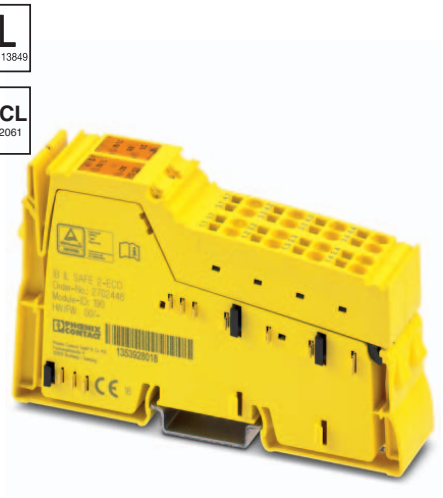
IB IL SAFE 2-ECO

Inline ECO safety module with sensor circuits



Data sheet
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1 Description

The Inline ECO safety module with sensor circuits for use inside a 24-V-area of an Inline station.

The module monitors two sensor circuits. The sensor circuits can be designed as single/two-channel, non-equivalent/equivalent.

If at least one sensor circuit is interrupted, the safety module initiates the safe state, and switches off the subsequent segment circuit for safety.

Possible signal generators

- Emergency stop button
- Safety door monitoring
- Light grids

Contact type

- 1 internal, two-channel enabling current path for safety-related shutdown of the segment voltage by means of potential routing

The enabling current path drops out without delay according to stop category 0 (EN 60204-1).

Control

- Single or two channel
- Equivalent or non-equivalent
- Automatic or manual, monitored start

Achievable safety integrity

- Suitable up to category 4, PL e (EN ISO 13849-1), SILCL 3 (EN 62061)

Additional features

- Various safety functions with one module
- Several modules can be cascaded
- Cross circuiting detection
- Diagnostic and status indicators
- Can be used in different bus systems
- Inline connector with spring-cage connection

Approvals

WARNING: Risk of electric shock

Observe the safety regulations and installation notes in the corresponding section.

Make sure you always use the latest documentation.
It can be downloaded from the product at phoenixcontact.net/products.

This document is valid for the products listed in the “Ordering data”.

This document meets the same requirements as the original operating instructions with respect to the contents.

This data sheet is only valid in association with the IL SYS INST UM E user manual.

2 Table of contents

3 Ordering data

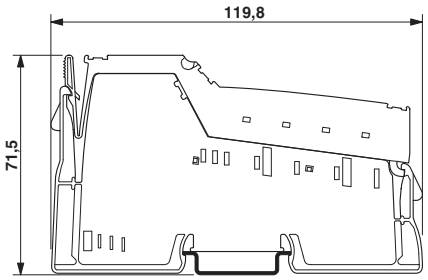
Description	Type	Order No.	Pcs./Pkt.
Inline ECO, Safety module, Digital inputs: 4 (for 2 sensor circuits (1- or 2-channel, non-equivalent/equivalent)), for safety-related shutdown of the segment voltage by means of potential routing, Transmission speed in the local bus 500 kbps, Degree of protection IP20, including Inline connectors and marking fields	IB IL SAFE 2-ECO	2702446	1

Accessories	Type	Order No.	Pcs./Pkt.
Inline ECO, Digital output terminal, Digital outputs: 4, 24 V DC, 500 mA, Connection technology: 3-conductor, Transmission speed in the local bus 500 kbps, Degree of protection IP20, including Inline connector	IB IL 24 DO 4/EF-ECO	2702825	1
Inline power terminal, complete with accessories (connector and labeling field), 24 V DC, without fuse	IB IL 24 PWR IN-PAC	2861331	1

Documentation	Type	Order No.	Pcs./Pkt.
User manual, English, Automation terminals of the Inline product range	IL SYS INST UM E	-	-

4 Technical data

Dimensions (nominal sizes in mm)	



Width	24.4 mm
Height	119.8 mm
Depth	71.5 mm
Note on dimensions	Housing dimensions

General data	
Housing material	PBT
Color	yellow
Weight	143 g (with connector)

General data	
Operating voltage display	1 x green LED
Status and diagnostic indicators	4 x green LED, 1 x yellow LED
Operating mode	Process data operation with 4 bits
Ambient temperature (operation)	0 °C ... 55 °C (observe derating)
Ambient temperature (storage/transport)	-25 °C ... 70 °C
Max. permissible relative humidity (operation)	75 % (on average, 85% infrequently, non-condensing)
Max. permissible humidity (storage/transport)	75 % (on average, 85% infrequently, non-condensing)
Degree of protection	IP20
Degree of protection at installation location	min. IP54
Overvoltage category	III
Degree of pollution	2 (according to EN 50178)
Mounting position	vertical or horizontal
Assembly instructions	See derating curve
Mounting type	DIN rail mounting
Maximum altitude	≤ 2000 m (Above sea level) See the “Use at altitudes greater than 2000 m above sea level” section.
Shock (operation)	15g
Vibration (operation)	10 Hz ...150 Hz, 2g
Air clearances and creepage distances	EN 50178

Connection data	
Designation	Inline connector
Connection method	Spring-cage connection
Conductor cross section solid / stranded	0.08 mm² ... 1.5 mm² / 0.08 mm² ... 1.5 mm²
Conductor cross section [AWG]	28 ... 16
Stripping length	8 mm

Interface Inline local bus	
Connection method	Inline data jumper
Transmission speed	500 kbps

Power consumption	
Main circuit supply U_M	24 V DC -20 % / +15 %
Current consumption from U_M	typ. 70 mA
Communications power U_L	7.5 V DC
Current consumption from U_L	max. 35 mA
Power consumption	typ. 1.9 W (at U_M)

Power dissipation	
Maximum power dissipation for nominal condition	4.7 W (at U_M = 30 V, I_L^2 = 36 A^2) See “Calculating the power dissipation”

Digital inputs	
Number of inputs	4 (for 2 sensor circuits (1- or 2-channel, non-equivalent/ equivalent))
Connection method	Spring-cage connection
Description of the input	IEC 61131-2 type 3
Input voltage range "0" signal	0 V DC ... 5 V DC (for safe Off; at inputs 1.2, 1.3, 3.2, 3.3) 0 V DC ... 5 V DC (at inputs 2.3, 4.3)
Input voltage range "1" signal	11 V DC ... 30 V DC (at inputs 1.2, 1.3, 2.3, 3.2, 3.3, 4.3) 19.2 V DC ... 30 V DC (at inputs 3.4, 4.4)
Input current range "0" signal	0 mA ... 2 mA (for safe Off; at inputs 1.2, 1.3, 3.2, 3.3) 0 mA ... 2 mA (at inputs 2.3, 4.3)
Inrush current	< 5 mA (at inputs 1.2, 1.3, 2.3, 3.2, 3.3, 4.3) > -5 mA (at inputs 2.2, 4.2) < 20 mA (at inputs 3.4, 4.4)
Current consumption	< 5 mA (at inputs 1.2, 1.3, 2.3, 3.2, 3.3, 3.4, 4.3, 4.4) > -5 mA (at inputs 2.2, 4.2)
Filter time	1 ms (in the event of voltage dips) max. 3 ms (Test pulse width at inputs 1.2, 1.3, 2.2, 2.3) 1 s (Test pulse rate at inputs 1.2, 1.3, 2.2, 2.3) Where test pulse width ≤ 1 ms: test pulse rate = 5 x test pulse width
Voltage at input/start and feedback circuit	22 V DC (U_M - 2 V; at terminal point 1.1 and 3.1)
Max. permissible overall conductor resistance	240 Ω
Concurrence input 1/2	∞
Surge voltage	Suppressor diode
Reverse polarity protection	yes

Relay outputs	
Contact type	N/O contact
Contact material	$AgSnO_2$
Switching current	min. 3 mA max. 6 A (30 V DC)
Limiting continuous current	6 A (observe derating)
Sq. Total current	36 A^2 (observe derating)
Switching capacity	min. 60 mW
Switching frequency	max. 0.5 Hz
Mechanical service life	10^6 cycles
Output fuse	6 A gL/gG (See “Application examples” section)

Times	
Typical response time	< 100 ms (manual, monitored start) < 150 ms (automatic start)
Typical release time	< 30 ms (when actuation is via the sensor circuit)
Restart time	< 1 s (Boot time)
Recovery time	< 500 ms

Error messages to the higher level control or computer system
None

Safety parameters for IEC 61508 - High demand	
HFT	1
SIL	3
PFH_D	1.00×10^{-9} (4 A DC13; 5 A AC15; 8760 switching cycles/year)
Demand rate	< 12 Months
Proof test interval	240 Months
Duration of use	240 Months

Safety characteristic data according to EN ISO 13849	
Category	4
Performance level (PL)	e (4 A DC13; 5 A AC15; 8760 switching cycles/year)
Duration of use	240 Months
For applications in PL e, the required demand rate for the safety function is once per month.	

Safety parameters for EN 62061	
SILCL	3

Approvals
For the latest approvals, please visit phoenixcontact.net/products.

5 Notes regarding documentation

5.1 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 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.

5.2 Validity

This data sheet is valid for the IB IL SAFE 2-ECO module in HW/FW Version 00/-- or later, as well as for the same or later versions if replaced with devices of the same type.

5.3 Target group

This data sheet is therefore aimed at:

– Qualified personnel who plan and design safety equipment for machines and systems and are familiar with regulations governing occupational safety and accident prevention.
– Qualified personnel who install and operate safety equipment in machines and systems.

Qualified personnel:

Qualified personnel are people who, because of their education, experience, and instruction and their knowledge of relevant standards, regulations, accident prevention, and service conditions, have been authorized by those responsible for the safety of the system to carry out any required operations and who are able to recognize and avoid any possible dangers.

