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Axioline F safety module with safe digital outputs

User manual

User manual

Axioline F safety module with safe digital outputs

This user manual is valid for:

Designation	From HW/FW revision	Order No.
AXL F SSDO8/3 1F	01/220	2702264

Please observe the following notes

User group of this manual

The use of products described in this manual is oriented exclusively to:

– Qualified electricians or persons instructed by them, who are familiar with applicable standards and other regulations regarding electrical engineering and, in particular, the relevant safety concepts.

– Qualified application programmers and software engineers, who are familiar with the safety concepts of automation technology and applicable standards.

Explanation of symbols used and signal words

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety measures that follow this symbol to avoid possible injury or death.

There are three different categories of personal injury that are indicated with a signal word.

DANGER   This indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING   This indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION   This indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

This symbol together with the signal word **NOTE** and the accompanying text alert the reader to a situation which may cause damage or malfunction to the device, hardware/software, or surrounding property.

This symbol and the accompanying text provide the reader with additional information or refer to detailed sources of information.

How to contact us

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Table of contents

1 For your safety

Purpose of this user manual

This user manual provides information about how the module works, its operating and connection elements, and its parameter settings.

Validity of the user manual

This user manual is valid for the AXL F SSDO8/3 1F module in the version indicated on the inner cover page, as well as for the same or later versions if replaced with devices of the same type.

1.1 General safety notes

⚠️

WARNING: Risk of injury

Depending on the application, inappropriate use of the module may result in serious injury.
• Observe all the safety notes and warning instructions provided in this section and elsewhere in this user manual.

Qualified personnel

In terms of this user manual, qualified personnel are persons who, because of their education, experience and instruction, and their knowledge of relevant standards, regulations, accident prevention, and service conditions, have been authorized to carry out any required operations, and who are able to recognize and avoid any possible dangers.

Furthermore, knowledge of the following topics and products is required:
– Non-safety-related target system (e.g., PROFIBUS, PROFINET, EtherCAT®)
– SafetyBridge system
– Components used
– Axioline F product range
– Operation of the software tools
– Safety regulations in the field of application

In the context of the use of the system, the following operations must only be carried out by qualified personnel:
– Planning
– Configuration, parameterization, programming
– Installation, startup, servicing
– Maintenance, decommissioning

Documentation

Observe all information in this user manual and the accompanying documents: see Section 1.6 "Documentation" on page 12.

Safety of personnel and equipment

The safety of personnel and equipment can only be assured if the module is used correctly: see Section 1.5 "Intended use" on page 11.

Error detection

Depending on the wiring and the parameterization, the module detects errors within the safety equipment.

Do not carry out any repairs or modifications	It is prohibited for the user to carry out repair work or make modifications to the module. The housing must not be opened. The module is protected against tampering by means of security labels. The security label is damaged in the event of unauthorized repairs or opening of the housing. In this case, the correct operation of the safety module can no longer be ensured.

In the event of an error, send the module to Phoenix Contact or contact Phoenix Contact immediately and engage a service engineer. |
| **Mismatching and polarity reversal of connections** | Take care to avoid the mismatching, polarity reversal or tampering of connections. For increased protection against mismatching, connectors and slot markings are color coded. |

1.2   Electrical safety

> **WARNING: Loss of safety function/hazardous shock currents**
> Incorrect installation can result in the loss of the safety function as well as hazardous shock currents.
> • Observe the notes on electrical safety.
> • Plan the modules used and their installation in the system according to the specific requirements.
> • Recheck plants and systems retrofitted with SafetyBridge.

Direct/indirect contact	Protection against direct and indirect contact according to VDE 0100 Part 410 must be ensured for all components connected to the system. In the event of an error, parasitic voltages must not occur (single-fault tolerance).

Measures required:
– Using power supply units with safe isolation (PELV).
– Decoupling circuits, which are not PELV systems, using optocouplers, relays, and other components which meet the requirements of safe isolation. |
| **Power supply units for 24 V supply** | Only use power supply units with safe isolation and PELV according to EN 50178/VDE 0160 (PELV). These power supply units prevent short circuits between the primary and secondary side.

Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error. |
| **Insulation rating** | When selecting the equipment, please take into consideration the dirt and surge voltages which may occur during operation.

