HIMatrix

Safety-Related Controller

F31 02 Manual

HIMA Paul Hildebrandt GmbH

Industrial Automation

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

Contact

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 and 3.4.2.1 Added: F31 024, 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 controllers 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 controller, refer to the following table:

Programming tool	Processor operating system	Communication operating system
SILworX	CPU OS V7 and higher	COM OS V12 and higher
ELOP II Factory	CPU OS up to V6.x	COM OS up to V11.x

Table 1:   Programming Tools for HIMatrix Controllers

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.

1.3.2   Operating Tips

Additional information is structured as presented in the following example:

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 **F31 02** controller is a compact system in a metal housing with 20 digital inputs and 8 digital outputs.

The controller is available in various model variants for SILworX and ELOP II Factory, see Table 4.

The device 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 controller is equipped with safety-related digital inputs and outputs.

3.1.1   Safety-Related Digital Inputs

The controller is equipped with 20 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
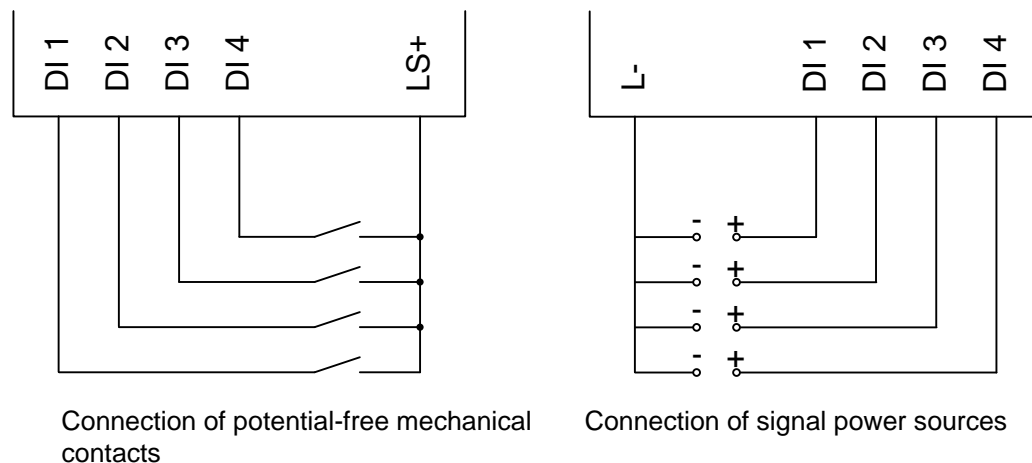
Figure 1:   Connections to Safety-Related Digital Inputs

For the external wiring and the connection of sensors, apply the de-energized-to-trip principle. Thus, if a fault occurs, the input signals adopt a de-energized, safe state (low level).

If an external wire is not monitored, an open-circuit is considered as safe low level.

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.

3.1.1.2 Line Control

Line control is used to detect short-circuits or open-circuits and can be configured for the F31 system, 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 digital outputs DO 1 through DO 8 of the system to the digital inputs DI of the same system as follows:

| | 1 EMERGENCY STOP 1 | EMERGENCY STOP switches in accordance with EN 60947-5-1 and EN 60947-5-5 |
| | 2 EMERGENCY STOP 2 | |
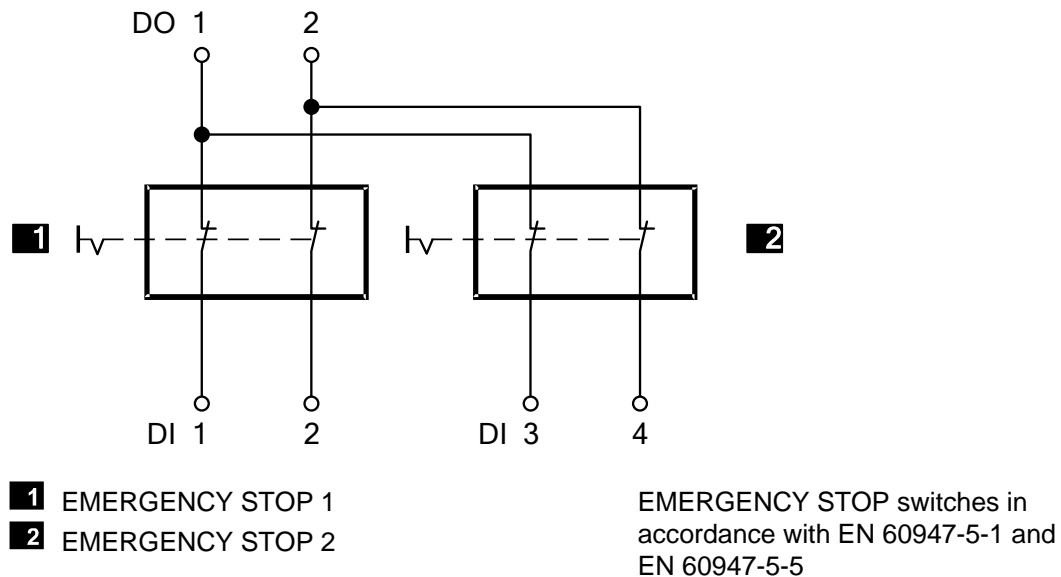
Figure 2:   Line Control

The controller pulses the digital outputs to detect the line short-circuits and open-circuits on the lines connected to the digital inputs. 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., DO 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.

3.1.2 Safety-Related Digital Outputs

The controller is equipped with 8 digital outputs. The state (HIGH, LOW) of each output is signaled by an individual LED (HIGH, LOW).

At the maximum ambient temperature, the outputs 1...3 and 5...7 can be loaded with 0.5 A each; and outputs 4 and 8 can be loaded with 1 A or with 2 A at an ambient temperature of up to 50 °C.

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 17.

The external wire of an output is not monitored, however, a detected short-circuit is signaled.
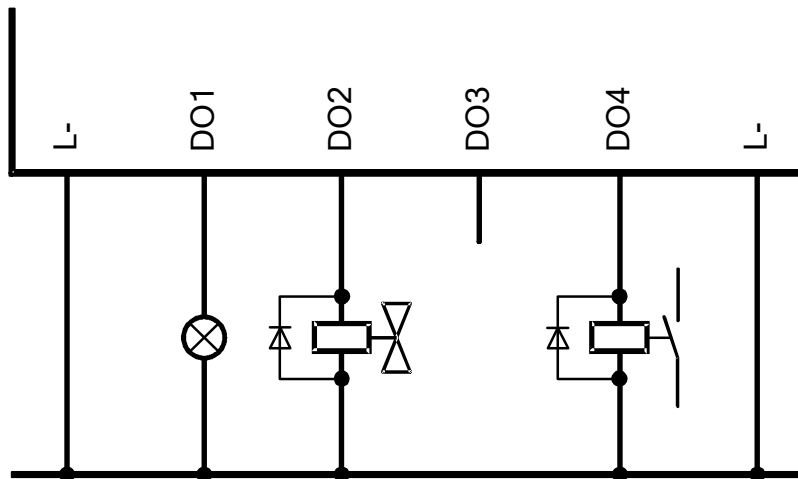
Figure 3:   Connection of Actuators to Outputs

The redundant connection of two outputs must be decoupled with diodes.

> ### ⚠ CAUTION
>
> **For connecting a load to a 1-pole switching output, use the corresponding L- ground of the respective channel group (2-pole connection) to ensure that the internal protective circuit can function.**

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.

3.1.2.1 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.

3.2 Equipment, Scope of Delivery

The following table specifies the available controller variants:

Designation	Description
F31 02	Controller (20 digital inputs, 8 digital outputs), Operating temperature: 0...+60 °C, for ELOP II Factory programming tool
F31 02 SILworX	Controller (20 digital inputs, 8 digital outputs), Operating temperature: 0...+60 °C, 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: 60 000.0.0

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

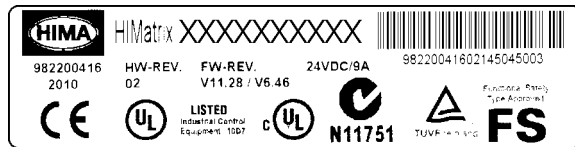Figure 4:   Sample Type Label

3.4   Structure

This chapter describes the layout and function of the controller, and its connection for communication.

