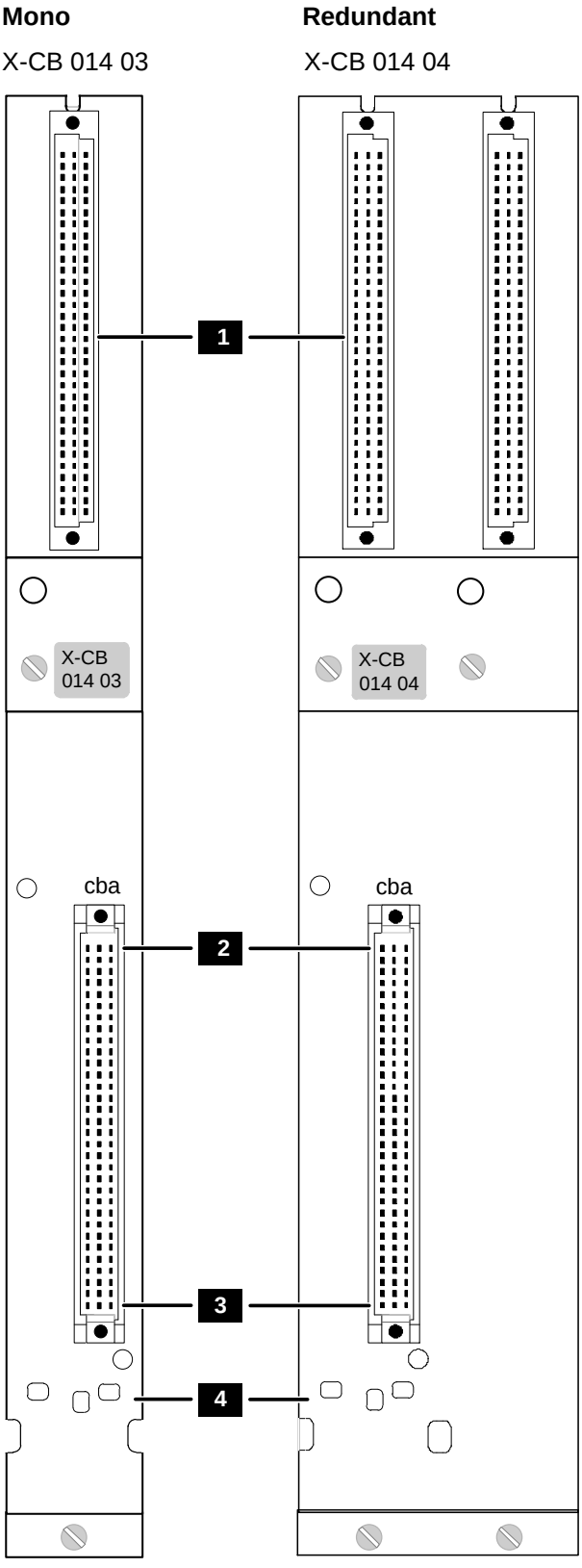
Cable plugs attached to the connector board pin headers are used to connect to the field level.

The cable plugs feature the following characteristics:

I/O wires	
Cable plugs	2 pieces, with 8 poles
Wire cross-section	0.2…1.5 mm^2 (single-wire) 0.2…1.5 mm^2 (finely stranded) 0.2…1.5 mm^2 (with wire end ferrule)
Stripping length	6 mm
Screwdriver	Slotted 0.4 x 2.5 mm
Tightening torque	0.2…0.25 Nm

Table 13: Cable Plug Characteristics

3.6.6 Connector Boards with Cable Plug



1 I/O module plug
2 Connection to the field level (cable plug in row 1)
3 Connection to the field level (cable plug in row 32)
4 Coding of cable plugs

Figure 7: Connector Boards with Cable Plug

3.6.7 Pin Assignment for Mono Connector Board with Cable Plug

HIMA provides ready-made system cables for use with this connector board, see Chapter 3.7. The cable plug and the connector boards are coded.

i **Connector pin assignment!**

The following table describes the connector pin assignment of the system cable plug.

The wire color coding complies with IEC 60304. The color abbreviations used are in accordance with IEC 60757.

Row	c		b		a	
	Signal	Color	Signal	Color	Signal	Color
1					Internal use[1)]	YEBK
2						GNBK
3						YERD
4						GNRD
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17	AO16+	YEBU	AO16-	GNBU		
18	AO15+	YEPK	AO15-	PKGN		
19	AO14+	YEGY	AO14-	GYGN		
20	AO13+	BNBK	AO13-	WHBK		
21	AO12+	BNRD	AO12-	WHRD		
22	AO11+	BNBU	AO11-	WHBU		
23	AO10+	PKBN	AO10-	WHPK		
24	AO9+	GYBN	AO9-	WHGY		
25	AO8+	YEBN	AO8-	WHYE		
26	AO7+	BNGN	AO7-	WHGN		
27	AO6+	RDBU	AO6-	GYPK		
28	AO5+	VT	AO5-	BK		
29	AO4+	RD	AO4-	BU		
30	AO3+	PK	AO3-	GY		
31	AO2+	YE	AO2-	GN		
32	AO1+	BN	AO1-	WH		

[1)] The wires must be isolated individually! No other use is permitted!

Table 14: Pin Assignment for Mono Connector Board with Cable Plug

3.6.8 Pin Assignment for Redundant Connector Boards with Cable Plug

HIMA provides ready-made system cables for use with this connector board, see Chapter 3.7. The cable plug and the connector boards are coded.

Connector pin assignment!

