HIMatrix

Safety-Related Controller

F3 AIO 8/4 01 Manual

HIMA Paul Hildebrandt GmbH + Co KG
Industrial Automation

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HI 800 161 E

Contact

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Revision index	Revisions	Type of change	
		technical	editorial
1.00	Added: Configuration with SILworX, Chapter *Connection Variants*	X	X
1.01	Deleted: Chapter *Monitoring the Temperature State* integrated in the system manual		X
2.00	Revised: Chapters 3.5.1, 3.5.2.1 and 4.5 Added: F3 AIO 8/4 014, SIL 4 certified according to EN 50126, EN 50128 and EN 50129, Chapter 4.1.3	X	X

Table of Contents

1 Introduction

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

1.1 Structure and Use of this Manual

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

This manual is organized in the following main chapters:

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

HIMatrix remote I/Os are available for the programming tools SILworX and ELOP II Factory. Which programming tool can be used, depends on the processor operating system of the HIMatrix remote I/O, refer to the following table:

Programming tool	Processor operating system
SILworX	CPU OS V7 and higher
ELOP II Factory	CPU OS up to V6.x

Table 1: Programming Tools for HIMatrix Remote I/Os

In the manual, the differences are specified by using:

- Separated chapters
- Tables differentiating among the versions

i **Projects created with ELOP II Factory cannot be edited with SILworX, and vice versa!**

i Compact controllers and remote I/Os are referred to as *devices*.

Additionally, the following documents must be taken into account:

Name	Content	Document number
HIMatrix System Manual Compact Systems	Hardware description of the HIMatrix compact systems	HI 800 141 E
HIMatrix System Manual Modular System F60	Hardware description of the HIMatrix modular system	HI 800 191 E
HIMatrix Safety Manual	Safety functions of the HIMatrix system	HI 800 023 E
HIMatrix Safety Manual for Railway Applications	Safety functions of the HIMatrix system using the HIMatrix in railway applications	HI 800 437 E
SILworX Online Help	Instructions on how to use SILworX	-
ELOP II Factory Online Help	Instructions on how to use ELOP II Factory, Ethernet IP protocol	-
SILworX First Steps	Introduction to SILworX using the HIMax system as an example	HI 801 103 E
ELOP II Factory First Steps	Introduction to ELOP II Factory	HI 800 006 E

Table 2: Additional Relevant Documents

The latest manuals can be downloaded from the HIMA website at www.hima.com. The revision index on the footer can be used to compare the current version of existing manuals with the Internet edition.

1.2 Target Audience

This document addresses system planners, configuration engineers, programmers of automation devices and personnel authorized to implement, operate and maintain the modules and systems. Specialized knowledge of safety-related automation systems is required.

1.3 Formatting Conventions

To ensure improved readability and comprehensibility, the following fonts 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	For parameters and system variables
`Courier`	Literal user inputs
RUN	Operating state are designated by capitals
Chapter 1.2.3	Cross references are hyperlinks even though they are not particularly marked. When the cursor hovers over a hyperlink, it changes its shape. Click the hyperlink to jump to the corresponding position.

Safety notes and operating tips are particularly marked.

1.3.1 Safety Notes

The safety notes are represented as described below.
These notes must absolutely be observed to reduce the risk to a minimum. The content is structured as follows:

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

⚠ SIGNAL WORD

Type and source of risk!
Consequences arising from non-observance
Risk prevention

The signal words have the following meanings:

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

NOTE

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 corresponding to the 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.

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

2.1 Intended Use

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

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

2.1.1 Environmental Requirements

Requirement type	Range of values [1]
Protection class	Protection class III in accordance with IEC/EN 61131-2
Ambient temperature	0...+60 °C
Storage temperature	-40...+85 °C
Pollution	Pollution degree II in accordance with IEC/EN 61131-2
Altitude	< 2000 m
Housing	Standard: IP20
Supply voltage	24 VDC

[1] The values specified in the technical data apply and are decisive for devices with extended environmental requirements.

Table 3: Environmental Requirements

Exposing the HIMatrix system to environmental conditions other than those specified in this manual can cause the HIMatrix system to malfunction.

2.1.2 ESD Protective Measures

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

NOTE

Device damage due to electrostatic discharge!

- **When performing the work, make sure that the workspace is free of static, and wear an ESD wrist strap.**
- **If not used, ensure that the device is protected from electrostatic discharge, e.g., by storing it in its packaging.**

2.2 Residual Risk

No imminent risk results from a HIMatrix system itself.

Residual risk may result from:

- Faults related to engineering
- Faults related to 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 HIMatrix system is a part of the safety equipment of a site. If a device or a module fails, the system enters the safe state.

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

3 Product Description

The safety-related **F3 AIO 8/4 01** remote I/O is a compact system in a metal housing with 8 analog inputs and 4 analog outputs.

The remote I/O is available in various model variants for SILworX and ELOP II Factory, see Table 10.

Remote I/Os are connected to individual HIMax or HIMatrix controllers via safe**ethernet**. They are used to extend the I/O level, but are not able to run any user program by themselves.

The remote I/O is suitable for mounting in Ex-zone 2, see Chapter 4.1.4.

The device is TÜV-certified for safety-related applications up to SIL 3 (IEC 61508, IEC 61511 and IEC 62061), Cat. 4 and PL e (EN ISO 13849-1) and SIL 4 (EN 50126, EN 50128 and EN 50129).
Further safety standards, application standards and test standards are specified in the certificates available on the HIMA website.

3.1 Safety Function

The remote I/O is equipped with safety-related analog inputs. The input values on the inputs are safely transmitted to the connected controller via safe**ethernet**. The outputs are safely assigned their values by the connected controller via safe**ethernet**.

3.1.1 Safety-Related Analog Inputs

The remote I/O is equipped with 8 analog inputs with transmitter supplies for the unipolar measurement of voltages, referenced to L-.

The remote I/O is intended to measure the voltage on the inputs. To measure the current on the inputs, the inputs must be connected with external shunt adapters, see Table 4.

Only shielded cables must be connected to the analog inputs. Each analog input must be connected to a twisted pair of wires. The shielding must be connected to the remote I/O and the sensor housing and earthed of one end to the remote I/O side to form a Faraday cage.

i Unused input channels must each be short-circuited to the ground (L-).

The following input values are available:

Input channels	Polarity	Current Voltage	Range of values in the application	Safety-related accuracy
8	Unipolar	0...+10 V	0...2000	2%
8	Unipolar	0/4...20 mA	0...1000[1)] 0…2000[2)]	2% 2%
[1)] with external Z 7301 shunt adapter, see Chapter 4.1.1.1 [2)] with external Z 7302 or Z 7309 shunt adapter, see Chapter 4.1.1.1				

Table 4: Input Values for the Analog Inputs

If an open-circuit occurs during voltage measurement (the line is not monitored), any input signals are processed on the high-resistance inputs. The value resulting from this fluctuating input voltage is not reliable; with voltage inputs, the channels must be terminated with a 10 kΩ resistor. The internal resistance of the source must be taken into account.

For a current measurement with the shunt connected in parallel, the 10 kΩ resistor is not required.

The analog inputs are designed to retain the metrological accuracy for 10 years. A proof test must be performed every 10 years.

3.1.1.1 Reaction in the Event of a Fault

If the device detects a fault on an analog input, the *AI.Error Code* parameter is set to a value greater than 0. If a device fault occurred, the SILworX system parameter *Module Error Code* is set to a value greater than 0, or if ELOP II Factory is used, the *Module.Error Code* signal is set to a value greater than 0.

In both cases, the device activates the *FAULT* LED.

In addition to the analog value the the error code must be evaluated. The analog value must be configured to ensure a safety-related reaction.

The error code allows the user to configure additional fault reactions in the user program.

3.1.2 Line Monitoring for Digital Outputs

The analog inputs (AI) of the F3 AIO 8/4 01 can also be used to monitor the line for open-circuits and short-circuits of digital outputs of other HIMatrix controllers (line monitoring). To this end, the transmitter supply must be set to 26 V. To do so, set the *Transmitter Voltage[01]* parameter in SILworX and ELOP II Factory to 2, see Table 29 and Table 33.

3.1.2.1 Requirements

Using HIMatrix devices with analog inputs, the digital outputs of any HIMatrix controller can be monitored under the following conditions:

- The transmitter supply of analog inputs exists,
- An external shunt can be connected to the analog inputs.

These conditions apply for all systems within the HIMatrix family, from compact to modular systems.

3.1.2.2 Examples

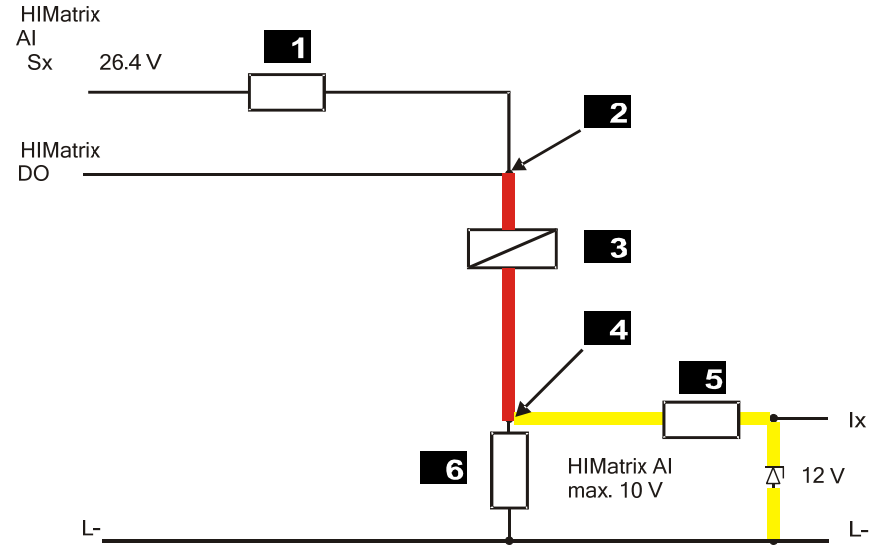
The digital outputs of the F2 DO 16 01 or F20 can be monitored with the analog inputs of the F3 AIO 8/4 01.

The analog inputs of the F3 AIO 8/4 01 can monitor the digital outputs of the DIO 24/16 01 (modular system).

