Manual

HIMax®

X-DO 24 02

Digital Output Module

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HI 801 094 D, Rev. 12.00 (2014)	German original document
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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-DO 24 02 digital output module is intended for use in the programmable electronic system (PES) HIMax.

The module is equipped with 24 digital outputs that have to be operated with 24 or 48 VDC external power supply. Each output can be loaded with a nominal current of max. 0.5 A The maximum permissible total current is 12 A.

External power must be supplied by power supply units complying with SELV and PELV. For the power supply units, the following applies:

- **24 VDC** power supply: The voltage of the power supply units may not exceed 35 V.
- **48 VDC** power supply: The voltage of the power supply units may not exceed 60 V.

The outputs are suitable for connecting to ohmic, inductive and capacitive loads as well as lamps.

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.

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 three safety switches connected in series for each channel. Each output is thus two-fault-tolerant with respect to the safety switch. Each safety switch of a channel can be individually switched off via the system bus (I/O bus) or via the second independent shutdown option (watchdog).

The safe state of an output is the de-energized state. Redundant processor systems monitor the values expected for the outputs. Outputs that do not correspond to the expected values are de-energized. One of the two read-back branches that were monitored for their expected values can be tested.

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 detects a module fault, the module adopts the safe state and all outputs are de-energized in accordance with the 'de-energize to trip principle'. If a channel fault occurs, only the affected channel is switched off.

If the system buses fail, the outputs are de-energized.

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 24 digital outputs. The outputs are operated with 24 VDC or 48 VDC external power, while the module is supplied with power via the base plate. The external and internal power supplies are galvanically separated from one another.

The module is equipped with line monitoring (SC/OC). If the open-circuit monitoring is configured in SILworX, see Chapter 4.3, the channels are automatically checked for open-circuits (OC) and short-circuits (SC). The switching thresholds for line monitoring are preset and cannot be modified.

The outputs are protected against high currents. If a short-circuit occurs, the current at each output is limited to 2 A.

If a current higher than 0.75 A flows through an output for 50 ms, the affected output is switched off for 5 s. If the overcurrent is still present after the outputs has automatically been switched on again, the output is switched off for another 5 s. This process is repeated as long as the overcurrent is present. To avoid the cyclic switch-on after an overcurrent, the user program must be configured accordingly.

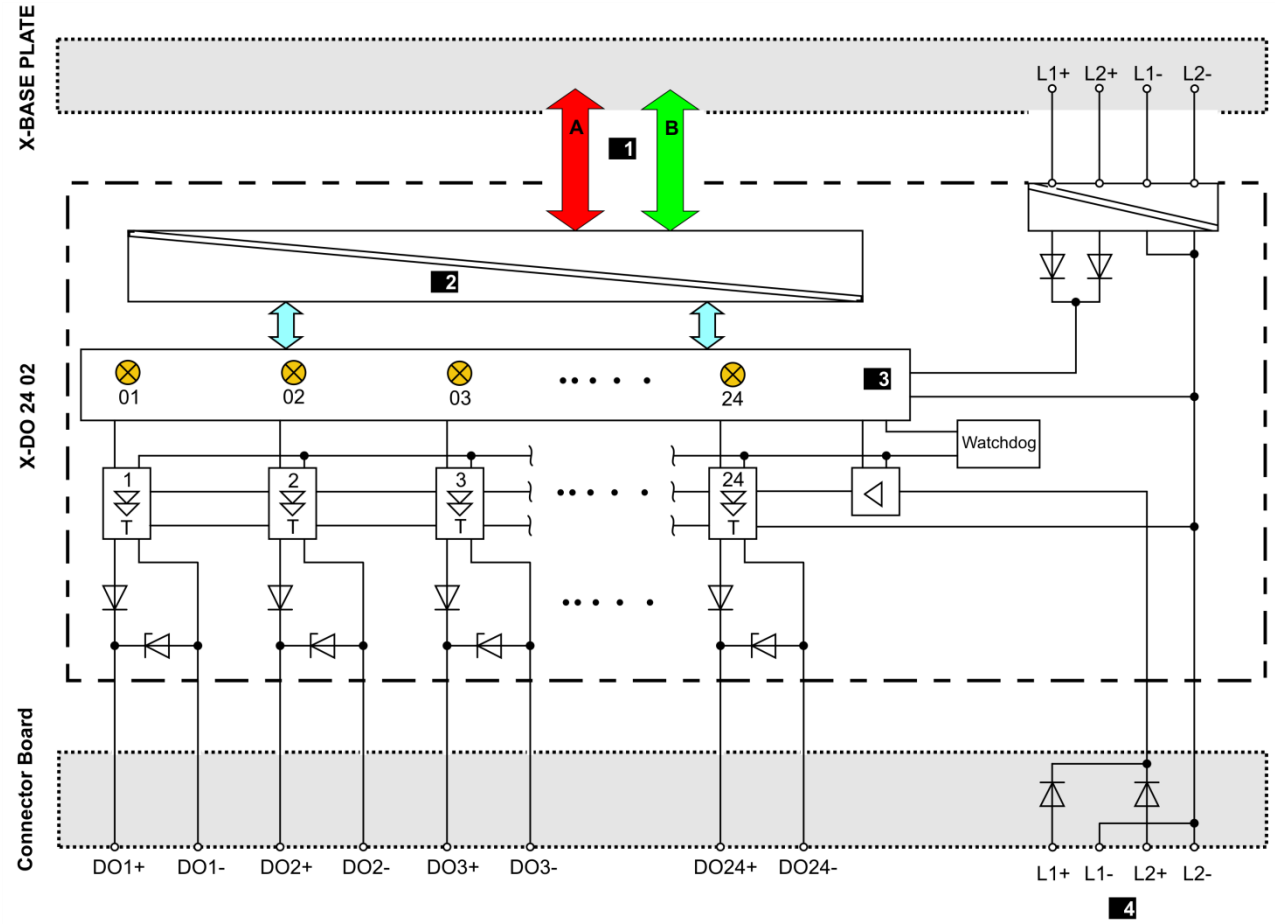
The total current allowed for the external power supply is 12 A. The module is equipped with an internal device fuse which protects the module against overload.

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.

The module is equipped with LEDs to indicate the status of the digital outputs, see Chapter 3.4.2.