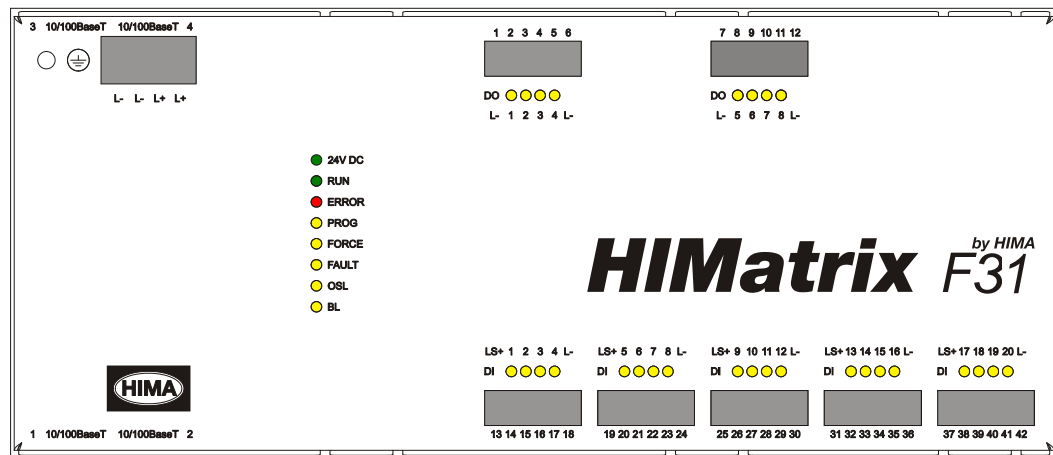Figure 5:   Front View
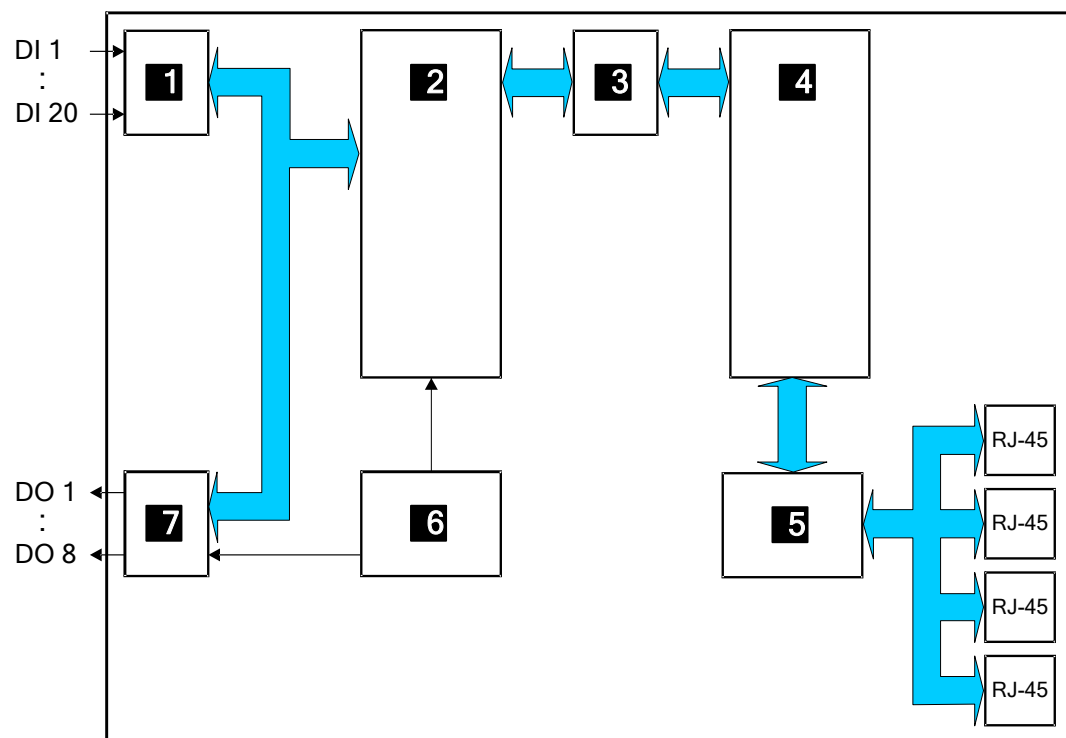
1	20 Digital Inputs	5	Switch
2	Safety-Related Processor System (CPU)	6	Watchdog
3	Dual Port RAM	7	8 Digital Outputs
4	Communication System (COM)		