Figure 1 shows how the lines connecting a digital output (DO) to an actuator (e.g., solenoid valve) can be monitored for open-circuits and short-circuits.

i The connection must be adapted to the field devices used and the functionality checked accordingly!

Circuitry:



1 Series Resistor ($R_{series\ resistor}$)
2 Field Clamp Terminal
3 Solenoid Valve 8 W, 24 VDC
4 Field Clamp Terminal
5 Series Resistor (R_{diode})
6 Shunt (R_{shunt})

Figure 1: Circuitry for Line Monitoring

Line monitoring range (short-circuits and open-circuits)

Protective circuit with short-circuit

Examples of how to configure line monitoring for the digital output DO (circuit with solenoid valve 8 W 24 VDC):

Resistance values:		
Resistor:	$R_{series\ resistor}$	1.6 kΩ
Solenoid valve resistance:	$R_{solenoid\ valve}$	75 Ω
Shunt:	R_{shunt}	10 Ω

Table 5: Examples of Line Monitoring - Resistance Values

Voltage values:	
Transmitter voltage:	26.4 V
Output voltage DO during normal operation:	24 V
Output voltage DO with a short-circuit:	26.8 V
Voltage drop on the solenoid valve:	21 V
Switching voltage of the Z-diode:	12 V

Table 6: Examples of Line Monitoring - Voltage Values

Measured values for voltage on AI with line monitoring of DO				
Voltage drop $R_{series\ resistor}$	Voltage drop $R_{solenoid\ valve}$	Voltage drop R_{shunt}	Values for AI (with FSx000 resolution)	
			FS1000	FS2000
Output DO False or 0 (output DO is deactivated; de-energized state)				
25.08 V	1.15 V	0.15 V	14	28
Output DO True or 1 (output DO activated)				
-	21 V	3 V	300	600
Break in the field wiring				
-	-	0 V	0	0
Short-circuit in the field wiring or actuator				
-	0 V	26.8 V	1000[1)]	2000[1)]
[1)] maximum resolution of the analog inputs AI with voltage limited to 12 V by Z-diode				

Table 7: Voltage Values with Line Monitoring of DO

Illustration of Figure 1 and Table 7

1. Open-Circuit:

The supply voltage of the series resistor (transmitter voltage) fluctuates within a tolerance range, see Specifications in Table 18. For this reason, the voltage drops on the resistors can change slightly. Within the fluctuation range, a measurable voltage drop is definitely still detected on shunt R_{shunt}.

The series resistor was dimensioned such that when DO = FALSE, the voltage drop on the solenoid valve is as low as possible (valve is slightly warmed up) and the voltage drop on the shunt is still measurable.

The shunt R_{shunt} was measured with dependence on the solenoid valve resistance such that if the output DO is activated (DO = TRUE), the voltage drop on the solenoid valve is higher than the switching threshold of the solenoid valve, i.e., the coil of the solenoid valve is energized.

Additionally, the shunt R_{shunt} is designed such that with any switching state of the output DO (TRUE or FALSE), a measurable voltage drop results (values for AI > 10, see Table 7).

On the other hand, if field wiring breakage occurs within the red-colored area, voltage drops are no longer present on the shunt.

An open-circuit within the red-colored area (see Figure 1) can be monitored through the voltage drop on the shunt R_{shunt} , i.e., the input value of AI, see Table 7.

To allow open-circuit monitoring, the value of AI must be evaluated in the logic of the user program.

i Connect the series resistor $R_{series\ resistor}$ and the shunt R_{shunt} directly to the terminals of the controller or remote I/O to maximize the monitored line area.

2. Short-Circuit:

An short-circuit within the actuator circuitry (including the actuator) results in a high voltage drop (≤ output voltage of DO) through the shunt, which causes the short-circuit to be detected (maximum resolution of AI, see Table 7). The overvoltage protection of the analog inputs is activated at approximately 15 V.

A protective circuit consisting of a Z-diode and series resistor must be implemented to avoid an overload of the internal overvoltage protection.

NOTE

To protect the input multiplexer of the analog inputs from overload, a protective circuit consisting of Z-diode and a series resistor must be connected within the input circuit in parallel to the existing shunt

The configuration of the Z-diode with series resistor depends on the overvoltage protection threshold and must be set up to ensure that the HIMatrix overvoltage protection is not activated if a short-circuit occurs.

Configuration example for short-circuits:		
Shunt:	R_{shunt}	10 Ω
Solenoid valve resistance:	$R_{solenoid\ valve}$	75 Ω
Maximum output voltage of the digital output DO	U_{max}	26.8 V

Table 8: Example of Short-Circuit

- Z-diode with switching voltage of 12 V
- Analog input with operating range of 0...10 V
- Overvoltage protection in the HIMatrix with input voltage > 15 V

Normal operation (no short-circuit):

$U_{max} = U_{solenoid\ valve} + U_{shunt} = 26.8\ V = 23.65\ V + 3.15\ V$

The voltage U_{shunt} is also present on the protective circuit consisting of Z-diode and series resistor.

The Z-diode does not switch on at 3.15 V, i.e., the voltage drop of 3.15 V on the shunt is present on the analog input.

Short-circuit:

$U_{max} = U_{solenoid\ valve} + U_{shunt} = 26.8\ V = 0\ V + 26.8\ V$

If a short-circuit occurs in the external circuit (actuator or line), the voltage from DO is dropped completely at the shunt.

The switching threshold of the overvoltage protection of AI is approximately 15 V.

The Z-diode should become conductive at 12 V such that no more than 12 V is present on AI and the entire scaling range of AI is available.

The maximum voltage drop U_{diode} on the series resistor R_{diode} of the Z-diode results from:

$U_{diode} = 26.8\ V – 12\ V = 14.8\ V$

The current through the Z-diode should be limited to 20 mA (specification of the Z-diode). This results in a minimum value for the series resistor of:

R_{diode} = 14.8 V / 20 mA = 740 Ω

The value for R_{diode} can be set to 1 KΩ.

This resistance limits the maximum current through the Z-diode to approximately 15 mA.

A short-circuit within the red-colored area (see circuit diagram) can be monitored through the voltage drop on the shunt R_{shunt}, i.e., the input value of AI, see Table 7.

To allow short-circuit monitoring, the value of AI must be evaluated in the logic of the user program.

3.2 Analog Outputs

The remote I/O is equipped with 4 analog outputs. These outputs are not safety-related, but all together they can be shut down safely thanks to the configuration in the user program.

To achieve SIL 3, the output values must be read back via safety-related analog inputs and evaluated in the user program. Reactions to incorrect output values must also be specified in the user program.

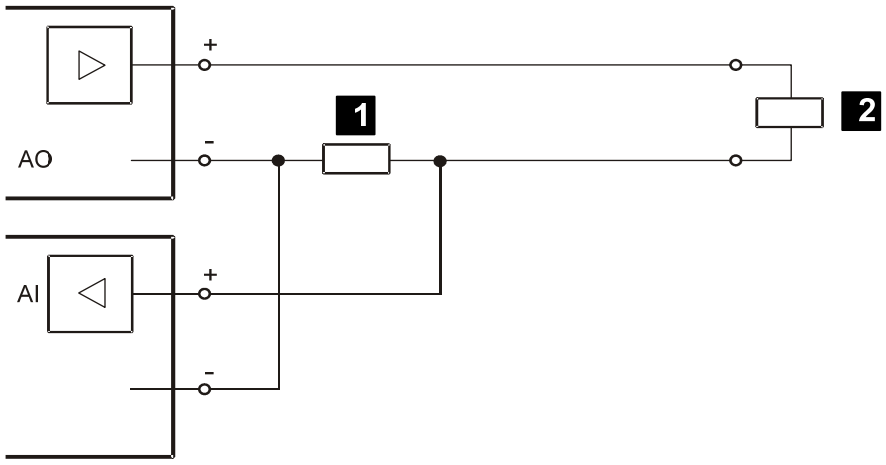
NOTE

The analog outputs may only be used as safety-related outputs, if the output values are read back to safety-related analog inputs and evaluated in the user program.

To configure the safe reaction, set the 4 *Channel Used [BOOL]* -> system parameters to FALSE (SILworX) or the 4 *AO[1..4].Used* system signals to FALSE (ELOP II Factory). This appears internal safety switches, ensuring that no output signal is output.

Alternatively, the safety reaction can be triggered using the *Emergency Stop* system variable.

Application example for safety-related analog outputs



1 R_{Shunt} 2 Actuator

Figure 2: Application Example for Safety-Related Analog Outputs

The following output values are available:

Range of values in the application	Output current
0	0.0 mA
2000	20.0 mA

Table 9: Output Values of the Analog Outputs

The analog outputs are designed to retain the metrological accuracy for 10 years. A proof test must be performed every 10 years.

3.3 Equipment, Scope of Delivery

The following table specifies the available remote I/O variants:

Designation	Description
F3 AIO 8/4 01	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: 0...+60 °C, for ELOP II Factory programming tool
F3 AIO 8/4 011 (-20 °C)	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -20...+60 °C, for ELOP II Factory programming tool
F3 AIO 8/4 012 (subsea / -20 °C)	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -20...+60 °C, subsea type approval according to ISO 13628-6, for ELOP II Factory programming tool
F3 AIO 8/4 014	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -25...+70 °C (temperature class T1), Vibration and shock tested according to EN 50125-3 and EN 50155, class 1B according to IEC 61373, for ELOP II Factory programming tool
F3 AIO 8/4 01 SILworX	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: 0...+60 °C, for SILworX programming tool
F3 AIO 8/4 011 SILworX (-20 °C)	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -20...+60 °C, for SILworX programming tool
F3 AIO 8/4 012 SILworX (subsea / -20 °C)	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -20...+60 °C, subsea type approval according to ISO 13628-6, for SILworX programming tool
F3 AIO 8/4 014 SILworX	Remote I/O (8 analog inputs, 4 non-safety-related analog outputs), Operating temperature: -25...+70 °C (temperature class T1), Vibration and shock tested according to EN 50125-3 and EN 50155, class 1B according to IEC 61373, for SILworX programming tool

Table 10: Available Variants

3.3.1 IP Address and System ID (SRS)

A transparent label is delivered with the device to allow one to note the IP address and the system ID (SRS for system rack slot) after a change.

