HIMatrix

Safety-Related Controller

F3 DIO 16/8 01 Manual

HIMA Paul Hildebrandt GmbH

Industrial Automation

Rev. 2.00

HI 800 177 E

All of the instructions and technical specifications in this manual have been written with great care and effective quality assurance measures have been implemented to ensure their validity. For questions, please contact HIMA directly. HIMA appreciates any suggestion on which information should be included in the manual.

Equipment subject to change without notice. HIMA also reserves the right to modify the written material without prior notice.

For further information, refer to the HIMA DVD and our website at `http://www.hima.de` and `http://www.hima.com`.

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Revision index	Revisions	Type of change	
		technical	editorial
1.00	Added: Configuration with SILworX	X	X
1.01	Deleted: Chapter *Monitoring the Temperature State* integrated in the system manual		X
2.00	Revised: Chapters 3.4.1, 3.4.2.1, 4.5 and 4.6.4 Added: F3 DIO 16/8 014, SIL 4 certified according to EN 50126, EN 50128 and EN 50129, Chapter 4.1.5	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

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

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 DIO 16/8 01** remote I/O is a compact system in a metal housing with 16 digital inputs, 8 2-pole digital outputs and 2 pulsed outputs. The 2-pole outputs consist of 2 switches connected in series, one switching to L+ and the other switching to L-.

The remote I/O is available in various model variants for SILworX and ELOP II Factory, see Table 4.

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 4.1.6.

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

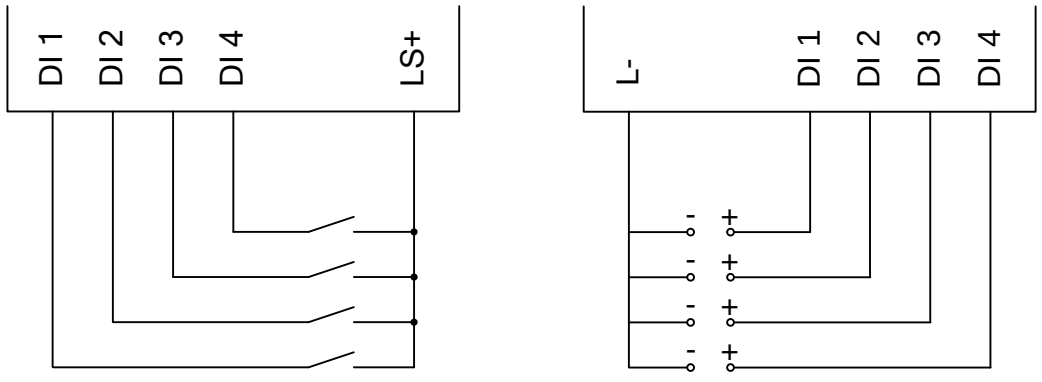
The remote I/O is equipped with safety-related digital inputs and outputs. The input values on the inputs are safely transmitted to the connected controller via safe**ethernet**. The outputs are safely assigned their values by the connected controller via safe**ethernet**.

3.1.1 Safety-Related Digital Inputs

The state (HIGH, LOW) of each input is signaled by an individual LED.

Mechanical contacts without own power supply or signal power source can be connected to the inputs. Potential-free mechanical contacts without own power supply are fed via an internal short-circuit-proof 24 V power source (LS+). Each of them supply a group of 4 mechanical contacts. Figure 1 shows how the connection is performed.

With signal voltage sources, the corresponding ground must be connected to the input (L-), see Figure 1.



Connection of potential-free mechanical contacts

Connection of signal power sources

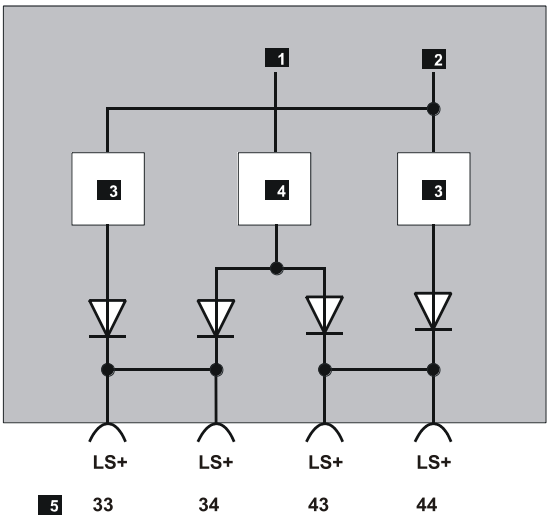
Figure 1: Connections to Safety-Related Digital Inputs

Table 18 shows the entire terminal assignment for the digital inputs.

In the default setting, each of the 24 V power sources (LS+) provides a current of 40 mA which is buffered against power failures for 20 ms.

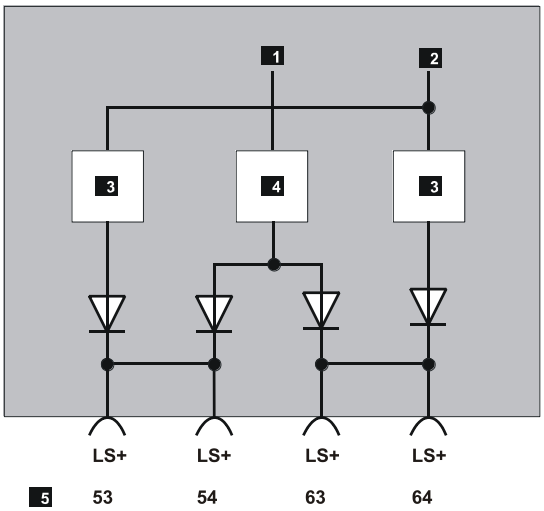
If higher current is required, the *DI Supply[xx]* system parameter can be set in the user program to connect an unbuffered power source (1 A) for each terminal pair (33, 34 and 43, 44) and (53, 54 and 63, 64), see Figure 2 and Figure 3.

The remote I/O reads back the state of the unbuffered power sources and if an overload occurs, it switches off. The power sources are protected with current limiting components.



1 Unbuffered Power Source
2 Buffered Power Source
3 40 mA Current Limiting
4 1 A Current Limiting
5 Terminal Number

Figure 2: Exemplary Structure of Buffered and Unbuffered Power Source



1 Unbuffered Power Source
2 Buffered Power Source
3 40 mA Current Limiting
4 1 A Current Limiting
5 Terminal Number

Figure 3: Exemplary Structure of Buffered and Unbuffered Power Source

The connector cables for the inputs are not monitored.

It is not necessary to terminate unused inputs.

3.1.1.1 Reaction in the Event of a Fault

If the device detects a fault on a digital input, the user program processes a low level in accordance with the de-energized to trip principle.

The device activates the *FAULT* LED.

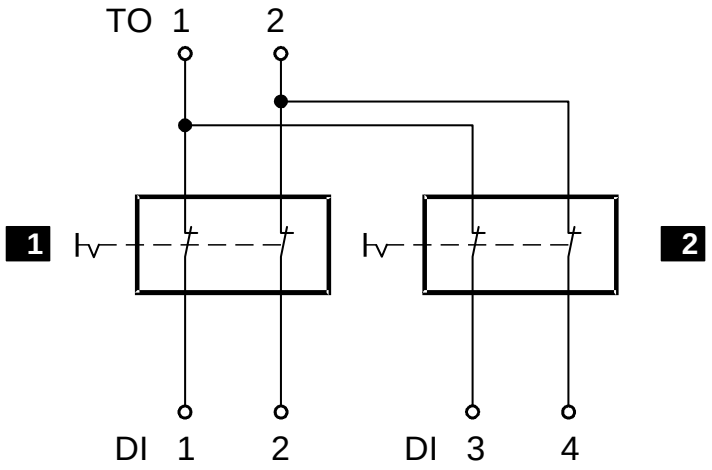
In addition to the channel signal value, the user program must also consider the corresponding error code.

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

3.1.2 Line Control

Line control is used to detect short-circuits or open-circuits and can be configured for the remote I/O, e.g., on EMERGENCY STOP inputs complying with Cat. 4 and PL e in accordance with EN ISO 13849-1.

