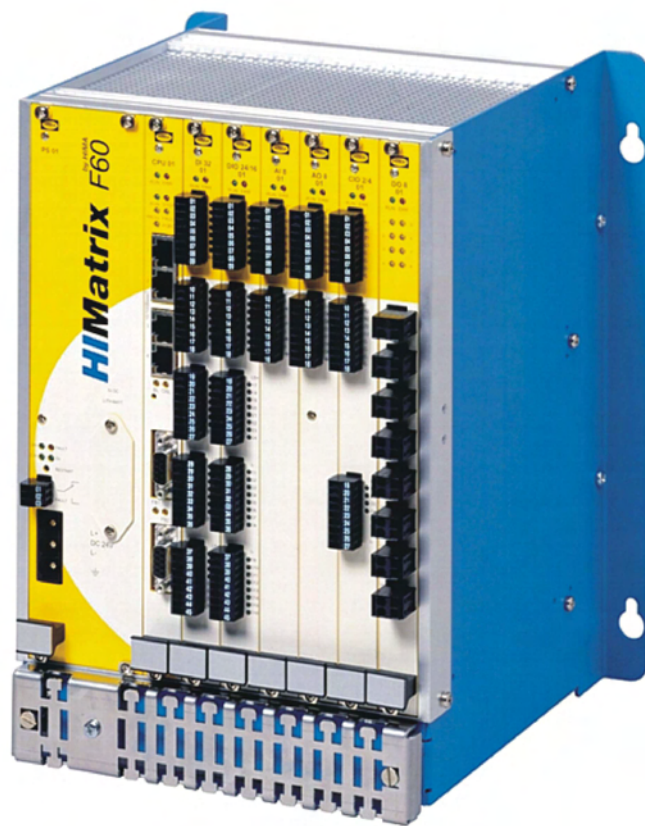


HIMatrix

Safety-Related Controller

AO 8 01 Manual



HIMA Paul Hildebrandt GmbH + Co KG
Industrial Automation

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 AO 8 01 is a module for the modular F60 HIMatrix system.

The module can be inserted in the F60 subrack's slot 3...8. Slots 1 and 2 are reserved for the power supply module and central module, respectively.

The safety-related analog AO 8 01 system has 8 outputs with a 12-bit resolution. Each group of 8 safety-related outputs is galvanically separated from the other output pairs and the supply voltage.

On the module, the outputs can be either configured as current outputs or voltage outputs.

The module has been certified by the TÜV 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

If a module fault occurs, the affected outputs are de-energized.

3.1.1 Safety-Related Analog Outputs

To configure the analog outputs as a voltage or current outputs, each channel of the AO 8 01 module has a DIP switch with 6 functions located on the printed circuit board (PCB), next to the front plate. The switches are arranged top-down following the the order of channels 1...8.

The switches are set individually prior to starting up the module and in accordance with the following table:

3.1.1.1 Switch Positions

Switch function	Output voltage 0...±10 V	Output current 0...+20 mA
1	OFF	ON
2	OFF	ON
3	OFF	ON
4	ON	OFF
5	ON	OFF
6	ON	OFF

Table 4: Switch Positions

3.1.1.2 Analog Output Values

Depending on which device type (...FS1000,...FS2000) has been selected, different values must be taken into account in the logic for the *Value [INT]* -> signal variable (SILworX) and for the *AO[0x].Value* system signal (ELOP II Factory) to get identical output values.

Value range in the application	Output voltage	Output current
Device version FS1000		
0	0.0 V	0.0 mA
+1000	+10.0 V	+20.0 mA
-1000	-10.0 V	0.0 mA
Device version FS2000		
0	0.0 V	0.0 mA
+2000	+10.0 V	+20.0 mA
-2000	-10.0 V	0.0 mA

Table 5: Output Values of the Analog Outputs

Every two analog outputs are galvanically connected to one another (output 1 and 2, output 3 and 4, output 5 and 6, output 7 and 8).

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

3.1.1.3 Reaction in the Event of a Fault

If the module detects a discrepancy between the read back value of the output signal and the configured value, the defective output is switched off via the safety switches.

The module activates the *ERR* LED.

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

3.1.1.4 Worst Case Reaction Time

The worst case reaction time WDT_{AO} is 12 ms.