The module is designed for overvoltage category II (according to DIN EN 60664-1). If you expect surge voltages in the system, which exceed the values defined in overvoltage category II, implement additional measures for voltage limitation. |

1.3   Safety of the machine or system

The machine/system manufacturer and the operator are responsible for the safety of the machine or system and the application in which the machine or system is used.

Draw up and implement a safety concept

In order to use the module, a safety concept is required for your machine or system. This includes a hazard and risk analysis as well as a test report (checklist) for validating the safety function: see Section 1.4 "Directives and standards" on page 11, see Section A "Appendix: checklists" on page 69.

The target safety integrity (SIL according to IEC 61508, SILCL according to EN 62061 or performance level and category according to EN ISO 13849-1) is ascertained on the basis of the risk analysis. The safety integrity ascertained determines how to connect and parameterize the module within the safety function.

Validate hardware and parameterization

Carry out a validation every time you make a safety-related modification to your overall system.

Use your test report to ensure that:
– The safe modules are connected to the correct sensors and actuators
– The safe input and output channels have been parameterized correctly
– The variables have been linked to the safe sensors and actuators (single-channel or two-channel) correctly

1.4   Directives and standards

The standards to which the module conforms are listed in the certificate issued by the approval body and in the EC declaration of conformity (see: phoenixcontact.net/products).

1.5   Intended use

The AXL F SSDO8/3 1F module is designed exclusively for use in a SafetyBridge system. It can only perform its tasks in the system if it is used according to the specifications in this document.

Only use the module according to the defined technical data and ambient conditions: see Section 10 "Technical data and ordering data" on page 63.

The module is designed for connecting single-channel or two-channel actuators, which can be used in association with safety technology.

Examples of use for the module:
– Safety circuits according to EN 60204 Part 1
– Safe shutdown of contactors, motors (24 V DC), valves, ohmic, inductive, and capacitive loads

The module is **not** suitable for applications in which stop category 1 also has to be observed in the event of an error.

1.6 Documentation

Currentness and availability of documentation

Always use the latest documentation. Changes or additions to documentation can be found on the Internet (see: phoenixcontact.net/products).

SafetyBridge user manuals

User manuals:
– For the controller used
– For the logic module of the SafetyBridge system
– For the SafetyBridge system I/O modules used
– For the SafetyBridge system function blocks

Please also observe the information on the bus system used.

Documentation for the Axioline F product range

Axioline F: system and installation user manual, UM EN AXL F SYS INST

Documentation for the bus coupler used

1.7 Abbreviations used

Table 1-1   Abbreviations for safety requirements

Abbreviation	Meaning	Standard	Example
SIL	Safety integrity level	IEC 61508	SIL 2, SIL 3
SILCL	SIL claim limit	EN 62061	SILCL 3
Cat.	Category	EN ISO 13849-1	Cat. 2, Cat. 4
PL	Performance level	EN ISO 13849-1	PL e, PL d

Table 1-2   General abbreviations

Abbreviation	Meaning
PELV	Protective extra-low voltage according to EN 50178/VDE 0160
EUC	Equipment under control

1.8 Safety hotline

Should you have any technical questions, please contact our 24-hour hotline.

Phone: + 49 5281 9-46277, e-mail: safety-service@phoenixcontact.com

2 Product description

2.1 Short description of the module

The AXL F SSDO8/3 1F module is an output module for use at any point in an Axioline F station.

The module is designed for use in the SafetyBridge system. The SafetyBridge address is set via a DIP switch.

The module has four safe positive switching digital outputs for two-channel assignment or eight safe positive switching digital outputs for single-channel assignment.

The outputs can be parameterized according to the specific application and enable the integration of actuators in the safe SafetyBridge system.

In the SafetyBridge system, the module can be used to achieve safety functions with the following requirements depending on the operating conditions:
–   Up to SIL 3 according to IEC 61508
–   Up to SILCL 3 according to EN 62061
–   Up to Cat. 4/PL e according to EN ISO 13849-1

2.2 Structure of the module
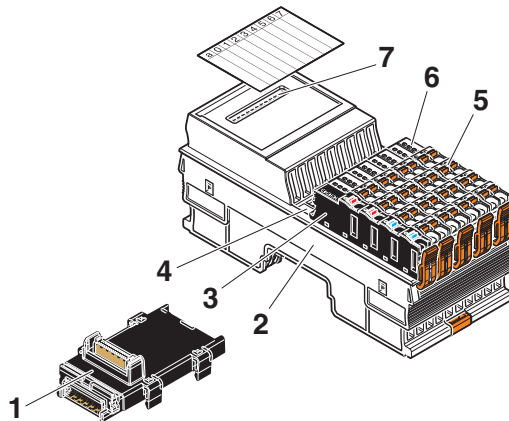
Figure 2-1   Structure of the module

1   Bus base module
2   Electronics module
3   Connector for connecting the supply voltage
4   Function identification
5   I/O connector
6   Diagnostics and status indicators
7   DIP switch

More detailed information on setting the switch: see Section 4.1.3 "Setting the DIP switch" on page 30.