Figure 6:   Block Diagram F31 02

3.4.1   LED Indicators

The light-emitting diodes (LEDs) indicate the operating state of the controller. The LEDs are classified as follows:

- Operating voltage LED
- System LEDs
- Communication LEDs
- I/O LEDs

Function and meaning of the system LEDs and communication LEDs depend on the CPU operating system (and thus on the COM operating system).

When the supply voltage is switched on, a LED test is performed and all LEDs are briefly lit.

Definition of Blinking Frequencies

The following table defines the blinking frequencies of the LEDs:

Name	Blinking frequencies
Blinking	Non-specified blinking, with CPU OS up to V7.x
Blinking1	Long (approx. 600 ms) on, long (approx. 600 ms) off, with CPU OS V8 and higher
Blinking-x	Ethernet communication: Blinking synchronously with data transfer, with CPU OS V8 and higher

Table 5:   Blinking Frequencies of LEDs

3.4.1.1   Operating Voltage LED

The operating voltage LED does not depend on the CPU operating system in use.

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

Table 6:   Operating Voltage LED

3.4.1.2 System LEDs

System LEDs with CPU OS V8 and Higher

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

LED	Color	Status	Description
RUN	Green	On	Device in RUN, normal operation A loaded user program is being processed.
		Blinking1	▪ Device in STOP ▪ A new operating system is being loaded.
		Off	The device is not in the RUN or STOP state.
ERROR	Red	On	Missing license for additional functions (communication protocols, reload), test mode.
		Blinking1	▪ The device is in the ERROR STOP state. Internal module faults detected by self-tests, e.g., hardware or voltage supply. The processor system can only be restarted with a command from the PADT (reboot). ▪ Fault while loading the operating system.
		Off	No faults detected.
PROG	Yellow	On	▪ A new configuration is being loaded into the device. ▪ A new operating system is being loaded. ▪ WDT or FTT change ▪ SRS change
		Off	None of the described events occurred.
FORCE	Yellow	On	Forcing prepared: The force switch is set for a variable, the force main switch is still deactivated. The device is in the RUN or STOP state.
		Blinking1	Forcing is active: At least one local or global variable has adopted the corresponding force value.
		Off	Forcing is not activated.
FAULT	Yellow	On/Blinking1	▪ Fault while loading a new operating system ▪ The new operating system is corrupted (after OS download). ▪ The loaded configuration is not valid. ▪ At least one I/O fault has been detected.
		Off	None of the described faults occurred.
OSL	Yellow	Blinking1	Operating system emergency loader active.
		Off	Operating system emergency loader not active.
BL	Yellow	On/Blinking1	▪ OS and OSL binary defective or INIT_FAIL hardware fault. ▪ Fault in the external process data communication.
		Off	None of the described events occurred.

Table 7:   System LEDs with CPU OS V8 and Higher

System LEDs with CPU OS up to V6.x

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

LED	Color	Status	Description
RUN	Green	On	Device in RUN, normal operation A loaded user program is being processed.
		Blinking	Device in STOP. No user program is being processed.
		Off	The device is in the ERROR STOP state, see ERROR LED.
ERROR	Red	On	Internal module faults detected by self-tests, e.g., hardware or cycle time overrun. The CPU stopped the user program execution, terminated all hardware and software tests and reset all outputs. The processor system can only be restarted with a command from the PADT (reboot).
		Off	No faults detected.
PROG	Yellow	On	A new configuration is being loaded into the device.
		Blinking	A new operating system is being loaded into the flash ROM. The LED also blinks during the device's initialization phase.
		Off	No configuration or operating system is being loaded.
FORCE	Yellow	On	The device is in RUN, forcing was activated.
		Blinking	The device is in STOP, forcing has been prepared and is activated when the device is started.
		Off	Forcing is not activated.
FAULT	Yellow	On	▪ Line control fault indicator ▪ The user program caused a fault. ▪ The device configuration is not valid. ▪ Loading of the new operating system was not successful and the operating system is corrupted.
		Blinking	▪ While the operating system was being updated, a fault occurred during the write cycle of a flash ROM. ▪ 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 not active.
BL	Yellow	Blinking	OS and OSL binary defective or hardware fault, INIT_FAIL.
		Off	None of the described faults occurred.