IP___.___.___.___SRS____.__.__

Default value for IP address:	192.168.0.99
Default value for SRS:	60 000.200.0 (SILworX)
	60 000.0.0 (ELOP II Factory)

The label must be affixed such that the ventilation slots in the housing are not obstructed.

Refer to the First Steps manual of the programming tool for more information on how to modify the IP address and the system ID.

3.4 Type Label

The type plate contains the following details:

- Product name
- Bar code (1D or 2D code)
- Part no.
- Production year
- Hardware revision index (HW Rev.)
- Firmware revision index (FW Rev.)
- Operating voltage
- Mark of conformity

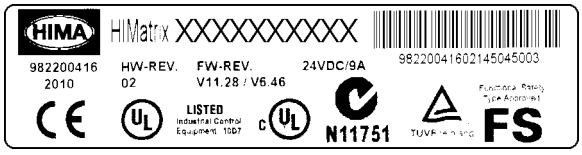


Figure 3: Sample Type Label

3.5 Structure

This chapter describes the layout and function of the remote I/Os, and their communication via safe**ethernet**.

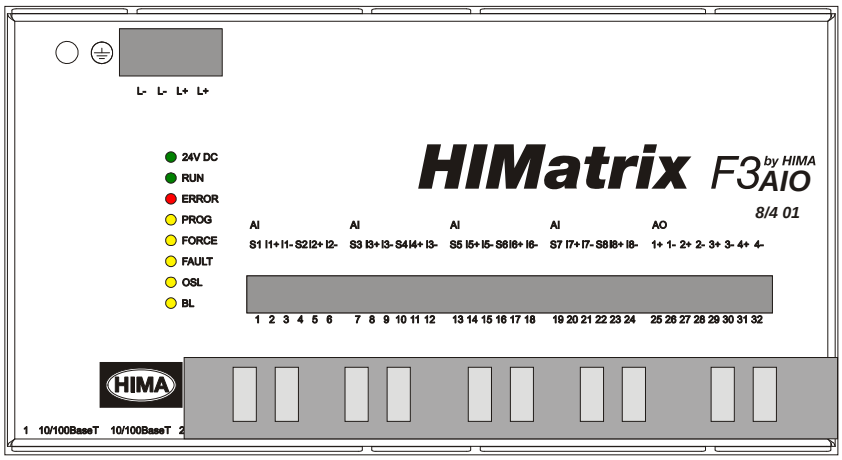
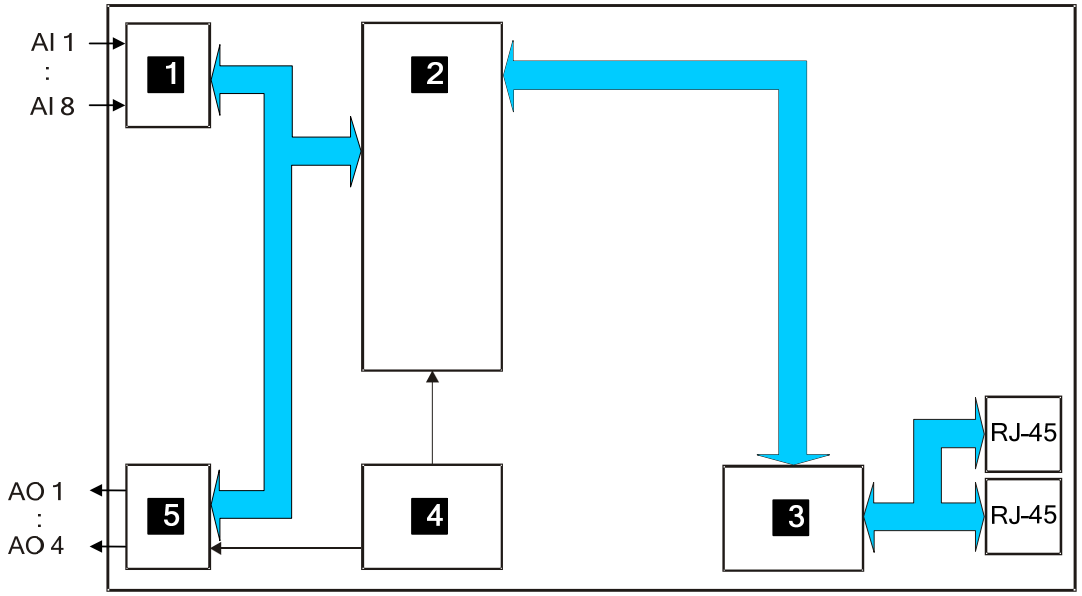


Figure 4: Front View



1 8 Analog Inputs
2 Safety-Related Processor System (CPU)
3 Switch
4 Watchdog
5 4 Analog Outputs

Figure 5: Block Diagram

3.5.1 LED Indicators

The light-emitting diodes (LEDs) indicate the operating state of the remote I/O. The LEDs are classified as follows:

- Operating voltage LED
- System LEDs
- Communication LEDs

3.5.1.1 Operating Voltage LED

LED	Color	Status	Description
24 VDC	Green	On	24 VDC operating voltage present
		Off	No operating voltage

Table 11: Operating Voltage LED

3.5.1.2 System LEDs

While the system is being booted, all LEDs are lit simultaneously.

LED	Color	Status	Description
RUN	Green	On	Device in RUN, normal operation
		Blinking	Device in STOP A new operating system is being loaded.
		Off	The device is not in the RUN state.
ERROR	Red	On	The device is in the ERROR STOP state. Internal fault detected by self-tests, e.g., hardware faults or cycle time overrun. The processor system can only be restarted with a command from the PADT (reboot).
		Blinking	If ERROR blinks and all others LEDs are lit simultaneously, the boot loader has detected an operating system fault in the flash memory and waits for a new operating system to be loaded.
		Off	No faults detected.
PROG	Yellow	On	A new configuration is being loaded into the device.
		Blinking	The device switches from INIT to STOP A new operating system is being loaded into the flash ROM.
		Off	No configuration or operating system is being loaded.
FORCE	Yellow	Off	The FORCE LED of a remote I/O is not functioning. The FORCE LED of the associated controller serves to signal the forcing of a remote I/O.
FAULT	Yellow	On	The loaded configuration is not valid. The new operating system is corrupted (after OS download).
		Blinking	Fault while loading a new operating system One or multiple I/O faults occurred.
		Off	None of the described faults occurred.
OSL	Yellow	Blinking	Operating system emergency loader active.
		Off	Operating system emergency loader inactive.
BL	Yellow	Blinking	OS and OSL binary defective or hardware fault, INIT_FAIL.
		Off	None of the described faults occurred.

Table 12: System LEDs

3.5.1.3 Communication LEDs

All RJ-45 connectors are provided with a small green and a yellow LEDs. The LEDs signal the following states:

LED	Status	Description
Green	On	Full duplex operation
	Blinking	Collision
	Off	Half duplex operation, no collision
Yellow	On	Connection available
	Blinking	Interface activity
	Off	No connection available

Table 13: Ethernet Indicators

3.5.2 Communication

The remote I/O communicates with the associated controller via safe**ethernet**.

3.5.2.1 Connections for Ethernet Communication

Property	Description
Port	2 x RJ-45
Transfer standard	10BASE-T/100BASE-Tx, half and full duplex
Auto negotiation	Yes
Auto crossover	Yes
IP address	Freely configurable[1)]
Subnet mask	Freely configurable[1)]
Supported protocols	▪ Safety-related: safe**ethernet** ▪ Standard protocols: Programming and debugging tool (PADT), SNTP
[1)] The general rules for assigning IP address and subnet masks must be adhered to.	

Table 14: Ethernet Interfaces Properties

The two RJ-45 connectors with integrated LEDs are located on the bottom left-hand side of the housing. Refer to Chapter 3.5.1.3 for a description of the LEDs' function.

The connection parameters are read based on the MAC address (media access control address) defined during manufacturing.

The MAC address for the remote I/O is specified on a label located above the two RJ-45 connectors (1 and 2).

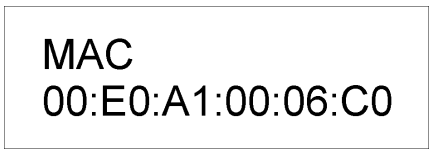


Figure 6: Sample MAC Address Label

The remote I/O is equipped with an integrated switch for Ethernet communication. For further information on the integrated switch and safe**ethernet**, refer to Chapter *Communication* of the system manual for compact systems (HI 800 141 E).

3.5.2.2 Network Ports Used for Ethernet Communication

UDP ports	Use
8000	Programming and operation with the programing tool
8001	Configuration of the remote I/O using the PES (ELOP II Factory)
8004	Configuration of the remote I/O using the PES (SILworX)
6010	safe**ethernet**
123	SNTP (time synchronization between PES and remote I/O, PES and external devices)

Table 15: Network Ports in Use

3.5.3 Reset Key

The remote I/O is equipped with a reset key. The key is only required if the user name or password for administrator access is not known. If only the IP address set for the remote I/O does not match the PADT (PC), the connection can be established with a `Route add` entry on the PC.

i Only the model variants without protective lacquer are equipped with a reset key.

The key can be accessed through a small round hole located approximately 5 cm from the upper left-hand side of the housing. The key is engaged using a suitable pin made of insulating material to avoid short-circuits within the remote I/O.

The reset is only effective if the remote I/O is rebooted (switched off and on) while the key is simultaneously engaged for at least 20 s. Engaging the key during operation has no effect.

Properties and behavior of the remote I/IO after a reboot with engaged reset key:

- Connection parameters (IP address and system ID) are set to the default values.
- All accounts are deactivated except for the *administrator* default account with empty password.

After a new reboot without the reset key engaged, the connection parameters (IP address and system ID) and accounts become effective.

- Those configured by the user.
- Those valid prior to rebooting with the reset key engaged, if no changes were performed.