To determine the worst case reaction time of the analog outputs, add the double watchdog time of the AO CPU ($2 * WDT_{AO-CPU}$) to the double watchdog time ($2 * WDT_{CPU}$), see safety manual (HI 800 023 E).

3.2 Equipment, Scope of Delivery

The following table specifies the available component:

Designation	Description
AO 8 01	Module with 8 analog outputs

Table 6: Available Component

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

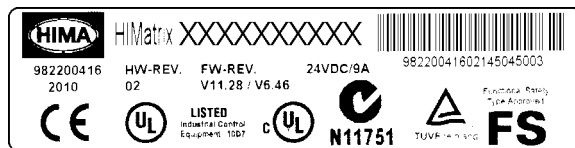
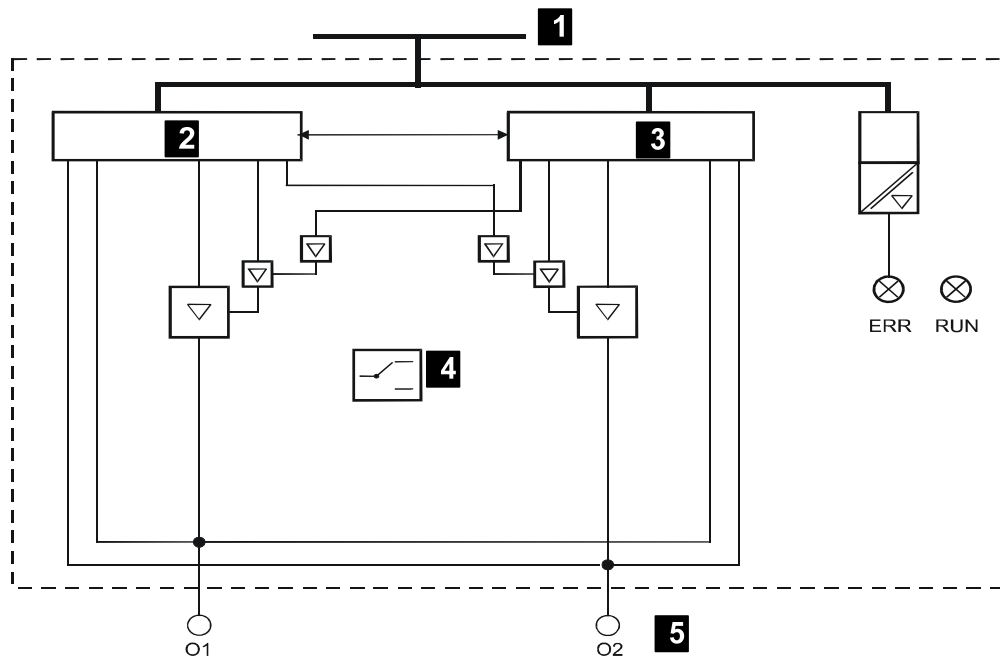


Figure 1: Sample Type Label

3.4 Structure

This chapter describes the layout and function of the module.

3.4.1 Block Diagram



- 1** I/O Bus
- 2** A/D Microcontroller
- 3** A/D Microcontroller
- 4** Voltage/Current Switch
- 5** 8 Output Channels

Figure 2: Block Diagram

3.4.2 Front View



Figure 3: Front View

3.4.3 Status Indicators

LED	Color	Status	Description
RUN	Green	On	Operating voltage present
		Off	No operating voltage
ERR	Red	On	Module faulty or external faults Reaction as dictated by the diagnosis
		Off	No module faults and / or no channel faults

Table 7: Status Indicators

3.5 Product Data

General	
Operating voltage	24 VDC, -15...+20 %, $r_{PP} \leq 15$ %, from a power supply unit with safe insulation, in accordance with IEC 61131-2
Operating data	3.3 V / 130 mA 5 V / 280 mA 24 V / 630 mA
Ambient temperature	0...+60 °C
Storage temperature	-40...+85 °C
Space requirement	6 RU, 4 HP
Weight	280 g

Table 8: Product Data

Analog outputs	
Number of outputs	8 analog outputs (each two outputs are galvanically separated from the other pairs and from the supply voltage).
Nominal range	0...±10 V or 0...+20 mA
Operating range	0...±10.25 V or 0...+21 mA
Output resistor	≤ 600 Ω (current operation) > 1 kΩ (voltage operation)
Digital resolution	12-bit
Measurement accuracy at 25 °C, max.	±0.3 % of final value
Metrological accuracy on full temperature, max.	±1 % of final value
Temperature coefficient, max.	±0.02 %/K of final value
Safety-related accuracy, max.	±1 % of final value

Table 9: Specifications for the Analog Outputs

4 Start-up

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

4.1 Installation and Mounting

The module is mounted in the subrack of the modular HIMatrix F60 system.