Table 8:   System LEDs with CPU OS up to V6

3.4.1.3 Communication LEDs

All RJ-45 connectors are provided with a small green and a yellow LEDs.

Communication LEDs with CPU OS V8 and Higher

The LEDs signal the following states:

LED	Status	Description
Green	On	Full duplex operation
	Blinking1	IP address conflict, all communication LEDs are blinking
	Blinking-x	Collision
	Off	Half duplex operation, no collision
Yellow	On	Connection available
	Blinking1	IP address conflict, all communication LEDs are blinking
	Blinking-x	Interface activity
	Off	No connection available

Table 9: Ethernet Indicators with CPU OS V8 and Higher

Communication LEDs up to CPU OS V6.x

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 10: Ethernet Indicators up to CPU OS V6.x

3.4.1.4 I/O LEDs

LED	Color	Status	Description
DI 1…24	Yellow	On	The related input is active (energized).
		Off	The related input is inactive (de-energized).
DO 1…8	Yellow	On	The related output is active (energized).
		Off	The related output is inactive (de-energized).

Table 11: I/O LEDs

3.4.2   Communication

The controller communicates with remote I/Os via safe**ethernet**.

3.4.2.1   Connections for Ethernet Communication

Property	Description
Port	4 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), OPC, Modbus TCP, TCP-SR, SNTP, EtherNet/IP[2]
[1] The general rules for assigning IP address and subnet masks must be adhered to.	
[2] EtherNet/IP is not supported in SILworX.	

Table 12:   Ethernet Interfaces Properties

Two RJ-45 connectors with integrated LEDs are located on the top and on the bottom left-hand side of the housing. Refer to Chapter 3.4.1.3 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 controller is specified on a label located above the two RJ-45 connectors (1 and 2).
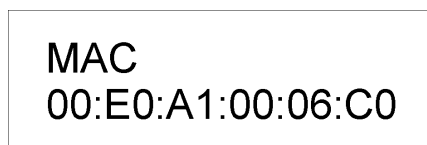
MAC
00:E0:A1:00:06:C0

Figure 7:   Sample MAC Address Label

The controller 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 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** and OPC
123	SNTP (time synchronization between PES and remote I/O, PES and external devices)
6005 / 6012	If TCS_DIRECT was not selected in the HH network
502	Modbus (can be modified by the user)
44 818	EtherNet/IP session protocol for device identification
2222	EtherNet/IP data exchange

Table 13:   Network Ports (UDP Ports) in Use

TCP ports	Use
502	Modbus (can be modified by the user)
xxx	TCP SR assigned by the user
44 818	EtherNet/IP explicit messaging services

Table 14: Network Ports (TCP Ports) in Use

3.4.3 Reset Key

The controller 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 controller 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 controller.

The reset is only effective if the controller 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 controller 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.
- With COM operating system version 10.42 and higher, loading a user program or operating system with default connection parameters is inhibited!
  The loading procedure is only allowed after the connection parameters and the account have been configured on the controller and the controller has been rebooted.

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 Hardware Clock

In case of loss of operating voltage, the power provided by an integrated capacitor is sufficient to buffer the hardware clock for approximately one week.