Requirements:

Knowledge of the following topics is required:

– Target system (e.g., INTERBUS, PROFIBUS, PROFINET)
– Standard control system used

6 Safety regulations and installation notes

WARNING: Death, serious personal injury or damage to equipment

Depending on the application, incorrect handling of the device may pose serious risks for the user or cause damage to equipment.

- Observe all the safety notes and warning instructions provided in this chapter and elsewhere in this document.

General

- Observe the safety regulations of electrical engineering and industrial safety and liability associations.

Disregarding these safety regulations may result in death, serious personal injury or damage to equipment.

The device contains components that can be damaged or destroyed by electrostatic discharge.

- When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and IEC 61340-5-1.

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).

Power supply units for 24 V supply

- Only use power supply units with safe isolation and SELV/PELV according to EN 50178/VDE 0160.
- Provide external protection for the 24 V area.
- Make sure that the power supply unit is able to supply **four times** the nominal current of the external fuse, to ensure that it trips in the event of an error.
- Make sure that the output voltage of the voltage supply does not exceed 32 V even in the event of error.

Startup, mounting, and modifications

Startup, mounting, modifications, and upgrades may only be carried out by an electrically skilled person.

- Before working on the device, disconnect the power.
- Carry out wiring according to the application. Refer to the “Application examples” section for this.

Reliable operation is only ensured if the device is installed in housing protected from dust and humidity.

- Install the device in housing protected from dust and humidity (min. IP54).

In operation

During operation, parts of electrical switching devices carry hazardous voltages.

- Protective covers must not be removed when operating electrical switching devices.

For emergency stop applications, automatic startup of the machine can pose serious risks for the user.

- The machine must be prevented from restarting automatically by a higher-level controller.

With the manual, monitored reset device, a machine start may not be triggered in accordance with EN ISO 13849-1.

Inductive loads can lead to welded relay contacts.

- Connect a suitable and effective protective circuit to inductive loads.
- Implement the protective circuit parallel to the load and not parallel to the switch contact.

Magnetic fields can influence the device. The magnetic field strength of the environment must not exceed 30 A/m.

- Do not use the device in the vicinity of strong magnetic fields (e.g., caused by transformers or magnetic iron).

Noise emission may occur when operating relay modules. Wireless reception may be disrupted in residential areas.

The device is a Class A product.

- Observe the requirements for noise emission for electrical and electronic equipment (EN 61000-6-4).
- Implement appropriate precautions against noise emission.

Faulty devices

The devices may be damaged following an error. Correct operation can no longer be ensured.

- In the event of an error, replace the device.

Only the manufacturer or their authorized representative may perform the following activities. Otherwise the warranty is invalidated.

– Repairs to the device
– Opening the housing

Taking out of service and disposal

- Dispose of the device in accordance with environmental regulations.
- Make sure that the device can never be reused.

7 Intended use

The module is designed for use within the 24 V area of an Inline station.

The module is designed for connecting single-channel or two-channel safety sensors.

The module switches off the subsequent segment circuit of the Inline station for safety.

Examples of use for the module:

– Single or two-channel emergency stop applications
– Single or two-channel safety door applications
– Safety-related light grid applications
– Safety circuits according to EN 60204 Part 1

Only use the module according to the defined technical data and ambient conditions.

7.1 Reasonably foreseeable misuse

The module is **not** suitable for use in the 230 V area of an Inline station.

8 Function description

8.1 Structure of the module

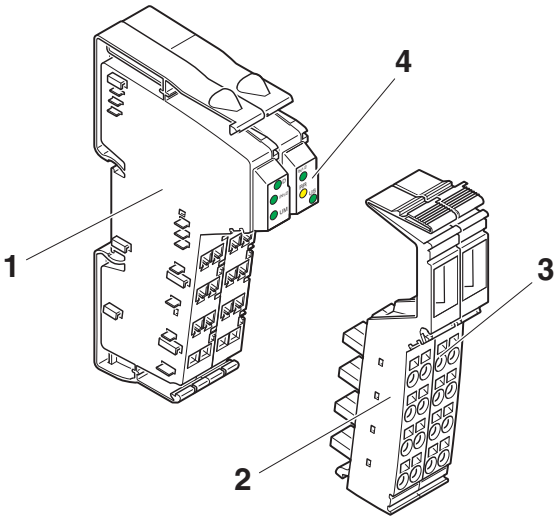


Figure 1 Structure

1 Electronics module
2 Periphery connector
3 Terminal points
4 Diagnostic and status indicators

8.2 Sensor circuits

The module monitors two sensor circuits. One connector on the module connects one sensor circuit.

The sensor circuits support single-channel or two-channel connection and various safety functions can be implemented per module.

The module can only be operated using both sensor circuits.

8.2.1 Single-channel sensor circuit

The sensor circuit does not have a redundant design. The module does not detect short circuits and cross-circuits in the sensor circuit.

8.2.2 Two-channel sensor circuit

The connection of the two-channel sensor circuit can be equivalent or non-equivalent. Depending on the wiring, the module detects short circuits and cross-circuits in the sensor circuit.

See “Connecting the sensor circuits” section.

8.3 Startup behavior

The module startup behavior is implemented via the corresponding input wiring.

In order to monitor external contactors or extension devices with force-guided contacts, the relevant N/C contacts can be integrated in the start and feedback circuit.

Following module startup, the subsequent segment circuit is switched on.

The following LEDs are activated:

– IN 1/2 (connector 1)
– IN 1/2 (connector 2)
– UM
– US

8.3.1 Automatic start

The module starts automatically after the sensor circuits have been closed.

8.3.2 Manual, monitored start

The start circuit is equipped with a reset button. A connected reset button is monitored.

For closed sensor circuits, the device starts once the reset button has been pressed and then released again.

See “Connecting the start and feedback circuit” section.

8.4 Safety-related segment circuit

The structure of the safety-related segment circuit in the Inline system is such that actuators/controlled devices, which are connected to output modules, can be switched separately via the bus system and can be switched off safely on a safety demand to the upstream safety module.

The safety-related segment circuit starts at the IB IL SAFE 2-ECO safety module and finishes at the last module before another feed-in or at the end of the station.

If at least one sensor circuit is interrupted, the internal enabling current path of the safety module opens without delay. When the enabling current path is open, the module is in the safe state.

In this state, the subsequent segment circuit is switched off safely. Shutdown is via the potential routing (U_S) of the Inline station.

The following LEDs are deactivated:

– IN 1/2 (connector 1)
– IN 1/2 (connector 2)
– US

8.4.1 Approved modules

Only use the approved devices from the table below in the safety-related segment circuit.

Observe the maximum number of devices.

Type (Order No.)	Description	Max. Number
IB IL SAFE 2-ECO (2702446)	Safety module with sensor circuits	7
IB IL 24 DO 4/EF- ECO (2702825)	Digital output module	10

WARNING: Loss of functional safety!

Ensure that errors are prevented for all modules used in the safety-related segment circuit.

Observe the wiring requirements for the safety-related segment circuit.

See “Requirements for the wiring in the safety-related segment circuit” section.

8.4.2 Cascading safety modules

It is possible to cascade several safety modules.

Cascade a maximum of seven safety modules in a safety-related segment circuit.

Refer to the “Application examples” section for this.

8.5 Diagnostics

The status of the safety module is transmitted via the bus system.

Information is also provided via the local diagnostic and status indicators on the front of the module.

See “Local diagnostic and status indicators” section.

9 Function and time diagrams

9.1 Time diagram for automatic start

9.1.1 Continuous autostart

– Permanent high signal at input 3.4

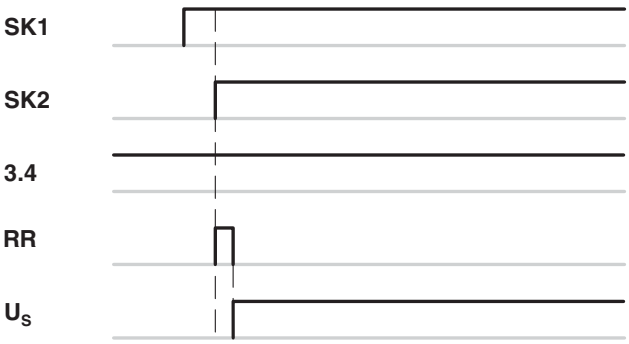


Figure 2 Time diagram for automatic start

9.1.2 Autostart pulse

– Start on rising edge at input 3.4

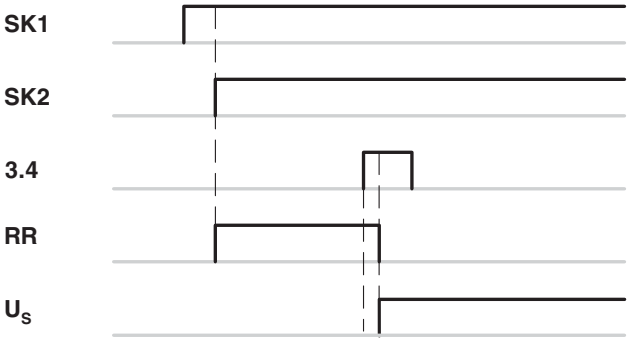


Figure 3 Time diagram for automatic start

9.2 Time diagram for manual, monitored start

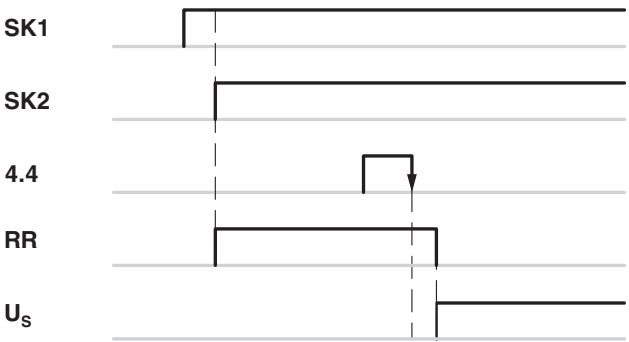


Figure 4 Time diagram for manual, monitored start

Key:

SK1	Sensor circuit 1
SK2	Sensor circuit 2
3.4	Input automatic start
RR	LED for signaling an acknowledgment request
4.4	Input manual, monitored start
U_S	Segment voltage

10 Internal circuit diagram

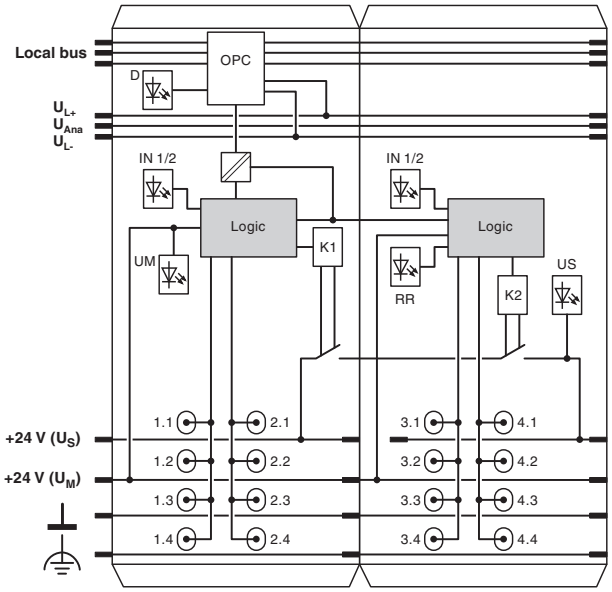


Figure 5 Internal wiring of the terminal points

Key:

Local bus	Data jumpers for the local bus
D, IN1/2, UM, RR, US	Diagnostic and status indicators (LEDs)
U_L	Communications power
U_{ANA}	I/O supply for analog modules
U_S	Segment supply
U_M	Main supply
K1/K2	Internal, force-guided N/O contacts
⊥	Ground (GND for U_M and U_S)
⏚	Functional earth ground
1.1 ... 4.4	Terminal points

11 Derating

11.1 1 device in vertical or horizontal mounting position

The derating curve applies for the following conditions:

– Mounting on a vertical or horizontal DIN rail

– Number of devices: 1 IB IL SAFE 2-ECO at U_M = 30 V DC

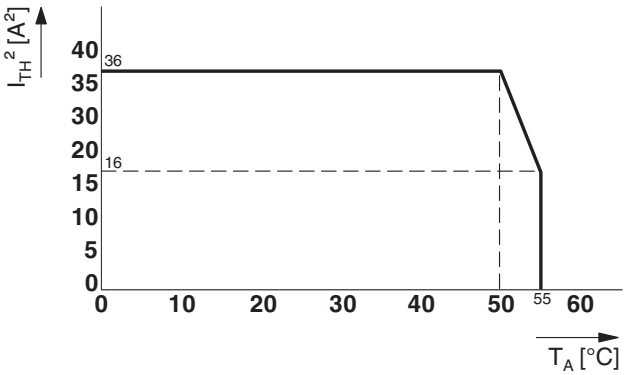


Figure 6 Derating curve - vertical or horizontal mounting position, 1 device

11.2 Several devices in vertical or horizontal mounting position

The derating curve applies for the following conditions:

– Mounting on a vertical or horizontal DIN rail

– Number of devices: max. 7 IB IL SAFE 2-ECO at U_M = 24 V DC

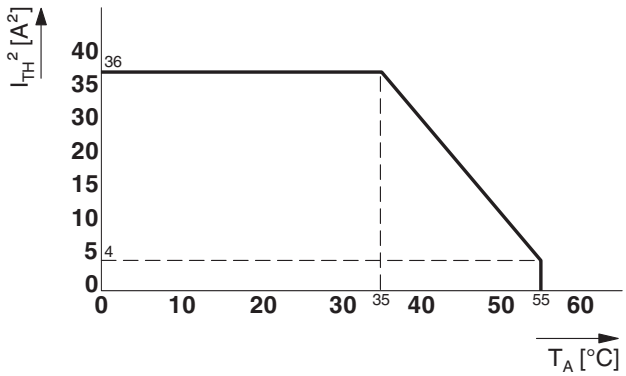
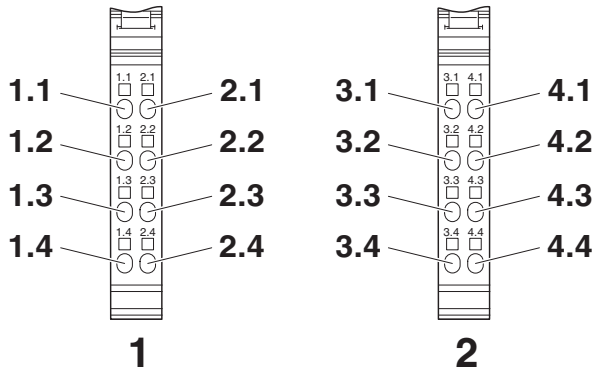


Figure 7 Derating curve - vertical or horizontal mounting position, max. 7 devices

12 Terminal point assignment



1 Left connector
2 Right connector

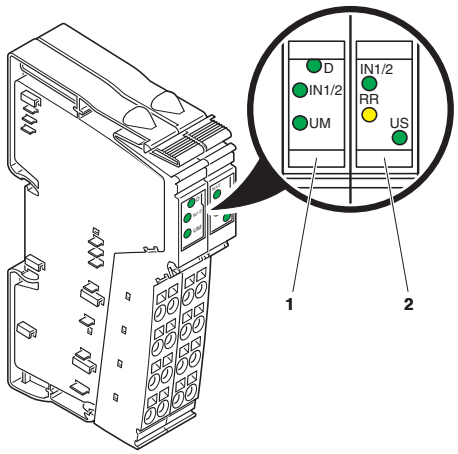
Only use the connectors supplied with the module.

Figure 8 Terminal point assignment

Terminal point	Function	Designation
1.1	Output 24 V DC sensor circuit 1	I/O cable
1.2	Input sensor circuit 1 (channel 1)	
1.3	Input sensor circuit 1 (channel 2)	
1.4	Input supply for start and feedback circuit, Monitoring of external contacts	
2.1	Output 0 V sensor circuit 1	
2.2	Input sensor circuit 1 (channel 1) for equivalent wiring	
2.3	Input sensor circuit 1 (channel 1) for non-equivalent wiring	
2.4	Supply for start circuit	
3.1	Output 24 V DC sensor circuit 2	
3.2	Input sensor circuit 2 (channel 2)	
3.3	Input sensor circuit 2 (channel 1)	
3.4	Input automatic start	I/O cable that is connected directly to the mains
4.1	Output 0 V sensor circuit 2	I/O cable
4.2	Input sensor circuit 2 (channel 2) for equivalent wiring	
4.3	Input sensor circuit 2 (channel 2) for non-equivalent wiring	
4.4	Input manual, monitored start	I/O cable that is connected directly to the mains

For the possible wiring of terminal points, see the “Electrical connection” and “Application examples” sections.

13 Local diagnostic and status indicators



1 Left connector
2 Right connector

The “Diagnostics” section lists the LED indicators for the general states and error messages for the IB IL SAFE 2-ECO safety module.

For additional information on diagnostics in the Inline system, please refer to the IL SYS INST UM E user manual.

Figure 9 Local diagnostic and status indicators

Left connector:

LED	Color	State	Meaning
Diagnostics for local bus communication			
D	Green	ON	Data transmission active within the station
		Flashing slowly (0.5 Hz)	Communications power present, Data transmission not active within the station
		Flashing quickly (4 Hz)	Communications power present, Error at the interface between the previous and flashing module (the modules after the flashing module cannot be addressed)
		OFF	Communications power not present.
Sensor circuit 1			
IN 1/2	Green	ON	Status sensor circuit 1
		OFF	
Main circuit supply			
UM	Green	ON	Main circuit supply present
		OFF	Main circuit supply not present

Right connector:

LED	Color	State	Meaning
Sensor circuit 2			
IN 1/2	Green	ON	Status sensor circuit 2
		OFF	
Acknowledgment request			
RR	Yellow	ON	Acknowledgment request present
		OFF	No acknowledgment request present
Segment circuit supply			
US	Green	ON	Segment circuit supply present
		OFF	Segment circuit supply not present

14 Mounting and removing

The system must only be started when neither the station nor the system can cause any damage.

- Do not assemble or remove the module while the power is connected.
- Before assembling or removing the module, disconnect the power to the module and the entire Inline station and make sure that it cannot be switched on again.
- Make sure the entire system is reassembled before switching the power back on.
- Observe the diagnostic indicators and any diagnostic messages.

14.1 Mounting location

- Mount the device on a 35 mm standard DIN rail in a closed control cabinet or control box (terminal box) with IP54 protection or higher.

14.2 Snap on base

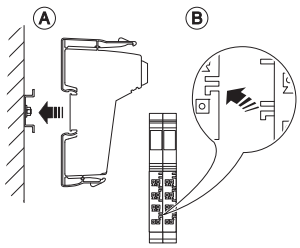


Figure 10 Snap on base

- Before snapping on the base, remove the inserted connectors from the module and the adjacent connector from the neighboring module on the left.
- Snap the base onto the rail (A).
- Make sure that the featherkeys and keyways on the adjacent modules are securely interlocked (B).