The following table describes the connector pin assignment of the system cable plug.

The wire color coding complies with IEC 60304. The color abbreviations used are in accordance with IEC 60757.

Row	c		b		a	
	Signal	Color	Signal	Color	Signal	Color
1					Internal use[1)]	YEBK
2						GNBK
3						YERD
4						GNRD
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18	AO15+	YEPK	AO15-	PKGN		
19						
20	AO13+	BNBK	AO13-	WHBK		
21						
22	AO11+	BNBU	AO11-	WHBU		
23						
24	AO9+	GYBN	AO9-	WHGY		
25						
26	AO7+	BNGN	AO7-	WHGN		
27						
28	AO5+	VT	AO5-	BK		
29						
30	AO3+	PK	AO3-	GY		
31						
32	AO1+	BN	AO1-	WH		

[1)] The wires must be isolated individually! No other use is permitted!

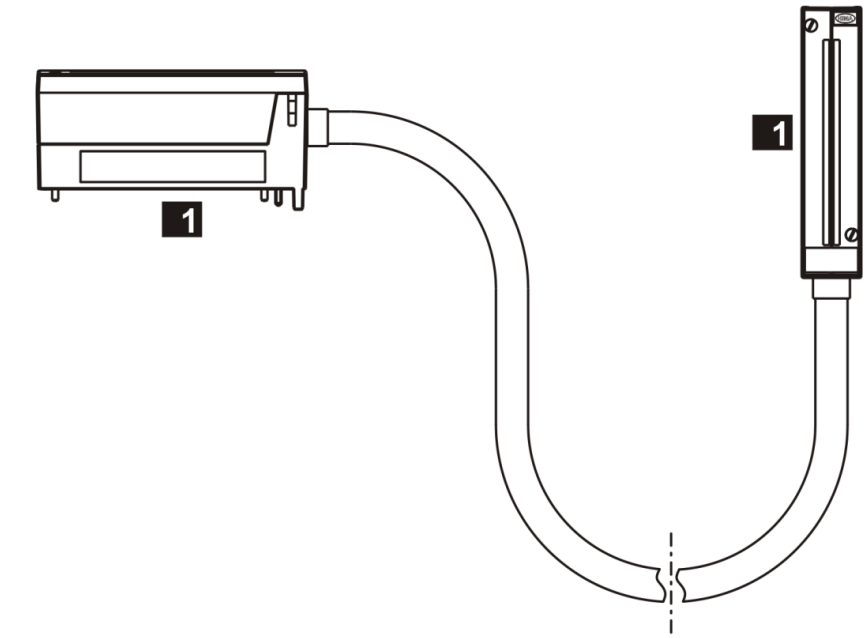
Table 15: Pin Assignment for Redundant Connector Boards with Cable Plug

3.7 System Cable X-CA 011

System cable X-CA 011 is used to connect the X-CB 014 03/04 connector board to the field termination assembly.

General	
Cable	LIYCY-TP 18 x 2 x 0.25 mm² (shielded)
Wire	Finely stranded
Average outer diameter (d)	Approx. 12.7 mm Max. 20 mm for all types of system cables
Minimum bending radius Fixed installation Flexible application	 5 x d 10 x d
Burning behavior	Flame retardant and self-extinguishing in accordance with IEC 60332-1-2, IEC 60332-2-2
Length	8…30 m
Color coding	Based on DIN 47100, see Table 14.

Table 16: Cable Data



1 Identical cable plugs

Figure 8: System Cable X-CA 011 01 n

The system cable is available in the following standard lengths:

System cables	Description	Length	Weight
X-CA 011 01 8	Coded cable plugs on both sides.	8 m	2.5 kg
X-CA 011 01 15		15 m	4.5 kg
X-CA 011 01 30		30 m	9 kg

Table 17: Available System Cables

3.7.1 Cable Plug Coding

The cable plugs are equipped with three coding pins. Therefore, cable plugs only match connector boards and FTAs with the corresponding recesses, see Figure 7.

4 Start-Up

This chapter describes how to install, configure and connect the module. For further details, refer to the HIMax system manual (HI 800 001 E).

i The safety-related application (SIL 3 in accordance with IEC 61508) of the outputs and the connected actuators must comply with the safety requirements. For further details, refer to the HIMax safety manual (HI 801 003 E).

4.1 Mounting

Observe the following points when mounting the module:

- Only operate the module with the appropriate fan components. For further details, see the system manual (HI 801 001 E).
- Only operate the module with the suitable connector board. For further details, see Chapter 3.6.
- The module, including its connected components, must be installed to ensure compliance with the requirements for degree of protection IP20 or higher in accordance with EN 60529:1991 + A1:2000.

NOTICE

Damage due to incorrect wiring!

Failure to comply with these instructions can damage the electronic components.

Observe the following points.

- Plugs and terminals connected to the field level.
  - Take the appropriate grounding measures when connecting the plugs and terminals to the field level.
  - Use shielded cables with twisted pairs for each measuring inputs.
  - The shielding must be connected on both sides. On the module side, the shielding must be connected to the cable shield rail (use SK 20 shield connection terminal block or similar).
  - If finely stranded wires are used, HIMA recommends fastening ferrules to the wire ends. The terminals must be suitable for fastening the cross-sections of the cables in use.
- Redundant wiring can be implemented using the corresponding connector boards. For further details, see Chapter 3.6 and Chapter 4.3.1.

4.1.1 Wiring Unused Outputs

Outputs that are not being used must be terminated, e.g. through wire bridges or resistors ≤ 600 Ω. To prevent short-circuits and sparks in the field, never connect a wire to a connector board if it is open on the field level.