3.5   Product Data

General	
User memory	Versions prior to 6.46 — max. 500 kB user program / max. 500 kB user data Version 6.100 — max. 2047 kB user program / max. 2047 kB user data Version 7 and higher — max. 1023 kB user program / max. 1023 kB user data
Response time	$\geq$ 20 ms
Ethernet interfaces	4 x RJ-45, 10BASE-T/100BASE-Tx with integrated switch
Operating voltage	24 VDC, -15...+20 %, $r_{PP} \leq$ 15 %, provided by a power supply unit with safe isolation, in accordance with IEC 61131-2
Current input	max. 8 A (with maximum load) Idle: approx. 0.4 A at 24 V
Fuse (external)	10 A time-lag (T)
Buffer for date/time	Gold capacitor
Operating temperature	0...+60 °C
Storage temperature	-40...+85 °C
Type of protection	IP20
Max. dimensions (without connectors)	Width: 257 mm (with housing screws) Height: 114 mm (with fixing bolt) Depth: 66 mm (with earthing screw)
Weight	1.2 kg

Table 15:   Product Data

Digital inputs	
Number of inputs	20 (non-galvanically separated)
High level: voltage current input	15...30 VDC $\geq$ 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
Supply	5 x 20 V / 100 mA (at 24 V), short-circuit-proof

Table 16:   Specifications for Digital Inputs

Digital outputs	
Number of outputs	8 (non-galvanically separated)
Output voltage	≥ L+ minus 2 V
Output current	Channels 1...3 and 5...7: 0.5 A up to 60 °C The output current of the channels 4 and 8 depends on the ambient temperature. <table><tr><td>Ambient temperature</td><td>Output current</td></tr><tr><td>< 50 °C</td><td>2 A</td></tr><tr><td>50…60 °C</td><td>1 A</td></tr></table>
Minimum load	2 mA for each channel
Internal voltage drop	max. 2 V at 2 A
Leakage current (with low level)	max. 1 mA at 2 V
Behavior upon overload	The affected output is switched off and cyclically switched on again
Total output current	max. 7 A, upon overload, all outputs are switched off and cyclically switched on again

Table 17:   Specifications for the Digital Outputs

3.6   Certified HIMatrix F31 02

HIMatrix F31 02	
CE	EMC, ATEX Zone 2
TÜV	IEC 61508 1-7:2000 up to SIL 3 IEC 61511:2004 EN ISO 16849-1:2008 up to Cat. 4 und PL e
TÜV ATEX	94/9/EG EN 1127-1 EN 61508
Lloyd's Register	Shipping certification ENV1, ENV2 and ENV3. Test Specification Number: 1 - 2002
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 18:   Certificates

4   Start-up

To start up the controller, it must be mounted, connected and configured in the programming tool.

4.1   Installation and Mounting

The controller is mounted on a 35 mm DIN rail such as described in the 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   Connecting the Digital Inputs

Use the following terminals to connect the digital inputs:

Terminal	Designation	Function (inputs)
13	LS+	Sensor supply of the inputs 1...4
14	1	Digital input 1
15	2	Digital input 2
16	3	Digital input 3
17	4	Digital input 4
18	L-	Ground
Terminal	Designation	Function (inputs)
19	LS+	Sensor supply of the inputs 5...8
20	5	Digital input 5
21	6	Digital input 6
22	7	Digital input 7
23	8	Digital input 8
24	L-	Ground
Terminal	Designation	Function (inputs)
25	LS+	Sensor supply of the inputs 9...12
26	9	Digital input 9
27	10	Digital input 10
28	11	Digital input 11
29	12	Digital input 12
30	L-	Ground
Terminal	Designation	Function (inputs)
31	LS+	Sensor supply of the inputs 13...16
32	13	Digital input 13
33	14	Digital input 14
34	15	Digital input 15
35	16	Digital input 16
36	L-	Ground

Terminal	Designation	Function (inputs)
37	LS+	Sensor supply of the inputs 17...20
38	17	Digital input 17
39	18	Digital input 18
40	19	Digital input 19
41	20	Digital input 20
42	L-	Ground

Table 19:   Terminal Assignment for the Digital Inputs

4.1.1.1   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).