14.3 Mount Inline connector

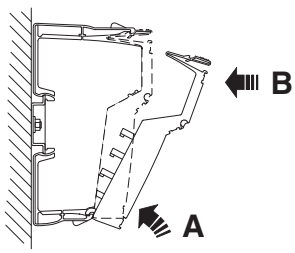


Figure 11 Insert Inline connector

- Insert the connectors in the specified order (A, B).

14.4 Remove Inline connector

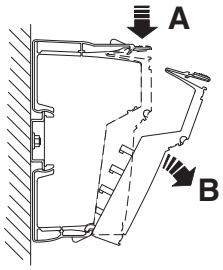


Figure 12 Remove Inline connector

- Remove the connector by pressing the back shaft latching (A) and levering it off (B).

14.5 Remove base

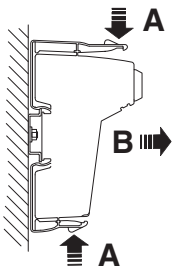


Figure 13 Remove base

- Before removing the base, remove the module connectors and each connector adjacent to the neighboring module (left and right).
- Release the base by pressing on the front and back snap-on mechanisms (A) and pull it out perpendicular to the DIN rail (B).

Assemble the Inline station as specified in the IL SYS INST UM E user manual.

15 Electrical connection

Electrical installation of the Inline station includes the following:

– Connecting the bus system to the Inline station
– Connecting the supply voltages for the Inline station

Perform the electrical installation for the Inline station as specified in the IL SYS INST UM E user manual.

Please also observe the specifications in the documentation for the other devices used.

WARNING: Electric shock/unintentional machine startup

The system may only be started provided the system does not pose a hazard.

- Prior to electrical installation, disconnect the power to the system and make sure that it cannot be switched on again unintentionally.
- Make sure installation has been completed before switching the power back on.

WARNING: Loss of safety function/damage to equipment

Improper installation, e.g., due to the mismatching or polarity reversal of connections, can result in the loss of the safety function as well as damage to equipment.

- Take measures to prevent the mismatching or polarity reversal of connections.
- Prevent the tampering of connections.

15.1 Connecting cables

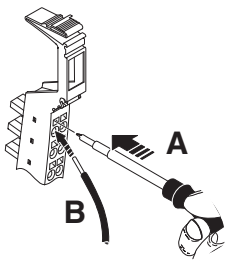


Figure 14 Connecting cables

- Strip 8 mm off the cables.
- Release the spring by pressing with the screwdriver (A).
- Insert the cable into the terminal point (B).
- Secure the cable by removing the screwdriver.

Inline wiring is normally carried out without ferrules. However, it is possible to use ferrules.

If using ferrules, make sure they are properly crimped.

UL note

For compliance with UL approval, use copper wire that is approved for > 75°C.

15.2 Removing the cable

- Trigger the release mechanism with the screwdriver.
- Remove the cable.

15.3 Connecting the supply voltage

The module is supplied with voltage via the potential jumpers of the Inline station.

The module is automatically powered and grounded when it is snapped onto the preconnected module.

- Use one of the following options to provide the supply voltage:
  - Bus coupler
  - Power terminal block
  - Inline controller (ILC 1xx/ILC 3xx)

Suitable power terminals and Inline controllers can be found in the “Ordering data, Accessories” section.

WARNING: Loss of safety function

The use of unsuitable power supplies and the incorrect connection of the power supply can result in the loss of the safety function.

- Only use power supplies according to EN 50178/VDE 0160 (PELV).
- Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.
- Provide external protection for the 24 V areas U_{BK}, U_M, and U_S.
- Make sure that the power supply unit is able to supply four times the nominal current of the external fuse, to ensure that it trips in the event of an error.
- Supply the supply voltages U_M and U_S from the same power supply unit so that parasitic voltages are prevented in the event of an error.

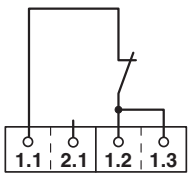
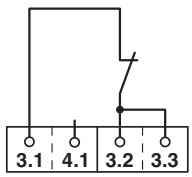
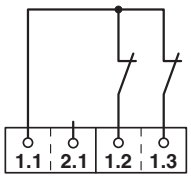
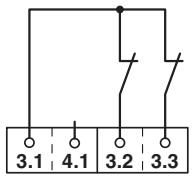
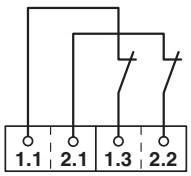
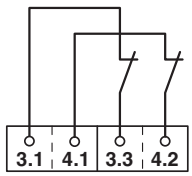
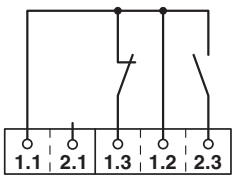
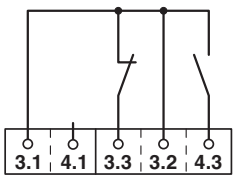
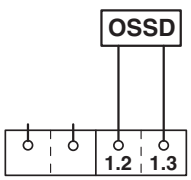
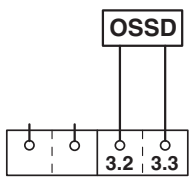
15.4 Connecting the sensor circuits

See “Terminal point assignment” section.

WARNING: Loss of functional safety!

For the non-equivalent connection of the sensor circuits, use only floating, contact-based signal generators (e.g., reed switches, mechanical switches).

The module offers the following options for connecting the sensor circuits.

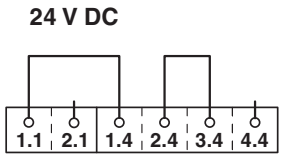
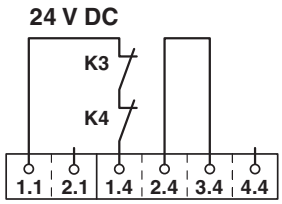
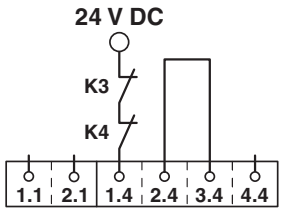
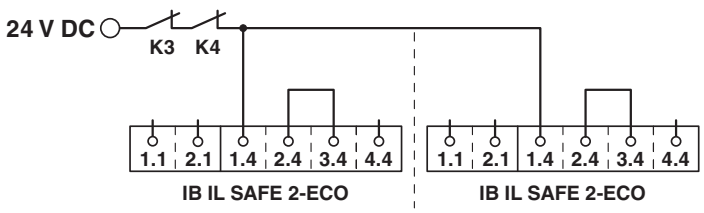
Connection	Terminal point assignment sensor circuit 1	Terminal point assignment sensor circuit 2
Single-Channel		
Equivalent **without** cross-circuit detection		
Equivalent **with** cross-circuit monitoring		
Non-equivalent (for floating signal generators)		
OSSD signals		

15.5 Connecting the start and feedback circuit

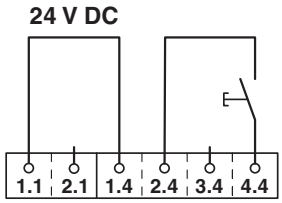
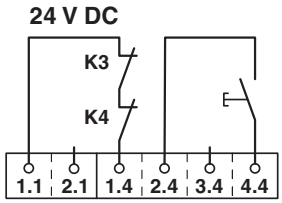
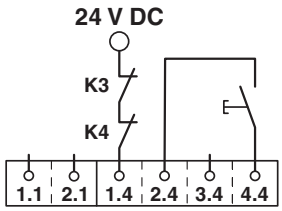
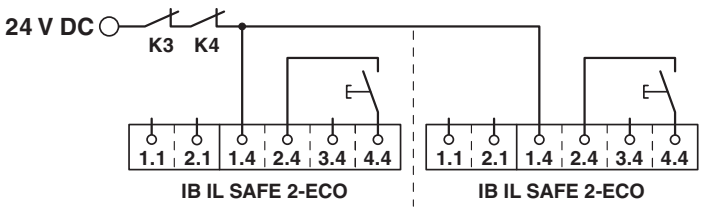
See “Terminal point assignment” section.

The module offers the following options for connecting the start and feedback circuit.

15.5.1 Automatic start

Connection	Terminal point assignment
Automatic start **without** readback of external contacts	
Automatic start **with** readback of external contacts	
Automatic start **with** readback of external contacts external supply	
Automatic start **with** readback of external contacts external supply cascaded modules	

15.5.2 Manual, monitored start

Connection	Terminal point assignment
Manual, monitored start **without** readback of external contacts	
Manual, monitored start **with** readback of external contacts	
Manual, monitored start **with** readback of external contacts external supply	
Manual, monitored start with readback of external contacts external supply cascaded modules	

15.6 Requirements for the wiring in the safety-related segment circuit

WARNING: Loss of safety function in the event of feedback

Feedback of the actuator voltage can result in the loss of the safety function.

- When wiring all Inline modules in safety applications, ensure that errors are prevented in terms of feedback for:
  - All connected cables that supply the device with actuator voltage
  - The connecting cables of the actuators
- Please take all connected loads into consideration.
  - This means, for example, that separate sheathed cables must be used for the cabling.

15.6.1 Requirements for the power supply

- Connect the safety-related segment circuit to the ground of the power supply unit directly after the safety module using only one separate ground cable.
- To connect the ground cable, use terminal point 1.2 or 2.2 of the IB IL 24 DO 4/EF-ECO output module.

In this way the effects of a ground connection interrupt in the Inline jumper are prevented.