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 External power supply 24 V/48 V

Figure 2: Block Diagram

3.4.2 Indicators

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

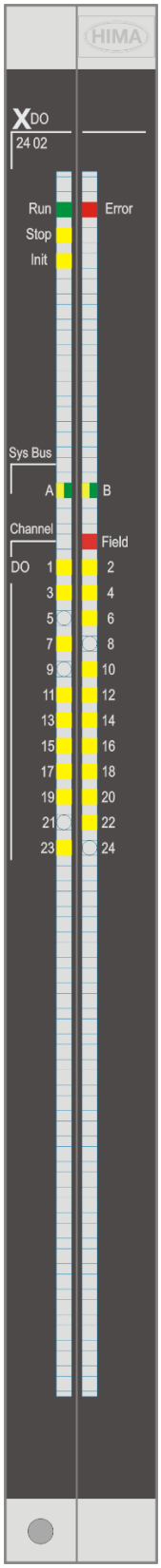


Figure 3: Indicators

The LEDs indicate the operating state of the module. All LEDs should be considered together. The LEDs on the module are divided into the following groups:

- Module status indicators (Run, Error, Stop, Init).
- System bus indicators (A, B).
- I/O indicators (DO 1…24, 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
DO 1…DO 24	Yellow	On	High level present
		Blinking2	Channel fault
		Off	Low level present
Field	Red	Blinking2	Field fault on at least one channel, e.g., open-circuit, short-circuit, overcurrent.
		Off	No field faults

Table 5: I/O Indicators

3.5 Product Data

General information	
Supply voltage	24 VDC, -15…+20 %, rp ≤ 5 % SELV, PELV
Current consumption	Min. 0.5 A (idle)
Continuous load through external power supply	Max. 12 A at 24 VDC or 48 VDC
Galvanic separation	Yes, between supply voltage and outputs (ext. power supply)
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 60664-1
Installation height	< 2000 m
Degree of protection	IP20
Dimensions (H x W x D)	310 x 29.2 x 230 mm
Weight	Approx. 1.1 kg

Table 6: Product Data

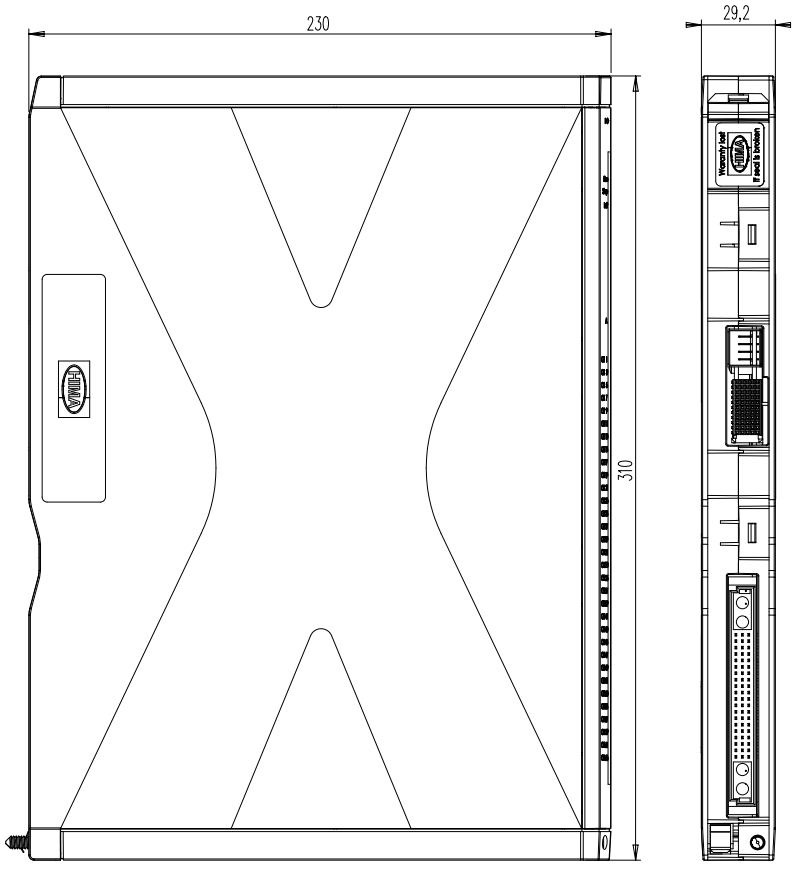


Figure 4: Views

Digital Outputs	
Number of outputs (number of channels)	24, not galvanically separated
External supply voltage	24/48 VDC, -15…+20 %, r_p ≤ 5 %, SELV, PELV
Output voltage	External supply voltage minus internal voltage drop
Voltage drop (with high level)	1.3 V at 0.75 A output current
Nominal rated current (with high level)	0.5 A, range 0.01…0.6 A
Total permissible current for the module	12 A
Leakage current (with low level)	< 500 µA
Current limiting in the event of a short-circuit	2 A, for each channel
Overcurrent interruption	I > 0.75 A
Behavior in the event of overcurrent and short-circuit	The affected output is switched off and cyclically switched on again, see Chapter 3.4.
Ohmic load	To nominal rated current 0.5 A
Inductive load	1 H
Lamp load (24 V lamps)	4 W
Capacitive load	100 µF
Line monitoring	
OC threshold	≤ 5 mA (24 V), ≤ 2 mA (48 V)
SC threshold	0.75 A (range 0.75…0.8 A)
Overload protection of the outputs, transient	60 V (max. 73 V)
Switching time of the channels (with ohmic load)	≤ 100 µs
Test pulse (with ohmic load)	typ. 200 µs

Table 7: Specifications for the Digital Outputs

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 010 01	Connector board with screw terminals
X-CB 010 02	Redundant connector board with screw terminals
X-CB 010 03	Connector board with cable plug
X-CB 010 04	Redundant connector board with cable plug