3.6 Product Data

General	
Response time	≥ 20 ms
Ethernet interfaces	2 x RJ-45, 10BASE-T/100BASE-Tx with integrated switch
Operating voltage	24 VDC, -15...+20 %, r_{PP} ≤ 15 %, from a power supply unit with safe insulation in accordance with IEC 61131-2
Current input	max. 0.8 A (with maximum load) Idle: approx. 0.4 A at 24 V
Fuse (external)	10 A time-lag (T)
Back-up battery	None
Operating temperature	0...+60 °C
Storage temperature	-40...+85 °C
Type of protection	IP20
Max. dimensions (without plug)	Width: 207 mm (with housing screws) Height: 114 mm (with fixing bolt) Depth: 97 mm (with earthing rail)
Weight	approx. 1 kg

Table 16: Product Data

Analog inputs	
Number of inputs	8 (non-galvanically separated)
Nominal range	0...+10 VDC, 0/4...+20 mA with 500 Ω shunt
Operating range	-0.1...+11.5 VDC, -0.4...+23 mA with 500 Ω shunt
Input resistance	> 2 MΩ
Source resistance input of the input signal	≤ 500 Ω
Digital resolution	12-bit
Measurement accuracy at 25 °C, max.	±0.1 % of final value
Metrological accuracy on full temperature, max.	±0.5 % of final value
Temperature coefficient, max.	±0.011 %/K of final value
Safety-related accuracy, max.	±2 % of final value
Measured value refresh	once per cycle of the controller
Sampling time	ca. 45 µs

Table 17: Specifications for the Analog Inputs

Supply outputs	
Number of supply outputs	8
Nominal voltages	8.2 VDC / 26 VDC, switchable
Tolerance	±5 %
Safely monitored limits Range: 8.2 V Range 26 V	 7.6...8.8 V, (tolerance range: 7.3...9.1 V) 24.3...27.7 V, (tolerance range: 24.0...28.0 V)
Current limiting	> 200 mA, the output is switched off

Table 18: Specifications for the Transmitter Supply

Analog outputs	
Number of outputs	4 non-galvanically separated, non-safety-related, common safe shutdown
Nominal value	4...20 mA
Operating value	0...21 mA
Digital resolution	12-bit
Load impedance	max. 600 Ω
Measurement accuracy at 25 °C, max.	±0.1 % of final value
Metrological accuracy on full temperature, max.	±0.5 % of final value
Temperature coefficient, max.	±0.011 %/K of final value
Safety-related accuracy, max.	±1 % of final value

Table 19: Specifications for the Analog Outputs

3.6.1 Product Data F3 AIO 8/4 011 (-20 °C)

The HIMatrix F3 AIO 8/4 011 (-20 °C) model variant is intended for use at the extended temperature range of -20…+60 °C. The electronic components are coated with a protective lacquer.

F3 AIO 8/4 011	
Operating temperature	-20...+60 °C
Weight	approx. 1 kg

Table 20: Product Data of F3 AIO 8/4 011 (-20 °C)

3.6.2 Product Data F3 AIO 8/4 012 (subsea / -20 °C)

The HIMatrix F3 AIO 8/4 012 (subsea / -20 °C) model variant is intended for subsea-use according to ISO 13628 Part 6: Subsea production control systems. The electronic components are coated with a protective lacquer. The housing of the remote I/O is made of V2A stainless steel; the remote I/O is intended for mounting on a mounting plate. The housing is equipped with a massive aluminum plate, see Figure 7. Figure 8 specifies the centre hole distances.

F3 AIO 8/4 012	
Housing material	V2A stainless steel
Operating temperature	-20...+60 °C
ISO 13628-6: 2006	Shock and vibration tests according to Level Q1 and Q2. Random vibration test, ESS (Environmental stress screening)
Max. dimensions (without connectors and aluminum plate)	Width: 207 mm (with housing screws) Height: 114 mm (with fixing bolt) Depth: 97 mm (with earthing rail)
Dimensions: Aluminum plate (W x H x D)	(200 x 160 x 6) mm
Weight	approx. 1.4 kg

Table 21: Product Data F3 AIO 8/4 012 (subsea / -20 °C)

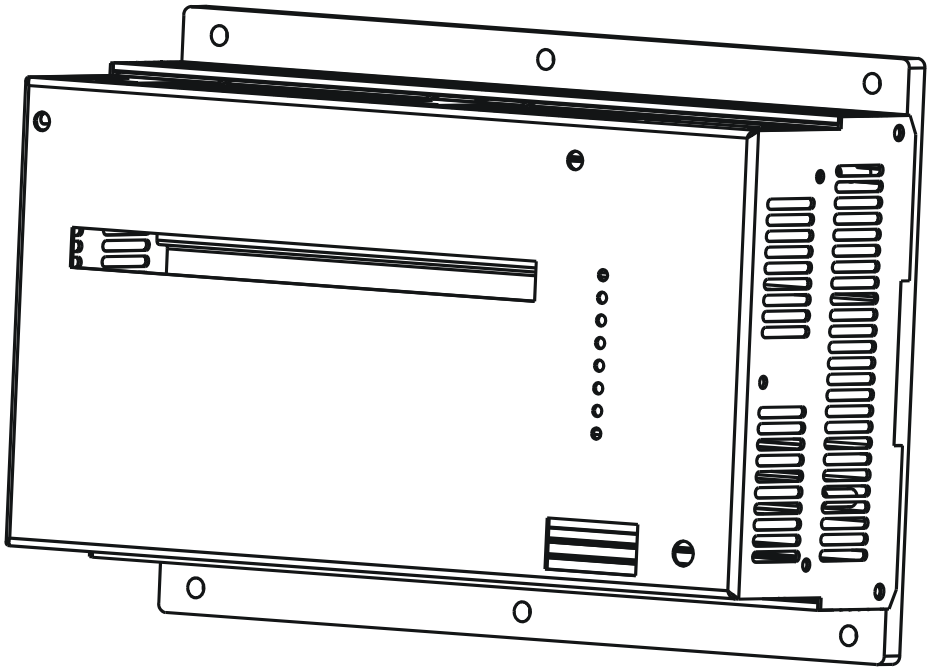


Figure 7: HIMatrix F3 AIO 8/4 012 with Aluminum Plate

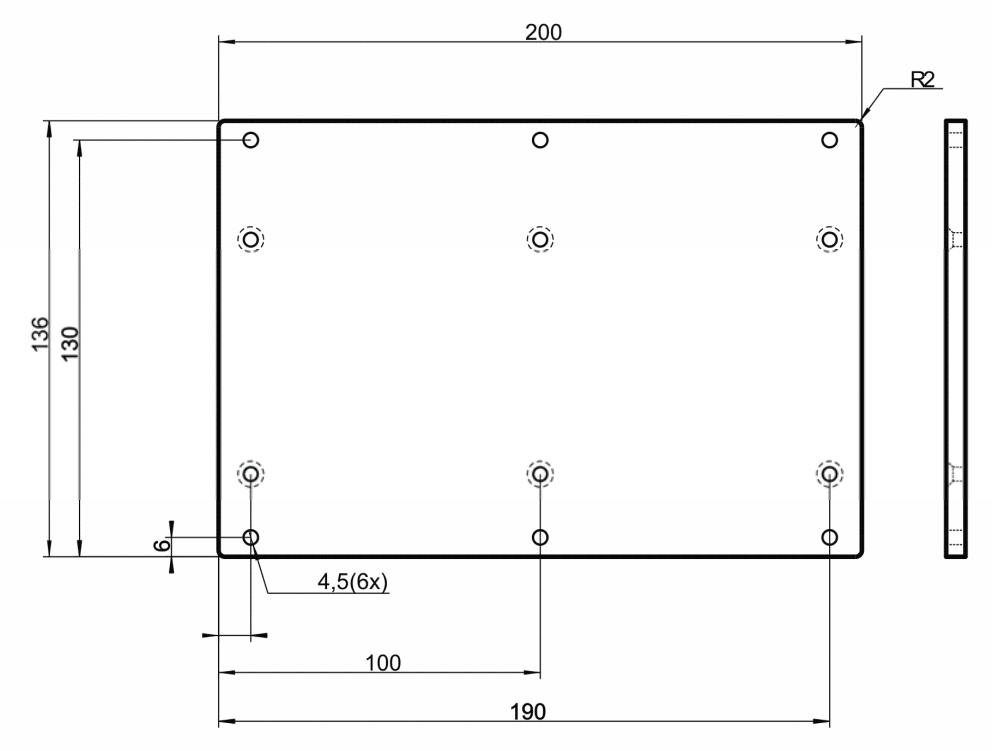


Figure 8: Aluminum Plate with Dimensions

3.6.3 Product Data F3 AIO 8/4 014

The F3 AIO 8/4 014 model variant is intended for use in railway applications. The electronic components are coated with a protective lacquer.

F3 AIO 8/4 014	
Operating temperature	-25…+70 °C (temperature class T1)
Weight	approx. 1 kg

Table 22: Product Data of F3 AIO 8/4 014

The remote I/O F3 AIO 8/4 014 meets the conditions for vibrations and shock test according to IEC 61373, category 1, class B.

3.7 Certified HIMatrix F3 AIO 8/4 01

HIMatrix F3 AIO 8/4 01	
CE	EMC, ATEX Zone 2
TÜV	IEC 61508 1-7:2000 up to SIL 3 IEC 61511:2004 EN ISO 13849-1:2008 up to Cat. 4 und PL e
UL Underwriters Laboratories Inc.	ANSI/UL 508, NFPA 70 – Industrial Control Equipment CSA C22.2 No.142 UL 1998 Software Programmable Components NFPA 79 Electrical Standard for Industrial Machinery IEC 61508
FM Approvals	Class I, DIV 2, Groups A, B, C and D Class 3600, 1998 Class 3611, 1999 Class 3810, 1989 Including Supplement #1, 1995 CSA C22.2 No. 142 CSA C22.2 No. 213
TÜV CENELEC	Railway applications EN 50126: 1999 up to SIL 4 EN 50128: 2001 up to SIL 4 EN 50129: 2003 up to SIL 4

Table 23: Certified HIMatrix F3 AIO 8/4 01

4 Start-up

To start up the remote I/O, it must be mounted, connected and configured in the programming tool.

4.1 Installation and Mounting

The remote I/O is mounted on a 35 mm DIN rail or a mounting plate in case of the F3 AIO 8/4 012.

When laying cables (long cables, in particular), take appropriate measures to avoid interference, e.g., by separating the signal lines from the power lines.

When dimensioning the cables, ensure that their electrical properties have no negative impact on the measuring circuit.

4.1.1 Connecting the Analog Inputs

Only shielded cables must be connected to the analog inputs. Each analog input must be connected to a twisted pair of wires. The shielding must be connected to the remote I/O and the sensor housing and earthed on the remote I/O side to form a Faraday cage.