To this end, connect the pulsed outputs TO 1 and TO 2 of the system to the digital inputs (DI) of the same system as follows:



1 EMERGENCY STOP 1
2 EMERGENCY STOP 2

EMERGENCY STOP switches in accordance with EN 60947-5-1 and EN 60947-5-5

Figure 4: Line Control

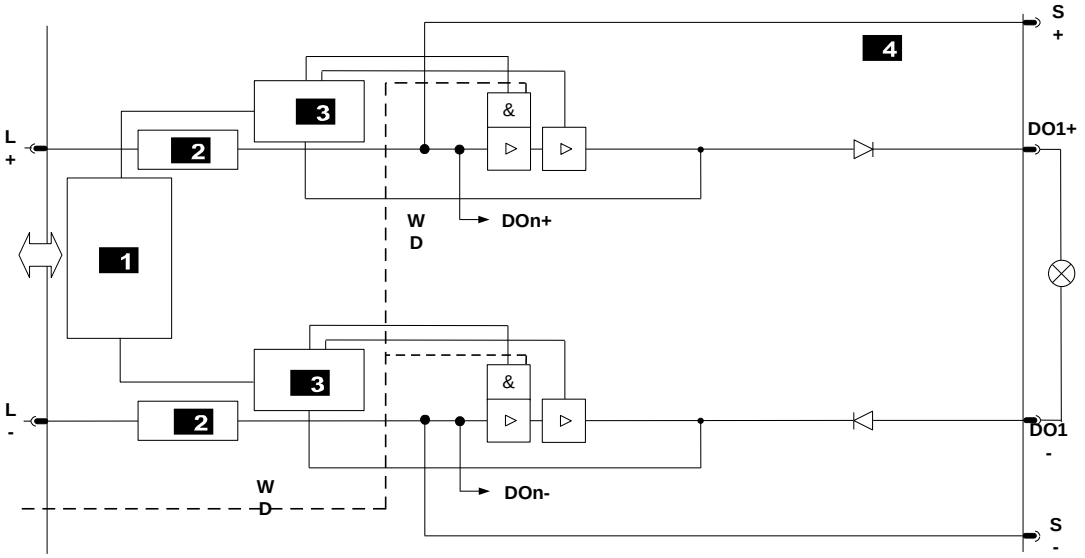
The remote I/O pulses the pulsed outputs to detect short-circuits and open-circuits on the lines connected to the digital inputs (DI). To do so, configure the *Value [BOOL] ->* system variable in SILworX or the *DO[01].Value* system signal in ELOP II Factory. The variables for the pulsed outputs must begin with channel 1 and reside in direct sequence, one after the other.

If the following faults occur, the *FAULT* LED located on the front plate of the controller blinks, the inputs are set to low level and an (evaluable) error code is created:

- Cross-circuit between two parallel wires.
- Invalid connections of two lines (e.g., TO 2 to DI 3),
- Earth fault on one wire (with earthed ground only).
- Open-circuit or open contacts, i.e., including when one of the two EMERGENCY STOP switches mentioned above has been engaged, the *FAULT* LED blinks and the error code is created.

3.1.3 Safety-Related Digital Outputs

The state (HIGH, LOW) of each output is signaled by an individual LED (HIGH, LOW). The following block diagram shows how the 2-pole digital outputs are connected:



1 Connection to I/O Bus
2 Current Limiting
3 Logic
4 2-Pole Output

Figure 5: Block Diagram for 2-pole Digital Outputs

The 1oo2 processor system directly energizes the digital outputs. Field zone and processor zone are not galvanically separated. The operating voltage directly supplies the outputs.

If a critical failure occurs, the processor system brings the outputs to the de-energized state directly, via the I/O bus or indirectly, using the watchdog (second independent shutdown function).

If communication is lost, the output is set to the initial value configured. This effect must be taken into account for the behavior of the connected output.

If an overload occurs, one or all digital outputs are switched off. If the overload is removed, the outputs are switched on again automatically, see Table 14.

3.1.3.1 Reaction in the Event of a Fault

If the device detects a faulty signal on a digital output, the affected module output is set to the safe (de-energized) state using the safety switches.

If a device fault occurs, all digital outputs are switched off.

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

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

3.1.4 Line Diagnosis with Digital Outputs

The remote I/O is provided with a line diagnosis (short-circuits and open-circuits) for the digital outputs. Line diagnosis of the digital outputs is only possible when used in a 2-pole configuration.

The line diagnosis is activated using the *Line Monitoring [BOOL]* -> system parameter in SILworX and the *DO[xx].LSLB Monitoring* system signal in ELOP II Factory.

The line diagnosis measures the impedance of the connected load.

The line diagnosis detects the following faults:

- Short-circuit between DO+ and external DO-
- Short-circuit between DO+ and external L+
- Short-circuit between DO+ and external L-
- Short-circuit between DO- and external L+
- Short-circuit between DO- and external L-
- Open-circuit between DO+ and DO-

The line diagnosis reports detected faults to the user program.

- In SILworX, with the system variables -> + *Error Code [WORD]* or -> - *Error Code [WORD]*.
- In ELOP II Factory, with the system signals *DO[xx].+Error Code* or *DO[xx].-Error Code*.

Line diagnosis is offered in two operating modes:

- Line diagnosis for lamp loads and inductive loads, and
- line diagnosis for ohmic, capacitive loads.

i A relay or actuator connected to the output may accidentally be switched on!

A requirement for applications in machine safety is that the outputs DO+, DO- are switched off if an open-circuit is detected.

i If the requirements previously described cannot be met, observe the following case:

If a short-circuit occurs between DO- and L-, a relay may be energized or some other actuator may be set to a different switching state.

Reason: During the monitoring time specified for line diagnosis, a 24 V level (DO+ output) is present on the load (relay, switching actuator) allowing it to receive enough electrical power to potentially switch to another state.

The monitoring time must be configured such that an actuator cannot be activated by the line diagnosis test pulse.

With line diagnosis, set a test period and an adequate monitoring time.

3.1.4.1 Line Diagnosis for Lamp Loads and Inductive Loads

To detect short-circuits, the remote I/O sends a 24 V pulse to the output circuit for the duration of 500 µs. After this time, it sends a 10 V pulse to detect open-circuits for the duration of the monitoring time.

Refer to Chapter 4.5.1 for more information on the configuration.

3.1.4.2 Line Diagnosis for Ohmic, Capacitive Loads

To diagnose the line for ohmic and capacitive loads, the remote I/O sends a 10 V test pulse to the output circuit for the duration of the monitoring time. This type of line diagnosis is particularly recommended for ohmic and ohmic capacitive loads. With inductive loads or lamp loads, error messages related to the short-circuit may be generated.

Refer to Chapter 4.5.2 for more information on the configuration.

3.1.4.3 Test Period and Monitoring Time

For line diagnosis, configure the test period and the monitoring time. These time parameters influence all the channels configured for line diagnosis.

During the monitoring time, the status is read back in 1 ms intervals and, if no faults are detected, the process values are rewritten to the output. The monitoring time can be set in intervals of 1 ms between 0 and 50 ms (default value 0 ms).

i The duration of the monitoring time is added to the cycle time. During the monitoring time, the output circuit is supplied with a reduced voltage.

The time period can be configured in intervals of 1 s between 1 and 100 s. The interval depends on following parameters:

- Number of test pulses allowed in the external circle.
- Monitoring time

If the time period is set to 1 s, a test pulse is sent in intervals of 250 ms for the duration of the monitoring time.

Within one test period, 4 test pulses are generally pulsed in intervals of 0.25 x time period.

After the period time the line diagnosis is finished and the next line diagnosis cycle starts.

3.2 Equipment, Scope of Delivery

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

Designation	Description
F3 DIO 16/8 01	Remote I/O (16 digital inputs, 8 2-pole digital outputs, 2 pulsed outputs) Operating temperature: 0...+60 °C, for ELOP II Factory programming tool
F3 DIO 16/8 01 SILworX	Remote I/O (16 digital inputs, 8 2-pole digital outputs, 2 pulsed outputs) Operating temperature: 0...+60 °C, for SILworX programming tool
F3 DIO 16/8 014 SILworX	Remote I/O (16 digital inputs, 8 2-pole digital outputs, 2 pulsed 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 4: Available Variants

3.2.1 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.