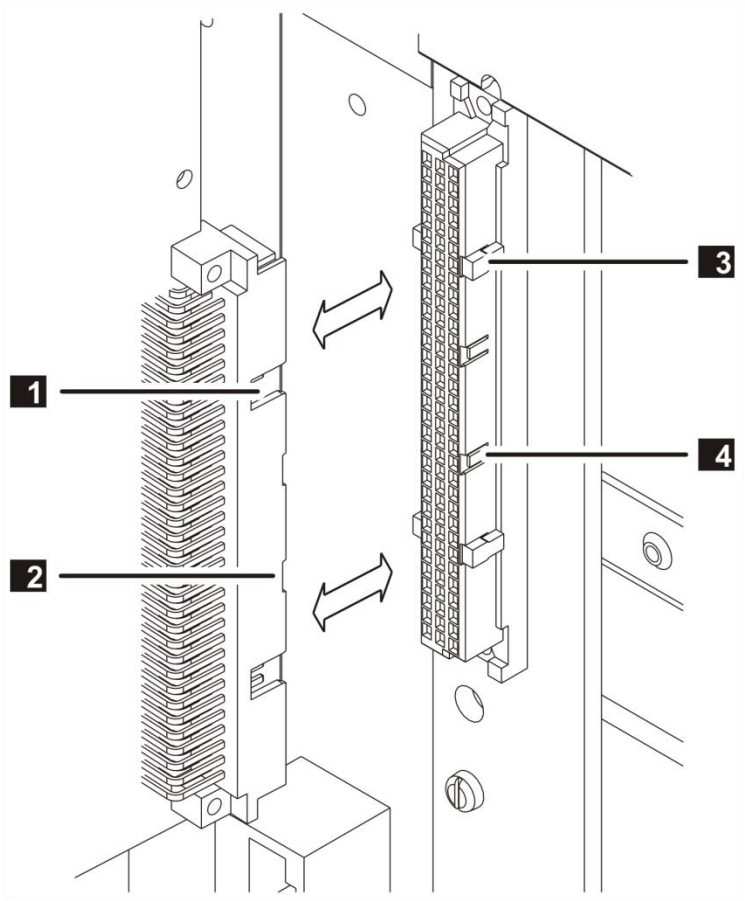
Table 8: Available Connector Boards

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 010 Connector Boards

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

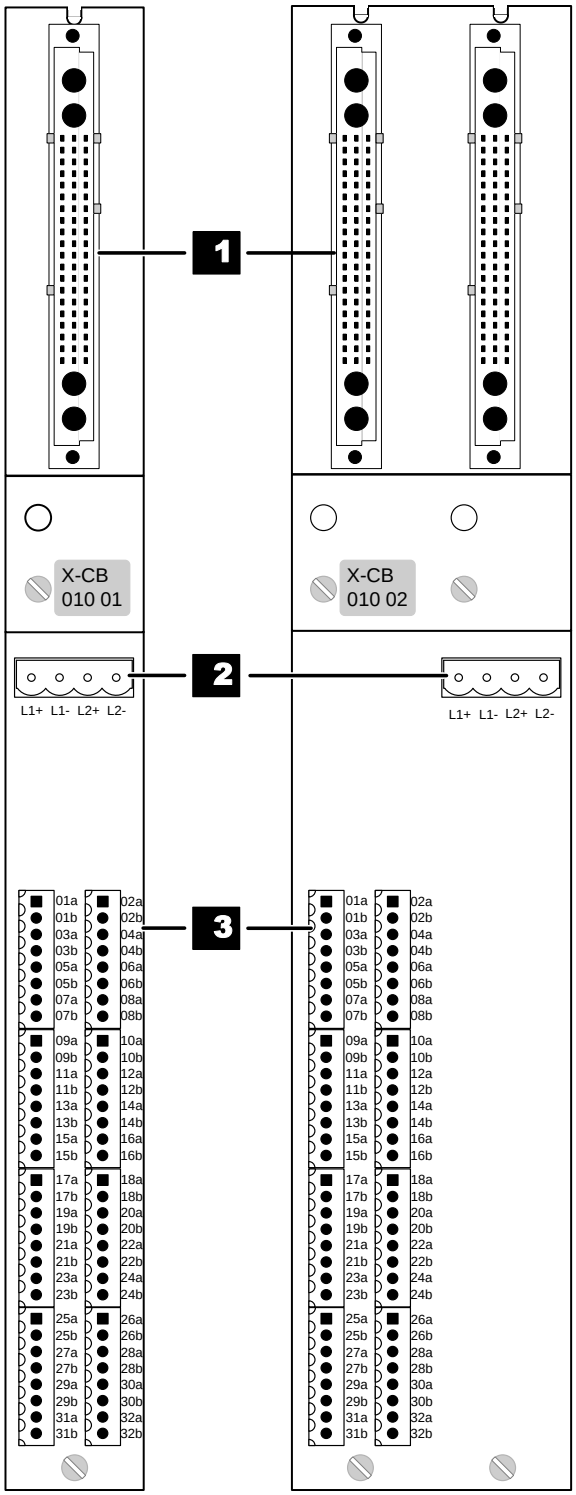
a7	a13	a20	a26	c7	c13	c20	c26
X		X		X	X		

Table 9: Position of Coding Wedges

3.6.3 Connector Boards with Screw Terminals

Mono **Redundant**

X-CB 010 01 X-CB 010 02



1 I/O module plug

2 Connection to the external power supply

3 Connection to the field level (screw terminals)

Figure 6: Connector Boards with Screw Terminals

3.6.4 Terminal Assignment for Connector Boards with Screw Terminals

Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	01a	DO1+	1	02a	DO2+
2	01b	DO1-	2	02b	DO2-
3	03a	DO3+	3	04a	DO4+
4	03b	DO3-	4	04b	DO4-
5	05a	DO5+	5	06a	DO6+
6	05b	DO5-	6	06b	DO6-
7	07a	DO7+	7	08a	DO8+
8	07b	DO7-	8	08b	DO8-
Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	09a	DO9+	1	10a	DO10+
2	09b	DO9-	2	10b	DO10-
3	11a	DO11+	3	12a	DO12+
4	11b	DO11-	4	12b	DO12-
5	13a	DO13+	5	14a	DO14+
6	13b	DO13-	6	14b	DO14-
7	15a	DO15+	7	16a	DO16+
8	15b	DO15-	8	16b	DO16-
Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	17a	DO17+	1	18a	DO18+
2	17b	DO17-	2	18b	DO18-
3	19a	DO19+	3	20a	DO20+
4	19b	DO19-	4	20b	DO20-
5	21a	DO21+	5	22a	DO22+
6	21b	DO21-	6	22b	DO22-
7	23a	DO23+	7	24a	DO24+
8	23b	DO23-	8	24b	DO24-
Pin no.	Designation	Signal	Pin no.	Designation	Signal
1	25a		1	26a	
2	25b		2	26b	
3	27a		3	28a	
4	27b		4	28b	
5	29a		5	30a	
6	29b		6	30b	
7	31a		7	32a	
8	31b		8	32b	

Table 10: Terminal Assignment for Connector Boards with Screw Terminals

Cable plugs attached to the connector board pin headers are used to connect to the field level and to external power supplies.

The cable plugs feature the following characteristics:

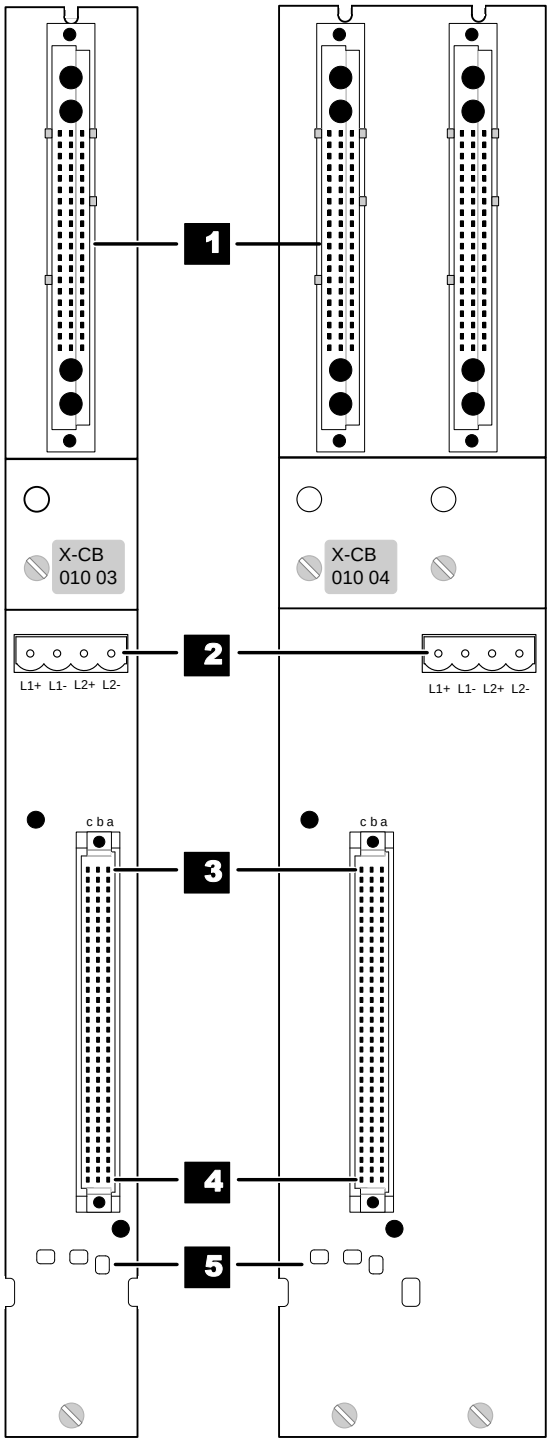
Connection to the field level	
Cable plugs	8 pieces, with 8 poles
Wire cross-section	0.2…1.5 mm^2 (single-wire) 0.2…1.5 mm^2 (finely stranded) 0.2…1.5 mm^2 (with wire end ferrule)
Stripping length	6 mm
Screwdriver	Slotted 0.4 x 2.5 mm
Tightening torque	0.2…0.25 Nm
External power supply	
Cable plugs	4-pole
Wire cross-section	0.2…2.5 mm^2 (single-wire) 0.2…2.5 mm^2 (finely stranded) 0.25…2.5 mm^2 (with wire end ferrule)
Stripping length	7 mm
Screwdriver	Slotted 0.6 x 3.5 mm
Tightening torque	0.5…0.6 Nm

Table 11: Cable Plug Characteristics

3.6.5 Connector Boards with Cable Plug

Mono X-CB 010 03

Redundant X-CB 010 04



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

Figure 7: Connector Boards with Cable Plug

3.6.6 Pin Assignment for Connector Boards with Cable Plug

HIMA provides ready-made system cables for use with these connector boards, 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.

Pin assignment						
Row	c		b		a	
	Signal	Color	Signal	Color	Signal	Color
1	DO32+	PKBN [1]	DO32-	WHPK [1]	Internal use [3]	YE [2]
2	DO31+	GYBN [1]	DO31-	WHGY [1]		GN [2]
3	DO30+	YEBN [1]	DO30-	WHYE [1]		BN [2]
4	DO29+	BNGN [1]	DO29-	WHGN [1]		WH [2]
5	DO28+	RDBU [1]	DO28-	GYPK [1]		
6	DO27+	VT [1]	DO27-	BK [1]		
7	DO26+	RD [1]	DO26-	BU [1]		
8	DO25+	PK [1]	DO25-	GY [1]		
9	DO24+	YE [1]	DO24-	GN [1]		
10	DO23+	BN [1]	DO23-	WH [1]		
11	DO22+	RDBK	DO22-	BUBK		
12	DO21+	PKBK	DO21-	GYBK		
13	DO20+	PKRD	DO20-	GYRD		
14	DO19+	PKBU	DO19-	GYBU		
15	DO18+	YEBK	DO18-	GNBK		
16	DO17+	YERD	DO17-	GNRD		
17	DO16+	YEBU	DO16-	GNBU		
18	DO15+	YEPK	DO15-	PKGN		
19	DO14+	YEGY	DO14-	GYGN		
20	DO13+	BNBK	DO13-	WHBK		
21	DO12+	BNRD	DO12-	WHRD		
22	DO11+	BNBU	DO11-	WHBU		
23	DO10+	PKBN	DO10-	WHPK		
24	DO9+	GYBN	DO9-	WHGY		
25	DO8+	YEBN	DO8-	WHYE		
26	DO7+	BNGN	DO7-	WHGN		
27	DO6+	RDBU	DO6-	GYPK		
28	DO5+	VT	DO5-	BK		
29	DO4+	RD	DO4-	BU		
30	DO3+	PK	DO3-	GY		
31	DO2+	YE	DO2-	GN		
32	DO1+	BN	DO1-	WH		

[1] Additional orange ring if one wire color is repeated.

[2] Additional violet ring if one wire color is repeated for the second time.

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

Table 12: Pin Assignment for the System Cable Plug

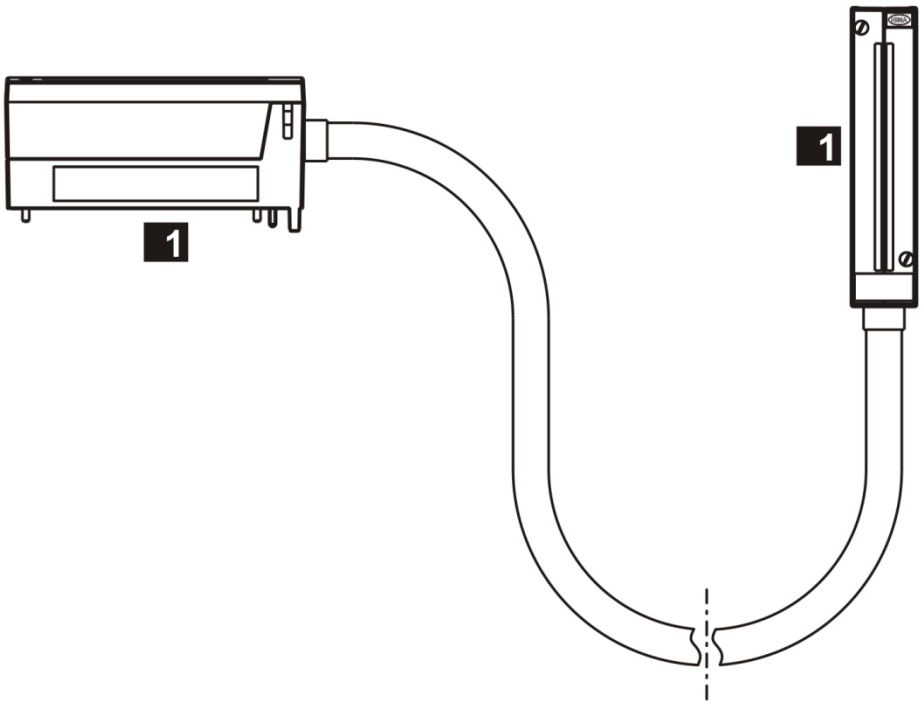
The external power supply is connected using a detachable 4-pole plug. For details on the permissible wire cross-sections, see Table 11.