15.6.2 Requirements for the connection between DIN rail and PE

WARNING: Loss of safety function on PE interrupt

An interrupt in the connection from the DIN rail to PE can result in the loss of the safety function.

- Ensure that errors are prevented for the connection between DIN rail and PE.
- If you cannot ensure that errors will be prevented, establish an additional, separate connection from the DIN rail to PE.

15.6.3 Requirements for output modules

WARNING: Loss of safety function due to parasitic voltages

Parasitic voltages can result in the loss of the safety function.

- The ground connection of the connected load is only to be connected to the ground connection of the Inline modules.
  This means, for example, that single-conductor connection is not permitted.

15.6.4 Requirements for controlled devices/actuators

- Use suitable actuators/controlled devices which are described in the applicable safety standards, for example.
- Observe the technical data for the output modules in the safety-related segment circuit.
- Dimension the controlled device used such that a leakage current of 2 mA does not cause a hazardous system state.
- Make sure that, even in the event of an error, no external voltage is led via the load to the device outputs (no feedback).

16 Startup

Refer to the following sections and additional documents:
– “Assembly and removal” section
– “Electrical connection” section
– “Application examples” section
– IL SYS INST UM E user manual
– Documentation for the other devices used

When installing, wiring, and starting up the safety module, observe the following points:

1. Install the safety module within the Inline station.
2. Connect the bus system and supply voltage cables to the Inline station.
3. Wire the inputs and outputs according to your application.

Before applying the operating voltage:

4. Make sure that there are no wiring errors (e.g., cross-circuit or short circuit) or grounding errors by testing with a multimeter.
5. Make sure that functional earth ground is connected.

Once the operating voltage has been applied:

6. If possible, measure the waveform of the voltages to make sure that there are no deviations.
7. Test all voltages to make sure that they are in the permissible range.
8. Use the LED indicators to check whether all modules have entered the correct operating state.
9. Check the assembly and installation.

16.1 Restart after triggering a safety function

1. Remove the cause that triggered the safety function.
2. Acknowledge the safety function (e.g., unlock the emergency stop button).

For manual, monitored start:

3. Press the reset button.
4. Release the reset button.

17 Validation

- Check your overall safety application.
- Perform a function test and error simulation.

Carry out a new validation every time you make a safety-related modification.

18 Service and maintenance

The duration of use of the module is 20 years during which it is maintenance-free.

Repeat testing within this time is not required.

Observe the relevant manufacturer specifications for carrying out maintenance on connected I/O devices.

Repair work may not be carried out on the safety module. In the event of an error, send the module to Phoenix Contact.

19 Replacing

When replacing a module, proceed with assembly and removal as described.

Ensure that the new safety module is mounted at the correct position in the local bus. The new module must meet the following requirements:

– Same device type
– Same or later version

After replacing the module, carry out a validation and perform a function test.

20 Calculating the power dissipation

The total power dissipation of the safety module is based on the input power dissipation, the contact power dissipation, and the power dissipation of the module logic.

Input power dissipation

$P_{Input} = U_B^2 / (U_M/I_M)$

Contact power dissipation

$P_{Contact} = I_L^2 \bullet 50\ m\Omega$

Logic power dissipation

$P_{Logic} = 7.5\ V \bullet 35\ mA = 263\ mW$

Total power dissipation

$P_{Total} = P_{Input} + P_{Contact} + P_{Logic}$
therefore
$P_{Total} = U_B^2 / (U_M/I_M) + I_L^2 \bullet 50\ m\Omega + 263\ mW$

Key:

P	Power dissipation in mW
U_B	Applied operating voltage
U_M	Main circuit supply
I_M	Current consumption from U_M
I_L	Contact load current

21 Diagnostics

The following section describes the LED indicators for general states and error messages as well as possible causes and remedies.

Plausibility errors are deleted when the supply voltage is switched off (power down reset).

In the event of an error or fault that is not listed, please contact Phoenix Contact.

21.1 Function test/proof test

To verify the device function, proceed as follows:

- Demand the safety function by actuating the corresponding safety equipment.
- Check whether the safety function was executed correctly by switching the device on again.

If the device does not switch on again, the proof test failed.

WARNING: Loss of functional safety due to malfunction.

If the proof test contains errors, the device no longer functions correctly.

- Replace the device.

21.2 General states

No.	LEDs, left connector		LEDs, right connector			State	Notes
	UM	IN 1/2	IN 1/2	RR	US		
1	ON	OFF	OFF	OFF	OFF	Sensor circuits 1 and 2 inactive Segment circuit open	Possible error see error messages
2	ON	ON	OFF	OFF	OFF	Sensor circuit 1 active Segment circuit open	
3	ON	OFF	ON	OFF	OFF	Sensor circuit 2 active Segment circuit open	
4	ON	ON	ON	ON	OFF	Sensor circuits 1 and 2 active Segment circuit open	Module expects reset/start command.
5	ON	ON	ON	OFF	ON	Sensor circuits 1 and 2 active Segment circuit closed	

21.3 Error Messages

No.	LEDs, left connector		LEDs, right connector			State	Notes	Corrective
	UM	IN 1/2	IN 1/2	RR	US			
1	ON	ON	OFF	OFF	OFF	Sensor circuit 1 active Reset/start circuit activated Segment circuit open	Cross-circuit detection active: possible cross-circuit in sensor circuit 2	Switch off operating voltage Remove cross-circuit Perform function test
2						Sensor circuits 1 and 2 active Reset/start circuit activated Segment circuit open	External error: Plausibility error in sensor circuit 2 Internal error: Diagnostics active	External error: Check affected sensor circuit Internal error: Perform power down reset with subsequent function test
3	ON	OFF	ON	OFF	OFF	Sensor circuit 2 active Reset/start circuit activated Segment circuit open	Cross-circuit detection active: possible cross-circuit in sensor circuit 1	Switch off operating voltage Remove cross-circuit Perform function test
4						Sensor circuits 1 and 2 active Reset/start circuit activated Segment circuit open	External error: Plausibility error in sensor circuit 1 Internal error: Diagnostics active	External error: Check affected sensor circuit Internal error: Perform power down reset with subsequent function test
5	ON	ON	ON	OFF	OFF	Sensor circuits 1 and 2 active Segment circuit open	External error: Plausibility error in sensor circuit 1 or 2 Internal error: Diagnostics active	External error: Check affected sensor circuit
6						Sensor circuits 1 and 2 active Reset/start circuit activated Segment voltage U_S not present	No supply of U_S 1. Upstream cascaded module is not forwarding the voltage. 2. External fuse has blown.	Check segment voltage U_S
7	ON	ON	ON	ON	OFF	Sensor circuits 1 and 2 active Reset/start circuit activated Segment circuit open	External error: Readback contact (external actuator) is open in the reset circuit Internal error: Welded N/O contact	External error: Check actuator Internal error: Perform power down reset with subsequent function test
8							Error during manual reset (stuck-at at the input)	Remove error in reset/start circuit Perform function test

No.	LEDs, left connector		LEDs, right connector			State	Notes	Corrective
	UM	IN 1/2	IN 1/2	RR	US			
9	ON	OFF	OFF	OFF	ON	Sensor circuits 1 and 2 active Segment voltage U_S present	Possible feedback in safe signal path not taken into account	Check wiring for connected actuators
10	OFF	OFF	OFF	OFF	OFF	Sensor circuits 1 and 2 are active	Supply voltage U_M not present	Check supply voltage

22 Process data

Assignment of safety module input data to bus system input data:

(Byte.Bit) view	0.3	0.2	0.1	0.0
Assignment	Segment voltage	Acknowledgment request	Sensor circuit 2	Sensor circuit 1
Status indicator	US	RR	IN 1/2	IN 1/2

23 Programming data/configuration data

Local bus (INTERBUS)		
ID code	BE (hex)	190 (dez)
Length code	41 (hex)	65 (dez)
Process data channel	4 bits	
Input address space	4 bits	
Output address space	0 bit	
Parameter channel (PCP)	0 bit	
Register length (bus)	4 bits	