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 Mounting and Removing the Modules

To mount and remove the modules, the connection cable clamp terminals must be unplugged.

Additionally, personnel must be protected from electrostatic discharge. For details, refer to Chapter 2.1.2.

Mounting the Modules

To mount a module into the subrack

1. Insert the module as far as it can go – without jamming it – into the two guiding rails which are located on the housing's upper and lower part.
2. Apply pressure to the upper and lower extremity of the front plate until the module plugs snap into the backplane socket.
3. Secure the module with the screws located on upper and lower extremity of the front plate.

The module is mounted.

Removing the Modules

To remove a module from the subrack

1. Remove the plugs from the module front plate.
2. Release the locking screws located on the upper and lower extremity of the front plate.
3. Loosen the module using the handle located on the lower part of the front plate and remove it from the guiding rails.

The module is removed.

4.1.2 Connecting the Analog Outputs

The outputs are connected using 9-pole connectors with numbered terminals. The terminal pins on the front plate of the module have the same numbered sequence to avoid invalid connections.

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Each unused analog output channels configured as current outputs, must be short-circuited to the assigned ground.

Use the following terminals to connect the analog outputs:

Terminal	Designation	Function
01	O1+	Analog output 1
02	O1-	Ground output 1
03	O2+	Analog output 2
04	O2-	Ground output 2
05	O3+	Analog output 3
06	O3-	Ground output 3
07	O4+	Analog output 4
08	O4-	Ground output 4
09	\perp	Ground / shielding
Terminal	Designation	Function
10	O5+	Analog output 5
11	O5-	Ground output 5
12	O6+	Analog output 6
13	O6-	Ground output 6
14	O7+	Analog output 7
15	O7-	Ground output 7
16	O8+	Analog output 8
17	O8-	Ground output 8
18	\perp	Ground / shielding

Table 10: Terminal Assignment for the Analog Outputs

4.1.3 Cable Plugs

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

Connection to the field zone	
Number of cable plugs	2 pieces, nine 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 11: Cable Plug Properties

4.1.4 Mounting the AO 8 01 in Zone 2

(EC Directive 94/9/EC, ATEX)

The module 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 F60 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 be performed when the controller is under voltage.

2. The enclosure in use must be able to safely dissipate the generated heat. The maximum power dissipation of the AO 8 01 module is 21 W.
3. 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 module is additionally equipped with the label represented below:

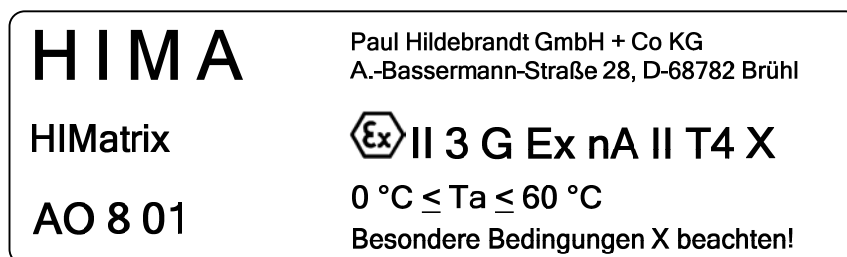


Figure 4: Label for Ex Conditions

4.2 Configuration

The module 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.

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How to switch between operating systems is described in Chapter *Loading Operating Systems* of the system manual for the modular F60 system (HI 800 191 E).

4.2.1 Module Slots

Slots 1 and 2 on the F60 subrack are reserved for the PS 01 power supply module and the central module, respectively. Any type of I/O modules can be plugged in to slots 3...8.