Use the following terminals to connect the analog inputs:

Terminal	Designation	Function (analog inputs AI)
1	S1	Transmitter supply 1
2	I1+	Analog input 1
3	I1-	Ground
4	S2	Transmitter supply 2
5	I2+	Analog input 2
6	I2-	Ground
Terminal	Designation	Function (analog inputs AI)
7	S3	Transmitter supply 3
8	I3+	Analog input 3
9	I3-	Ground
10	S4	Transmitter supply 4
11	I4+	Analog input 4
12	I4-	Ground
Terminal	Designation	Function (analog inputs AI)
13	S5	Transmitter supply 5
14	I5+	Analog input 5
15	I5-	Ground
16	S6	Transmitter supply 6
17	I6+	Analog input 6
18	I6-	Ground
Terminal	Designation	Function (analog inputs AI)
19	S7	Transmitter supply 7
20	I7+	Analog input 7
21	I7-	Ground
22	S8	Transmitter supply 8
23	I8+	Analog input 8
24	I8-	Ground

Table 24: Terminal Assignment for the Analog Inputs

4.1.1.1 Shunt Adapter

The shunt adapter is a plug-in module for the analog inputs of the safety-related remote I/O F3 AIO 8/4 01.

Five variants are available:

Model	Equipment
Z 7301	250 Ω shunt
Z 7302	500 Ω shunt
Z 7306	▪ 250 Ω shunt ▪ Overvoltage protection ▪ HART series resistor (current limiting)
Z 7308	▪ Voltage divider ▪ Overvoltage protection
Z 7309 [1)]	500 Ω shunt
[1)] If proximity switches are connected, see Chapter 4.5.1	

Table 25: Shunt Adapter

Refer to the corresponding manuals for further information on the shunt adapters.

4.1.2 Connecting the Analog Outputs

Use the following terminals to connect the analog outputs:

Terminal	Designation	Function (analog outputs AO)
25	1+	Analog output 1
26	1-	Ground output 1
27	2+	Analog output 2
28	2-	Ground output 2
29	3+	Analog output 3
30	3-	Ground output 3
31	4+	Analog output 4
32	4-	Ground output 4

Table 26: Terminal Assignment for the Analog Outputs

4.1.3 Cable Plugs

Cable plugs attached to the pin headers of the devices are used to connect to the power supply and to the field zone. The cable plugs are included within the scope of delivery of the HIMatrix devices and modules.

The devices power supply connections feature the following properties:

Connection to the power supply	
Cable plugs	Four poles, screw terminals
Wire cross-section	0.2…2.5 mm^2 (single-wire) 0.2…2.5 mm^2 (finely stranded) 0.2…2.5 mm^2 (with wire end ferrule)
Stripping length	10 mm
Screwdriver	Slotted 0.6 x 3.5 mm
Tightening torque	0.4…0.5 Nm

Table 27: Power Supply Cable Plug Properties

Connection to the field zone	
Number of cable plugs	4 pieces, six poles, screw terminals 1 piece, eight poles, screw terminals
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 28: Input and Output Cable Plug Properties

4.1.4 Mounting the F3 AIO 8/4 01 in Zone 2

(EC Directive 94/9/EC, ATEX)

The remote I/O is suitable for mounting in zone 2. Refer to the corresponding declaration of conformity available on the HIMA website.

When mounting the device, observe the special conditions specified in the following section.

Specific Conditions X

1. Mount the remote I/O in an enclosure that meets the EN 60079-15 requirements and achieves a type of protection of at least IP54, in accordance with EN 60529. Provide the enclosure with the following label:

   Work is only permitted in the de-energized state

   Exception:
   If a potentially explosive atmosphere has been precluded, work can also performed when the controller is under voltage.
2. The enclosure in use must be able to safely dissipate the generated heat. The power dissipation of the module F3 AIO 8/4 01 is 18 W at maximum.
3. Protect the HIMatrix F3 AIO 8/4 01 with a 10 A time-lag fuse.
   The 24 VDC power must come from a power supply unit with safe isolation. Use power supply units of type PELV or SELV only.
4. Applicable standards:

VDE 0170/0171 Part 16,	DIN EN 60079-15: 2004-5
VDE 0165 Part 1,	DIN EN 60079-14: 1998-08

Pay particular attention to the following sections:

DIN EN 60079-15:	
Chapter 5	Design
Chapter 6	Terminals and cabling
Chapter 7	Air and creeping distances
Chapter 14	Connectors
DIN EN 60079-14:	
Chapter 5.2.3	Equipment for use in zone 2
Chapter 9.3	Cabling for zones 1 and 2
Chapter 12.2	Equipment for zones 1 and 2

The remote I/O is additionally equipped with the label represented below:

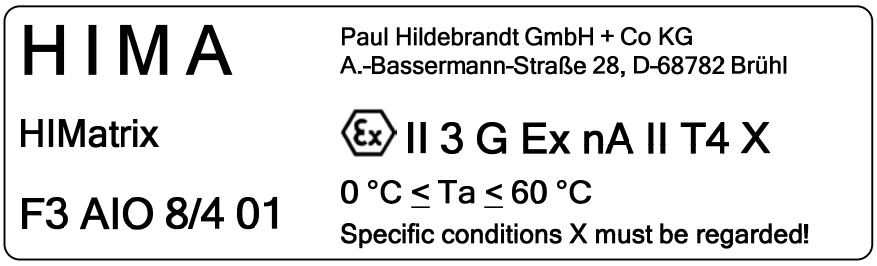


Figure 9: Label for Ex Conditions

4.2 Configuration

The remote I/O can be configured using a programming tool, SILworX or ELOP II Factory. Which programming tool should be used, depends on the revision status of the operating system (firmware):

- SILworX is required for CPU OS V7 and higher.
- ELOP II Factory is required for CPU OS up to V6.x.

i How to switch between operating systems is described in Chapter *Loading Operating Systems* of the system manual for compact systems (HI 800 141 E).

Observe the following points when configuring the module:

- In SILworX, the *Transmitter Voltage[01]* system parameter must be assigned a global variable. This global variable is used to set the value for the transmitter supply, see Table 29.
- In ELOP II Factory, the *Transmitter Voltage[01] [USINT]* system signal must be assigned a signal. This signal is used to set the value for the transmitter supply, see Table 33.

i **The transmitter supply must be configured even if it is not used.**

4.3 Configuration with SILworX

In the Hardware Editor, the remote I/Os are represented like a base plate equipped with the following modules:

- Processor module (CPU)
- Input module (AI 8)
- Output module (AO 4)

Double-click the module to open the Detail View with the corresponding tabs. The tabs are used to assign the global variables configured in the user program to the system variables of the corresponding module.

4.3.1 Parameters and Error Codes for the Inputs and Outputs

The following tables specify the system parameters that can be read and set for the inputs and outputs, including the corresponding error codes.

In the user program, the error codes can be read using the variables assigned within the logic.

The error codes can also be displayed in SILworX.

4.3.2 Analog Inputs F3 AIO 8/4 01

The following tables present the statuses and parameters for the input module (AI 8) in the same order as given in the Hardware Editor.

4.3.2.1 Tab **Module**

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

<table>
<tr><th>System parameter</th><th>Data type</th><th>R/W</th><th>Description</th></tr>
<tr><td>AI.Error Code</td><td>WORD</td><td>R</td><td>Error codes for all analog inputs
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Module fault</td></tr>
<tr><td>0x0004</td><td>Time monitoring of conversion faulty</td></tr>
<tr><td>0x0008</td><td>FTT test: Walking bit of data bus faulty</td></tr>
<tr><td>0x0010</td><td>FTT test: Error while checking coefficients</td></tr>
<tr><td>0x0020</td><td>FTT test: Operating voltages faulty</td></tr>
<tr><td>0x0040</td><td>A/D conversion faulty (DRDY_LOW)</td></tr>
<tr><td>0x0080</td><td>Cross links of MUX faulty</td></tr>
<tr><td>0x0100</td><td>Walking bit of data bus faulty</td></tr>
<tr><td>0x0200</td><td>Multiplexer addresses faulty</td></tr>
<tr><td>0x0400</td><td>Faulty operating voltages</td></tr>
<tr><td>0x0800</td><td>Measuring system (characteristic) faulty (unipolar)</td></tr>
<tr><td>0x1000</td><td>Measuring system (final values, zero point) faulty (unipolar)</td></tr>
<tr><td>0x8000</td><td>A/D conversion faulty (DRDY_HIGH)</td></tr>
</table></td></tr>
<tr><td>Module Error Code</td><td>WORD</td><td>R</td><td>Module error code
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0000</td><td>I/O processing, if required with errors, see other error codes</td></tr>
<tr><td>0x0001</td><td>No I/O processing (CPU not in RUN)</td></tr>
<tr><td>0x0002</td><td>No I/O processing during the booting test</td></tr>
<tr><td>0x0004</td><td>Manufacturer interface operating</td></tr>
<tr><td>0x0010</td><td>No I/O processing: invalid configuration</td></tr>
<tr><td>0x0020</td><td>No I/O processing: fault rate exceeded</td></tr>
<tr><td>0x0040/
0x0080</td><td>No I/O processing: configured module not plugged in</td></tr>
</table></td></tr>
<tr><td>Module SRS</td><td>UDINT</td><td>R</td><td>Slot number (System Rack Slot)</td></tr>
<tr><td>Module Type</td><td>UINT</td><td>R</td><td>Type of module, target value: 0x001E [30_{dez}]</td></tr>
<tr><td>Transmitter.Error Code</td><td>WORD</td><td>R</td><td>Error codes for the transmitter unit
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Fault in the transmitter supply</td></tr>
<tr><td>0x0400</td><td>FTT test: 1st temperature threshold exceeded</td></tr>
<tr><td>0x0800</td><td>FTT test: 2nd temperature threshold exceeded</td></tr>
</table></td></tr>
<tr><td>Transmitter[01].Error Code</td><td>BYTE</td><td>R</td><td>Error codes for each transmitter group
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x01</td><td>Module fault of transmitter supply</td></tr>
<tr><td>0x02</td><td>Overcurrent of transmitter supply</td></tr>
<tr><td>0x04</td><td>Undervoltage of transmitter supply.</td></tr>
<tr><td>0x08</td><td>Overvoltage of transmitter supply.</td></tr>
</table></td></tr>
</table>

System parameter	Data type	R/W	Description
Transmitter Voltage[01]	USINT	W	Switching of the transmitter supply for each group: 1 = 8.2 V 2 = 26.0 V

Table 29: SILworX - System Parameters for Analog Inputs, **Module** Tab

4.3.2.2 Tab AI 8: Channels

The **AI 8: Channels** tab contains the following system variables.