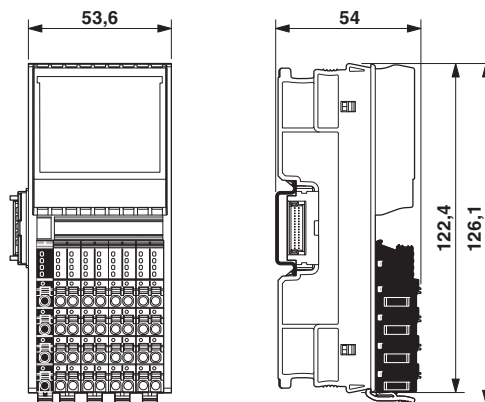## 2.3 Housing dimensions

Figure 2-2   Housing dimensions (in mm)

2.4 Safe digital outputs

The module has safe digital outputs which can be used as follows:
– For two-channel assignment: four two-channel outputs
– For single-channel assignment: eight single-channel outputs

Technical data for the safe outputs: "Safe digital outputs" on page 65.

Parameterization

The safe digital outputs of a module can be parameterized in pairs. This means that the outputs can be adapted to various operating conditions and different safety integrity levels can be implemented (SIL, SILCL, Cat., PL).

In order to achieve a high level of error detection, the test pulses must be enabled. If this is not possible for the connected loads, the test pulses can be disabled, however, error detection is then reduced.

> The safety integrity (SIL, SILCL, Cat., PL) and error detection that can be achieved depend on the parameterization, the structure of the actuator, and the cable installation: see Section 6 "Connection examples for safe outputs" on page 39.

Information on the parameterization of the outputs: see Section 5.2 "Parameterization of the safe outputs" on page 36.

Diagnostics

Diagnostics are provided via both the local diagnostics indicators and the diagnostic messages which are transmitted to the logic module.

Information on the diagnostic messages of the outputs: see Section 8 "Errors: messages and removal" on page 53.

> **WARNING: Loss of safety function**
> Using diagnostic data for safety-related functions can result in the loss of the safety function as diagnostic data is not safety-related.
> • Do not use the diagnostic data for safety-related functions or actions.

Requirements for actuators/controlled devices

Functional safety places requirements on the design of actuators/controlled devices.
• Use suitable actuators/controlled devices which are described in the applicable safety standards, for example.

The module's ability to detect errors depends on the parameterization.
• Adapt the module parameterization to the relevant actuator/controlled device: see Section 5 "Parameterization of the module" on page 35.

If the outputs are parameterized with test pulses, the output circuits are tested by test pulses at regular intervals. These test pulses are visible at the output and can trigger undesirable reactions with quick responding actuators. The test pulses are either light pulses (brief activation) which can be disabled or dark pulses (brief deactivation) which cannot be disabled.

⚠

WARNING: Unintentional machine startup

Reactions from test pulses can cause unintentional machine startup.

• If the process does not tolerate this behavior, the following measures must be taken:
  – Use actuators with sufficient inertia.
  – Make sure that the load is not so dynamic that it causes hazardous states within 1 ms.

Quick actuators which offer a safety-related response to pulses in under 1 ms are not generally permitted.

Disabling the test pulses affects the error detection of the module.

• Observe the achievable safety integrity: see Section 6 "Connection examples for safe outputs" on page 39.
• Observe the notes on the safe assignment of outputs: see Section 6.4 "Single-channel assignment of safe outputs" on page 43, see Section 6.5 "Two-channel assignment of safe outputs" on page 45.

2.5 Connection options for actuators depending on the parameterization

Actuators that meet various safety requirements depending on the parameterization can be connected to the outputs.

