

ESR5-NO-31-UC

Safety relay

for emergency stop, safety door

and light grid monitoring with wide range input

PL
EN ISO 13849

SIL
IEC 62061



EATON

Powering Business Worldwide

All brand and product names are trademarks or registered trademarks of their respective owners.

Service

For service and support, please contact your local sales organization.

[Eaton.com/contacts](https://www.eaton.com/contacts)

[Eaton.com/aftersales](https://www.eaton.com/aftersales)

Original operating manual

The German-language edition of this document is the original operating manual.

Translation of the original operating manual

All editions of this document other than those in German language are translations of the original operating manual.

3rd Edition 2025, publication date 11/25

See revision protocol in the chapter "About this manual".

© 2017 by Eaton Industries GmbH, 53105 Bonn, Germany

All rights, including those of translation, reserved.

No part of this manual may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, micro-filming, recording, or otherwise, without the prior written permission of Eaton Industries GmbH, Bonn, Germany.

Subject to alteration.



Danger! **Dangerous electrical voltage!**

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally restarted.
- Verify isolation from the supply.
- Earth and short circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (AWA/IL) of the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalisation. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O interface so that a line or wire breakage on the signal side does not result in undefined states in the automation devices.
- Ensure a reliable electrical isolation of the low voltage for the 24 volt supply. Only use power supply units complying with IEC 60364-4-41 (VDE 0100 Part 410) or HD 384.4.41 S2.
- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specifications, otherwise this may cause malfunction and dangerous operation.
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency-stop devices must not cause restart.
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been installed with the housing closed. Desktop or portable units must only be operated and controlled in enclosed housings.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency-stop devices should be implemented.
- Wherever faults in the automation system may cause damage to persons or property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks etc.).

Table of Contents

0.1	List of revisions	3
0.2	Target group.....	3
0.3	Additional documents	3
1	Description.....	5
1.1	Approvals	6
2	Technical data	7
3	Safety regulations and installation notes.....	11
4	Function description	13
4.1	Single-channel sensor circuit.....	13
4.2	Two-channel sensor circuit	13
4.3	Automatic start.....	13
4.4	Manual, monitored start.....	13
4.5	Safe shutdown	13
5	Function and time diagrams	14
5.1	Time diagram for automatic start	14
5.2	Time diagram for manual, monitored start.....	14
5.3	Time diagram for non-equivalent wiring.....	15
6	Basic circuit diagram	16
6.1	Insulation coordination	17
7	Derating	18
7.1	Horizontal mounting position	18
7.2	Horizontal mounting position with spacing	18
7.3	Vertical mounting position.....	19
8	Load curve	20
8.1	Ohmic load.....	20
9	Operating and indication elements.....	21
9.1	Connection version	21
9.2	Connection assignment	21
10	Mounting and removing.....	22

11	Wiring	23
11.1	Signal generator connection versions	23
11.2	Start and feedback circuit connection variants	24
12	Start-up.....	25
13	Calculating the power dissipation	26
14	Diagnostics	27
14.1	General states.....	27
14.2	Error messages.....	28
15	Application examples	29
15.1	Emergency stop monitoring/automatic start/ with cross-circuits detection in the input circuit	29
15.2	Emergency stop monitoring / automatic start / without cross-circuit detection.....	30
15.3	Emergency stop monitoring/manual, monitored start/with cross- circuit detection in the input circuit.....	31
15.4	Emergency stop monitoring / manual, monitored start / without cross-circuit detection.....	32
15.5	Single-channel emergency stop monitoring.....	33
15.6	Magnetic switch monitoring/automatic start	34
15.7	Magnetic switch monitoring/manual, monitored start	35
15.8	Light grid monitoring/manual, monitored start.....	36
16	Attachment.....	37
16.1	Using at altitudes greater than 2000 m above sea level	37
17	Glossary	39

0 About This Manual

This manual applies to the ESR5-NO-31-UC safety relay.

0.1 List of revisions

The following significant amendments have been introduced since previous issues:

Publica- tion date	Page	Keyword	new	modified	deleted
09/17		First edition	–	–	–
04/20		Corrections	–	✓	–
11/25	5, 10	Re-certification EN IEC 62061 SII, CLaim Limit removed	–	–	✓

0.2 Target group

This manual is intended for qualified personnel installing, operating, and maintaining the ESR5-NO-31-UC safety relay.