System parameter	Data type	R/W	Description
-> Error Code [BYTE]	BYTE	R	Error codes for the analog input channels Coding: Description 0x01: Fault in the analog input module 0x02: Out of the defined limit values. 0x04: A/D converter faulty, measured values invalid 0x08: Measured value out of the safety-related accuracy 0x10: Measured value overflow 0x20: Channel not operating 0x40: Address error of both A/D converters
-> Value [INT]	INT	R	Analog value for each channel [INT] from 0...+2000 (0...+10 V) The validity depends on *AI.Error Code*
Channel Used [BOOL] ->	BOOL	W	Channel configuration: 1 = operating 0 = not operating
Threshold LOW [INT] ->	INT	W	Voltage range upper limit for low level -> *Underflow [BOOL]*
Limit Value HIGH [INT] ->	INT	W	Voltage range low limit for high level -> *Overflow [BOOL]*
Transmitter Used [BOOL] ->	BOOL	W	AI channel used with transmitter supply: 1 = used 0 = not used
-> Underflow [BOOL]	BOOL	R	Underflow -> *Value [INT]* in accordance with *Limit Value LOW [INT]* ->* The validity depends on *AI.Error Code*
-> Overflow [BOOL]	BOOL	R	Overflow -> *Value [INT]* in accordance with *Limit Value HIGH [INT]* ->* The validity depends on *AI.Error Code*

Table 30: SILworX - System Parameters for Analog Inputs, **AI 8: Channels** Tab

4.3.3 Analog Outputs F3 AIO 8/4 01

The following tables present the statuses and parameters for the output module (AO 4) in the same order as given in the Hardware Editor.

4.3.3.1 Tab **Module**

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

<table>
<tr><th>System parameter</th><th>Data type</th><th>R/W</th><th>Description</th></tr>
<tr><td>AO.Error Code</td><td>WORD</td><td>R</td><td>Error codes for all analog outputs
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Module fault</td></tr>
<tr><td>0x0002</td><td>Safety switch 1 faulty</td></tr>
<tr><td>0x0004</td><td>Safety switch 2 faulty</td></tr>
<tr><td>0x0008</td><td>FTT test of test pattern faulty</td></tr>
<tr><td>0x0010</td><td>FTT test: Error while checking coefficients</td></tr>
<tr><td>0x0400</td><td>FTT test: 1st temperature threshold exceeded</td></tr>
<tr><td>0x0800</td><td>FTT test: 2nd temperature threshold exceeded</td></tr>
<tr><td>0x2000</td><td>Status of safety switches</td></tr>
<tr><td>0x4000</td><td>Active shutdown via watchdog faulty</td></tr>
</table></td></tr>
<tr><td>Module Error Code</td><td>WORD</td><td>R</td><td>Module error code
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0000</td><td>I/O processing, if required with errors, see other error codes</td></tr>
<tr><td>0x0001</td><td>No I/O processing (CPU not in RUN)</td></tr>
<tr><td>0x0002</td><td>No I/O processing during the booting test</td></tr>
<tr><td>0x0004</td><td>Manufacturer interface operating</td></tr>
<tr><td>0x0010</td><td>No I/O processing: invalid configuration</td></tr>
<tr><td>0x0020</td><td>No I/O processing: fault rate exceeded</td></tr>
<tr><td>0x0040/
0x0080</td><td>No I/O processing: configured module not plugged in</td></tr>
</table></td></tr>
<tr><td>Module SRS</td><td>UDINT</td><td>R</td><td>Slot number (System Rack Slot)</td></tr>
<tr><td>Module Type</td><td>UINT</td><td>R</td><td>Type of module, target value: 0x0069 [105_{dec}]</td></tr>
</table>

Table 31: SILworX - System Parameters for Analog Outputs, **Module** Tab

4.3.3.2 Tab **AO 4: Channels**

The **AO 4: Channels** tab contains the following system parameters:

System parameter	Data type	R/W	Description
-> Error Code [BYTE]	BYTE	R	Error codes for the analog output channels Coding: 0x01 – Fault in the analog output unit Coding: 0x80 – -> *Value [INT]* out of the specified range
-> Value [INT]	INT	R	Output value of AO channels: Current characteristic curve: 0...+2000 (0...+20 mA) Current characteristic curve: -2000...0 (0 mA) ***Before being normalized, the values are checked for plausibility.*** Current characteristic curve: ▪ Values < 0: are normalized to 0 ▪ Values < intermediate data point LOW: Normalization with intermediate data point LOW ▪ Values > intermediate data point HIGH: Normalization with intermediate data point HIGH ***Outputs must not be used as safety-related outputs!***
Channel Used [BOOL] ->	BOOL	W	Channel configuration: 1 = operating 0 = not operating

Table 32: SILworX - System Parameters for Analog Outputs, **AO 4: Channels** Tab

4.4 Configuration with ELOP II Factory

4.4.1 Configuring the Inputs and Outputs

The signals previously defined in the Signal Editor (Hardware Management) are assigned to the individual channels (inputs and outputs) using ELOP II Factory. Refer to the system manual for compact systems or the online help for more details.

The following chapter describes the system signals used for assigning signals in the remote I/O.

4.4.2 Signals and Error Codes for the Inputs and Outputs

The following tables specify the system signals that can be read and set for the inputs and outputs, including the corresponding error codes.

In the user program, the error codes can be read using the signals assigned within the logic.

The error codes can also be displayed in ELOP II Factory.

4.4.3 Analog Inputs F3 AIO 8/4 01

<table>
<tr><th>System Signal</th><th>R/W</th><th>Description</th></tr>
<tr><td>Mod.SRS [UDINT]</td><td>R</td><td>Slot number (System Rack Slot)</td></tr>
<tr><td>Mod. Type [UINT]</td><td>R</td><td>Type of module, target value: 0x001E [30_{dec}]</td></tr>
<tr><td>Mod. Error Code [WORD]</td><td>R</td><td>Module error code
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0000</td><td>I/O processing, if required with errors
see other error codes</td></tr>
<tr><td>0x0001</td><td>No I/O processing (CPU not in RUN)</td></tr>
<tr><td>0x0002</td><td>No I/O processing during the booting test</td></tr>
<tr><td>0x0004</td><td>Manufacturer interface operating</td></tr>
<tr><td>0x0010</td><td>No I/O processing: invalid configuration</td></tr>
<tr><td>0x0020</td><td>No I/O processing: fault rate exceeded</td></tr>
<tr><td>0x0040/
0x0080</td><td>No I/O processing: configured module not plugged in</td></tr>
</table></td></tr>
<tr><td>AI.Error Code [WORD]</td><td>R</td><td>Error codes for all analog inputs
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Module fault</td></tr>
<tr><td>0x0004</td><td>Time monitoring of conversion faulty</td></tr>
<tr><td>0x0008</td><td>FTT test: Walking bit of data bus faulty</td></tr>
<tr><td>0x0010</td><td>FTT test: Error while checking coefficients</td></tr>
<tr><td>0x0020</td><td>FTT test: Operating voltages faulty</td></tr>
<tr><td>0x0040</td><td>A/D conversion faulty (DRDY_LOW)</td></tr>
<tr><td>0x0080</td><td>Cross links of MUX faulty</td></tr>
<tr><td>0x0100</td><td>Walking bit of data bus faulty</td></tr>
<tr><td>0x0200</td><td>Multiplexer addresses faulty</td></tr>
<tr><td>0x0400</td><td>Faulty operating voltages</td></tr>
<tr><td>0x0800</td><td>Measuring system (characteristic) faulty (unipolar)</td></tr>
<tr><td>0x1000</td><td>Measuring system (final values, zero point) faulty (unipolar)</td></tr>
<tr><td>0x8000</td><td>A/D conversion faulty (DRDY_HIGH)</td></tr>
</table></td></tr>
<tr><td>AI[xx].Error Code [BYTE]</td><td>R</td><td>Error codes for the analog input channels
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x01</td><td>Fault in the analog input module</td></tr>
<tr><td>0x02</td><td>Out of the defined limit values.</td></tr>
<tr><td>0x04</td><td>A/D converter faulty, measured values invalid</td></tr>
<tr><td>0x08</td><td>Measured value out of the safety-related accuracy</td></tr>
<tr><td>0x10</td><td>Measured value overflow</td></tr>
<tr><td>0x20</td><td>Channel not operating</td></tr>
<tr><td>0x40</td><td>Address error of both A/D converters</td></tr>
</table></td></tr>
<tr><td>AI[xx].Value [INT]</td><td>R</td><td>Analog value for each channel [INT] from 0...+2000 (0...+10 V)
The validity depends on AI[xx].Error Code</td></tr>
<tr><td>AI[xx].Used [BOOL]</td><td>W</td><td>Channel configuration:
1 = operating
0 = not operating</td></tr>
<tr><td>AI[xx].Transmitter Used [BOOL]</td><td>W</td><td>AI channel used with transmitter supply:
1 = used
0 = not used</td></tr>
</table>

<table>
<tr><th>System signal</th><th>R/W</th><th>Description</th></tr>
<tr><td>Transmitter Voltage[01] [USINT]</td><td>W</td><td>Switching of the transmitter supply for each group:
1 = 8.2 V
2 = 26.0 V</td></tr>
<tr><td>Transmitter.
Error Code [WORD]</td><td>R</td><td>Error codes for the transmitter unit
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Fault in the transmitter supply</td></tr>
<tr><td>0x0400</td><td>FTT test: 1st temperature threshold exceeded</td></tr>
<tr><td>0x0800</td><td>FTT test: 2nd temperature threshold exceeded</td></tr>
</table></td></tr>
<tr><td>Transmitter[01].
Error Code [BYTE]</td><td>R</td><td>Error codes for each transmitter group
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x01</td><td>Module fault of transmitter supply</td></tr>
<tr><td>0x02</td><td>Overcurrent of transmitter supply</td></tr>
<tr><td>0x04</td><td>Undervoltage of transmitter supply.</td></tr>
<tr><td>0x08</td><td>Overvoltage of transmitter supply.</td></tr>
</table></td></tr>
<tr><td>AI[xx].Underflow [BOOL]</td><td>R</td><td>Underflow AI[INT].Value in accordance with AI[xx].Limit Value LOW
The validity depends on AI[xx].Error Code</td></tr>
<tr><td>AI[xx].Overflow [BOOL]</td><td>R</td><td>Overflow AI[INT].Value in accordance with AI[xx].Limit Value HIGH
The validity depends on AI[xx].Error Code</td></tr>
<tr><td>AI[xx].Threshold LOW [INT]</td><td>W</td><td>Voltage range upper limit for low level AI[xx].Underflow</td></tr>
<tr><td>AI[xx].Limit Value HIGH [INT]</td><td>W</td><td>Voltage range low limit for high level AI[xx].Overflow</td></tr>
</table>