3.3 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

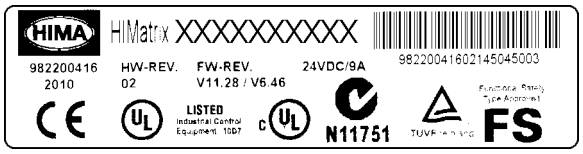


Figure 6: Sample Type Label

3.4 Structure

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

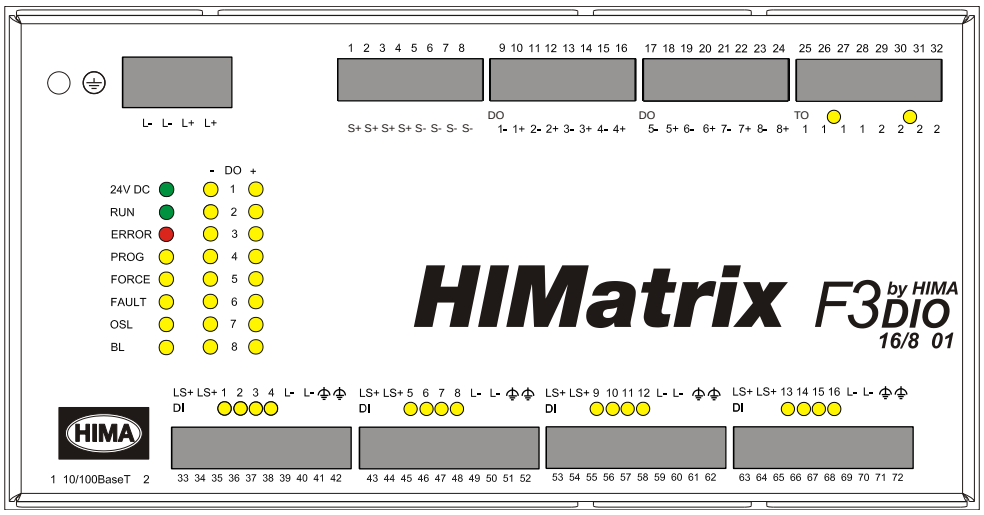
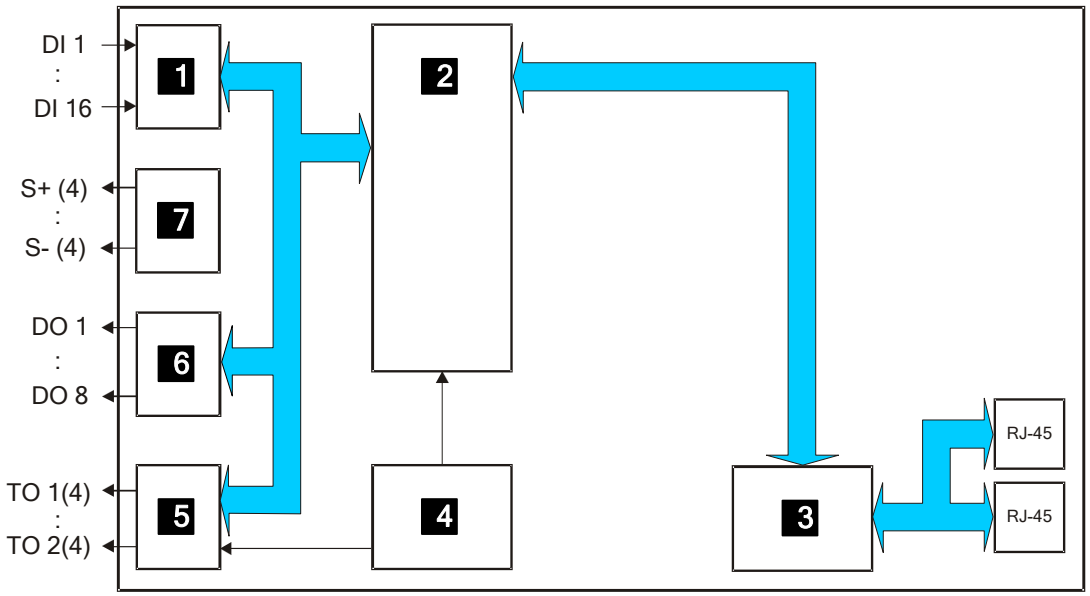


Figure 7: Front View



1 16 Digital Inputs
2 Safety-Related Processor System (CPU)
3 Switch
4 Watchdog
5 2 Pulsed outputs
6 8 Digital Outputs, 2-Pole (DO+, DO-)
7 Ground for Digital Outputs

Figure 8: Block Diagram

3.4.1 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
- I/O LEDs

3.4.1.1 Operating Voltage LED

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

Table 5: Operating Voltage LED

3.4.1.2 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 6: System LEDs

3.4.1.3 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 7: Ethernet Indicators

3.4.1.4 I/O LEDs

LED	Color	Status	Description
DI 1...16	Yellow	On	The related channel is active (energized).
		Off	The related channel is inactive (de-energized).
DO 1...8	Yellow	On	The related output is active (energized).
		Off	The related output is inactive (de-energized).
TO 1...2	Yellow	On	Pulsed output activated.
		Off	Pulsed output deactivated.

Table 8: I/O LEDs

3.4.2 Communication

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

3.4.2.1 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 9: Ethernet Interfaces Properties

The two RJ-45 connectors with integrated LEDs are located on the bottom left-hand side of the housing. For more information on the communication LEDs, refer to Chapter 3.4.1.3.

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).

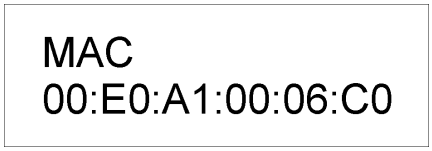


Figure 9: Sample MAC Address Label

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).

3.4.2.2 Network Ports Used for Ethernet Communication

UDP ports	Use
8000	Programming and operation with the programming tools
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 10: Network Ports in Use

3.4.3 Pulsed Outputs

The digital pulsed outputs can be used to detect short-circuits and open-circuits on digital inputs, e.g., on EMERGENCY STOP button complying with Cat. 4 and PL e in accordance with EN ISO 13849-1.

i Pulsed outputs must not be used as safety-related outputs (e.g., for activating safety-related actuators)!

3.4.4 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 default account administrator 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.

3.4.4.1 Ampacity of the Digital Outputs

The ampacity of the digital outputs depends on the temperature. The following table specifies channel-related current loads that should maintain the temperature load of the outputs below the critical limit.

	Output channel								Ambient temperature
	1	2	3	4	5	6	7	8	
max. current	2 A	0.5 A	1 A	0.5 A	0.5 A	1 A	0.5 A	2 A	< 40 °C with free convection
max. current	**1 A**	0.5 A	1 A	0.5 A	0.5 A	1 A	0.5 A	**1 A**	≥ 40 °C with free convection

Table 11: Ampacity of the Digital Outputs

3.5 Product Data

General	
Response time	≥ 10 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. 11 A (with maximum load) for UL, only 10 A allowed Idle current: 0.45 A
Fuse (external)	12 A time-lag (T)
Operating temperature	0...+60 °C
Storage temperature	-40...+85 °C
Type of protection	IP20
Max. dimensions (without plug)	Width: 205 mm (with housing screws) Height: 114 mm (with fixing bolt) Depth: 88 mm (with earth)
Weight	approx. 1.3 kg

Table 12: Product Data of F3 DIO 16/8 01

Digital inputs	
Number of inputs	16 (non-galvanically separated)
Low level: voltage current input	15...30 VDC ≥ 2 mA at 15 V
Low level: voltage current input	max. 5 VDC max. 1.5 mA (1 mA at 5 V)
Switching point	typ. 7.5 V
Switching time	250 µs
Supply	4 x LS+ minus 4 V / 40 mA, short-circuit-proof Buffered for 20 ms 2x LS+ minus 2 V / 1 A total, short-circuit-proof, unbuffered Current input: max. 1 A at 60 °C