23.1 Other bus systems or networks

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

24 Application examples

24.1 Example of an Inline station with safety-related segment circuit

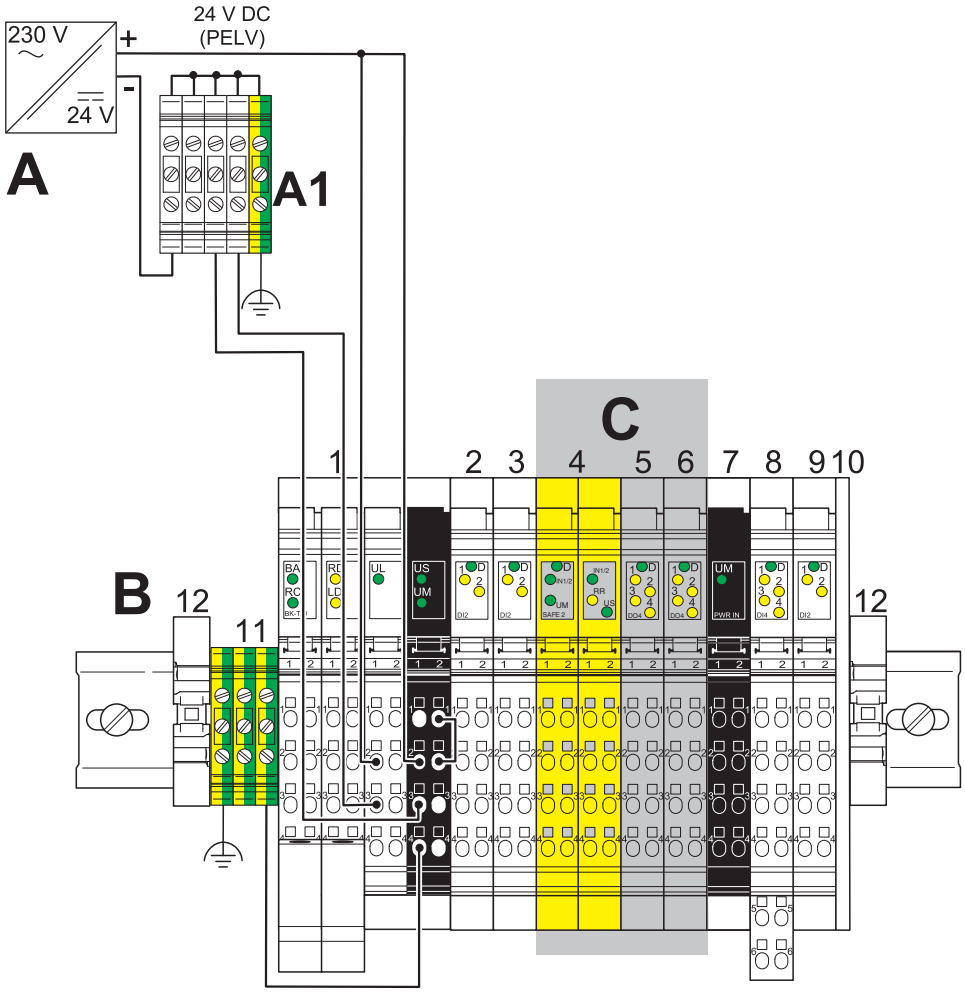


Figure 15 Example of an Inline station with safety-related segment circuit

Key:

A	Power supply unit for supplying the bus coupler and I/O devices
A1	Create this connection as a star point.
B	Inline station with one safety-related circuit and several non-safety-related segment circuits
C	Safety-related segment circuit

No.	Function	Example
1	Bus coupler	IBS IL 24 BK-T/U-PAC
2	Modules corresponding to the application in the non-safety-related segment circuit	IB IL 24 DI 2-PAC
3		IB IL 24 DI 2-PAC
4	Safety module	IB IL SAFE 2-ECO
5	Approved modules for the safety-related segment circuit	IB IL 24 DO 4/EF-ECO
6		IB IL 24 DO 4/EF-ECO
7	Power terminal as termination of the safety-related segment circuit and start of a non-safety-related segment circuit	IB IL 24 PWR IN-PAC
8	Modules corresponding to the application in the non-safety-related segment circuit	IB IL 24 DI 4-PAC
9		IB IL 24 DI 4-PAC
10	End plate as termination of the Inline station	supplied with the bus coupler
11	Grounding terminal blocks (universal ground terminal)	USLKG ... according to the configuration
12	End block	CLIPFIX 35

If the Inline station is not to be continued after the safety-related segment circuit, the end plate (10) must be installed instead of the power terminal (7).

24.2 Note: shutdown time

The shutdown time for the load depends on the number of output modules aligned on the right and on the load switched at one digital output.

After the demand of the safety function, the digital outputs in the safety-related segment circuit should also be shut down by the process data. The shutdown time can be reduced in this way.

24.3 Note: protection of internal relay contacts

In order to protect the contacts, the digital outputs should only be activated when segment voltage U_S is active as a signal.

24.4 Note: wear for mechanically switching actuators

High switching cycles result in wear for the actuators.

For two-channel applications, wear can be reduced by separate switching of the contactors.

Use contactors K3 and K4 for example as follows:

K4: In-application switching cycles and safety shutdown

K3: Safety shutdown only

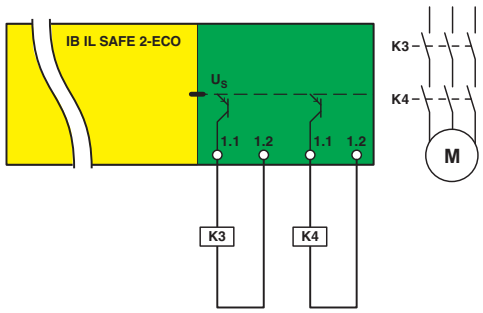


Figure 16 Example: separate switching of the contactors

24.5 Note: safety-related classification of applications with the module

One module offers the option of implementing different safety functions within an overall application. The safety-related classification is achieved for each safety function, which comprises a sensor/logic/actuator group. Depending on the constellation and safety-related suitability of the sensor/logic/actuator components in your overall application, you can achieve various safety integrity levels.

Example for different safety functions and classifications within the overall application:

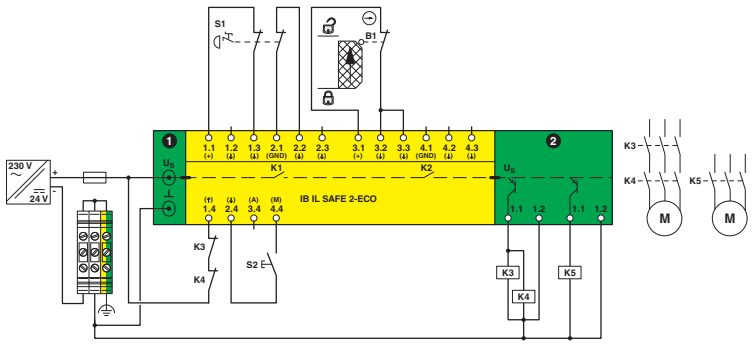


Figure 17 Overall application: two-channel emergency stop monitoring and single-channel safety door monitoring

The illustrated overall application can be grouped in the following safety functions with the corresponding safety-related classifications.

Safety function 1

– Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061)

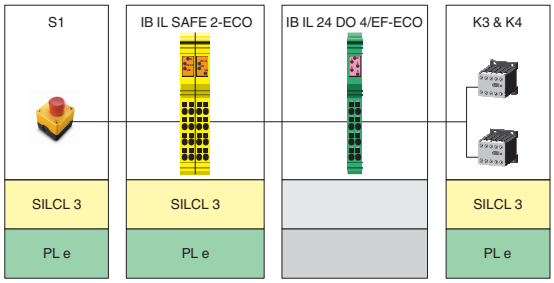


Figure 18 Safety function 1

Safety function 2

– Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)

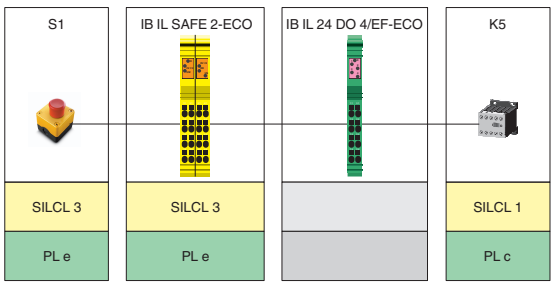


Figure 19 Safety function 2

Safety function 3

– Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)

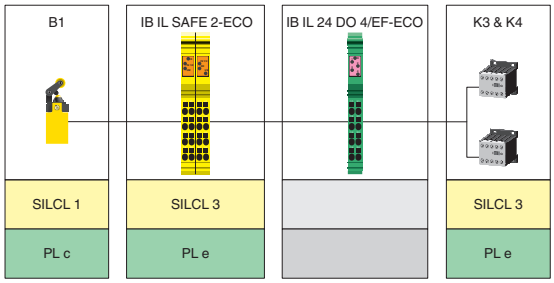


Figure 20 Safety function 3

Safety function 4

– Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)

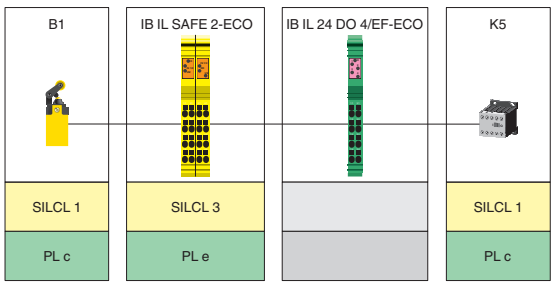


Figure 21 Safety function 4

24.6 Single-channel emergency stop and safety door monitoring

- **Safety function 1:**
  Single-channel emergency stop monitoring at sensor circuit 1
- **Safety function 2:**
  Single-channel safety door monitoring at sensor circuit 2
- Manual, monitored start
- Monitoring of external contactor
- Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061) for safety function 1 and 2

WARNING: Loss of functional safety!

Make sure that the supply voltage for actuator readback and U_S have the same ground potential.

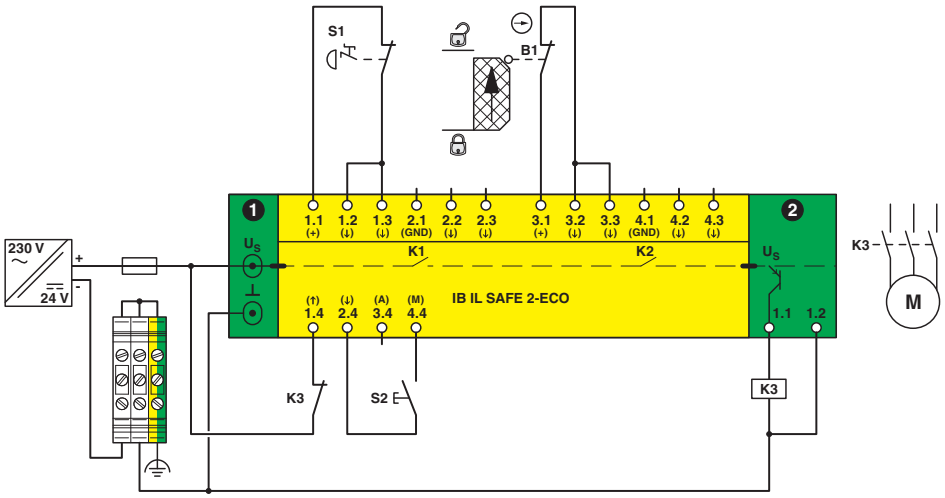


Figure 22 Single-channel emergency stop and safety door monitoring

Key:

S1	Emergency stop button
S2	Manual reset device
B1	Mechanical safety door switch
K1/K2	Internal, force-guided N/O contacts
K3	Contactor
U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

24.7 Two-channel emergency stop and safety door monitoring

- **Safety function 1:**
  Two-channel emergency stop monitoring at sensor circuit 1
- **Safety function 2:**
  Two-channel safety door monitoring at sensor circuit 2
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Fault exclusion required:
  - for cross-circuits in the actuator control
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061) for safety function 1
- Suitable up to category 3, PL d (EN ISO 13849-1), SIL 2 (EN 62061) for safety function 2

WARNING: Loss of functional safety!