Table 33: ELOP II Factory - System Signals for the Analog Inputs

4.4.4 Analog Outputs F3 AIO 8/4 01

<table>
<tr><th>System signal</th><th>R/W</th><th>Description</th></tr>
<tr><td>Mod.SRS [UDINT]</td><td>R</td><td>Slot number (System Rack Slot)</td></tr>
<tr><td>Mod. Type [UINT]</td><td>R</td><td>Type of module, target value: 0x0069 [105_{dec}]</td></tr>
<tr><td>Mod. Error Code [WORD]</td><td>R</td><td>Module error code
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0000</td><td>I/O processing, if required with errors, see other error codes</td></tr>
<tr><td>0x0001</td><td>No I/O processing (CPU not in RUN)</td></tr>
<tr><td>0x0002</td><td>No I/O processing during the booting test</td></tr>
<tr><td>0x0004</td><td>Manufacturer interface operating</td></tr>
<tr><td>0x0010</td><td>No I/O processing: invalid configuration</td></tr>
<tr><td>0x0020</td><td>No I/O processing: fault rate exceeded</td></tr>
<tr><td>0x0040/
0x0080</td><td>No I/O processing: configured module not plugged in</td></tr>
</table></td></tr>
<tr><td>AO.Error Code [WORD]</td><td>R</td><td>Error codes for the analog output channels
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Module fault</td></tr>
<tr><td>0x0002</td><td>Safety switch 1 faulty</td></tr>
<tr><td>0x0004</td><td>Safety switch 2 faulty</td></tr>
<tr><td>0x0008</td><td>FTT test of test pattern faulty</td></tr>
<tr><td>0x0010</td><td>FTT test: Error while checking coefficients</td></tr>
<tr><td>0x0400</td><td>FTT test: 1st temperature threshold exceeded</td></tr>
<tr><td>0x0800</td><td>FTT test: 2nd temperature threshold exceeded</td></tr>
<tr><td>0x2000</td><td>Status of safety switches</td></tr>
<tr><td>0x4000</td><td>Active shutdown via watchdog faulty</td></tr>
</table></td></tr>
<tr><td>AO[xx].Error Code [BYTE]</td><td>R</td><td>Error codes for the analog output channels
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x01</td><td>Fault in the analog output unit</td></tr>
<tr><td>0x80</td><td>AO [xx].Value out of specified range</td></tr>
</table></td></tr>
<tr><td>AO[xx].Value [INT]</td><td>W</td><td>Output value of AO channels:
Current characteristic curve: 0...+2000 (0...+20 mA)
Current characteristic curve: -2000...0 (0 mA)

Before being normalized, the values are checked for plausibility.
Current characteristic curve:
▪ Values < 0:
are normalized to 0
▪ Values < intermediate data point LOW:
Normalization with intermediate data point LOW
▪ Values > intermediate data point HIGH:
Normalization with intermediate data point HIGH

Outputs must <u>not</u> be used as safety-related outputs!</td></tr>
<tr><td>AO[x].Used [BOOL]</td><td>W</td><td>Channel configuration
1 = Channel operating
0 = Channel not operating</td></tr>
</table>

Table 34: ELOP II Factory - System Signals for the Analog Outputs

4.5 Connection Variants

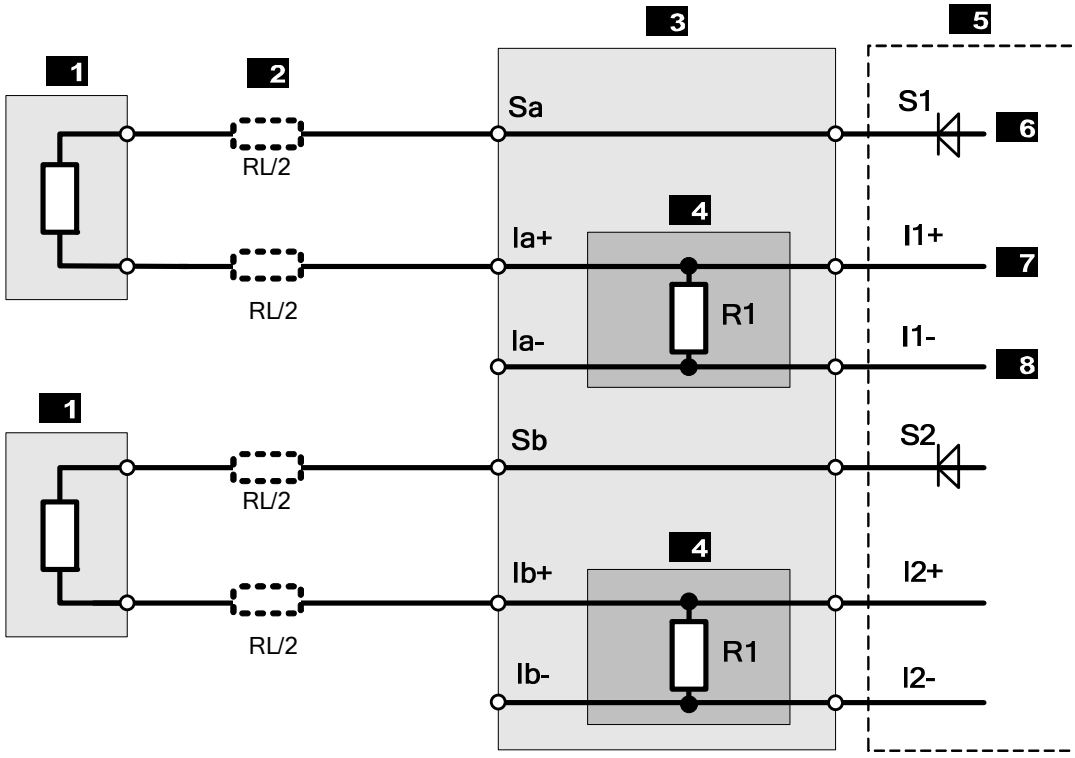
This chapter describes the permissible wiring of the remote I/O in safety-related applications.

Only the connection variants specified here are permitted for SIL 3 applications.

4.5.1 Connecting Proximity Switches

Proximity switches are connected to the analog inputs using the Z 7309 shunt adapter, see Figure 10.

The proximity switch is connected to its supply via the line resistor RL. Afterwards, it is connected in series to the R1 resistor.



1 Proximity Switch
2 Line Resistance of < 50 Ω
3 Z 7309 Shunt Adapter
4 R1 = 500 Ω within the Shunt Adapter
5 F3 AIO 8/4 01 Remote I/O
6 Supply
7 Analog Input
8 Ground

Figure 10: Proximity Switch on Analog Inputs

i Unshielded cables may be used (zone A, in accordance with EN 61131 – 2: 2007). Shielded cables must be used if the system is located in a hostile EMC environment (zone B or C). The shielding must be earthed by attaching it to the shroud.

NOTE

Overload, failure due to improperly set voltage (8.2 V / 26 V)!

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

Prior to start-up, set the *Transmitter Supply[01]* system parameter to 1 (8.2 V). If the shunt adapter has been overloaded, it must be replaced.

Switching Thresholds of the Analog Inputs

With the shunt adapter Z 7309, the current measurement of 0/4…20 mA is set at a resolution of 2000 digits.

The switch-on and switch-off thresholds, the open-circuit (OC) and short-circuit (SC) thresholds and the corresponding fault reaction must be configured in the user program. The line resistance has already been taken into account with the limits.

Switching thresholds	Range of 2000 digits [1)]	Description
NAMUR proximity switches in accordance with EN 60947-5-6		
Switch-on threshold L → H	1.75 mA [175 digits]	Transition from Low to High
Switch-off threshold H → L	1.55 mA [155 digits]	Transition from High to Low
OC Limit	≤ 0.20 mA [20 digits]	Fault reaction to be configured: Set the input value to faulty.
SC Limit	≥ 10.86 mA [1086 digits]	Fault reaction to be configured: Set the input value to faulty.
SN / S1N proximity switches from Pepperl+Fuchs		
Switch-on threshold L → H	2.45 mA [245 digits]	Transition from Low to High
Switch-off threshold H → L	2.25 mA [225 digits]	Transition from High to Low
OC Limit	≤ 0.20 mA [20 digits]	Fault reaction to be configured: Set the input value to faulty.
SC Limit	≥ 5.63 mA [563 digits]	Fault reaction to be configured: Set the input value to faulty.
[1)] Verify the values of the proximity switches actually in use.		