Table 13: Specifications for the Digital Inputs

Digital outputs		
Number of outputs	8 (non-galvanically separated) 2-pole switching DO+ 2 A (inrush current typ. 10 A at 2 ms) DO- 2 A (inrush current typ. 10 A at 2 ms)	
Output voltage	≥ L+ minus voltage drop (L+ and L- leg)	
Voltage drop 2-pole outputs	max. 3 V at 2 A	
Voltage drop Outputs DO+	max. 1.5 V at 2 A	
Voltage drop Outputs DO-	max. 1.5 V at 2 A	
Output current, see also Table 11	max. 2 A at < 40 °C max. 1 A at 40…60 °C min. 10 mA	
Total permissible current	max. 8 A	
Leakage current (with low level)	max. 1 mA at 2 V	
Lamp load	max. 25 W	
Inductive load	max. 500 mH	
Line Diagnosis	Open-circuit	> 4 kΩ
	Short-circuit	< 10 Ω
Behavior upon overload	The affected output is switched off and cyclically switched on again	

Table 14: Specifications for the Digital Outputs

Pulsed outputs	
Number of outputs	2 (non-galvanically separated)
Output voltage	≥ L+ minus 4 V
Output current	approx. 60 mA
Minimum load	None
Switching time	≤ 100 µs
Behavior upon overload	2 x ≥ 19.2 V, short-circuit current 60 mA at 24 V

Table 15: Specifications for the Pulsed Outputs

3.5.1 Product Data F3 DIO 16/8 014

The F3 DIO 16/8 014 model variant is intended for use in railway applications. The electronic components are coated with a protective lacquer.

F3 DIO 16/8 014	
Operating temperature	-25…+70 °C (temperature class T1)
Output current	The output current of the digital outputs depends on the ambient temperature.

Ambient temperature	Output current
< 40 °C	2 A
40…60 °C	1 A
> 60 °C	0.5 A

Weight	approx. 1.3 kg

Table 16: Product Data of F3 DIO 16/8 014

3.6 Certified HIMatrix F3 DIO 16/8 01

Test institute	Standard, Scope
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 17: Certificates

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 such as described in the HIMatrix System Manual for Compact Systems.

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 Installation and Terminals of the Digital Inputs

Terminal	Designation	Function
33, 34	LS+	Sensor supply for inputs 1...4, buffered/unbuffered supply.
35	1	Digital input 1
36	2	Digital input 2
37	3	Digital input 3
38	4	Digital input 4
39, 40	L-	Ground
41, 42	PA	Shielding
Terminal	Designation	Function
43, 44	LS+	Sensor supply for inputs 5...8, buffered/unbuffered supply.
45	5	Digital input 5
46	6	Digital input 6
47	7	Digital input 7
48	8	Digital input 8
49, 50	L-	Ground
51, 52	PA	Shielding
Terminal	Designation	Function
53, 54	LS+	Sensor supply for inputs 9...12, buffered/unbuffered supply.
55	9	Digital input 9
56	10	Digital input 10
57	11	Digital input 11
58	12	Digital input 12
59, 60	L-	Ground
61, 62	PA	Shielding
Terminal	Designation	Function
63, 64	LS+	Sensor supply for inputs 13...16, buffered/unbuffered supply.
65	13	Digital input 13
66	14	Digital input 14
67	15	Digital input 15
68	16	Digital input 16
69, 70	L-	Ground
71, 72	PA	Shielding

Table 18: Terminal Assignment for the Digital Inputs

4.1.2 Surges on Digital Inputs

Due to the short cycle time of the HIMatrix systems, a surge pulse as described in EN 61000-4-5 can be read in to the digital inputs as a short-term high level.

The following measures ensure proper operation in environments where surges may occur:

1. Install shielded input wires
2. Program noise blanking in the user program. A signal must be present for at least two cycles before it is evaluated. The fault reaction is triggered with a corresponding delay.

i The measures specified above are not necessary if the plant design precludes surges from occurring within the system.

In particular, the design must include protective measures with respect to overvoltage, lightning, earth grounding and plant wiring in accordance with the relevant standards and the instructions specified in the System Manual (HI 800 141 E or HI 800 191 E).

4.1.3 Installation and Terminals of the Digital Inputs

Use the following terminals to connect the digital outputs:

Terminal	Designation	Function (outputs)
1...4	S+	Positive sensor supply
5...8	S-	Negative sensor supply
Terminal	Designation	Function (outputs)
9	1-	Digital output 1, S+ switching
10	1+	Digital output 1, S- switching
11	2-	Digital output 2, S+ switching
12	2+	Digital output 2, S- switching
13	3-	Digital output 3, S+ switching
14	3+	Digital output 3, S- switching
15	4-	Digital output 4, S+ switching
16	4+	Digital output 4, S- switching
Terminal	Designation	Function (outputs)
17	5-	Digital output 5, S+ switching
18	5+	Digital output 5, S- switching
19	6-	Digital output 6, S+ switching
20	6+	Digital output 6, S- switching
21	7-	Digital output 7, S+ switching
22	7+	Digital output 7, S- switching
23	8-	Digital output 8, S+ switching
24	8+	Digital output 8, S- switching

Table 19: Terminal Assignment for the Digital Outputs

The digital outputs can be configured in three ways:

- Digital output, 1-pole switching without line diagnosis
- Digital output, 2-pole switching without line diagnosis
- Digital output, 2-pole switching with line diagnosis

Line diagnosis means line monitoring of digital outputs for short-circuits and open-circuits.

4.1.3.1 Overview of Configuration Variants for the Digital Outputs

The following table specifies all configuration variants permitted for the digitals outputs. Additional system signals have no influence on other variants (e.g., *Signal DO[xx].SC monitoring with reduced voltage*). With improper parameter setting, a diagnostic entry (*IOA Wrong Initial Data*) is generated. Simultaneously, the parameter setting is displayed. Use the table below to locate errors.

Configuration Variants with Digital Outputs					
Application	Channel 1 2-pole	Channel 2 2-pole	Channel 1 SC/OC	Channel 2 SC/OC	Common ground
1-pole					
2-pole		X[1)]			
		X[1)]		X[1)]	
	X[1)]				
	X[1)]		X[1)]		
	X[1)]	X[1)]			
	X[1)]	X[1)]		X[1)]	
	X[1)]	X[1)]	X[1)]		
	X[1)]	X[1)]	X[1)]	X[1)]	
3-pole	X[1)]	X[1)]		X[1)]	X[1)]
	X[1)]	X[1)]			X[1)]
	X[1)]	X[1)]	X[1)]		X[1)]
	X[1)]	X[1)]	X[1)]	X[1)]	X[1)]
[1)] Option is selected SC/OC: Line diagnosis (SC = short-circuit, OC = open-circuit)					

Table 20: Configuration Variants with Digital Outputs

4.1.4 Pulsed Outputs

Terminal assignment for the pulsed outputs.

Terminal	Designation	Function (non-safe pulsed outputs TO)
25	1	Pulsed output 1
26	1	Pulsed output 1
27	1	Pulsed output 1
28	1	Pulsed output 1
29	2	Pulsed output 2
30	2	Pulsed output 2
31	2	Pulsed output 2
32	2	Pulsed output 2

Table 21: Terminal Assignment for the Pulsed Outputs

4.1.5 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 22: Power Supply Cable Plug Properties

Connection to the field zone	
Number of cable plugs	2 pieces, eight poles, screw terminals 4 pieces, ten 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 23: Input and Output Cable Plug Properties

4.1.6 Mounting the F3 DIO 16/8 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. Depending on the output load and supply voltage, the HIMatrix F3 DIO 16/8 01 has a power dissipation ranging between 13 W and 31 W.
3. Protect the HIMatrix F3 DIO 16/8 01 with a 12 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:

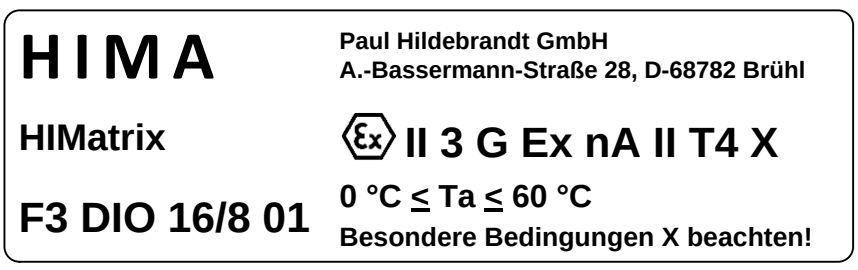


Figure 10: Label for Ex Conditions

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).