CAUTION

Installation requires a qualified electrician

0.3 Additional documents

For further information, see the following documentation:

- Instruction leaflet IL049009ML
- Safety relay data sheet ESR5-NO-31-UC, article no.191796

WARNING

Make sure you always use the latest documentation.
It can be downloaded from the product at: www.eaton.com/esr5

0.4 Abbreviations and symbols

The symbols used in this manual have the following meanings:

▶ indicates actions to be taken.

0.4.1 Risk of material damage

CAUTION

Warns about the possibility of material damage.

0.4.2 Hazard warnings of personal injury



CAUTION

Warns of the possibility of hazardous situations that may possibly cause slight injury.



WARNING

Warns of the possibility of hazardous situations that could result in serious injury or even death.



DANGER

Warns of hazardous situations that result in serious injury or death.

0.4.3 Tips



Indicates useful tips.

1 Description

Intended Use

The safety relay is used to monitor single or two-channel signal generators and to control actuators.

When the sensor circuit is interrupted, the safety relay initiates the safe state.

The safety relay interrupts circuits in a safety-related way.

Possible signal generators

- Emergency stop button
- Door locking mechanisms
- Light grids

Contact type

- 3 undelayed enabling current paths
- 1 undelayed enabling current path

The enabling current paths drop 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), SIL 3 (EN 62061)

Additional features

- 24V AC/DC...230 V AC/DC wide range input
- Cross circuiting detection
- Option of screw or spring-cage terminal blocks for plug-in
- 22,5 mm housing width

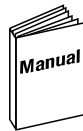
1.1 Approvals



WARNING

RISK OF ELECTRIC SHOCK!

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



NOTICE

Make sure you always use the latest documentation. It can be downloaded from the product at www.eaton.com/esr5.

2 Technical data

Hardware/firmware version	
HW/FW	> 00/--
The technical data and safety characteristics are valid as of the specified HW/FW version.	
Input data	
Nominal input voltage U_N	24 V AC/DC ... 230 V AC/DC -15 % / +10 %
Input current	typ. 103 mA (24 V DC) typ. 47 mA (48 V DC) typ. 38 mA (110 V AC) typ. 21 mA (230 V AC)
Input voltage range "0" signal	0 V DC ... 5 V DC (for safe Off; to S10/S12/S13)
Input current range "0" signal	0 mA ... 2 mA (for safe Off; to S10/S12/S13)
Inrush current	< 80 A ($\Delta t = 50 \mu s$ at U_N) < 5 mA (at U_N/I_x to S10/S12/S13) > -5 mA (at U_N/I_x to S22) < 10 mA (at U_N/I_x to S34/S35)
Current consumption	< 5 mA (at U_N/I_x to S10/S12/S13/S34/S35) > -5 mA (at U_N/I_x to S22)
Power consumption at U_N	2,7 W (at DC) 2,9 W (at AC)
Apparent power	typ. 5 VA (at U_N)
Voltage at input/start and feedback circuit	24 V DC -20 % / +25 %
Filter time	2 ms (at A1 in the event of voltage dips at U_N) max. 1,5 ms (to S10-S12; test pulse width; at 24 V DC) 7,5 ms (to S10-S12; test pulse rate; at 24 V DC) test pulse rate = 5 x test pulse width
Max. permissible overall conductor resistance (Input and reset circuit at U_N)	150 Ω
Typical response time at U_N	< 100 ms (manual, monitored start) < 150 ms (automatic start)
Typical starting time at U_N	< 200 ms (at controlled via A1)
Typical release time at U_N	< 20 ms (at controlled via sensor circuit)
Recovery time	< 500 ms
Restart time	< 1 s
Maximum switching frequency	1 Hz
Concurrence input 1/2	∞
Operating voltage display	1 x green LED
Status display	3 x green LED
Protective circuit	U_N : surge protection 275 V varistor / 411 V suppressor diode Inputs: protection against polarity reversal, surge protection 38.6 V suppressor diode