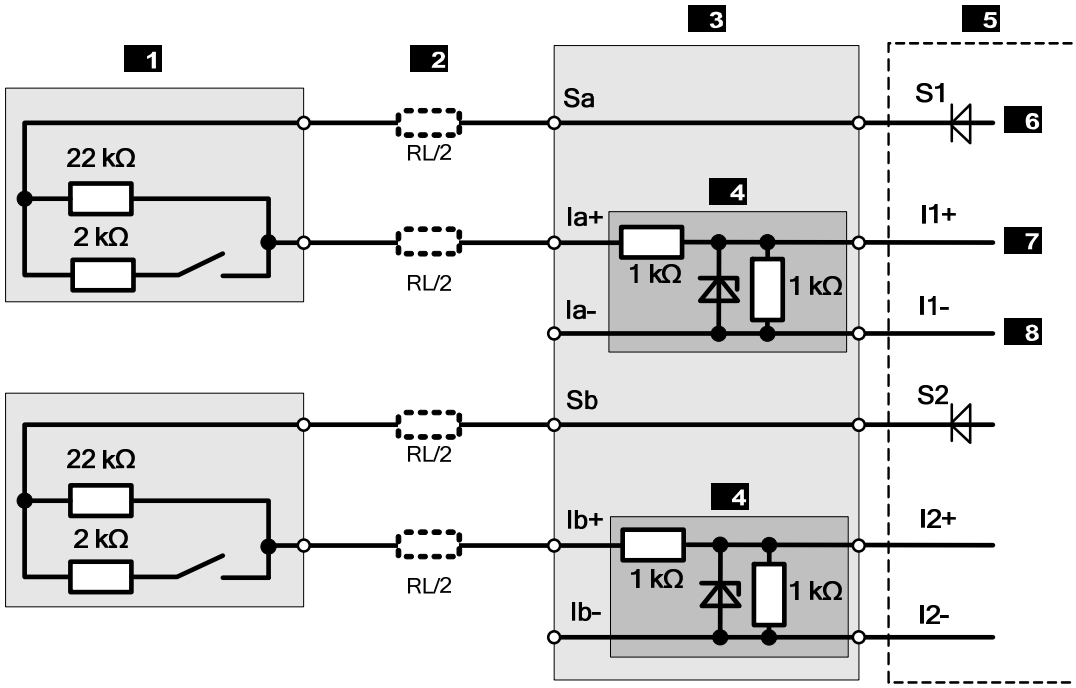
Table 35: Thresholds for the Inputs with Proximity Switches

4.5.2 Connecting Wired Mechanical Contacts

Wired mechanical contacts are connected as described in Figure 11 and Figure 12. Wired mechanical contacts are connected to the analog inputs using the Z 7308 shunt adapter. The shunt adapter protects the analog inputs against overvoltage and short-circuits from the field zone.

The supply voltage must be set to 26 V.

4.5.2.1 Wired Mechanical Contacts with Resistance Values of 2 kΩ and 22 kΩ



1 Wired Mechanical Contact
2 Line Resistance of < 50 Ω
3 Z 7308 Shunt Adapter
4 Protective Circuit within Z 7308
5 F3 AIO 8/4 01 Remote I/O
6 Supply
7 Analog Input
8 Ground

Figure 11: Wired Mechanical Contact

Switching Thresholds of the Analog Inputs

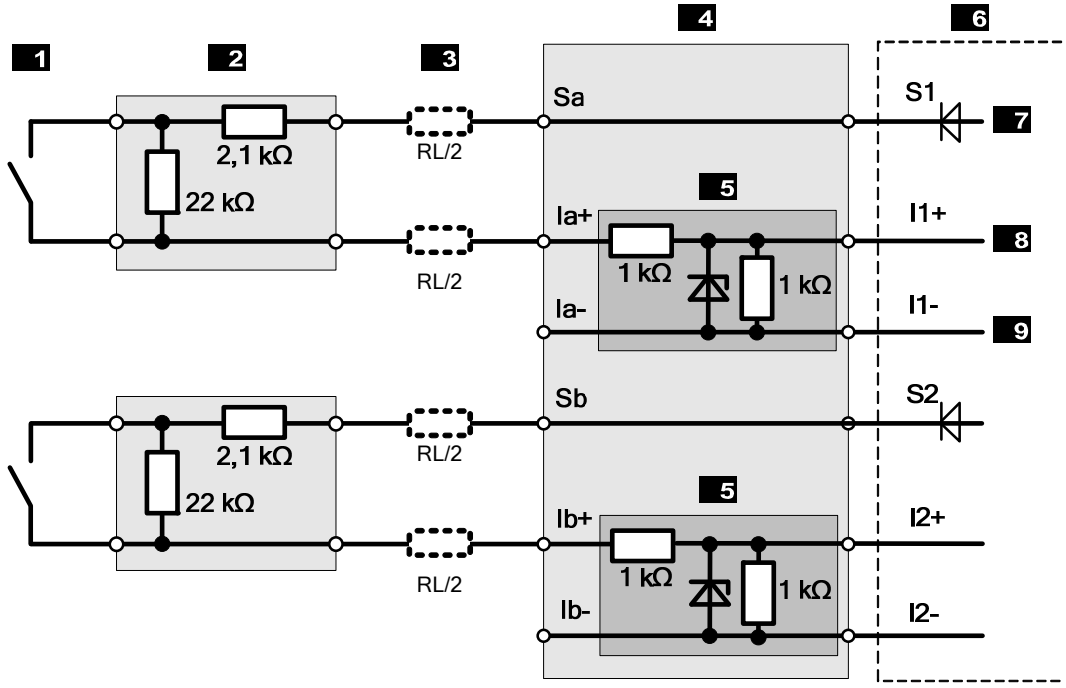
The switch-on and switch-off thresholds, the open-circuit (OC) and short-circuit (SC) thresholds and the corresponding fault reaction must be configured in the user program. The line resistance has already been taken into account with the limits.

Switching threshold	Value	Description
Switch-on threshold L → H	> 5 V [1000 digits]	Transition from Low to High
Switch-off threshold H → L	< 4 V [800 digits]	Transition from High to Low
OC Limit	< 0.4 V [80 digits]	Fault reaction to be configured: Set the input value to zero.
SC Limit	> 11 V [2200 digits]	Fault reaction to be configured: Set the input value to zero.

Table 36: Thresholds for the Inputs with Wired Mechanical Contacts

4.5.2.2 Wired Mechanical Contacts with Resistance Values of 2.1 kΩ and 22 kΩ

A BARTEC resistive coupling element (2, HIMA part no. 88 0007829) is connected upstream to the mechanical contact and connected to the analog inputs using the Z 7308 shunt adapter, see Figure 12.



1 Mechanical Contact
2 Resistive Coupling Element
3 Line Resistance of < 50 Ω
4 Z 7308 Shunt Adapter
5 Protective Circuit within Z 7308
6 F3 AIO 8/4 01 Remote I/O
7 Supply
8 Analog Input
9 Ground

Figure 12: Mechanical Contact with Resistive Coupling Element

Switching Thresholds of the Analog Inputs

The switch-on and switch-off thresholds, the open-circuit (OC) and short-circuit (SC) thresholds and the corresponding fault reaction must be configured in the user program. The line resistance has already been taken into account with the limits.

Switching threshold	Value	Description
Switch-on threshold L → H	> 5 V [1000 digits]	Transition from Low to High
Switch-off threshold H → L	< 4 V [800 digits]	Transition from High to Low
OC Limit	< 0.4 V [80 digits]	Fault reaction to be configured: Set the input value to zero.
SC Limit	> 9 V [1800 digits]	Fault reaction to be configured: Set the input value to zero.

Table 37: Switching Thresholds for the Inputs for Mechanical Contacts with Resistive Coupling Element

5 Operation

The remote I/O can only operated together with a controller. No specific monitoring is required for remote I/Os.

5.1 Handling

Handling of the remote I/O during operation is not required.

5.2 Diagnosis

A first diagnosis results from evaluating the LEDs, see Chapter 3.5.1.

The device diagnostic history can also be read using the programming tool.

6 Maintenance

No maintenance measures are required during normal operation.

If a failure occurs, the defective module or device must be replaced with a module or device of the same type or with a replacement model approved by HIMA.

Only the manufacturer is authorized to repair the device/module.

6.1 Faults

Refer to Chapter 3.1.1.1, for more information on the fault reaction of inputs.

Refer to Chapter 3.2, for more information on the fault reaction of the outputs.

If the test harnesses detect safety-critical faults, the module enters the STOP_INVALID state and will remain in this state. This means that the input signals are no longer processed by the device and the outputs switch to the de-energized, safe state. The evaluation of diagnostics provides information on the fault cause.

6.2 Maintenance Measures

The following measures are required for the device:

- Loading the operating system, if a new version is required
- Executing the proof test

6.2.1 Loading the Operating System

HIMA is continuously improving the operating system of the devices. HIMA recommends to use system downtimes to load a current version of the operating system into the devices.

Refer to the release list to check the consequences of the new operation system version on the system!

The operating system is loaded using the programming tool.

Prior to loading the operating system, the device must be in STOP (displayed in the programming tool). Otherwise, stop the device.

For more information, refer to the programming tool documentation.

6.2.2 Proof Test

HIMatrix devices and modules must be subjected to a proof test in intervals of 10 years. For more information, refer to the safety manual (HI 800 023 E).

7 Decommissioning

Remove the supply voltage to decommission the device. Afterwards pull out the pluggable screw terminal connector blocks for inputs and outputs and the Ethernet cables.

8 Transport

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

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

9 Disposal

Industrial customers are responsible for correctly disposing of decommissioned HIMatrix 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
ARP	Address resolution protocol: Network protocol for assigning the network addresses to hardware addresses
AI	Analog input
AO	Analog output
COM	Communication module
CRC	Cyclic redundancy check
DI	Digital input
DO	Digital output
ELOP II Factory	Programming tool for HIMatrix systems
EMC	Electromagnetic compatibility
EN	European norm
ESD	Electrostatic discharge
FB	Fieldbus
FBD	Function block diagrams
FTT	Fault tolerance time
ICMP	Internet control message protocol: Network protocol for status or error messages
IEC	International electrotechnical commission
MAC address	Media access control address: Hardware address of one network connection
PADT	Programming and debugging tool (in accordance with IEC 61131-3), PC with SILworX or ELOP II Factory
PE	Protective earth
PELV	Protective extra low voltage
PES	Programmable electronic system
R	Read: The system variable or signal provides value, e.g., to the user program
Rack ID	Base plate identification (number)
Interference-free	Supposing that two input circuits are connected to the same source (e.g., a transmitter). An input circuit is termed *interference-free* if it does not distort the signals of the other input circuit.
R/W	Read/Write (column title for system variable/signal type)
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 for HIMatrix systems
SNTP	Simple network time protocol (RFC 1769)
SRS	System.rack.slot addressing of a module
SW	Software
TMO	Timeout
W	Write: System variable/signal is provided with value, e.g., from the user program
r_{PP}	Peak-to-peak value of a total AC component
Watchdog (WD)	Time monitoring for modules or programs. If the watchdog time is exceeded, the module or program enters the ERROR STOP state.
WDT	Watchdog time

Index of Figures

Index of Tables

Index

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