4.2 Mounting and Removing the Module

This chapter describes how to replace an existing module or mount a new one.

When removing the module, the connector board remains in the HIMax base plate. This saves additional wiring effort at the clamp terminals since all field terminals are connected via the connector board of the module.

4.2.1 Mounting a Connector Board

Tools and utilities:

- Screwdriver, cross PH 1 or slotted 0.8 x 4.0 mm.
- Matching connector board.

To install the connector board

1. Insert the connector board into the guiding rail with the groove facing upwards (see following drawing). Fit the groove into the guiding rail pin.
2. Place the connector board on the cable shield rail.
3. Secure the captive screws to the base plate. First screw in the lower screws than the upper ones.

To remove the connector board

1. Release the captive screws from the base plate.
2. Carefully lift the lower section of the connector board from the cable shield rail.
3. Remove the connector board from the guiding rail.

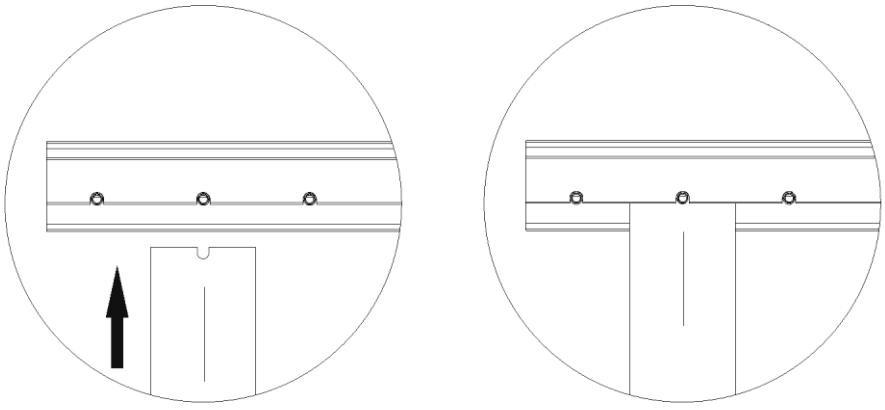


Figure 9: Example of how to Insert the Mono Connector Board

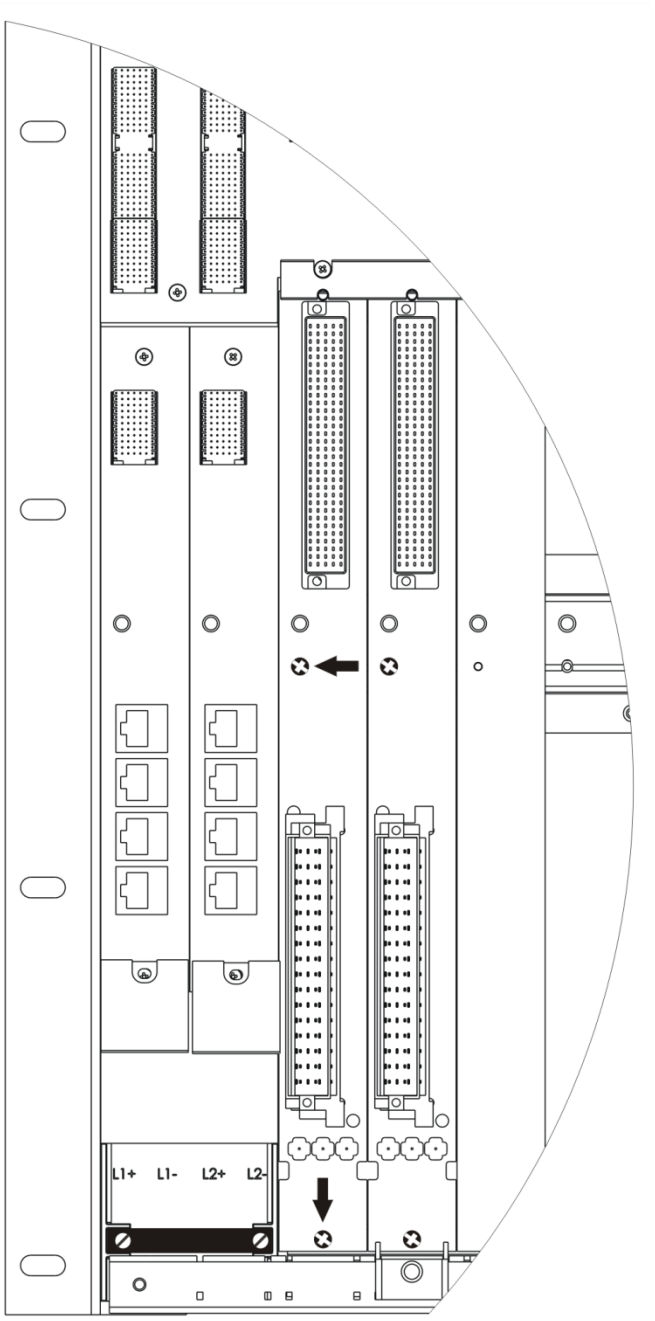


Figure 10: Example of how to Secure the Mono Connector Board with Captive Screws

i These instructions also apply for redundant connector boards. The number of used slots varies in accordance with the connector board type. The number of captive screws depends on the connector board type.

4.2.2 Mounting and Removing a Module

This chapter describes how to mount and remove the HIMax module. A module can be mounted and removed while the HIMax system is operating.

NOTICE

Damage to bus and power sockets due to module jamming!

Failure to comply with these instructions can damage the controller.