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 (DI 16 LC) with Line Control
- Output module (DO 8 03)
- Pulsed module (DO 2 01) with 2 outputs

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 parameter 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 Digital Inputs of F3 DIO 16/8 01

The following tables present the statuses and parameters for the input module (DI 16 LC) in the same order as given in the Hardware Editor.

4.3.2.1 Tab: **Module**

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

System parameter	Data type	R/W	Description
DI Number of Pulsed Channels	USINT	W	Number of pulsed outputs (supply outputs) Coding: 0 – No pulsed output planned for SC/OC[1] detection 1 – Pulsed output 1 planned for SC/OC[1] detection 2 – Pulsed output 1 and 2 planned for SC/OC[1] detection **Pulsed outputs must not be used as safety-related outputs!**
DI Supply [01]	BOOL	W	Triggering the single DI supplies Coding: FALSE – Sensor supply (1 A) is off. TRUE – Sensor supply (1 A) is on. Default setting FALSE: Feeding current 40 mA
DI Supply [02]	BOOL	W	
DI Pulse Slot	UDINT	W	Pulse module slot (SC/OC[1] detection), set the value to 3
DI Pulse Delay [µs]	UINT	W	Waiting time for line control (detection of short-circuits or cross-circuits)
DI.Error Code	WORD	R	Error codes for all digital inputs Coding: 0x0001 – Fault within the digital inputs 0x0002 – FTT test of test pattern faulty
DI.Error Code Supply	WORD	R	Error code of the DI supply unit as a whole Coding: 0x0001 – Module fault
DI[01].Error Code Supply	BYTE	R	Error codes of the single DI supplies Coding: 0x01 – Error DI supply unit 0x02 – Supply shutdown due to overcurrent 0x04 – Error while reading back the supply
DI[02].Error Code Supply	BYTE	R	
Module Error Code	WORD	R	Module error code Coding: 0x0000 – I/O processing, if required with errors see other error codes 0x0001 – No I/O processing (remote I/O not in RUN) 0x0002 – No I/O processing during the booting test 0x0004 – Manufacturer interface operating 0x0010 – No I/O processing: invalid configuration 0x0020 – No I/O processing: fault rate exceeded 0x0040/ 0x0080 – No I/O processing: configured module not plugged in
Module SRS	UDINT	R	Slot number (System Rack Slot)
Module Type	UINT	R	Type of module, target value: 0x00E2 [226 $_{dec}$]

[1] SC/OC (short-circuits/open-circuits)

Table 24: SILworX - System Parameters for Digital Inputs, **Module** Tab

4.3.2.2 Tab: **DI 16 LC: Channels**

The **DI 16 LC: Channels** tab contains the following system parameters.

<table>
<tr><th>System Signal</th><th>Data type</th><th>R/W</th><th>Description</th></tr>
<tr><td>Channel no.</td><td>---</td><td>R</td><td>Channel number, defined by default</td></tr>
<tr><td>-> Error Code [BYTE]</td><td>BYTE</td><td>R</td><td>Error codes for the digital 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>0x10</td><td>Short-circuit of the channel</td></tr>
<tr><td>0x80</td><td>Intermittence between pulsed output TO and digital input DI, e.g.,
▪ Open-circuit
▪ Open switch
▪ L+ undervoltage</td></tr>
</table></td></tr>
<tr><td>-> Value [BOOL]</td><td>BOOL</td><td>R</td><td>Input values for the digital input channels
0 = input de-energized
1 = input energized</td></tr>
<tr><td>Pulsed Output [USINT] -></td><td>USINT</td><td>W</td><td>Source channel for pulsed supply
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0</td><td>Input channel</td></tr>
<tr><td>1</td><td>Pulse of the 1st TO channel</td></tr>
<tr><td>2</td><td>Pulse of the 2nd TO channel</td></tr>
</table></td></tr>
</table>

Table 25: SILworX - System Parameters for Digital Inputs, **DI 16 LC: Channels** Tab

4.3.3 Digital Outputs of F3 DIO 16/8 01

The following table presents the statuses and parameters for the output module (DO 8 03) in the same order given in the SILworX 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>DO.Error Code</td><td>WORD</td><td>R</td><td>Error codes for all digital outputs
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>0x0001</td><td>Fault within the digital outputs</td></tr>
<tr><td>0x0002</td><td>Test of safety shutdown returns a fault</td></tr>
<tr><td>0x0004</td><td>Test of auxiliary voltage returns a fault</td></tr>
<tr><td>0x0008</td><td>FTT test of test pattern faulty</td></tr>
<tr><td>0x0010</td><td>Output switch test pattern faulty</td></tr>
<tr><td>0x0020</td><td>Output switch test pattern (shutdown test of the outputs) faulty</td></tr>
<tr><td>0x0040</td><td>Active shutdown via WD faulty</td></tr>
<tr><td>0x0080</td><td>FTT test of monitoring time returns a fault</td></tr>
<tr><td>0x0100</td><td>FTT read back of monitoring time returns a fault</td></tr>
<tr><td>0x0200</td><td>All outputs are switched off, total current exceeded</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>0x1000</td><td>FTT test: Monitoring of auxiliary voltage 1: Undervoltage</td></tr>
<tr><td>0x2000</td><td>FTT test: Monitoring of auxiliary voltage 2: Undervoltage</td></tr>
<tr><td>0x4000</td><td>Flipflop of the voltage monitoring (18 V) provides undervoltage</td></tr>
<tr><td>0x8000</td><td>Test of monitoring time returns a fault</td></tr>
</table></td></tr>
<tr><td>DO.Line Monitoring Time</td><td>UINT</td><td>W</td><td>Monitoring time for line diagnosis in [ms],
Range 1...50 ms, Default: 0 ms</td></tr>
<tr><td>DO.LM period</td><td>WORD</td><td>W</td><td>Period [s] required for the line diagnosis
Range 1…100 s, 1 s steps</td></tr>
<tr><td>DO[xx].SC Monitoring with Reduced Voltage</td><td>BOOL</td><td>W</td><td>Line diagnosis with reduced voltage
<table>
<tr><th>Coding</th><th>Description</th></tr>
<tr><td>FALSE</td><td>Normal signal voltage level</td></tr>
<tr><td>TRUE</td><td>Reduced signal voltage level</td></tr>
</table>
(Reduced signal voltage level with Line Monitoring [BOOL] -> = TRUE only)</td></tr>
</table>

<table>
<tr><th>System parameter</th><th>Data type</th><th>R/W</th><th>Description</th></tr>
<tr><td>DO.[xx][xx].in pairs</td><td>BOOL</td><td>W</td><td>Common ground for each pair
(DO- outputs form the common ground)
<table><tr><th>Coding</th><th>Description</th></tr><tr><td>FALSE</td><td>No common ground for each pair</td></tr><tr><td>TRUE</td><td>No common ground for each pair</td></tr></table>Default value: 0
Pair 1 = Channel 1 [01] and channel 2 [02]
Pair 2 = Channel 3 [03] and channel 4 [04]
Pair 3 = Channel 5 [05] and channel 6 [06]
Pair 4 = Channel 7 [07] and channel 8 [08]</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 (remote I/O 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: 0x00C4 [196_{dec}]</td></tr>
</table>