Output data	
Contact type	3 enabling current paths 1 signaling current path
Contact material	AgSnO ₂
Minimum switching voltage	5 V AC/DC
Maximum switching voltage	250 V AC/DC (Note the load curve)
Limiting continuous current	6 A
Maximum inrush current	6 A
Inrush current, minimum	10 mA
Sq. Total current $I_{TH}^2 = I_1^2 + I_2^2 + \dots + I_N^2$	72 A ² (observe derating)
Interrupting rating (ohmic load) max.	1500 VA (N/O contact, 250 V AC, $\tau = 0$ ms) For additional values → Section 8, „Load curve“, page20
Maximum interrupting rating (inductive load)	48 W (N/O contact, 24 V DC, $\tau = 40$ ms) 40 W (N/O contact, 48 V DC, $\tau = 40$ ms) 36 W (N/O contact, 60 V DC, $\tau = 40$ ms) 35 W (N/O contact, 110 V DC, $\tau = 40$ ms) 33 W (N/O contact, 220 V DC, $\tau = 40$ ms) 1500 VA (N/O contact, 250 V AC, $\tau = 40$ ms)
Switching capacity	min. 50 mW
Mechanical service life	10 x 10 ⁶ cycles
Switching capacity according to IEC 60947-5-1	5 A (24 V (DC13)) 5 A (250 V (AC15))
Output fuse	6 A gL/gG 4 A gL/gG (for Low-Demand-Applications)

General data	
Relay type	Electromechanical relay with forcibly guided contacts according to EN 50205
Dimensions W x H x D	22,5 x 112,2 x 114,5 mm
Nominal operating mode	100 % ED
Degree of protection	IP20
Min. degree of protection of inst. location	IP54
Mounting type	DIN rail mounting
Mounting position	vertical or horizontal
Assembly instructions	→ Section 7, „Derating“, page18
Type of housing	PBT yellow
Air clearances and creepage distances between the power circuits	according to DIN EN 50178; EN 60947-5-1
Rated insulation voltage	250 V AC
Rated surge voltage/insulation	Basic insulation 4 kV between enabling current path (23/24) and enabling current path (33/34) and signaling current path (41/42) Basic insulation 4 kV between all current paths and housing Safe isolation, reinforced insulation 6 kV between all other circuits → Section 6.1, „Insulation coordination“, page17
Degree of pollution	2
Overvoltage category	III
Maximum power dissipation for nominal condition	17,3 W (bei $I_L^2 = 72 \text{ A}^2$)
Note on power dissipation	→ Section 13, „Calculating the power dissipation“, page26

Connection data	Screw connection
Conductor cross section, solid	0,2 mm ² ... 2,5 mm ²
Conductor cross section, flexible	0,2 mm ² ... 2,5 mm ²
Conductor cross section AWG/kcmil	24 ... 12
Stripping length	7 mm
Screw thread	M3

Ambient conditions	
Ambient temperature (operation)	-40 °C ... 55 °C (observe derating)
Ambient temperature (storage/transport)	-40 °C ... 85 °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)
Maximum altitude	≤ 2000 m (Above sea level)
Information on operating height	→ Section 16.1, „Using at altitudes greater than 2000 m above sea level“, page37
Shock	15g
Vibration (operation)	10 Hz ... 150 Hz, 2g

Conformance/Approvals

Conformance	CE-compliant
-------------	--------------

The full EC Declaration of Conformity can be downloaded for the product at www.eaton.com/esr5.

Approvals



Safety data

Stop category according to IEC 60204-1	0
--	---

Safety parameters for IEC 61508 - High Demand

SIL	3
-----	---

PFHD	$1,00 \times 10^{-9}$ 1/h (5 A DC13; 5 A AC15; 8760 switching cycles/year)
------	--

Demand rate	< 12 Months
-------------	-------------

Proof test intervall	240 Months
----------------------	------------

Duration of use	240 Months
-----------------	------------

Safety parameters for IEC 61508 - Low Demand

SIL	3
-----	---

PFDavg	$1,49 \times 10^{-4}$
--------	-----------------------

Proof test intervall	56 Months
----------------------	-----------

Duration of use	240 Months
-----------------	------------

Safety characteristic data according to EN ISO 13849

Category	4
----------	---

Performance Level	e (5 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

SIL	3
-----	---

3 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.

Power supply units for power supply

- Provide external protection for the input area (A1/A2).
- 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.

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.