Always insert the module in the base plate carefully.

Tools and utilities:

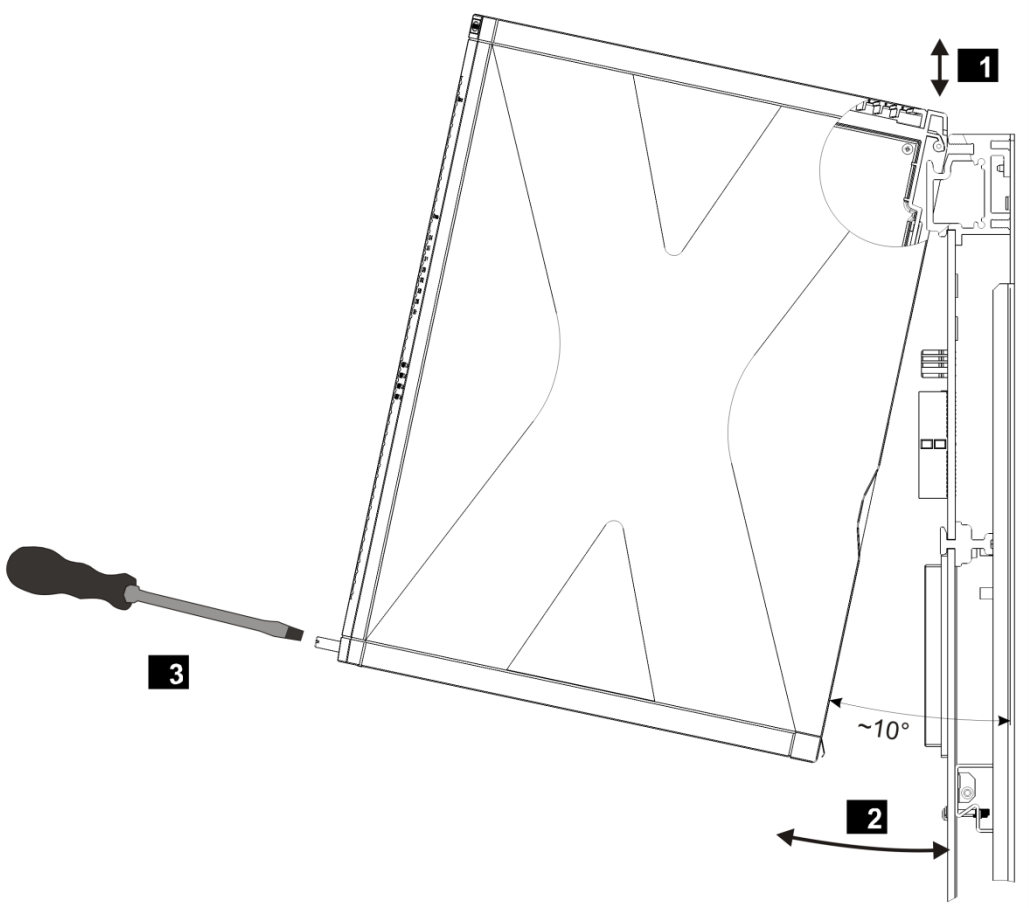
- Screwdriver, slotted 0.8 x 4.0 mm.
- Screwdriver, slotted 1.2 x 8.0 mm.

To insert the modules

1. Open the cover plate on the fan rack:
   ☑ Move the locks to the *open* position.
   ☑ Lift the cover plate and insert it into the fan rack.
2. Insert the top of the module into the hook-in rail, see 1.
3. Swivel the lower edge of the module towards the base plate and apply light pressure to snap it into place, see 2.
4. Tighten the screws, see 3.
5. Pull the cover plate out of the fan rack and close it.
6. Lock the cover plate.

To remove the modules

1. Open the cover plate on the fan rack:
   ☑ Move the locks to the *open* position.
   ☑ Lift the cover plate and insert it into the fan rack.
2. Release the screw, see 3.
3. Swivel the lower edge of the module away from the base plate. Lift and apply light pressure to remove the module from the hook-in rail, see 2 and 1.
4. Pull the cover plate out of the fan rack and close it.
5. Lock the cover plate.



1 Inserting and removing a module
2 Swiveling the module in and out
3 Securing and releasing a module

Figure 11: Mounting and Removing a Module

i If the HIMax system is operating, do not open the cover plate of the fan rack for more than a few minutes (< 10 min) since this affects the forced cooling.

4.3 Configuring the Module in SILworX

The module is configured in the Hardware Editor of the SILworX programming tool.

Observe the following points when configuring the module:

- To diagnose the module and channels, both the statuses and the measured value can be evaluated within the user program. For further details on the system parameters, refer to the following tables.
- If a redundancy group is created, its configuration is defined in the tabs. The tabs specific to the redundancy group differ from those of the individual modules, see the following tables.

To evaluate the system parameters in the user program, they must be assigned to global variables. Perform this step in the Hardware Editor using the module's detail view.

The following tables present the system parameters for the module in the same order as in the SILworX Hardware Editor.

TIP A scientific calculator such as the Windows® calculator with the corresponding view can be used to convert hexadecimal values to bit strings.