The module slots in SILworX and ELOP II Factory are numbered as follows:

Module	Slot on the rack	Slot in SILworX	Slot in ELOP II Factory
PS 01	1	-	-
CPU/COM	2	0/1	-
I/O	3	2	1
I/O	4	3	2
I/O	5	4	3
I/O	6	5	4
I/O	7	6	5
I/O	8	7	6

Table 12: Module Slots

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- The PS 01 power supply module is not configured.
 - CPU and COM are both on the central module. In the programming tools, however, they are represented as separate items.
-

4.3 Configuration with SILworX

In the Hardware Editor, the controller is represented with the following modules:

- one processor module (CPU)
- one communication module (COM)
- 6 slots available for I/O modules

To insert I/O modules, drag them from the module list onto an available slot.

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 parameters of the corresponding module.

4.3.1 Parameters and Error Codes for the Output

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

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

The error codes can also be displayed in SILworX.

4.3.2 Analog Outputs

The following tables present the statuses and parameters for the output module 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	
AO.Error Code	WORD	R	Error codes for the analog output channels	
			Coding	Description
			0x0001	Module fault
			0x0002	FTT test: Error while checking coefficients
			0x0004	No communication to AO module, PES 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: 0xFB04 [64 260 _{dez}]	

Table 13: SILworX - System Parameters for Analog Outputs, **Module** Tab

4.3.2.2 Tab: **AO 8: Channels**

System parameter	Data type	R/W	Description																																		
-> Error code [DWORD]	DWORD	R	Error codes for the analog output channels <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 30%;">Coding</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0000 0001</td> <td>CPU F60: AO module error</td> </tr> <tr> <td>0x0000 0002</td> <td>CPU F60: Faulty monotonicity counter</td> </tr> <tr> <td>0x0000 0004</td> <td>CPU F60: Faulty secure addressing</td> </tr> <tr> <td>0x0000 0008</td> <td>CPU F60: CRC faulty</td> </tr> <tr> <td>0x0000 0010</td> <td>CPU F60: Faulty WD time in ADyC</td> </tr> <tr> <td>0x0000 0020</td> <td>CPU F60: Impossible to communicate with ADyC</td> </tr> <tr> <td>0x0000 0040</td> <td>CPU F60: Current operating state of AO (current / voltage) does not match initial state</td> </tr> <tr> <td>0x0000 0080</td> <td>CPU F60: AO [0x]. Value out of the specified range</td> </tr> <tr> <td>0x0001 0000</td> <td>ADyC: Error while reading back</td> </tr> <tr> <td>0x0004 0000</td> <td>ADyC: Error with analog supply voltage</td> </tr> <tr> <td>0x0008 0000</td> <td>ADyC: Error with test of safety switches</td> </tr> <tr> <td>0x0080 0000</td> <td>ADyC: Two safety switches faulty</td> </tr> <tr> <td>0x0200 0000</td> <td>ADyC: Initialization of ADyC</td> </tr> <tr> <td>0x1000 0000</td> <td>ADyC: Error due to temperature overrun</td> </tr> <tr> <td>0x2000 0000</td> <td>ADyC: Warning due to temperature overrun</td> </tr> <tr> <td>0x8000 0000</td> <td>CPU F60: Redundant ADyC channel indicates error</td> </tr> </tbody> </table>	Coding	Description	0x0000 0001	CPU F60: AO module error	0x0000 0002	CPU F60: Faulty monotonicity counter	0x0000 0004	CPU F60: Faulty secure addressing	0x0000 0008	CPU F60: CRC faulty	0x0000 0010	CPU F60: Faulty WD time in ADyC	0x0000 0020	CPU F60: Impossible to communicate with ADyC	0x0000 0040	CPU F60: Current operating state of AO (current / voltage) does not match initial state	0x0000 0080	CPU F60: AO [0x]. Value out of the specified range	0x0001 0000	ADyC: Error while reading back	0x0004 0000	ADyC: Error with analog supply voltage	0x0008 0000	ADyC: Error with test of safety switches	0x0080 0000	ADyC: Two safety switches faulty	0x0200 0000	ADyC: Initialization of ADyC	0x1000 0000	ADyC: Error due to temperature overrun	0x2000 0000	ADyC: Warning due to temperature overrun	0x8000 0000	CPU F60: Redundant ADyC channel indicates error
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Value [INT] ->	INT	W	Output value of AO channels (device version: FS1000): Current characteristic curve: 0...+1000 (0...+20 mA) Current characteristic curve: -1000...0 (0 mA)																																		
			Before being normalized, the values are checked for plausibility and limited to the valid range. Current characteristic curve: <ul style="list-style-type: none"> ▪ Values < 0: are limited to 0 ▪ Values > 1000: are limited to 1000 Voltage characteristic curve: <ul style="list-style-type: none"> ▪ Values < -1000: are limited to -1000 ▪ Values > 1000: are limited to 1000 																																		
			Output value of AO channels (device version: FS2000): Voltage characteristic curve: -2000...+2000 (-10...+10 V) Current characteristic curve: 0...+2000 (0...+20 mA) Current characteristic curve: -2000...0 (0 mA)																																		
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System parameter	Data type	R/W	Description
Channel Used [BOOL] ->	BOOL	W	Channel configuration: 1 = operating 0 = not operating
Mode [UINT] ->	UINT	W	Channel current or voltage measurement: 0 Voltage characteristic curve 1 Current characteristic curve