Table 26: SILworX - System Parameters for Digital Outputs, **Module** Tab

4.3.3.2 Tab: **DO 8 03: Channels**

The DO 8 03: Channels 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>Channel no.</td><td>---</td><td>R</td><td>Channel number, defined by default</td></tr>
<tr><td>-> + Error Code [WORD]</td><td>WORD</td><td>R</td><td rowspan="2">Error codes for the digital output channels DO+
Error codes for the digital output channels DO-
<table><tr><th>Coding</th><th>Description</th></tr><tr><td>0x0001</td><td>Fault in the digital output module</td></tr><tr><td>0x0002</td><td>Channel shutdown due to overload</td></tr><tr><td>0x0004</td><td>Error while reading back the digital outputs</td></tr><tr><td>0x0008</td><td>Error while reading back the status of the digital outputs</td></tr><tr><td>0x0010</td><td>Short-circuit</td></tr><tr><td>0x0020</td><td>Channel is switched off due to fault on the corresponding channel</td></tr><tr><td>0x0040</td><td>Z-diode are destroyed at the output</td></tr><tr><td>0x0080</td><td>Open-circuit</td></tr><tr><td>0x0100</td><td>Test of the output switches provides in DO+ line causes an error</td></tr><tr><td>0x0200</td><td>Test of the output switches provides in DO- line causes an error</td></tr><tr><td>0x0400</td><td>Test of the test switches L- causes an error</td></tr><tr><td>0x0800</td><td>External supply L+ at DO+</td></tr></table></td></tr>
<tr><td>-> - Error Code [WORD]</td><td>WORD</td><td>R</td></tr>
<tr><td>+ Value [BOOL] -></td><td>BOOL</td><td>W</td><td>Output value for DO+ channels, 1-pole (value: 0 or 1)
Output value for DO+ channels, 2-pole, identical to DO-
(Value: 0 or 1)</td></tr>
<tr><td>- Value [BOOL] -></td><td>BOOL</td><td>W</td><td>Output value for DO- channels, 1-pole (value: 0 or 1)
Output value for DO- channels, 2-pole, identical to DO+
(Value: 0 or 1)</td></tr>
<tr><td>2-pole [BOOL] -></td><td>BOOL</td><td>W</td><td>Configuration for a 2-Pole channel<table><tr><th>Coding</th><th>Description</th></tr><tr><td>FALSE</td><td>Channel used for a 1-pole</td></tr><tr><td>TRUE</td><td>Channel used for a 2-pole</td></tr></table></td></tr>
<tr><td>Line Monitoring [BOOL] -></td><td>BOOL</td><td>W</td><td>Configuration of Line Diagnosis<table><tr><th>Coding</th><th>Description</th></tr><tr><td>FALSE</td><td>LSLB[1)] diagnosis is not performed</td></tr><tr><td>TRUE</td><td>LSLB[1)] diagnosis is performed</td></tr></table></td></tr>
<tr><td colspan="4">[1)] SC/OC (SC = short-circuits, OC = open-circuits)</td></tr>
</table>

Table 27: SILworX - System Parameters for Digital Outputs, **DO 8 03: Channels** Tab

4.3.4 Pulsed Outputs for F3 DIO 16/8 01

The following table presents the statuses and parameters for the pulse module (DO 2 01) in the same order given in the SILworX Hardware Editor.

4.3.4.1 Tab: **Module**

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

System parameter	Data type	R/W	Description
DO.Error Code	WORD	R	Module error code Coding: 0x0001 – Description: Error of the TO unit as a whole:
Module Error Code	WORD	R	Module error code 0x0000 – I/O processing, if required with errors, see other error codes 0x0001 – No I/O processing (remote I/O not in RUN) 0x0002 – No I/O processing during the booting test 0x0004 – Manufacturer interface operating 0x0010 – No I/O processing: invalid configuration 0x0020 – No I/O processing: fault rate exceeded 0x0040/ 0x0080 – No I/O processing: configured module not plugged in
Module SRS	UDINT	R	Slot number (System Rack Slot)
Module Type	UINT	R	Type of module, target value: 0x00D3 [211_{dec}]

Table 28: SILworX - System Parameters for Pulsed Outputs, **Module** Tab

4.3.4.2 Tab: **DO 2 01: Channels**

The DO 2 01: Channels tab contains the following system parameters.

System parameter	Data type	R/W	Description
Channel no.	---	R	Channel number, defined by default
-> Error Code [BYTE]	BYTE	R	Error code of the individual digital pulsed output channels: Coding: 0x01 – Description: Fault in the digital output module
Value [BOOL] ->	BOOL	R	Output value for TO channels: FALSE – Output de-energized TRUE – Output energized **Do not use pulsed outputs as safety-related outputs!**

Table 29: SILworX - System Parameters for Pulsed Outputs, **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 Digital Inputs of F3 DIO 16/8 01

System Signal	R/W	Description	
Mod.SRS [UDINT]	R	Slot number (System Rack Slot)	
Mod. Type [UINT]	R	Type of module, target value: 0x00E2 [226 $_{dec}$]	
Mod. Error Code [WORD]	R	Module error code	
		0x0000	I/O processing, if required with errors, see other error codes
		0x0001	No I/O processing (remote I/O not in RUN)
		0x0002	No I/O processing during the booting test
		0x0004	Manufacturer interface operating
		0x0010	No I/O processing: invalid configuration
		0x0020	No I/O processing: fault rate exceeded
		0x0040/ 0x0080	No I/O processing: configured module not plugged in
DI.Error Code Supply [WORD]	R	Error code of the DI supply unit as a whole	
		0x0001	Module fault
DI[xx].Error Code Supply [BYTE]	R	Error codes of the single DI supplies	
		0x01	Error DI supply unit
		0x02	Supply shutdown due to overcurrent
		0x04	Error while reading back the supply
DI.Error Code [WORD]	R	Error codes for all digital inputs	
		0x0001	Fault within the digital inputs
		0x0002	FTT test of test pattern faulty
DI[xx].Error Code [BYTE]	R	Error codes for the digital input channels	
		0x01	Fault in the analog input module
		0x10	Short-circuit of the channel
		0x80	Intermittence between pulsed output TO and digital input DI, e.g., ▪ Open-circuit ▪ Open switch ▪ L+ undervoltage
DI[xx].Value [BOOL]	R	Input values for the digital input channels	
		0	Input de-energized
		1	Input energized
DI Number of Pulsed Channels [USINT]	W	Number of pulsed outputs (supply outputs)	
		0	No pulsed output planned for SC/OC[1)] detection
		1	Pulsed output 1 planned for SC/OC[1)] detection
		2	Pulsed output 1 and 2 planned for Sc/OC[1)] detection
		Pulsed outputs must not be used as safety-related outputs!	
DI Supply[xx] [BOOL]	W	Triggering the single DI supplies	
		0	Sensor supply (1 A) is off.
		1	Sensor supply (1 A) is on.
		Default setting 0: Feeding current 40 mA	
DI Pulse.Slot [UDINT]	W	Pulse module slot (SC/OC[1)] detection), set the value to 3	
DI[xx].Pulsed Channel [USINT]	W	Source channel for pulsed supply	
		0	Input channel
		1	Pulse of the 1st TO channel
		2	Pulse of the 2nd TO channel

System signal	R/W	Description
DI Pulse Delay [10E-6 s] [UINT]	W	Waiting time for line control (detection of short-circuits or cross-circuits)
[1)] SC/OC (short-circuits/open-circuits)		

Table 30: ELOP II Factory - Digital Input System Signals

4.4.4 Digital Outputs of F3 DIO 16/8 01

System signal	R/W	Description	
Mod.SRS [UDINT]	R	Slot number (System Rack Slot)	
Mod. Type [UINT]	R	Type of module, target value: 0x00C4 [196_{dec}]	
Mod. Error Code [WORD]	R	Module error code	
		0x0000	I/O processing, if required with errors, see other error codes
		0x0001	No I/O processing (remote I/O not in RUN)
		0x0002	No I/O processing during the booting test
		0x0004	Manufacturer interface operating
		0x0010	No I/O processing: invalid configuration
		0x0020	No I/O processing: fault rate exceeded
		0x0040/ 0x0080	No I/O processing: configured module not plugged in
DO.Error Code [WORD]	R	Error codes for all digital outputs	
		0x0001	Fault within the digital outputs
		0x0002	Test of safety shutdown returns a fault
		0x0004	Test of auxiliary voltage returns a fault
		0x0008	FTT test of test pattern faulty
		0x0010	Output switch test pattern faulty
		0x0020	Output switch test pattern (shutdown test of the outputs) faulty
		0x0040	Active shutdown via WD faulty
		0x0080	FTT test of monitoring time returns a fault
		0x0100	FTT read back of monitoring time returns a fault
		0x0200	All outputs are switched off, total current exceeded
		0x0400	FTT test: 1st temperature threshold exceeded
		0x0800	FTT test: 2nd temperature threshold exceeded
		0x1000	FTT test: Monitoring of auxiliary voltage 1: Undervoltage
		0x2000	FTT test: Monitoring of auxiliary voltage 2: Undervoltage
		0x4000	Flipflop of the voltage monitoring (18 V) provides undervoltage
		0x8000	Test of monitoring time returns a fault