4.1.2   Connecting the Digital Outputs

Use the following terminals to connect the digital outputs:

Terminal	Designation	Function (outputs)
1	L-	Ground channel group
2	1	Digital output 1
3	2	Digital output 2
4	3	Digital output 3
5	4	Digital output 4 (for increased load)
6	L-	Ground channel group
Terminal	Designation	Function (outputs)
7	L-	Ground channel group
8	5	Digital output 5
9	6	Digital output 6
10	7	Digital output 7
11	8	Digital output 8 (for increased load)
12	L-	Ground channel group

Table 20:   Terminal Assignment for the Digital 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 21: Power Supply Cable Plug Properties

Connection to the field zone	
Number of cable plugs	7 pieces, six 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 22: Input and Output Cable Plug Properties

4.1.4   Mounting the F31 02 in Zone 2

(EC Directive 94/9/EC, ATEX)

The controller 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 HIMatrix F31 02 controller 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 F31 02 has a power dissipation ranging between 9 W and 25 W.

3. Protect the HIMatrix F31 02 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 controller is additionally equipped with the label represented below:
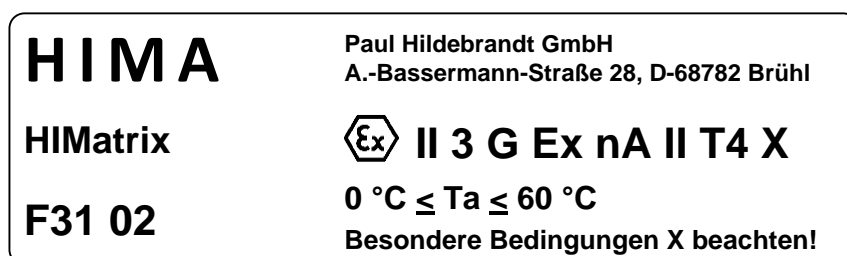

Figure 8:   Label for Ex Conditions

4.2   Configuration

The controller 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 controller is represented like a base plate equipped with the following modules:

- Processor module (CPU)
- Communication module (COM)
- Input module (DI 20)
- Output module (DO 8)

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.

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 for F31 02

The following tables present the statuses and parameters for the input module (DI 20) 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	Description
				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
				…	…
				8	Pulsed outputs 1...8 planned for SC/OC[1] detection
			Pulsed outputs must not be used as safety-related outputs!		
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	Description
				0x0001	Fault within the digital inputs
				0x0002	FTT test of test pattern faulty
Module Error Code	WORD	R	Module error code		
				Coding	Description
				0x0000	I/O processing, if required with errors see other error codes
				0x0001	No I/O processing (CPU 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: 0x00A5 [165_{dec}]		
[1] SC/OC (SC = short-circuit, OC = open-circuit)					

Table 23:   SILworX - System Parameters for Digital Inputs, **Module** Tab

4.3.2.2 Tab **DI 20: Channels**

The **DI 20: 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 codes for the digital input channels		
			Coding	Description	
			0x01	Fault in the analog input module	
			0x10	Short-circuit of the channel	
			0x80	Intermittence between pulsed output DO and digital input DI, e.g., ▪ Open-circuit ▪ Open switch ▪ L+ undervoltage	
-> Value [BOOL]	BOOL	R	Input values for the digital input channels 0 = input de-energized 1 = input energized		
Pulsed Output [USINT] ->	USINT	W	Source channel for pulsed supply		
			Coding	Description	
			0	Input channel	
			1	Pulse of the 1st DO channel	
			2	Pulse of the 2nd DO channel	
			…	…	
			8	Pulse of the 8th DO channel	

Table 24:   SILworX - System Parameters for Digital Inputs, **DI 20: Channels** Tab

4.3.3 Digital Outputs for F31 02

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

4.3.3.1 Tab **Module**

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

System parameter	Data type	R/W	Description	
DO.Error Code	WORD	R	Error codes for all digital outputs	
			Coding	Description
			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
			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
Module Error Code	WORD	R	Module error code	
			Coding	Description
			0x0000	I/O processing, if required with errors, see other error codes
			0x0001	No I/O processing (CPU 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: 0x00B4 [180_{dec}]	

Table 25: SILworX - System Parameters for Digital Outputs, **Module** Tab

4.3.3.2   Tab **DO 8: Channels**

The **DO 8: 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 codes for the digital output channels<table><tr><td>Coding</td><td>Description</td></tr><tr><td>0x01</td><td>Fault in the digital output module</td></tr><tr><td>0x02</td><td>Channel shutdown due to overload</td></tr><tr><td>0x04</td><td>Error while reading back the digital outputs</td></tr><tr><td>0x08</td><td>Error while reading back the status of the digital outputs</td></tr></table>
Value [BOOL] ->	BOOL	W	Output value for DO channels: 1 = output energized 0 = output de-energized **Pulsed outputs must not be used as safety-related outputs!**

Table 26:   SILworX - System Parameters for Digital Outputs, **DO 8: 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 controller.