4.3.1 The **Module** Tab

The **Module** tab contains the following system parameters for the module:

System parameter	Data type	S [1]	R/W	Description
Name	---	---	W	Module name.
Spare Module	BOOL	Y	W	Activated: It is not considered a fault if a module of the redundancy group is missing in the base plate. Deactivated: It is considered a fault if a module of the redundancy group is missing in the base plate. Default setting: Deactivated **It is only displayed in the redundancy group tab!**
Noise Blanking	BOOL	Y	W	Allow noise blanking performed by the process module (activated/deactivated). Default setting: Activated The processor module delays its response to transient interference until the safety time. The user program retains its last valid process value. Refer to the system manual (HI 801 001 E) for further details on noise blanking.
System parameter	Data type	S [1]	R/W	Description
The following statuses and parameters can be assigned global variables and used in the user program.				
Module OK	BOOL	Y	R	TRUE: No faults. Mono operation: No module faults. Redundancy operation: At least one of the redundant modules has no module fault (OR logic). FALSE: Module fault. Channel fault (no external faults). The module is not plugged in. Observe the *Module Status* parameter!
Module Status	DWORD	Y	R	Status of the module.

Coding	Description
0x00000001	Module fault. [2]
0x00000002	Temperature threshold 1 exceeded.
0x00000004	Temperature threshold 2 exceeded.
0x00000008	Incorrect temperature value.
0x00000010	Voltage on L1+ is defective
0x00000020	Voltage on L2+ is defective
0x00000040	Internal voltage is defective.
0x80000000	No connection to the module. [2]

[2] These faults affect the *Module OK* status and need not be separately evaluated in the user program.

System parameter	Data type	S [1]	R/W	Description
Timestamp [µs]	DWORD	N	R	Microsecond fraction of the timestamp. Time: Testing of the analog outputs completed.
Timestamp [s]	DWORD	N	R	Second fraction of the timestamp. Time: Testing of the analog outputs completed.
[1] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 18: The **Module** Tab in the Hardware Editor

4.3.2 The **I/O Submodule AO16_01** Tab

The **I/O Submodule AO16_01** tab contains the following system parameters:

System parameter	Data type	S [1]	R/W	Description
Name	---	---	W	Module name.
Output Noise Blanking	BOOL	Y	W	Allow output noise blanking by the output module Activated: If the channel's default and read-back values are not consistent, the channel switch-off is suppressed. Refer to the system manual (HI 801 001 E) for further details on output noise blanking. Deactivated: Output noise blanking deactivated To prevent transient interference from occurring on the outputs when connecting or disconnecting actuators, activate the output noise blanking function. Default setting: Deactivated
System parameter	Data type	S [1]	R/W	Description
The following statuses and parameters can be assigned global variables and used in the user program.				
Diagnostic Request	DINT	N	W	To request a diagnostic value, the appropriate ID must be sent to the module using the parameter *Diagnostic Request* (for coding details, see Chapter 4.3.5).
Diagnostic Response	DINT	N	R	As soon as *Diagnostic Response* returns the ID of *Diagnostic Request* (for coding details, see Chapter 4.3.5), *Diagnostic Status* contains the diagnostic value requested.
Diagnostic Status	DWORD	N	R	Requested diagnostic value in accordance with *Diagnostic Response*. The IDs of *Diagnostic Request* and *Diagnostic Response* can be evaluated in the user program. *Diagnostic Status* only contains the requested diagnostic value when both *Diagnostic Request* and *Diagnostic Response* have the same ID.
Background Test Error	BOOL	N	R	TRUE: Background test is faulty. FALSE: Background test is not faulty.
Restart on Error	BOOL	Y	W	The *Restart on Error* parameter can be used to cause any I/O module that is shut down permanently due to errors or faults to once again enter the RUN state. To do so, set the *Restart on Error* parameter from FALSE to TRUE. The I/O module performs a complete self-test and only enters the RUN state if no faults are detected. Default setting: FALSE

System parameters	Data type	S [1)]	R/W	Description
Submodule OK	BOOL	Y	R	TRUE: No submodule fault, no channel faults. FALSE: Submodule fault, channel faults (external faults included).
Submodule Status	DWORD	Y	R	Bit-coded submodule status. For coding details, see Chapter 4.3.4.
[1)] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 19: The **I/O Submodule AO16_01** Tab in the Hardware Editor

4.3.3 The **I/O Submodule AO16_01: Channels** Tab

The **I/O Submodule AO16_01: Channels** tab contains the following system parameters for each analog output.
Global variables can be assigned to the system parameters with **->** and used in the user program. The value without **->** must be directly entered.

System parameters	Data type	S [1)]	R/W	Description
Channel no.	---	---	R	Channel number, preset and cannot be changed.
Process Value [REAL] ->	REAL	Y	R	The *Process Value* is mapped to the output current using two data points *4 mA* and *20 mA.* If the *Process Value* is identical to the output current 4…20 mA, or the channel is not used, both data points must be set to the default settings, i.e., *4 mA* = 4.0 und *20 mA* = 20.0. An output current will result in an output current if the process value between the two data points is 0.0. This also applies if no global variable is connected to the *Process Value [REAL]* -> parameter. Example: Mapping the range of values of a physical value (-60…+60) to the output current. Data point *4 mA* = -60.0 und Data point *20 mA* = +60.0. If the process value is 0.0, the output current is 12 mA.
4 mA	REAL	Y	W	Data point at the lowest full scale (4 mA) of the channel. Enter the process value for which 4 mA should be output to the output. If the process value is identical to the output current 4…20 mA or the channel is not used, the default setting 4.0 must be used. Default setting: 4.0
20 mA	REAL	Y	W	Data point at the highest full scale (20 mA) of the channel. Enter the process value for which 20 mA should be output to the output. If the process value is identical to the output current 4…20 mA or the channel is not used, the default setting 20.0 must be used. Default setting: 20.0