System signal	R/W	Description	
DO[xx].+Error Code DO[xx].-Error Code [WORD]	R R	Error codes for the digital output channels DO+ Error codes for the digital output channels DO-	
		0x0001	Fault in the digital output module
		0x0002	Channel shutdown due to overload
		0x0004	Error while reading back the digital outputs
		0x0008	Error while reading back the status of the digital outputs
		0x0010	Short-circuit
		0x0020	Channel is switched off due to fault on the corresponding channel
		0x0040	Z-Diode at the output destroyed
		0x0080	Open-circuit
		0x0100	Test of the output switches provides in DO+ line causes an error
		0x0200	Test of the output switches provides in DO- line causes an error
		0x0400	Test of the test switches L- causes an error
		0x0800	External supply L+ at DO+
DO.LSLB period [WORD]	W	Period [s] required for the line diagnosis Range 1…100 s, 1 s steps	
DO.LSLB monitoring time [UINT]	W	Monitoring time for line diagnosis in [ms], Range 1...50 ms, Default: 0 ms	
DO2[xx].2-Pole [BOOL]	W	Configuration for a 2-Pole channel	
		0	Channel used for a 1-pole
		1	Channel used for a 2-pole
DO[xx].+Value [BOOL]	W	Output value for DO+ channels, 1-pole (value: 0 or 1) Output value for DO+ channels, 2-pole, identical to DO- (Value 0 or 1)	
DO[xx].-Value [BOOL]	W	Output value for DO- channels, 1-pole (value: 0 or 1) Output value for DO- channels, 2-pole, identical to DO+ (Value: 0 or 1)	
DO[xx].LSLB Monitoring [BOOL]	W	Configuration of line diagnosis	
		0	LSLB[1)] diagnosis is not performed
		1	LSLB[1)] diagnosis is performed
DO[xx].SC Monitoring with reduced voltage [BOOL]	W	Line diagnosis with reduced voltage	
		0	Normal signal voltage level
		1	Reduced signal voltage level
		(Reduced signal voltage level only at DO[xx].LSLB Monitoring = 1 effective!)	
DO[xx][xx].in pairs [BOOL]	W	Common ground for each pair (DO- outputs form the common ground)	
		0	No common ground for each pair
		1	No common ground for each pair
		Default value: 0 Pair 1 = Channel 1 [01] and channel 2 [02] Pair 2 = Channel 3 [03] and channel 4 [04] Pair 3 = Channel 5 [05] and channel 6 [06] Pair 4 = Channel 7 [07] and channel 8 [08]	
[1)] SC/OC (short-circuits/open-circuits)			

Table 31: ELOP II Factory - Digital Output System Signals

4.4.5 Pulsed Outputs for F3 DIO 16/8 01

System Signal	R/W	Description	
Mod.SRS [UDINT]	R	Slot number (System Rack Slot)	
Mod. Type [UINT]	R	Type of module, target value: 0x00D3 [211_{dec}]	
Mod. Error Code [WORD]	R	Module error code	
		0x0000	I/O processing, if required with errors see other error codes
		0x0001	No I/O processing (remote I/O not in RUN)
		0x0002	No I/O processing during the booting test
		0x0004	Manufacturer interface operating
		0x0010	No I/O processing: invalid configuration
		0x0020	No I/O processing: fault rate exceeded
		0x0040/ 0x0080	No I/O processing: configured module not plugged in
DO.Error Code [WORD]	R	Error code of the TO unit as a whole	
		0x0001	Error of the TO unit as a whole:
DO[xx].Error Code [BYTE]	R	Error code of the individual digital pulsed output channels:	
		0x01	Fault in the digital output module
DO[xx].Value [BOOL]	W	Output value for TO channels:	
		0	Output de-energized
		1	Output energized
		Pulsed outputs must not be used as safety-related outputs!	

Table 32: ELOP II Factory - System Signals for the Pulsed Outputs

4.5 Configuration of Line Diagnosis

4.5.1 Line Diagnosis for Lamp Loads and Inductive Loads

To detect short-circuits, a 24 V pulse (normal voltage level) is sent to the output circuit for the duration of 500 µs. After this time, a 10 V pulse is sent to detect open-circuits for the duration of the monitoring time.

To configure the line diagnosis, the following parameters must be set in SILworX and the following signals must be set in ELOP II Factory Hardware Management.

SILworX	ELOP II Factory	Value
DO.LM period	DO.LSLB Interval	Freely configurable 1…100 s
DO.Line Monitoring Time	DO.LSLB Monitoring Time	Freely configurable 0…50 ms Default: 0 ms
2-pole [BOOL] ->	DO[xx].2-Pole	TRUE
Line Monitoring [BOOL] ->	DO[xx].LSLB Monitoring	TRUE
DO[xx].SC Monitoring with Reduced Voltage	DO[xx].SC Monitoring with Reduced Voltage	FALSE

Table 33: Configuration of Line Diagnosis for Lamp Loads and Inductive Loads

4.5.2 Line Diagnosis for Ohmic, Capacitive Loads

To diagnose the line for ohmic capacitive loads, the remote I/O sends a 10 V test pulse (reduced voltage level) to the output circuit for the duration of the monitoring time. This type of line diagnosis is particularly recommended for ohmic and ohmic capacitive loads. With inductive loads or lamp loads, error messages related to the short-circuit may be generated.

To configure the line diagnosis, the following parameters must be set in SILworX and the following signals must be set in ELOP II Factory Hardware Management.

SILworX	ELOP II Factory	Value
DO.LM period	DO.LSLB Interval	Freely configurable 1…100 s
DO.Line Monitoring Time	DO.LSLB Monitoring Time	Freely configurable 0…50 ms Default: 0 ms
2-pole [BOOL] ->	DO[xx].2-Pole	TRUE
Line Monitoring [BOOL] ->	DO[xx].LSLB Monitoring	TRUE
DO[xx].SC Monitoring with Reduced Voltage	DO[xx].SC Monitoring with Reduced Voltage	TRUE

Table 34: Configuration of Line Diagnosis with Reduced Voltage with Ohmic, Capacitive Loads

4.6 Connection Variants

This chapter describes the proper wiring of device in safety-related applications.

4.6.1 1-Pole Connection

For 1-pole applications, the outputs DO+ must be connected to supply S- (load on S-) and the outputs DO- must be connected to the supply S+ (load on S+).

In this case, 8 outputs DO+ and 8 outputs DO- are available.

No line diagnosis is possible for 1-pole applications.

i A direct connection of the DO+ output to the external L- via the load or a connection of DO- output to external L- via the load is not permitted!

Inductive loads may be connected with no free-wheeling diode on the actuator. However, HIMA strongly recommends connecting a protective diode directly to the actuator.