The maximum achievable SIL/SILCL/Cat./PL is specified in the table.
In order to meet the safety requirements:

• Observe the information in the connection examples: see Section 6 "Connection examples for safe outputs" on page 39.
• Observe the requirements of the standards with regard to the external wiring and the actuators to be used to achieve a SIL/SILCL/Cat./PL: see Section 6.3 "Measures to achieve a specific safety integrity" on page 41.

	Output OUT0 to OUT3	
"Output" parameterization	Single-channel	Two-channel
Test pulses	Any	On/off*
Achievable safety integrity	SIL 2/SILCL 2/Cat. 3/PL d	SIL 3/SILCL 3/Cat. 4/PL e
For connection example, see page	43	45

* If the test pulses are disabled, a cross-circuit between the outputs is only detected if the output is enabled.

ℹ

To achieve Cat. 3, two-channel actuators are usually used.
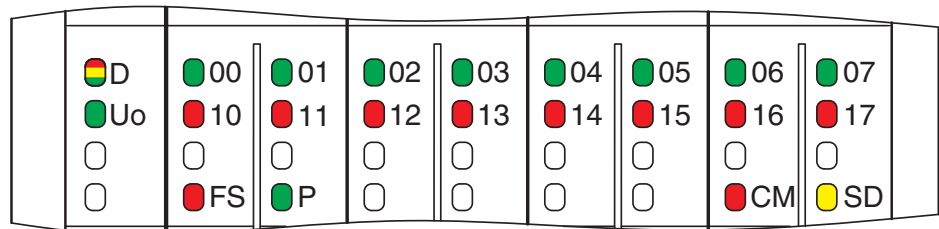
2.6 Local diagnostics and status indicators

Figure 2-3   Local diagnostics and status indicators

Table 2-1   Overview of diagnostics LEDs

Des.	Color	State	Description
D	Red/yellow/ green	**Diagnostics for local bus communication**	
		Green on	The device is ready for operation, communication within the station is OK. All data is valid. There is no error.
		Flashing green	The device is ready for operation, communication within the station is OK. The data is **not** valid. Valid data from the controller/higher-level network not available. There is no error on the module.
		Flashing green/yellow	The device is ready for operation, communication within the station is OK. Output data **cannot** be output and/or input data **cannot** be read. There is an error on the I/O side of the module.
		Yellow on	The device is ready for operation, but has still not detected a valid cycle after power on.
		Flashing yellow	The device is not (yet) part of the active configuration.
		Red on	The device is ready for operation, but has lost the connection to the bus head.
		Flashing red	The device is ready for operation, but there is no connection to the previous device.
		Off	Device is in (power) reset.
UO	Green	**Diagnostics for digital output supply**	
		Green on	Supply for the digital outputs is present and is > around 17 V DC.
		Flashing green	Supply for the digital outputs is not present or is < around 17 V DC.
FS	Red	**Diagnostics for failure state**	
		Off	The safety application has a valid parameterization. (Only applies if UI is on or flashing at the same time.)
		Red on	Hardware fault. Communication to the higher-level controller is disabled. The module has entered the safe state (failure state).
		Flashing red	The module is not parameterized.

Des.	Color	State	Description
P	Green	**Diagnostics for safe communication protocol**	
		Off	No safe communication.
		Green on	Safe communication is running without errors.
		Flashing green	Safe communication is running. The SafetyBridge system is requesting an acknowledgment.
CM	Red	**Startup mode**	
		Off	SafetyBridge mode.
		Red on	Startup mode. ⚠ **WARNING:** In startup mode, the device is in **standard** operation. Startup mode: see Section 7.1.1 "Startup mode" on page 50.
SD	Yellow	**Acknowledgment request**	
		Off	No diagnostic message present that needs to be acknowledged.
		Yellow on	A diagnostic message is present that needs to be acknowledged for safe digital output errors, supply voltage errors or general errors. Acknowledgment: see Section 8.2 "Acknowledging an error" on page 53.
00 - 07	Green	**Status of each output from 0 - 7**	
		Off	Output at logic "0".
		Green on	Output at logic "1".
10 - 17	Red	**Diagnostics for each output from 0 - 7**	
		Off	No error present at the output.
		Red on	Error at the output (e.g., short circuit).

2.7 Safe state

The safe state for the module is the no load state at the output terminal blocks: see Section 2.4 "Safe digital outputs" on page 15.

The safe state can be entered in the following cases:
1. Operating state
2. Error detection in I/O devices
3. Device errors
4. Parameterization errors
5. Error detection during safe communication

2.7.1 Operating state

In the operating state, the outputs can enter states "1" or "0". State "0" is the safe state.