Make sure that the supply voltage for actuator readback and U_S have the same ground potential.

Cross-circuits in the cable installation can be ruled out in the same electrical installation space or through mechanically protected cable installation.

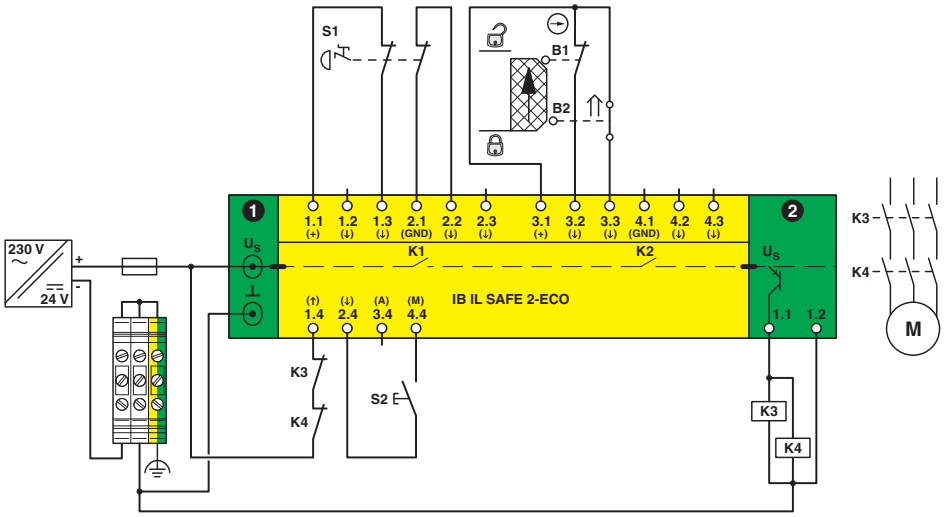


Figure 23 Two-channel emergency stop and safety door monitoring

Key:

S1	Emergency stop button
S2	Manual reset device
B1/B2	Mechanical safety door switches
K1/K2	Internal, force-guided N/O contacts
K3/K4	Force-guided contactors
U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

24.8 Two-channel, non-equivalent magnetic switch monitoring

- **Safety functions 1 and 2:**
  Two-channel, non-equivalent magnetic switch monitoring at sensor circuits 1 and 2
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Fault exclusion required:
  - for cross-circuits in the actuator control
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061) for safety function 1 and 2

WARNING: Loss of functional safety!

Make sure that the supply voltage for actuator readback and U_S have the same ground potential.

WARNING: Loss of functional safety!

For the non-equivalent connection of the sensor circuits, use only floating, contact-based signal generators (e.g., reed switches, mechanical switches).

Cross-circuits in the cable installation can be ruled out in the same electrical installation space or through mechanically protected cable installation.

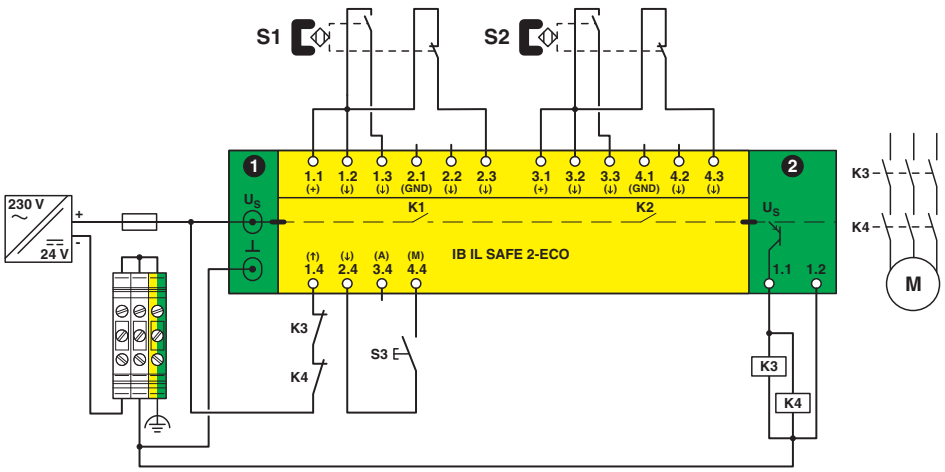


Figure 24 Two-channel, non-equivalent magnetic switch monitoring

Key:

S1/S2	Solenoid switch
S3	Manual reset device
K1/K2	Internal, force-guided N/O contacts
K3/K4	Force-guided contactors
U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

24.9 Cascade: two-channel emergency stop and safety door monitoring

- Cascade with two safety modules and two DO modules
- **Safety functions 1 and 3:**
  Two-channel emergency stop monitoring at sensor circuit 1 of each module
- **Safety functions 2 and 4:**
  Two-channel safety door monitoring at sensor circuit 2 of each module
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Fault exclusion required:
  - for cross-circuits in the actuator control
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061) for all safety functions

WARNING: Loss of functional safety!

Make sure that the supply voltage for actuator readback and U_S have the same ground potential.

Cross-circuits in the cable installation can be ruled out in the same electrical installation space or through mechanically protected cable installation.

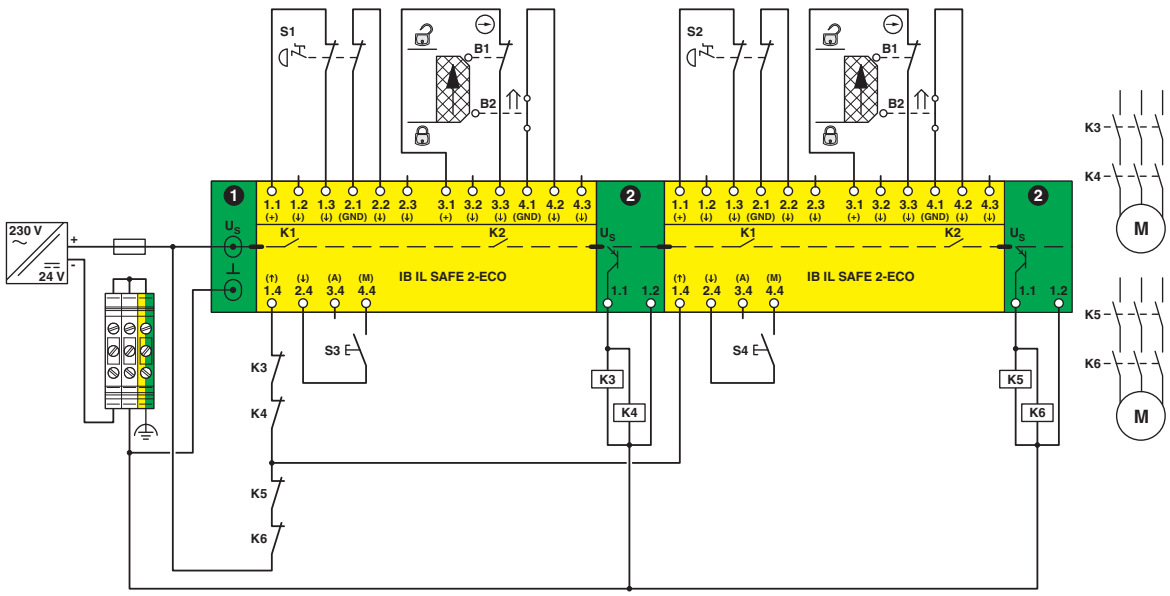


Figure 25 Cascade: two-channel emergency stop and safety door monitoring

Key:

S1/S2	Emergency stop button
S3/S4	Manual reset device
B1/B2	Mechanical safety door switches
K1/K2	Internal, force-guided N/O contacts
K3 ... K6	Force-guided contactors
U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

24.9.1 Notes regarding the application example

If you want to cascade safety modules, as shown in application example 24.9 (Figure 25), refer to the following connection note.

Readback of external contacts

- Perform readback of external contacts in series for the first safety module of the cascade.

WARNING: Loss of safety function due to restricted error detection

When the readback of external contacts is performed in a parallel circuit, the safety modules do not detect all errors.

- Do **not** perform the readback of external contacts in parallel; this should always be done in series.