System parameters	Data type	S [1)]	R/W	Description
-> Channel OK [BOOL]	BOOL	Y	R	TRUE: Fault-free channel. The output value is valid. FALSE: Faulty channel. The output value is set to 0.
-> Channel Voltage [DINT]	DINT	N	R	Current voltage on the module output of the channel. 1 mV [10 000 Digit]
-> OC [BOOL]	BOOL	Y	R	TRUE: Open-circuit present. FALSE: No open-circuit present. Defined through *OC Limit*
-> OC Monitoring Defective [BOOL]	BOOL	N	R	TRUE: Open-circuit detection is faulty or not operational. FALSE: Open-circuit detection OK. With an output current of about 0 mA, an open-circuit is no longer detected!
Redund.	BOOL	Y	W	Requirement: The redundant module must exist. Activated: The channel redundancy for this channel is active. Deactivated: The channel redundancy for this channel is not active. Default setting: Deactivated
[1)] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 20: The **I/O Submodule AO16_01: Channels** Tab in the Hardware Editor

4.3.4 Description of **Submodule Status [DWORD]**

The following table specifies the coding of the *Submodule Status* parameter:

Coding	Description
0x00000001	Fault in hardware unit (submodule).
0x00000002	Reset of an I/O bus.
0x00000004	Fault detected while initializing the hardware.
0x00000008	Fault detected while checking the coefficients.
0x01000000	Trimming data has been corrupted
0x02000000	Fault in an FPGA header

Table 21: Coding of *Submodule Status [DWORD]*

4.3.5 Description of **Diagnostic Status [DWORD]**

The following table specifies the coding of the *Diagnostic Status* parameter:

<table>
<tr><th>ID</th><th>Description</th></tr>
<tr><td>0</td><td>Diagnostic values are indicated consecutively.</td></tr>
<tr><td>100</td><td>Bit-coded temperature status.
0 = normal.
Bit0 = 1: Temperature threshold 1 has been exceeded.
Bit1 = 1: Temperature threshold 2 has been exceeded.
Bit2 = 1: Fault in temperature measurement.</td></tr>
<tr><td>101</td><td>Measured temperature (10 000 digits/ °C).</td></tr>
<tr><td>200</td><td>Bit-coded voltage status.
0 = normal.
Bit0 = 1 : L1+ (24 V) is faulty.
Bit1 = 1 : L2+ (24 V) is faulty.</td></tr>
<tr><td>201</td><td>Not used!</td></tr>
<tr><td>202</td><td>Actual value of the internal 3V3 operating voltage.</td></tr>
<tr><td>203</td><td>Actual value of the internal core voltage.</td></tr>
<tr><td>204…207</td><td>Not used!</td></tr>
<tr><td>300</td><td>Comparator 24 V undervoltage (BOOL).</td></tr>
<tr><td>1001…1016</td><td>Status of the channels 1…16
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Fault occurred in hardware unit (submodule).</td></tr>
<tr><td>0x0002</td><td>Channel fault due to internal fault.</td></tr>
<tr><td>0x0020</td><td>Open-circuit detected.</td></tr>
<tr><td>0x0040</td><td>Unauthorized access to the D/A converter detected</td></tr>
<tr><td>0x0200</td><td>Limit values are violated.</td></tr>
<tr><td>0x0400</td><td>Read-back value and output value differ from one another beyond the safety-related accuracy.</td></tr>
<tr><td>0x0800</td><td>Error while reading back the outputs.</td></tr>
<tr><td>0x2000</td><td>Group switch faulty, read-back value violated.</td></tr>
<tr><td>0x4000</td><td>Error in monitoring the internal 3.3 V operating voltage.</td></tr>
</table></td></tr>
</table>

Table 22: Coding of *Diagnostic Status [DWORD]*

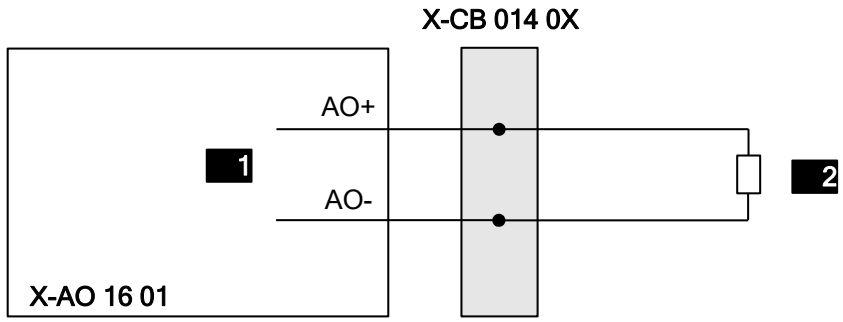
4.4 Connection Variants

This chapter describes the proper wiring of the module in safety-related applications. The following connection variants are permitted.

The outputs are wired via connector boards.

4.4.1 1-Channel Wiring

Connector boards X-CB 014 01 (with screw terminals) or X-CB 014 03 (with cable plug) can be used to perform the wiring in accordance with Figure 12.