2.7.2 Error detection in I/O devices

Outputs

If an error is detected at an output, this output is disabled ("0" = safe state).

Operating time in the error state

⚠️ **WARNING: Loss of the safe state in the failure state**

In the failure state, internal module tests are no longer run and it is possible that the safe state may be exited due to an accumulation of errors.

• If the module enters an error state, assess, acknowledge or remove the error within 72 hours.

Depending on the parameterization, the following errors can be detected at outputs:
– Short circuit
– Cross-circuit
– Overload

The diagnostic message is transmitted to the logic module: see Section 8 "Errors: messages and removal" on page 53. Information on which errors are detected and when: see Section 6 "Connection examples for safe outputs" on page 39.

ℹ️ If an error occurs on a channel of an output parameterized as "two-channel", the other corresponding channel also enters the safe state.

2.7.3   Device errors

Outputs

If a hardware fault in the internal circuit is detected at an output, **all** module outputs are disabled ("0" = off = safe state).

The diagnostic message is transmitted to the logic module: see Section 8 "Errors: messages and removal" on page 53.

Failure state: serious errors

Serious errors that can result in the loss of or adversely affect the safety function cause the entire module to enter the safe state. The FS LED on the module is permanently on. The failure state can only be exited by means of a power up.

The following serious errors result in the safe state:

– Serious hardware faults in the internal circuit
– User errors
– Module overload
– Module overheating

The diagnostic message is transmitted to the logic module: see Section 8 "Errors: messages and removal" on page 53.

⚠ **WARNING: Loss of safety function**

Sequential errors can result in the loss of the safety function.

• In the event of a device error, the module should be completely disconnected from the power supply and replaced so as to prevent sequential errors.

2.7.4   Parameterization errors

The module switches to the safe state following parameterization errors. The FS LED on the module flashes.

In the event of faulty parameterization, a diagnostic message is transmitted to the logic module: see Section 8 "Errors: messages and removal" on page 53.

2.8   Process data words

The module occupies four words in the Axioline F system.

ℹ️ Access the process data words via the "Operate" function block.

The module has feedback data and enable data.

Feedback data

The bits in this register mirror the states of the digital outputs as diagnostic data. This data can be used if an output has been parameterized with a switch-off delay. In this case, the feedback data can be used to determine the actual state of the output and derive information for the standard control process from this.

•   Please note that the feedback data for certain errors (e.g., communication error) can differ from the actual state of the outputs.

•   Do not use the diagnostic data to execute safety-related functions or actions.

The structure and function of the register are as follows:

Table 2-2   Feedback data register (mirrored data)

7	6	5	4	3	2	1	0
OUT3 _Ch2	OUT3 _Ch1	OUT2 _Ch2	OUT2 _Ch1	OUT1 _Ch2	OUT1 _Ch1	OUT0 _Ch2	OUT0 _Ch1

Enable

The enable principle is implemented in the SafetyBridge system. For this, all modules with local outputs have an enable function integrated in the device firmware (ANDed bit-by-bit) for each local safe output channel. The enable function can be parameterized (enabled/disabled) for each output pair.

The structure and function of the register are as follows:

Table 2-3   Enable data register

7	6	5	4	3	2	1	0
OUT3 _Ch2	OUT3 _Ch1	OUT2 _Ch2	OUT2 _Ch1	OUT1 _Ch2	OUT1 _Ch1	OUT0 _Ch2	OUT0 _Ch1

When the enable function is enabled, the relevant safe local output is ANDed bit-by-bit with the corresponding output bit of the standard controller. This output is then only set if the result of the safety function calculation permits this and the standard controller has set the corresponding output.

The enable function is performed according to the single-channel or two-channel parameterization of the safe outputs.

⚠️ **WARNING: Loss of safety function**

The safety function must be triggered and canceled via the SafetyBridge system. If the safety function is triggered and canceled via standard components, there is no safety function.

•   Check this when validating the overall safety function.

ℹ️ The enable function is not graphically represented in SAFECONF in the safety logic editor. Parameterize the enable function when parameterizing the channels.