3.7 System Cable X-CA 006

System cable X-CA 006 is used to connect the X-CB 010 03/04 connector board to field termination assemblies.

General information	
Cable	LIYY 64 x 0.34 mm² + 2 x 2 x 0.25 mm²
Wire	Finely stranded
Average outer diameter (d)	Approx. 17.2 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 12.

Table 13: Cable Data



1 Identical cable plugs

Figure 8: X-CA 006 01 n

The system cable is available in the following standard lengths:

System cables	Description	Length	Weight
X-CA 006 01 8	Coded cable plugs on both sides.	8 m	4.25 kg
X-CA 006 01 15		15 m	8 kg
X-CA 006 01 30		30 m	16 kg

Table 14: 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 801 001 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.
  - An unshielded, twisted pair cable may be used for connecting field current circuits to the digital outputs.
  - If shielded cables are used, connect the shielding 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.

The outputs may be wired redundantly using the corresponding connector boards. For further details, see Chapter 3.6 and Chapter 4.4.1.

4.1.1 Wiring Unused Outputs

Outputs that are not being used may stay open and need not be terminated. 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.

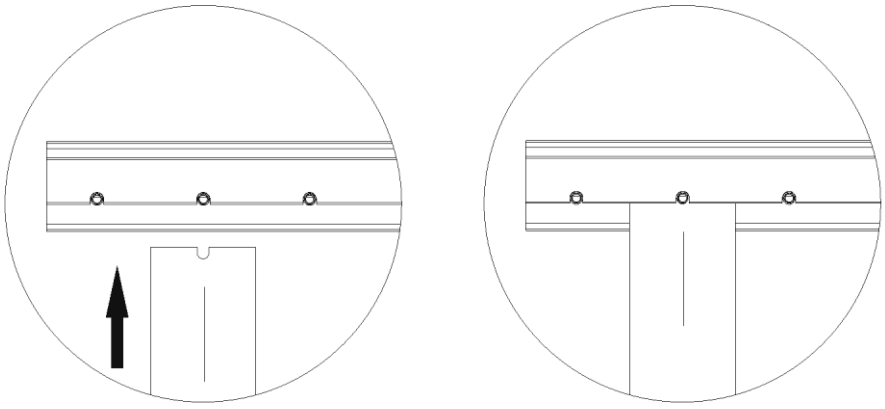


Figure 9: Example of how to Insert the Mono Connector Board

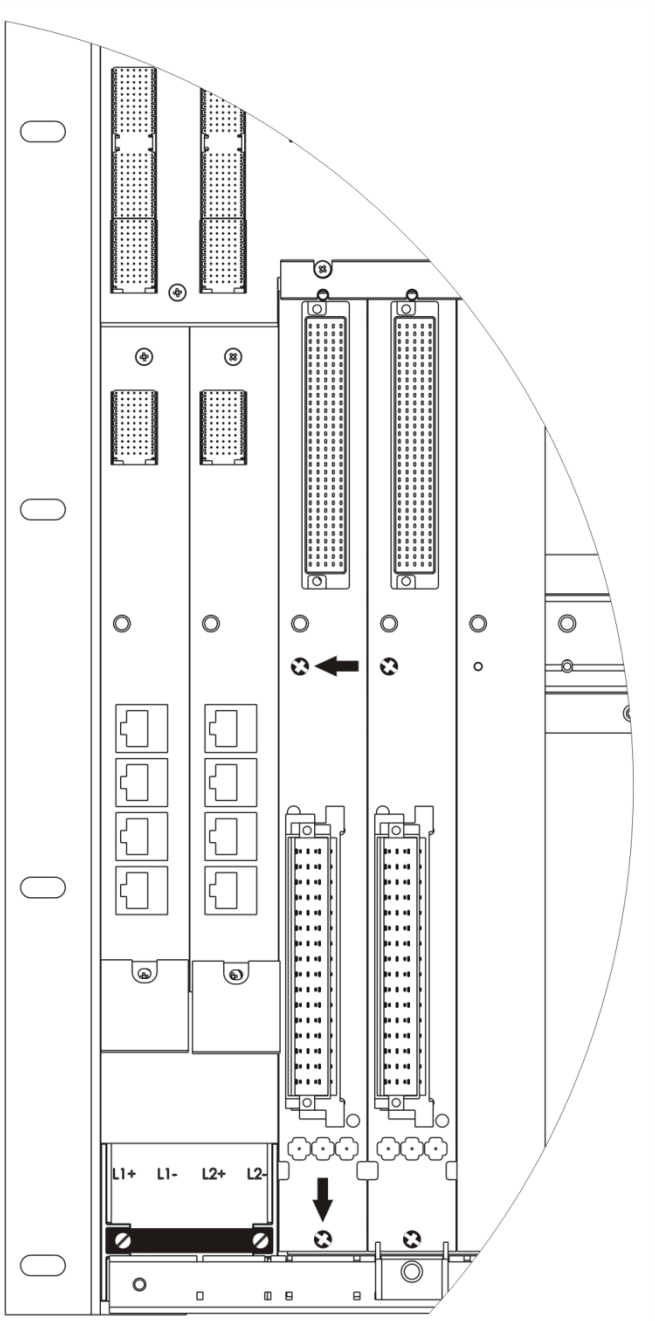


Figure 10: Example of how to Secure the Mono Connector Board with Captive Screws

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:

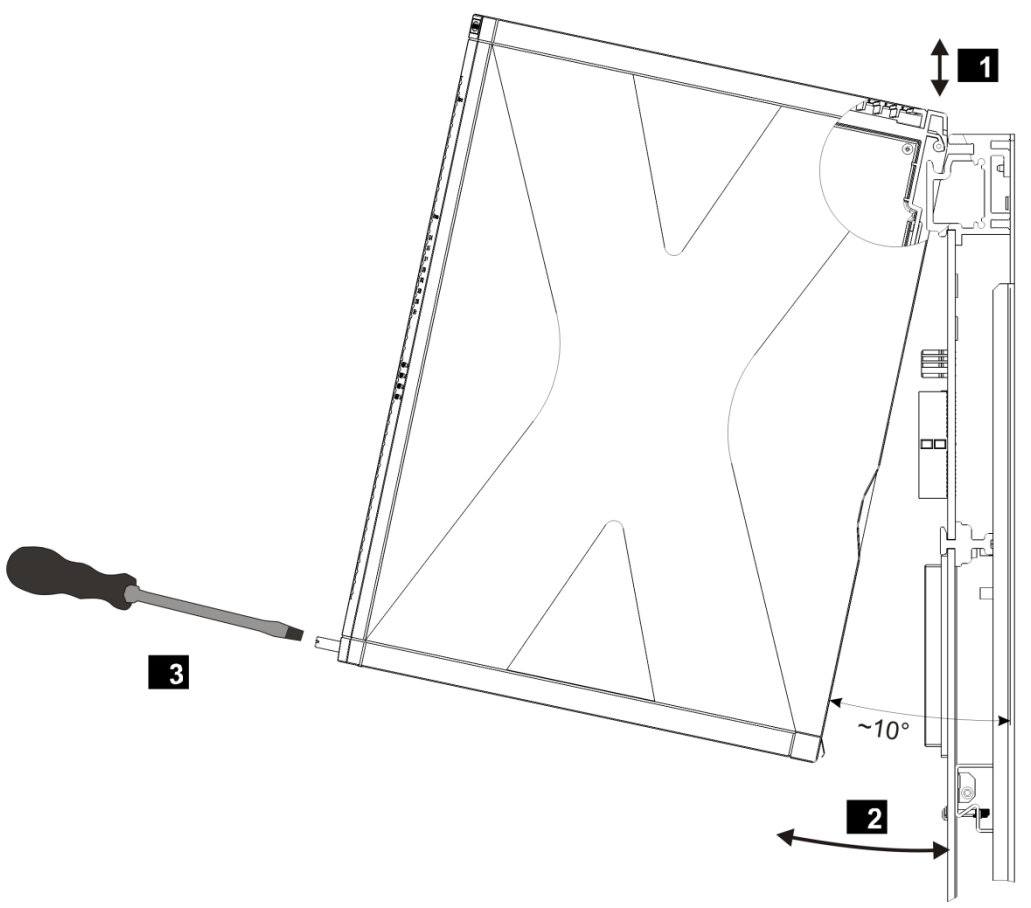
- Screwdriver, slotted 0.8 x 4.0 mm.
- Screwdriver, slotted 1.2 x 8.0 mm.

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 Line Monitoring (SC/OC)

Line monitoring consists of monitoring for both short-circuits and open-circuits and can be configured for each channel. The switching thresholds for short-circuit monitoring are preset und fixed, see the product data (Table 7).

The following points must be taken into account for line monitoring (SC/OC):

- Line monitoring reliably detects an open-circuit (OC) if a load with current consumption of at least 10 mA is connected.
- If an actuator is redundantly connected to two modules, line monitoring reliably detects an open-circuit (OC) if a load with current consumption of at least 20 mA is connected.
- Line monitoring reliably detects a short-circuit (SC) when currents exceed 0.8 A.
- If an actuator is redundantly connected to two modules, line monitoring reliably detects a short-circuit (SC) when currents exceed 1.6 A.

Line monitoring (OC/SC) can be configured for each channel as follows:

- In the **I/O Submodule DO24 02** tab, set *SC/OC Interval [µs]* to a value ≥ 40 ms for all channels.
  Default setting: 40 ms
- In the **I/O Submodule DO24_02**, activate *Show Open-Circuit* and *Show Short-Circuit* (indicated via the *Field* LED)
  Default setting: Activated
- In the **I/O Submodule DO24_02: Channels**, activate *SC/OC Active*,
  Default setting: Activated
- In the **I/O Submodule DO24_02: Channels**, enter 0 µs…50 ms for *Max. Test Pulse Duration [µs]*, see recommended values Table 15.
  Default setting: 0
  The test pulse duration is at least 200 µs, even with the default setting or inputs < 1000. The parameter granularity is 1 ms (1000). The values are entered in µs.

4.3.1 Recommended Values for Line Monitoring (SC/OC)

Test pulse duration	SC/OC Interval	Relationship
200 µs	40 ms	Max. 0.5 %
1 ms	200 ms	Max. 0.5 %
10 ms	2 s	Max. 0.5 %
20 ms	4 s	Max. 0.5 %
50 ms	10 s	Max. 0.5 %

Table 15: Relationship Between Test Pulse Duration and SC/OC Interval

For actuators, a pulse-duty factor of 0.5 % between the SC/OC interval and the test pulse duration has provided good results in practice. The value for the test pulse duration must always be lower than the value for the SC/OC interval.

If line monitoring is faulty, a short-circuit or an open-circuit is indicated.

Line monitoring does not affect the *Channel OK*, *Submodule OK* and *Module OK* statuses, see Chapter 4.4.

4.3.2 OC Blanking (Number of SC/OC Intervals)

The *OC Blanking (Number of SC/OC Intervals)* parameter specifies the number of test intervals (parameter *SC/OC Interval [µs]*) that must run before a detected field error is reported to the processor module (X-CPU) as an open-circuit. Transient disturbances are blanked until the fault response occurs. The setting of *OC Blanking (Number of SC/OC Intervals)* applies to all channels.

The default setting of *OC Blanking (Number of SC/OC Intervals)* is 1. This means that a detected field error is reported to the processor module in the first CPU cycle.

Setting *OC Blanking (Number of SC/OC Intervals)* to a value greater than 1 increases the response time. This must be taken into account when configuring the safety time and the watchdog time.

4.4 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.
- Activate the parameter *External Power Supply over* by selecting:
  - Redundant L1/L2
  - Mono L1
  - Mono L2

  Use *Redundant L1 + L2* to select a redundant external power supply or choose the connection to the single power supply.
- 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.

4.4.1 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 on one channel (no external faults). The module is not plugged in. Observe the *Module Status* parameter!
Module Status	DWORD	Y	R	Status of the module.
Timestamp [µs]	DWORD	N	R	Microsecond fraction of the timestamp. Time: Testing of the digital outputs completed.
Timestamp [s]	DWORD	N	R	Second fraction of the timestamp. Time: Testing of the digital outputs completed.
[1] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

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.