4 Function description

4.1 Single-channel sensor circuit

The sensor circuit is not designed with redundancy.

The safety relay does not detect short and cross-circuits in the sensor circuit.

4.2 Two-channel sensor circuit

The sensor circuit is designed with redundancy.

With the corresponding wiring, the safety relay detects short and cross-circuits in the sensor circuit.

4.3 Automatic start

The device starts automatically after the sensor circuit has been closed.

4.4 Manual, monitored start

When the sensor circuit is closed, the device starts once the start circuit has been closed and opened again by pressing and releasing the reset button.

A connected reset button is monitored.

4.5 Safe shutdown

When the sensor circuit opens, the enabling current paths open without delay.

When the enabling current paths are open, the device is in the safe state.

The signaling current path closes.

5 Function and time diagrams

5.1 Time diagram for automatic start

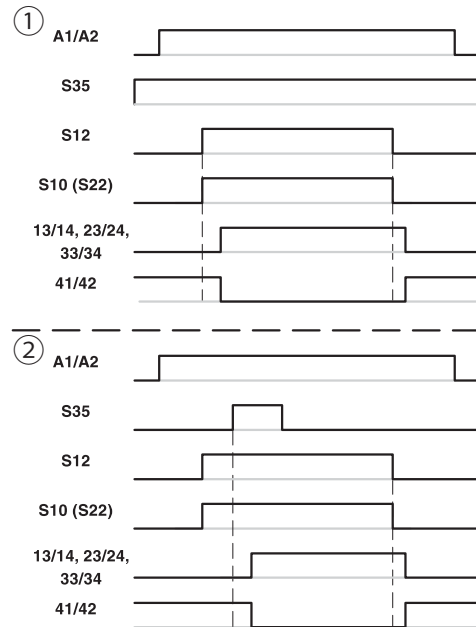


Figure 1: Time diagram for automatic start

5.2 Time diagram for manual, monitored start

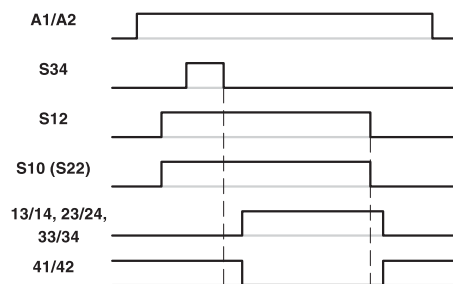


Figure 2: Time diagram for manual, monitored start

5.3 Time diagram for non-equivalent wiring

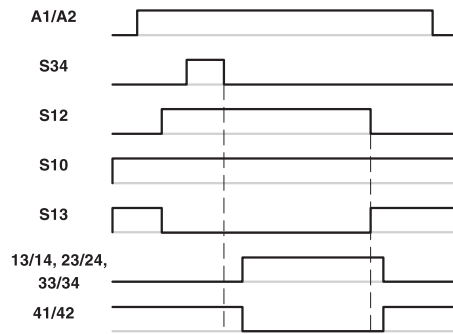


Figure 3: Time diagram for non-equivalent wiring (manual, monitored start)

Key:

①	Automatic start
②	Start via external signal at S35 which is not monitored
A1/A2	Power supply
S34	Manual, monitored start
S35	Automatic start
S10	Input sensor circuit (channel 2) for equivalent wiring without cross-circuit detection
S11	Output 24 V
S12	Input sensor circuit (channel 1)
S13	Input sensor circuit (channel 2) for non-equivalent wiring
S21	Output 0 V
S22	Input sensor circuit (channel 2) for equivalent wiring with cross-circuit detection
13/14, 23/24, 33/34	Undelayed enabling current paths
41/42	Signaling current path, undelayed

6 Basic circuit diagram

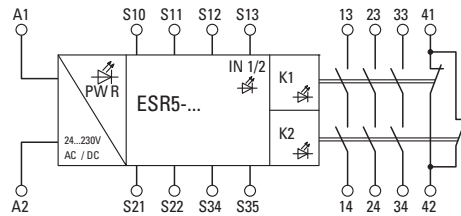


Figure 4: Block diagram

Key:

A1	24 V AC/DC ... 230 V AC/DC power supply (L)
A2	Power supply (N)
S10	Input sensor circuit (channel 2) for equivalent wiring without cross-circuit detection
S11	Output 24 V
S12	Input sensor circuit (channel 1)
S13	Input sensor circuit (channel 2) for non-equivalent wiring
S21	Output 0 V
S22	Input sensor circuit (channel 2) for equivalent wiring with cross-circuit detection
S34	Manual, monitored start
S35	Automatic start
13/14	Undelayed enabling current paths
23/24	
33/34	
41/42	Signaling current path, undelayed

6.1 Insolation coordination

	A1/A2	Logik	13/14	23/24	33/34	41/42
A1/A2	-	6 kV ST	6 kV ST	6 kV ST	6 kV ST	6 kV ST
Logik	-	-	6 kV ST	6 kV ST	6 kV ST	6 kV ST
13/14	-	-	-	6 kV ST	6 kV ST	6 kV ST
23/24	-	-	-	-	4 kV BI	4 kV BI
33/34	-	-	-	-	-	4 kV BI
41/42	-	-	-	-	-	-

Key:

BI	Basic insulation
ST	Safe isolation

i

BASIC ISULATION

(rated surge voltage of 4 kV)

A mixture of SELV and PELV is strictly prohibited. Only switch 230 V AC at one of the enable contacts if the adjacent contact carries the same potential.

Safe isolation/reinforced insulation

(rated surge voltage of 6 kV)

Reinforced insulation (e.g., thanks to greater air clearances and creepage distances between conductive paths) is designed for one overvoltage category higher than basic insulation. This means that SELV circuits of U ? 25 V AC or U ? 60 V DC and circuits with higher voltages can be mixed.

7 Derating

7.1 Horizontal mounting position

The derating curve applies for the following conditions:

- Mounting on a horizontal DIN rail
- Devices mounted next to each other without spacing

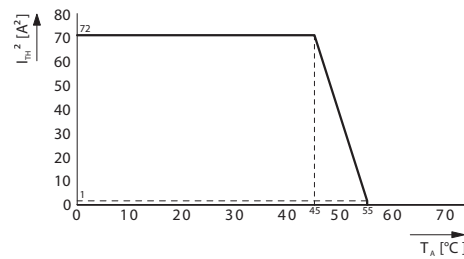


Figure 5: Derating curve - horizontal mounting position, without spacing

7.2 Horizontal mounting position with spacing



If the devices are mounted in the horizontal mounting position with ≥ 9 mm spacing between one another, no derating is required up to 60 °C.

7.3 Vertical mounting position

The derating curve applies for the following conditions:

- Mounting on a vertical DIN rail
- Devices mounted next to each other without spacing

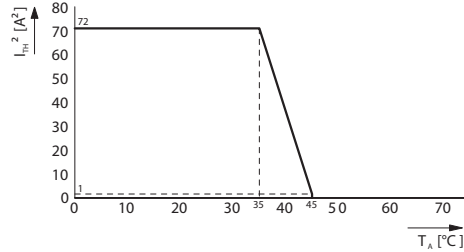


Figure 6: Derating curve - vertical mounting position, without spacing

7.3.1 Vertical mounting position with spacing

The derating curve applies for the following conditions:

- Mounting on a vertical DIN rail
- Devices mounted next to each other with ≥ 9 mm spacing