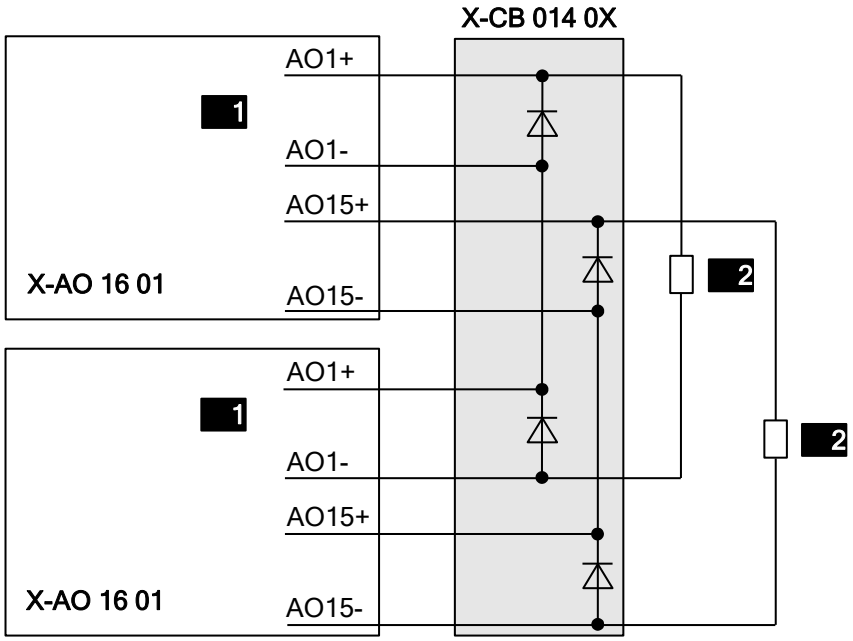


1 Analog output 2 Load

Figure 12: 1-Channel Wiring

4.4.2 Redundant Wiring (Serial Connection)

When redundantly wired as specified in Figure 13, the modules are inserted next to each other on a common connector board in the base plate. The X-CB 014 02 or X-CB 014 04 connector board can be used. Use the *Create Redundant Connection* function to configure the redundancy in the SILworX Hardware Editor.

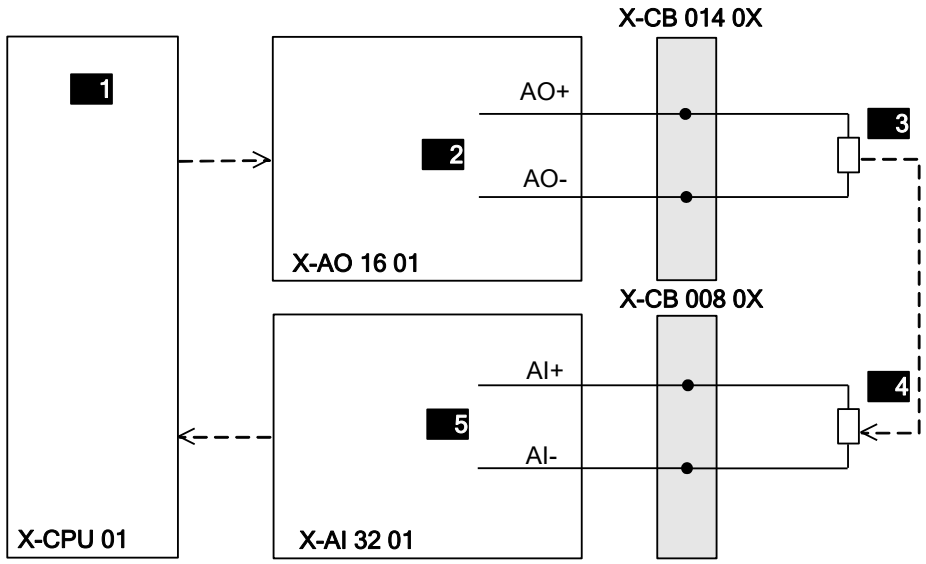


1 Analog output 2 Actuator

Figure 13: Redundant Wiring (Serial Connection)

4.4.3 Control Wiring

There is a physical coupling between the actuator of the analog output (AO) and the readings recorder of the analog input (AI). The data measured for the analog input is processed in the processor module and becomes the new data for the analog output.



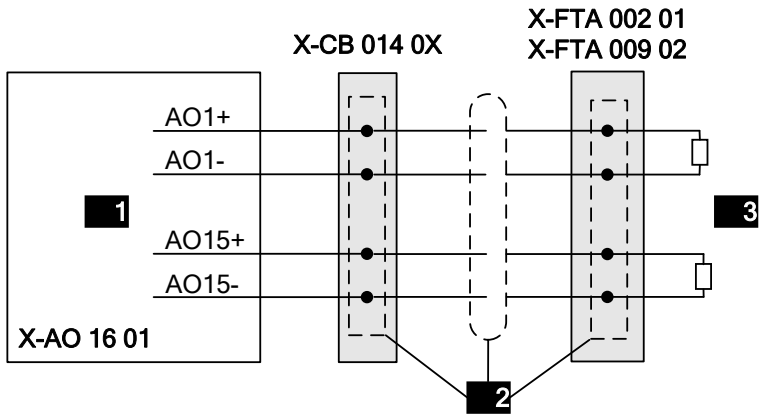
1 Processor module
2 Analog output (AO)
3 Actuator
4 Sensor
5 Analog input (AI)

Figure 14: Control Wiring

i Delays due to process data processing of the HIMax controller must be taken into account.

4.4.4 Connection via Field Termination Assembly

The connection via the X-FTA 002 01 is performed as described in Figure 15. For further information, refer to the X-FTA 002 01 and X-FTA 009 02L manuals.