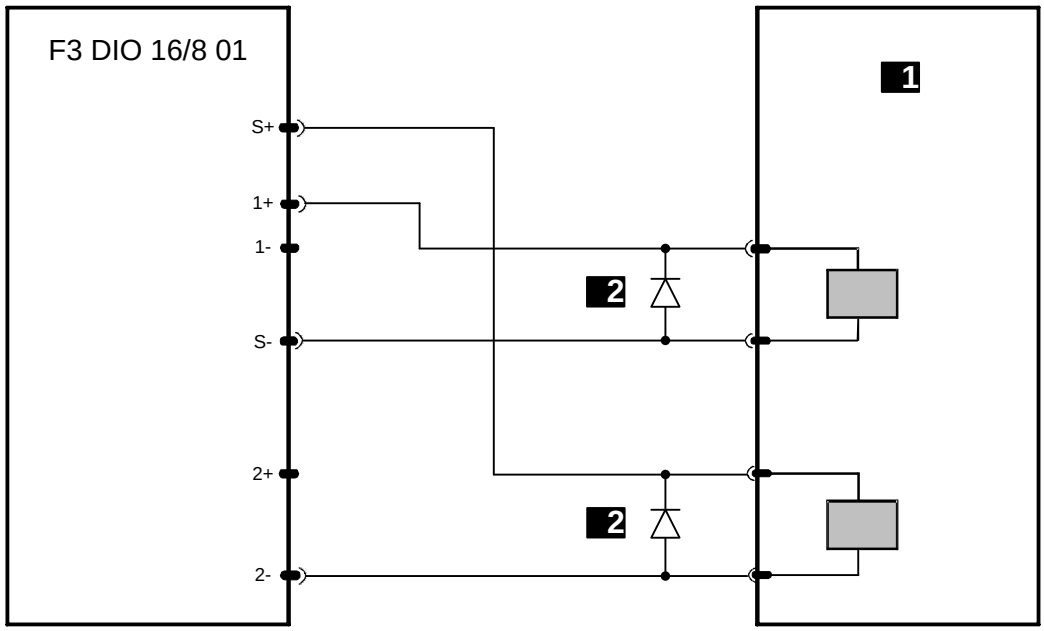


Figure 11: 1-Pole Connection of an Actuator to the DO+ or DO- Output

4.6.2 2-Pole Connection

The DO+ output and DO- output of a channel are required for 2-pole applications. In each channel, the DO+ output is permanently assigned to DO- output.

In this case, 8 channels with 16 outputs are available.

i To allow 2-pole connection, the corresponding channels must be configured using the *DO[xx].2-Pole* system signal.

In a 2-pole connection, no DI input must be connected to a DO output. This would inhibit the detection of open-circuits.

i The DO+ output must be connected to the DO- output with the same channel via actuator. DO+ outputs must not be connected together and DO- outputs must not be connected together.

Exception: in pairs wiring

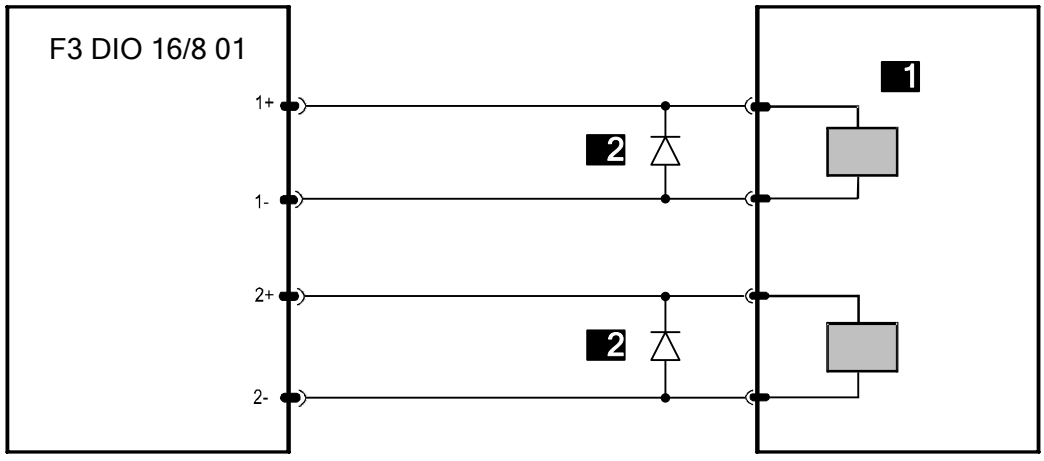


Figure 12: 2-Pole Connection of an Actuator

i Inductive loads must be connected with a free-wheeling diode on the consumer load.

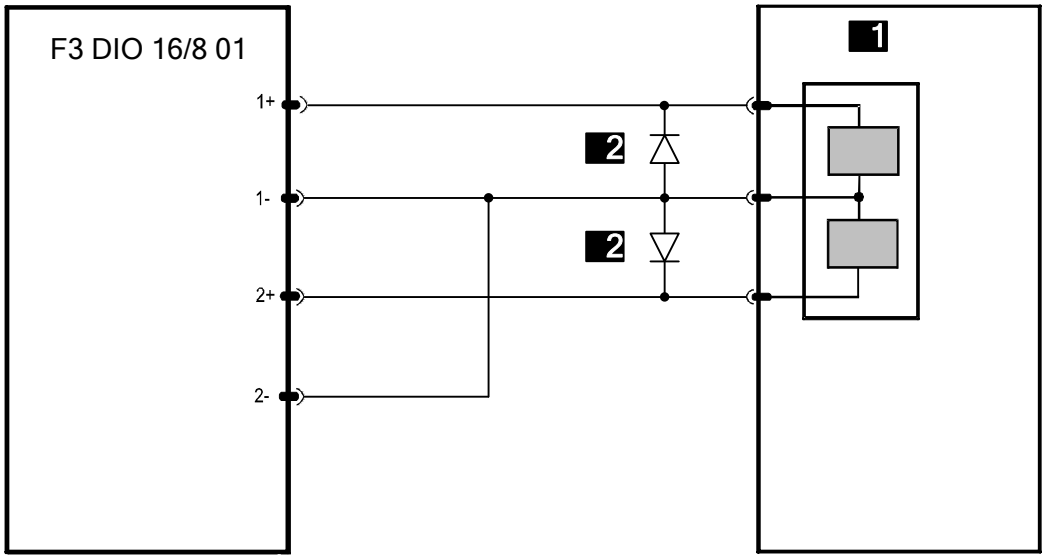
4.6.3 2-Pole Connection to Common Ground (3-pole Connection)

2-pole channels can be interconnected on a common ground to allow line diagnosis, e.g., with motors (dual motor drivers) or dual valves. The common ground is created using the DO-outputs of the channels concerned. To do so, the *DO[xx][xx].In Pairs* system parameter must be configured for each pair (2 channels). For further configuration variants, also refer to Table 26 and Table 31. If the line diagnosis is configured on both channels, the line is diagnosed pairwise on both 2-pole channels (channel 1 and 2, channel 3 and 4, channel 5 and 6, channel 7 and 8). To this end, set the *Line Monitoring [BOOL]* -> system variable in SILworX to TRUE and the *DO[xx]-LSLB Monitoring* system signal in ELOP II Factory to TRUE. If a test is performed on one channel, the second channel is switched off to ensure that the line diagnosis is not distorted.

A short-circuit between the two DO+ lines is not detected.

A detected line fault is reported to the user:

- In SILworX, with the system variables -> + *Error Code [WORD]* or -> - *Error Code [WORD]*.
- In ELOP II Factory, with the system signals *DO[xx].+Error Code* or *DO[xx].-Error Code*.



1 Load (Motor, Valve) 2 Free-Wheeling Diode

Figure 13: 2-Pole Connection to Common Ground (3-pole Connection)

i Inductive loads must be connected with a free-wheeling diode on the consumer load.

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 3.4.1. The remote I/O writes diagnostic entries in the diagnostic memory of the connected controller.

5.2.1 Diagnostic Entries

At the remote I/O there are supplement entries (see chapter *Diagnosis* in the System Manual Compact Systems HI 800 140 E). These entries should help the user to configure and detect errors in the line diagnosis.

Faulty parameter setting

- IOA: invalid LS/OC parameters on channel pair
- IOA: Invalid open-circuit or short-circuit monitoring time: (max. ... ms are allowed)
- IOA: Invalid open-circuit or short-circuit interval: (min....s allowed)
- IOA: Invalid open-circuit or short-circuit interval: (min....s allowed)

The messages specified above are stored to the long-term and short-term diagnosis.

Channel fault:

Each faulty channel is registered in one row of the diagnosis. This row identifies the channel with the corresponding output/branch.

Example: Faulty channel 1 on both branches

IO CHANNEL ERROR: Slot:2 I/O module type:00C4 channel:1 status[L plus:0080 L minus:0080]

The message specified above is only stored to the short-term diagnosis.

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 digital inputs.

Refer to Chapter 3.1.3.1, for more information on the fault reaction of digital 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

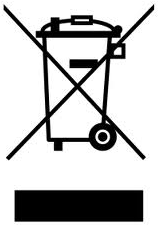
To avoid mechanical damage, HIMatrix components must be transported in packaging.

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

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