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 for F31 02

System signal	R/W	Description
Mod.SRS [UDINT]	R	Slot number (System Rack Slot)
Mod. Type [UINT]	R	Type of module, target value: 0x00A5 [165$_{dec}$]
Mod. Error Code [WORD]	R	Module error code<table><tr><td>Coding</td><td>Description</td></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>
DI.Error Code [WORD]	R	Error codes for all digital inputs<table><tr><td>Coding</td><td>Description</td></tr><tr><td>0x0001</td><td>Fault within the digital inputs</td></tr><tr><td>0x0002</td><td>FTT test of test pattern faulty</td></tr></table>
DI[xx].Error Code [BYTE]	R	Error codes for the digital input channels<table><tr><td>Coding</td><td>Description</td></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 DO and digital input DI, e.g., ▪ Open-circuit ▪ Open switch ▪ L+ undervoltage</td></tr></table>
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)<table><tr><td>Coding</td><td>Description</td></tr><tr><td>0</td><td>No pulsed output planned for SC/OC[1] detection</td></tr><tr><td>1</td><td>Pulsed output 1 planned for SC/OC[1] detection</td></tr><tr><td>2</td><td>Pulsed output 1 and 2 planned for SC/OC[1] detection</td></tr><tr><td>…</td><td>…</td></tr><tr><td>8</td><td>Pulsed outputs 1...8 planned for SC/OC[1] detection</td></tr></table>**Pulsed outputs must not be used as safety-related outputs!**
DI Pulse Slot [UDINT]	W	Pulse module slot (SC/OC[1] detection) set the value to 2
DI[xx]. Pulsed Output [USINT]	W	Source channel for pulsed supply<table><tr><td>Coding</td><td>Description</td></tr><tr><td>0</td><td>Input channel</td></tr><tr><td>1</td><td>Pulse of the 1st DO channel</td></tr><tr><td>2</td><td>Pulse of the 2nd DO channel</td></tr><tr><td>…</td><td>…</td></tr><tr><td>8</td><td>Pulse of the 8th DO channel</td></tr></table>

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

Table 27:   ELOP II Factory - Digital Input System Signals

4.4.4   Digital Outputs for F31 02

System signal	R/W	Description
Mod.SRS [UDINT]	R	Slot number (System Rack Slot)
Mod. Type [UINT]	R	Type of module, target value: 0x00B4 [180_{dec}]
Mod. Error Code [WORD]	R	Module error code

			Coding	Description
			0x0000	I/O processing, if required with errors, see other error codes
			0x0001	No I/O processing (CPU 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

System signal	R/W	Description
DO.Error Code [WORD]	R	Error codes for all digital outputs

			Coding	Description
			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
			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

System signal	R/W	Description
DO[xx].Error Code [BYTE]	R	Error codes for the digital output channels

			Coding	Description
			0x01	Fault in the digital output module
			0x02	Channel shutdown due to overload
			0x04	Error while reading back the digital outputs
			0x08	Error while reading back the status of the digital outputs

System signal	R/W	Description
DO[xx].Value [BOOL]	W	Output value for DO channels: 1 = output energized 0 = output de-energized **Pulsed outputs must not be used as safety-related outputs!**

Table 28:   ELOP II Factory - Digital Output System Signals

5   Operation

The F31 02 controller is ready to operate. No specific monitoring is required for the controller.

5.1   Handling

Handling of the controller during operation is not required.

5.2   Diagnosis

A first diagnosis results from evaluating the LEDs, see Chapter 3.4.1.

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 digital inputs.

Refer to Chapter 3.1.2.1, 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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HIMA SAFETY NONSTOP