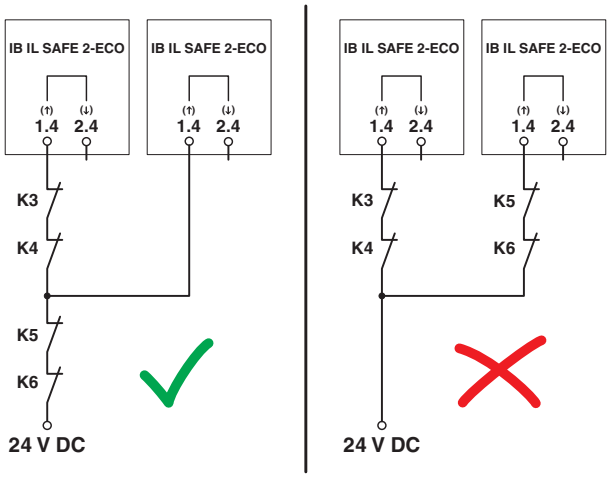


Figure 26 Readback of external contacts when cascading two safety modules

Explanation of the figure

Left:	Correct readback
Right:	**Incorrect** readback

Decouple start release

- Tap the start circuit of a module after the relevant assigned, monitored contacts.

This will decouple the start release of the cascaded modules. Otherwise, there will be a dependency between the start release of the individual modules.

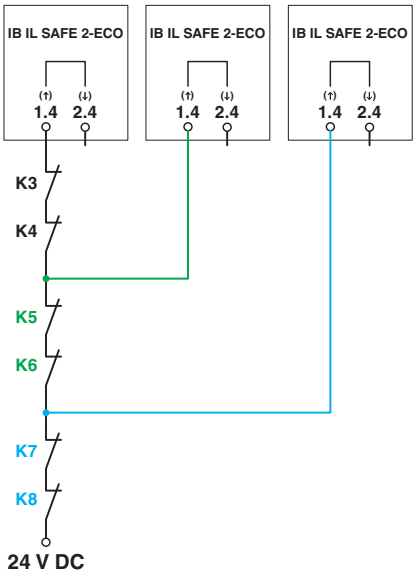


Figure 27 Decouple start release when cascading safety modules

Explanation of the figure

Green:	Tap start circuit module 2 after K5/K6
Blue:	Tap start circuit module 3 after K7/K8

24.10 Cascade: two-channel emergency stop and light grid monitoring

- Cascade: two-channel emergency stop and light grid monitoring
- **Safety functions 1 and 2:**
  Two-channel emergency stop monitoring at sensor circuits 1 and 2 of the first module
- **Safety functions 3 and 4:**
  Two-channel light grid monitoring at sensor circuits 1 and 2 of the second module
- Monitoring of external, force-guided contactors
- Cross-circuit detection via light grid
- Fault exclusion required:
  - for cross-circuits in the actuator control
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061) for all safety functions

WARNING: Loss of functional safety!

Make sure that the supply voltage for actuator readback and U_S have the same ground potential.

Make sure that the signal generator and U_S have the same ground potential.

WARNING: Loss of functional safety!

Demand on light grid type 4:

- Make sure that the ground loss of the leakage current is under 2 mA and the voltage does not exceed 5 V.

Cross-circuits in the cable installation can be ruled out in the same electrical installation space or through mechanically protected cable installation.

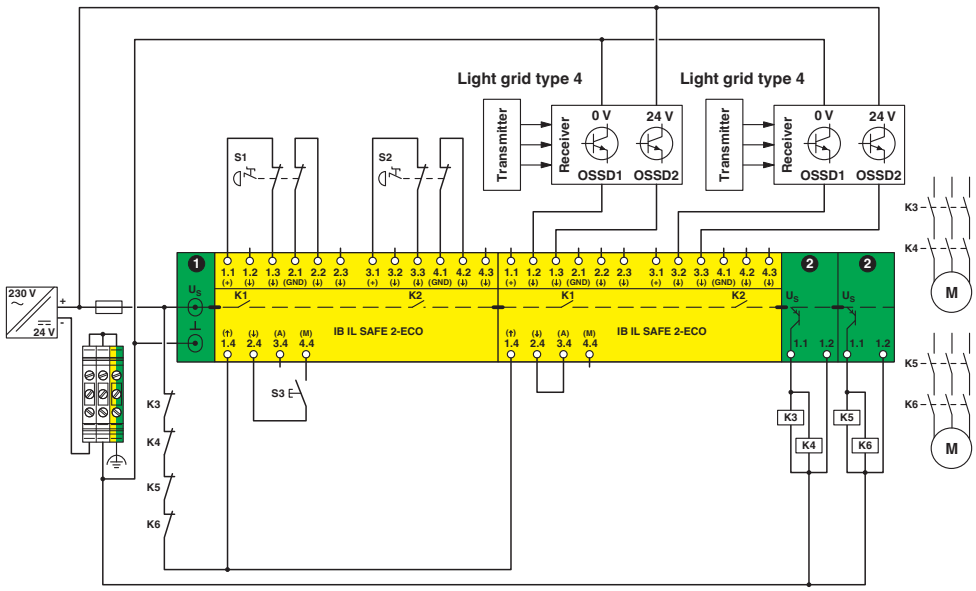


Figure 28 Cascade: two-channel emergency stop and light grid monitoring

Key:

S1/S2	Emergency stop button
S3	Manual reset device
K1/K2	Internal, force-guided N/O contacts
K3 ... K6	Force-guided contactors

U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

24.11 Control of a frequency inverter

- **Safety functions 1 and 2:**
  Two-channel emergency stop monitoring at sensor circuits 1 and 2 of the first module
- Control of a Cat. 4 compatible FI with safety-related diagnostics
- Fault exclusion required:
  - for feedback through the actuator
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061) for safety function 1 and 2

WARNING: Loss of functional safety!

The safety characteristics of the FI restrict the achievable safety integrity of the application.

Use a FI that is suitable for category 4, PL e (EN ISO 13849-1) and performs safety-related diagnostics.

WARNING: Loss of functional safety!

Make sure that the supply voltage for the start and feedback circuit and U_S have the same ground potential.

Note for additional actuators in this application

If feedback cannot be eliminated by the FI, use a suitable PSR-FTB/... filter terminal block (Order No. 2904476, 2904477) before the FI to protect the additional actuators from the feedback.

The application with additional actuators and the filter terminal block is suitable up to category 3, PL c (EN ISO 13849-1), SIL 3 (EN 62061).

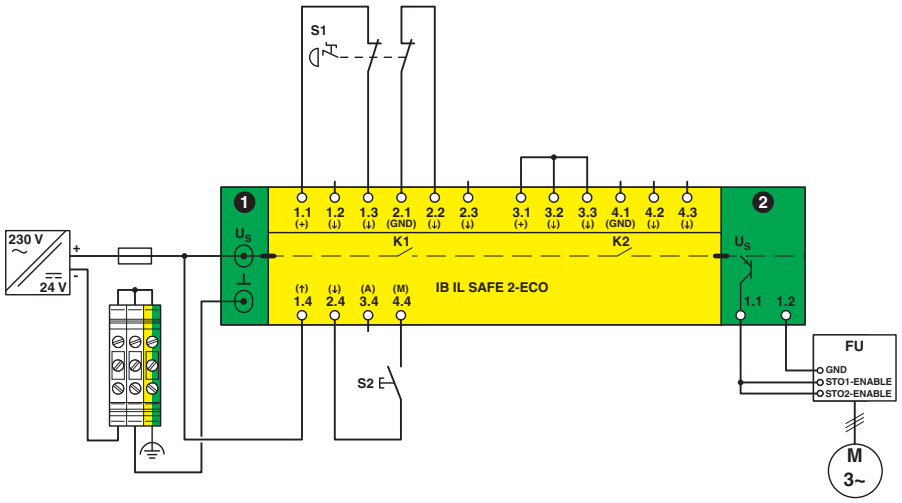


Figure 29 Control of a frequency inverter

Key:

S1	Emergency stop button
S2	Manual reset device
K1/K2	Internal, force-guided N/O contacts
FU	Frequency inverter
U_S	Segment voltage
	Functional earth ground
❶	Bus coupler/power terminal/Inline PLC
❷	Approved module for the safety-related segment circuit

25 Attachment

25.1 Use at altitudes greater than 2000 m above sea level

This section describes the conditions for using safe Inline I/O modules at altitudes greater than 2000 m above sea level up to a maximum of 4500 m above sea level.

Observe the relevant data (technical data, derating, etc.) that is specific to the module being used. Refer to the data in the respective user documentation for the module.

25.1.1 Conditions

The use of the module at altitudes **greater than 2000 m above sea level up to a maximum of 4500 m above sea level** is possible under the following conditions:

1. Determine the maximum ambient temperature for operation with the corresponding factor in accordance with the table below.
2. If derating is specified, offset all the derating points by the corresponding factor in accordance with the table below.

Altitude above sea level	Temperature derating factor
2000 m	1
2500 m	0.953
3000 m	0.906
3500 m	0.859
4000 m	0.813
4500 m	0.766

For relay outputs:

3. Limit the maximum switching voltage for relay outputs in accordance with the table below. Observe the technical data for the module.

Max. switching voltage according to the technical data for the device	Max. switching voltage when used at altitudes greater than 2000 m above sea level
< 150 V AC/DC	Max. switching voltage according to the technical data for the device still valid
> 150 V AC/DC	Limited to max. 150 V AC/DC

25.1.2 Example calculation

The following calculation is an example for using a safe Inline I/O module at an altitude of 3000 m above sea level. Perform the actual calculation for the module used according to the technical data from the user documentation for the module.

Data in the “Technical data and ordering data” section (example):

Derating	up to 50°C total current of all outputs 6 A, maximum up to 55°C total current of all outputs 4 A, maximum

Calculation:

50°C • 0.906 ≈ 45°C
55°C • 0.906 ≈ 50°C

Reduced derating:

Derating at 3000 m above sea level	up to **45°C** total current of all outputs 6 A, maximum up to **50°C** total current of all outputs 4 A, maximum

25.2 Revision history

Version	Date	Contents
00	2017-02-15	First publication