The following figure illustrates the enable principle. For the corresponding parameterization of the output channels for this example, see Table 2-4.
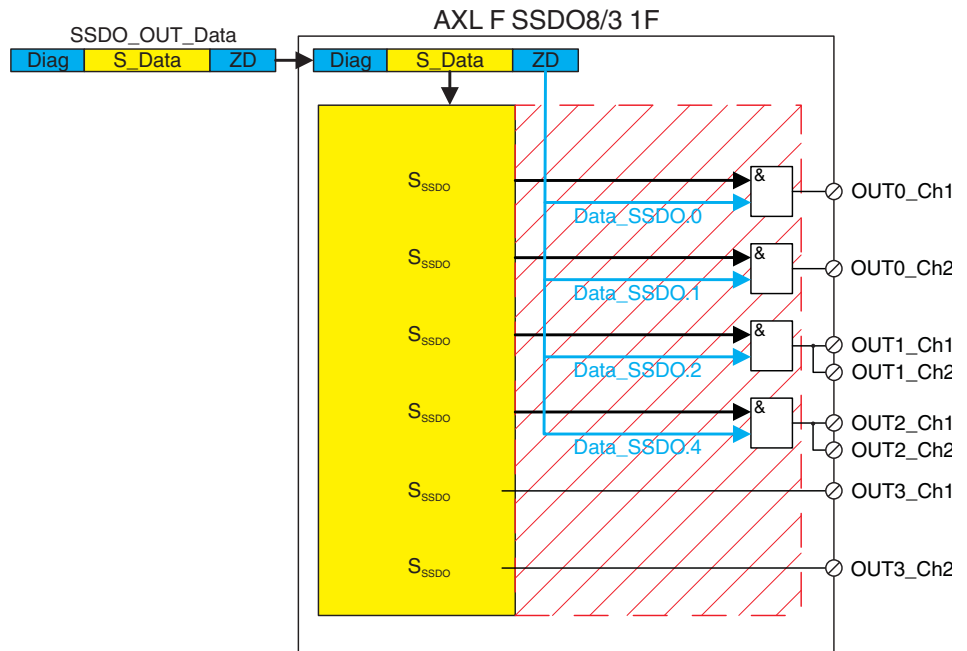

Figure 2-4   Enable principle (example)

Explanations for Figure 2-4:

SSDO_OUT_Data	Output data from the logic module to the AXL F SSDO8/3 1F
S_Data	Safety data from the logic module
Diag	Diagnostic data
ZD	Enable data from the standard controller
&	Standard function block for ANDing
S_{SSDO}	Safe control signal from the logic module
Data_SSDO.x	Standard data of the standard controller, which is to enable the AXL F SSDO8/3 1F; bit x
	See block description for the relevant controller.
OUTx_Chy	Safe output x, channel y
▨	Internal functionality that is enabled by means of parameterization; not visible in SAFECONF

Table 2-4   Parameterization of output channels for the example in Figure 2-4

Output/channel	Output	Enable	
		Parameterization	**Bit**
OUT0_Ch1	Single-channel	Enabled	0
OUT0_Ch2	Single-channel	Enabled	1
OUT1_Ch1	Two-channel	Enabled	2
OUT1_Ch2	Two-channel	Enabled	Not relevant
OUT2_Ch1	Two-channel	Enabled	4
OUT2_Ch2	Two-channel	Enabled	Not relevant
OUT3_Ch1	Single-channel	Disabled	Not relevant
OUT3_Ch2	Single-channel	Disabled	Not relevant

i For two-channel parameterization, only use the process data bit of the first channel.

2.9   Programming data/configuration data

Phoenix Contact provides device description files for various control systems.

i The programming data/configuration data is defined in the device description (FDCML, GSD, GSDML, etc.) according to the bus or network used.

3 Integration of the Axioline F local bus

The module is integrated for operation in an Axioline F station.

| i | More detailed information on the structure of an Axioline F station: see UM EN AXL F SYS INST user manual. |

3.1 Supply voltage of the module logic

The supply voltage for the module logic is generated in the bus coupler and led to the Axioline F module via the bus base module.

| ⚠ | **WARNING: Loss of safety function**
The use of unsuitable power supplies can result in the loss of the safety function.
• Only use power supplies according to EN 50178/VDE 0160 (PELV) for the voltage supply at the bus coupler.
• Observe the general safety notes: see Section 1.2 "Electrical safety" on page 10. |

Technical data for the supply voltage: see "Supply voltage U_{BUS} (logic)" on page 65.

The current carrying capacity for supply voltage U_{BUS} depends on the bus coupler used.

• Observe the technical data and information in the documentation for the bus coupler.