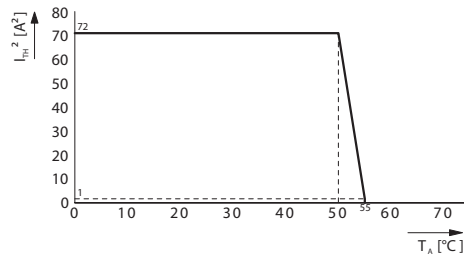


Figure 7: Derating-Kurve - vertical mounting position, without spacing

8 Load curve

8.1 Ohmic load

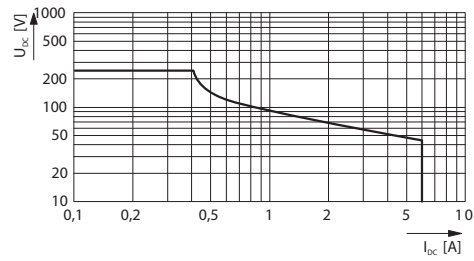


Figure 8: Relay load curve - ohmic load

9 Operating and indication elements

9.1 Connection version

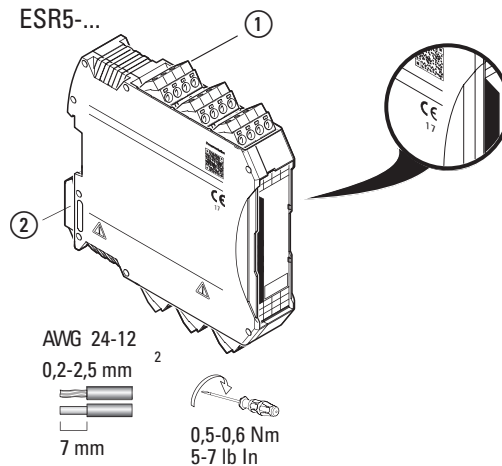


Figure 9: Connection version

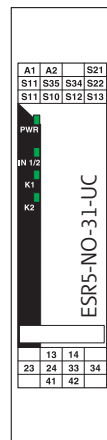
Key:

- ① COMBICON plug-in screw terminal block
- ② Metal lock for fixing to DIN rail



The year the device was constructed can be found underneath the CE designation on the housing.

9.2 Connection assignment



A1	24 V AC/DC ... 230 V AC/DC power supply (L)
A2	Power supply (N)
S21	Output 0 V
S11	Output 24 V
S35	Automatic start
S34	Manual, monitored start
S22	Input sensor circuit (channel 2) for equivalent wiring with cross-circuit detection
S10	Input sensor circuit (channel 2) for equivalent wiring without cross-circuit detection
S12	Input sensor circuit (channel 1)
S13	Input sensor circuit (channel 2) for non-equivalent wiring
PWR	Power LED (green)
IN1/2	Status indicator sensor circuit; LED (green)
K1	Status indicator safety circuit; LED (green)
K2	Status indicator safety circuit; LED (green)
41/42	Signaling current path, undelayed
13/14	Undelayed enabling current paths
23/24	
33/34	

10 Mounting and removing

- Mount the device on a 35 mm DIN rail according to EN 60715.
- To remove the device, use a screwdriver to release the snap-on foot.

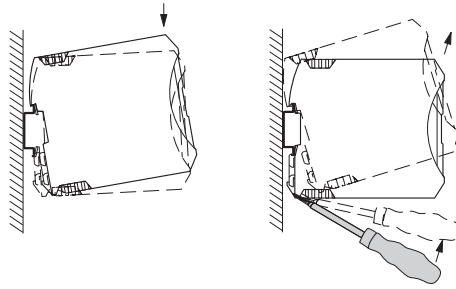


Figure 10: Mounting and removing

11 Wiring

- ▶ Connect the cables to the connection terminal blocks using a screwdriver.

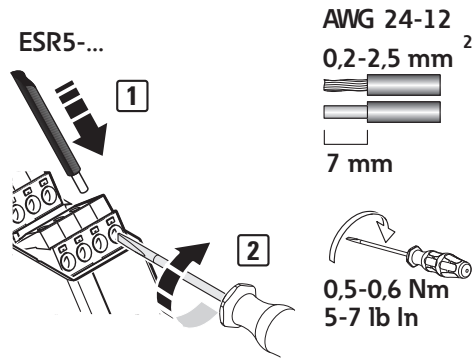


Figure 11: Connecting the cables



It is recommended that ferrules are used to connect stranded cables.



For compliance with UL approval, use copper wire that is approved up to 60 °C/75 °C.

11.1 Signal generator connection versions

- ▶ Connect suitable signal generators to S10/S11/S12/S13 and S21/S22.

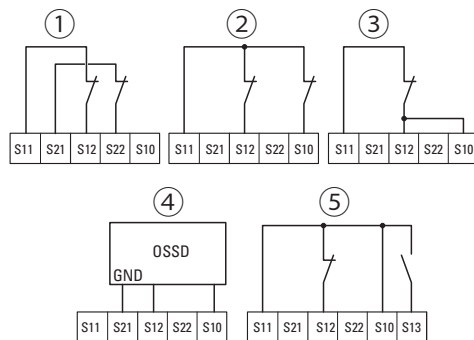


Figure 12: Signal generator connection versions

Key:

- ① Two-channel connection with cross-circuit monitoring
- ② Two-channel connection without cross-circuit monitoring
- ③ Single-channel connection
- ④ Two-channel connection with external cross-circuit monitoring
- ⑤ Two-channel, non-equivalent connection

11.2 Start and feedback circuit connection variants

Automatic start

- ▶ Bridge the contacts S11/S35.