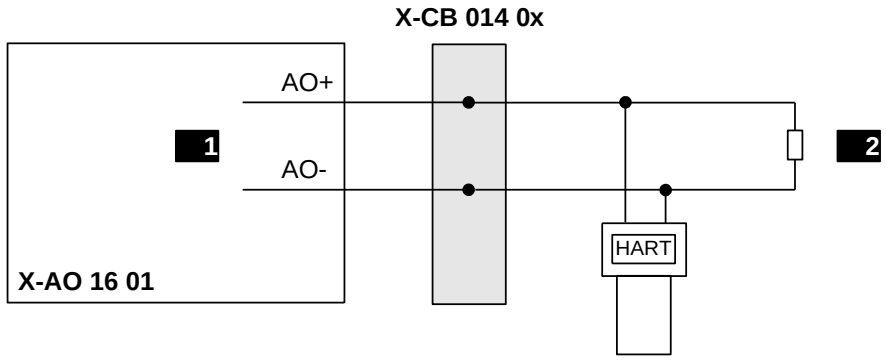
1 Analog output
2 System cable
3 Actuator

Figure 15: Connection via Field Termination Assembly

4.4.5 Behavior during HART Communication

To ensure HART communication, a HART handheld can be connected in parallel to the actuator. The current fluctuations caused by the HART communications are largely compensated by the analog output so that the maximum residual error of the configured current is 2 % of full scale.

i Increased residual error in HART communication. Remove the HART terminal immediately after diagnosis!



1 Analog output
2 Actuator

Figure 16: HART Handheld in Parallel to the Transmitter and Output Module

4.4.6 Connecting Actuators with Low-Pass Behavior

Switching on actuators with low-pass behavior at 0 mA can delay the increase of the output current beyond the module's tolerance time.

If the output current cannot be achieved within this tolerance time, the module responds by switching off the affected channel.

To prevent the channel from switching off, these actuators must be switched on in stages from within the user program (e.g., by setting the first HIMax cycle to 4 mA, and the second HIMax cycle to the process value).

5 Operation

The module runs within a HIMax base plate and does not require any specific monitoring.

5.1 Handling

Direct handling of the module is not foreseen.

The module is operated from within the PADT, e.g., for forcing the analog outputs. For further details, refer to the SILworX documentation.

5.2 Diagnostics

LEDs on the front side of the module indicate the module state, see Chapter 3.4.2.

The diagnostic history of the module can also be read out using SILworX. Chapters 4.3.4 through 4.3.5 describe the most important diagnostic statuses.

i If a module is plugged in to a base plate, it generates diagnostic messages during its initialization phase indicating faults such as incorrect voltage values.

These messages only indicate a module fault if they occur after the system starts operation.

6 Maintenance

Defective modules must be replaced with modules of the same type or with approved replacement models.

When replacing modules, observe the instructions specified in the HIMax system manual (HI 801 001 E) and HIMax safety manual (HI 801 003 E).

6.1 Maintenance Measures

The following maintenance measures must be implemented for the modules:

- Proof testing.
- Loading of enhanced operating system versions.

6.1.1 Proof Test

The proof test interval for HIMax modules must be in accordance with the interval required by the application-specific safety integrity level (SIL). For further details, refer to the safety manual (HI 801 003 E).

6.1.2 Loading of Enhanced Operating System Versions

As part of product maintenance, HIMA is continuously improving the operating systems of the modules. HIMA recommends using system downtimes to load the current operating system versions into the modules.

i The current operating system versions of modules are displayed in the SILworX Control Panel. The type label specifies the delivered module version, see Chapter 3.4.

Before loading operating systems into the modules, check the system compatibilities and restrictions of the operating system versions. To this end, use the applicable release notes. Use SILworX to load the operating systems into the modules and ensure that these are in the STOP state.

7 Decommissioning

To decommission the module, remove it from the base plate. For more details, refer to Chapter *Mounting and Removing the Module*.

8 Transport

To avoid mechanical damage, the components must be transported in packaging.

Always store the components in their original product packaging. This packaging also provides protection against electrostatic discharge (ESD). Note that the product packaging alone is not sufficient for transport.

9 Disposal

Industrial customers are responsible for correctly disposing of decommissioned hardware. Upon request, a disposal agreement can be arranged with HIMA.

All materials must be disposed of in an ecologically sound manner.

Appendix

Glossary

Term	Description
AI	Analog input
AO	Analog output
ARP	Address resolution protocol, network protocol for assigning the network addresses to hardware addresses
COM	Communication module
CRC	Cyclic redundancy check
DI	Digital input
DO	Digital output
EMC	Electromagnetic compatibility
EN	European standard
ESD	Electrostatic discharge
FB	Fieldbus
FBD	Function block diagrams
HW	Hardware
ICMP	Internet control message protocol, network protocol for status or error messages
IEC	International electrotechnical commission
Interference-free	Inputs are designed for interference-free operation and can be used in circuits with safety functions
MAC	Media access control address, hardware address of one network connection
PADT	Programming and debugging tool (in accordance with IEC 61131-3), PC with SILworX
PELV	Protective extra low voltage
PES	Programmable electronic system
R	Read, the variable is read out
R/W	Read/Write, column title for system variable type
Rack ID	Base plate identification (number)
r_P	Peak value of a total AC component
SB	System bus (module)
SC/OC	Short-circuit/open-circuit
SELV	Safety extra low voltage
SFF	Safe failure fraction, portion of faults that can be safely controlled
SIL	Safety integrity level (in accordance with IEC 61508)
SILworX	Programming tool
SNTP	Simple network time protocol (RFC 1769)
SRS	System.Rack.Slot, addressing of a module
SW	Software
TMO	Timeout
W	Write, the variable receives a value, e.g., from the user program
WD	Watchdog, device for monitoring the system's correct operation. Signal for fault-free process
WDT	Watchdog time

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