Table 14: SILworX - System Parameters for Analog Outputs, **AO 8: Channels** Tab

4.4 Configuration with ELOP II Factory

4.4.1 Configuring the Outputs

The signals previously defined in the Signal Editor (Hardware Management) are assigned to the individual channels (outputs) using ELOP II Factory. Refer to the system manual for the modular F60 system 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 Output

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

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

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

4.4.3 Analog Outputs

System signal	R/W	Description																																
Mod.SRS [UDINT]	R	Slot number (System.Rack.Slot)																																
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System signal	R/W	Description
AO[xx].Value [BOOL]	W	<p>Output value of AO channels (device version: FS1000): Voltage characteristic curve: -1000...+1000 (-10...+10 V) Current characteristic curve: 0...+1000 (0...+20 mA) Current characteristic curve: -1000...0 (0 mA)</p> <p>Before being normalized, the values are checked for plausibility and limited to the valid range.</p> <p>Current characteristic curve:</p> <ul style="list-style-type: none"> ▪ Values < 0: are limited to 0 ▪ Values > 1000: are limited to 1000 <p>Voltage characteristic curve:</p> <ul style="list-style-type: none"> ▪ Values < -1000: are limited to -1000 ▪ Values > 1000: are limited to 1000 <p>Output value of AO channels (device version: FS2000): Voltage characteristic curve: -2000...+2000 (-10...+10 V) Current characteristic curve: 0...+2000 (0...+20 mA) Current characteristic curve: -2000...0 (0 mA)</p> <p>Before being normalized, the values are checked for plausibility and limited to the valid range.</p> <p>Current characteristic curve:</p> <ul style="list-style-type: none"> ▪ Values < 0: are limited to 0 ▪ Values > 2000: are limited to 2000 <p>Voltage characteristic curve:</p> <ul style="list-style-type: none"> ▪ Values < -2000: are limited to -2000 ▪ Values > 2000: are limited to 2000
AO[0x].Mode [USINT]	W	<p>Channel current or voltage measurement: 0 Voltage characteristic curve 1 Current characteristic curve</p>
AO[x].Used [BOOL]	W	<p>Channel configuration: 1 = operating 0 = not operating</p>

Table 15: ELOP II Factory - System Signals for the Analog Outputs

5 Operation

The AO 8 01 can only operate together with a F60 controller. No specific monitoring is required.

5.1 Handling

Handling of the module during operation is not required.

5.2 Diagnosis

A first diagnosis results from evaluating the LEDs, see Chapter 3.4.3.

The module 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 or module.

6.1 Faults

Refer to Chapter 3.1.1.3, for more information on the fault reaction of the analog outputs.

NOTE



If a failure occurs, the module must be replaced to ensure the plant's safety.

A module may only be replaced while the power is switched off.

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Modules may not be removed or inserted during operation.

The instructions specified in Chapter 4.1.1 must be observed when replacing an existing module or installing a new one.

6.2 Maintenance Measures

The following measures are required for the modular F60 system:

- Load the operating system, if a new version is required
- Perform the proof test

6.2.1 Loading the Operating System

HIMA is continuously improving the operating system of the F60 central module. HIMA recommends to use system downtimes to load the current version of the operating system into the F60 controller.

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 F60 controller must be in STOP (displayed in the programming tool). Otherwise, stop the controller.

For more information, refer to the programming tool documentation and the system manual for the modular F60 system (HI 800 191 E).

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 of the PS 01 supply module to decommission the module.
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.