Table 16: The **Module** Tab in the Hardware Editor

4.4.2 The **I/O Submodule DO 24_02** Tab

The **I/O Submodule DO24_02** tab contains the following system parameters:

System parameter	Data type	S [1)]	R/W	Description
This parameter cannot be changed.				
Name	---	---	W	Module name.
Output Noise Blanking	BOOL	Y	W	Allow output noise blanking by the output module (Activated/Deactivated). Default setting: Deactivated (**recommended!**) 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.
SC/OC Interval [µs]	UDINT	Y	W	SC/OC interval of the test pulses (≥ 40 m). Default setting: 40 000 = 40 ms See Chapter 4.3.
OC Blanking (Number of SC/OC Intervals)	UDINT	Y	W	Specifies the number of test intervals (parameter *SC/OC Interval [µs]*) that must run before a detected field error is reported to the processor module (X-CPU) as an open-circuit. Range of values: 1…max. UDINT Default setting: 1
Show Open-Circuit	BOOL	Y	W	Displayed via LED *Field* (Activated/Deactivated) Default setting: Activated
Show Short-Circuit	BOOL	Y	W	Displayed via LED *Field* (Activated/Deactivated) Default setting: Activated
External Power Supply over	DWORD	Y	W	It specifies the type of external power supply: ▪ Redundant *Redundant L1/L2* ▪ Mono on *Mono L1* ▪ Mono on *Mono L2* Default setting: *Redundant L1/L2*

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 4.4.5).
Diagnostic Response	DINT	N	R	As soon as *Diagnostic Response* returns the ID of *Diagnostic Request* (for coding details, see Chapter 4.4.5), *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
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 4.4.4.
[1] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 17: The **I/O Submodule DO 24_02** Tab in the Hardware Editor

4.4.3 The **I/O Submodule DO 24_02: Channels** Tab

The **I/O Submodule DO24_02: Channels** tab contains the following system parameters for each digital 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 parameter	Data type	S [1)]	R/W	Description
Channel no.	---	---	R	Channel number, preset and cannot be changed.
Channel Value [BOOL] ->	BOOL	Y	W	Binary value in accordance with the switching levels LOW (dig) and HIGH (dig). TRUE: Channel energized. FALSE: Channel de-energized.
-> Channel OK [BOOL]	BOOL	Y	R	Status of the channel: TRUE: Fault-free channel. The channel value is valid. FALSE: Faulty channel. The channel is de-energized. An external SC or OC has no influence on *-> Channel OK [BOOL]*. Observe the statuses *-> OC* and *-> SC*!
SC/OC Active	BOOL	Y	W	Short-circuit and open-circuit monitoring (Activated/Deactivated). Default setting: Activated
Max. Test Pulse Duration [µs]	UDINT	Y	W	Test pulse duration with short-circuit and open-circuit monitoring. Range of values: 0…50 000 µs Default setting: 0 µs
-> OC	BOOL	Y	R	TRUE: Open-circuit. FALSE: No open-circuit.
-> SC	BOOL	Y	R	TRUE: Short-circuit. FALSE: No short-circuit.
Redund.	BOOL	Y	W	Requirement: The redundant module must exist. Activated: The channel redundancy for this channel is active. Deactivated: Deactivate the channel redundancy for this channel. Default setting: Deactivated
[1)] The operating system handles the system parameter in a safety-related manner, yes (Y) or no (N).				

Table 18: The **I/O Submodule DO24_02: Channels** Tab in the Hardware Editor

4.4.4 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.
0x00000040	Overcurrent, module shutdown.
0x00000080	Reset of CS monitoring (Chip Select monitoring).
0x00800000	Voltage monitoring of WD1: voltage error.
0x01000000	Voltage monitoring of WD2: voltage error.
0x02000000	Voltage monitoring of L1+ HIGH voltage defective.
0x04000000	Voltage monitoring of L1+ LOW voltage defective.
0x08000000	Voltage monitoring of L2+ HIGH voltage defective.
0x10000000	Voltage monitoring of L2+ LOW voltage defective.
0x20000000	Voltage monitoring of AGND: voltage defective.
0x40000000	Voltage monitoring of VMOS: HIGH voltage defective.
0x80000000	Voltage monitoring of VMOS: LOW voltage defective.

Table 19: Coding of *Submodule Status [DWORD]*

4.4.5 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>Maximum value of the 24 V voltage supply (L1+ and L2+).</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…1024</td><td>Status of channels 1…24
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Fault in hardware unit (submodule).</td></tr>
<tr><td>0x0002</td><td>Reset of an I/O bus.</td></tr>
<tr><td>0x0004</td><td>Overcurrent, channel shutdown.</td></tr>
<tr><td>0x0008</td><td>Read-back value 0 on the output with reference value 1, due to hardware fault.</td></tr>
<tr><td>0x0010</td><td>Short-circuit detected.</td></tr>
<tr><td>0x0020</td><td>Open-circuit detected.</td></tr>
<tr><td>0x0030</td><td>Line monitoring hardware fault.</td></tr>
<tr><td>0x0040</td><td>Read-back value 1 at setpoint 0 due to fault.</td></tr>
<tr><td>0x0080</td><td>Read-back value 0 at setpoint 1 due to field fault.</td></tr>
</table></td></tr>
</table>

Table 20: Coding of *Diagnostic Status [DWORD]*

4.5 Connection Variants

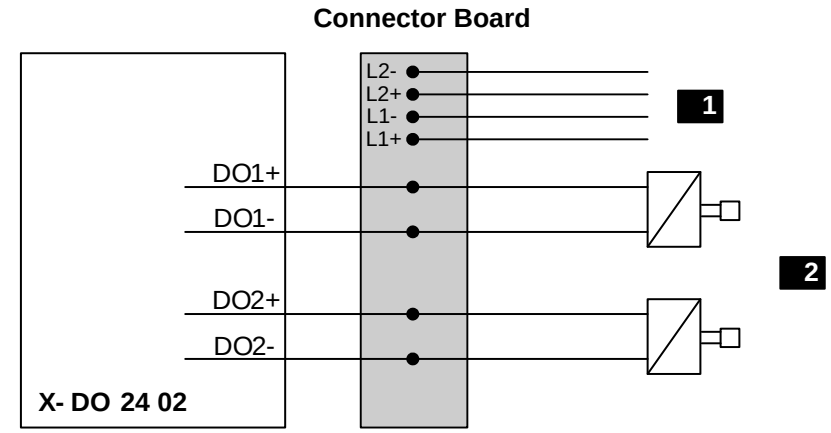
The chapter describes the proper wiring of the module in safety-related applications. The following connection variants are permitted.

The outputs are wired via connector boards. Special connector boards are available for redundantly wiring the modules, see Chapter 3.6.

The following points must be taken into account when connecting the loads to the outputs:

- A protective circuit (free-wheeling diode) is required when connecting inductive loads.
- Unshielded, twisted pairs of cables may be connected.
- The ground wires of the outputs may not be interconnected.

4.5.1 Wiring Actuators



1 External power supply 24 V/48 V 2 Actuators

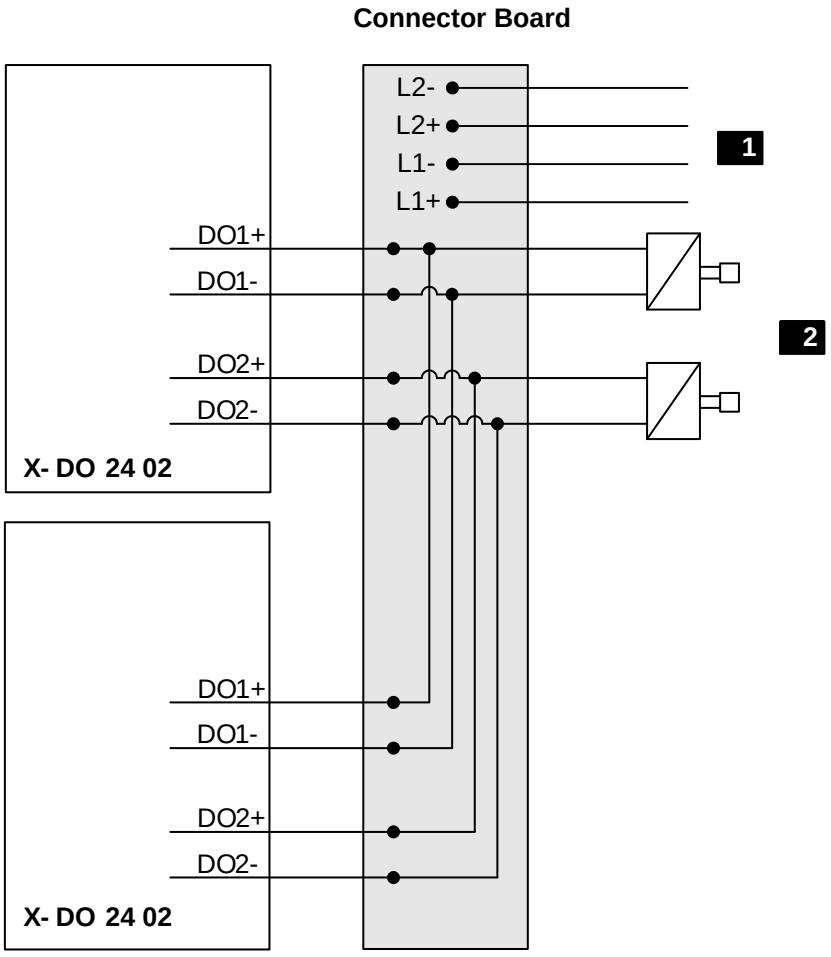
Figure 12: Wiring of the Module with Actuators

NOTICE

The module outputs must be connected with two poles.
The ground wires of actuators may not be interconnected.
The use of common lines can result in interfering coupling loops that may cause the module or the safety shutdown to fail.

4.5.2 Redundant Wiring of Actuators via Two Modules

When actuators are redundantly wired, the general requirements for line monitoring must be observed, see Chapter 4.3.



1 External power supply 24 V/48 V **2** Actuators

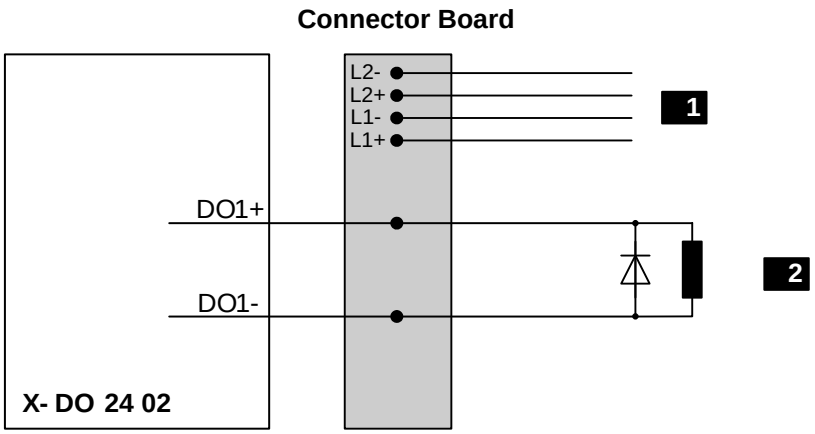
Figure 13: Redundant Wiring of Actuators

NOTICE

The wiring described above is only allowed if the two channels have identical channel numbers.

4.5.3 Wiring Inductive Loads

When connecting inductive loads, a protective circuit (such as a suitable free-wheeling diode or varistor) must be connected in parallel to the load.



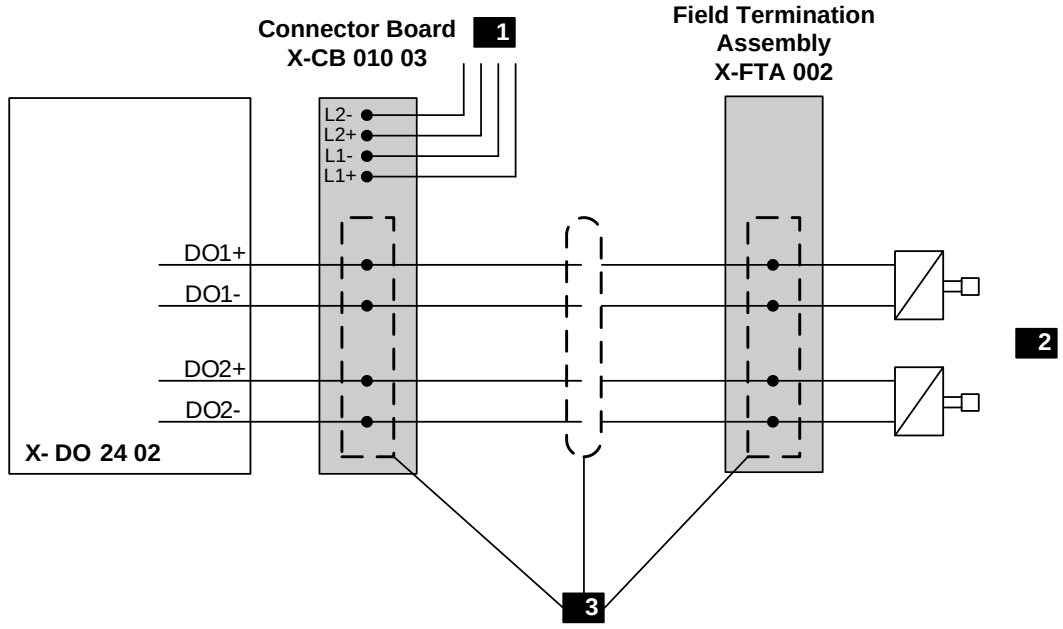
1 External power supply 24 V/48 V

2 Inductive load with free-wheeling diode

Figure 14: Wiring for Inductive Loads

4.5.4 Connecting to Actuators via Field Termination Assembly

Actuators are connected via the X-FTA 002 01 as described in Figure 15. For further information, refer to the X-FTA 002 01 manual (HI 801 117 E).



1 External power supply 24 V/48 V

2 Actuators

3 System cable with cable plug

Figure 15: Connection to Actuators via Field Termination Assembly

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 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. Chapter 4.4.4 and Chapter 4.4.5 describe the most important module-specific diagnostic messages.

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.

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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MANUAL
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HI 801 095 E

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