Manual, monitored start

- ▶ Connect a reset button to S11/S34.

A connected reset button is monitored.

Start and feedback circuit

- ▶ Place the relevant N/C contacts in path S11/S34 or S11/S35 to monitor external contactors or extension devices with force-guided contacts.

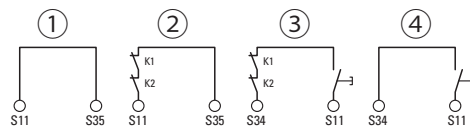


Figure 13: Start and feedback circuit connection variants

Key:

- ① Automatic start
- ② Automatic start with monitored contact extension
- ③ Manual, monitored start with monitored contact extension
- ④ Manual, monitored start

12 Start-up

- Apply the Nominal input voltage U_N (24 V AC/DC ... 230 V AC/DC) at terminal blocks A1/A2.

The Power LED lights up.

- Close the sensor circuit at S10/S11/S12/S13 and S21/S22 as per the wiring.

The IN1/2 LED lights up.



Single or two-channel sensor circuit:
→ Section 11.1, „Signal generator connection versions“, page23.

Automatic start

The enabling current paths 13/14, 23/24 and 33/34 close.

The K1 and K2 LEDs light up.

Signaling current path 41/42 opens.

Manual, monitored start

- ▶ Press the reset button.
- ▶ Release the reset button.

The enabling current paths 13/14, 23/24 and 33/34 close.

The K1 and K2 LEDs light up.

Signaling current path 41/42 opens.

13 Calculating the power dissipation



The total power dissipation of the safety relay is based on the input power dissipation and the contact power dissipation for the same and for different load currents.

Input power dissipation

$$P_{\text{Input}} = 2,7 \text{ W (at DC)}$$

$$P_{\text{Input}} = 2,9 \text{ W (at AC)}$$

Contact power dissipation

With the same load currents:

$$P_{\text{Contact}} = n \cdot I_L^2 \cdot 200 \text{ m}\Omega$$

With different load currents:

$$P_{\text{Contact}} = (I_{L1}^2 + I_{L2}^2 + \dots + I_{Ln}^2) \cdot 200 \text{ m}\Omega$$

Total power dissipation

$$P_{\text{Total}} = P_{\text{Input}} + P_{\text{Contact}}$$

therefore

$$P_{\text{Total}} = P_{\text{Input}} + n \cdot I_L^2 \cdot 200 \text{ m}\Omega$$

or

$$P_{\text{Total}} = P_{\text{Input}} + (I_{L1}^2 + I_{L2}^2 + \dots + I_{Ln}^2) \cdot 200 \text{ m}\Omega$$

Key:

P Power dissipation in mW

n Number of enabling current paths used

I_L Contact load current

14 Diagnostics

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

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.

14.1 General states

PWR LED	IN1/2 LED	K1 LED	K2 LED	State	Notes
ON	OFF	OFF	OFF	No relay has picked up. The sensor circuit is inactive.	Possible error → Section 14.2, „Error messages“, page28
ON	ON	OFF	OFF	The sensor circuit is active. Relays K1 and K2 are ready to start and await reset/start command (S34 or S35).	
ON	ON	ON	ON	The sensor circuit is active. All relays are picked up.	-

14.2 Error messages

PWR LED	IN1/2 LED	K1 LED	K2 LED	State	Possible cause	Corrective
ON	OFF	OFF	OFF	The sensor circuit is actively controlled, but no input LEDs are lit up.	Internal cross-circuit detection is active: potential cross-circuit in the sensor circuit.	Switch off the operating voltage and rectify the cross-circuit. Then perform a function test.
ON	ON	OFF	OFF	The sensor circuit is active. The reset/start circuit (S34 or S35) is/was activated. The safety circuit (K1 and K2) is not picking up.	External Error: the readback contact (external actuator) is open in the reset circuit. Internal Error: 1. The diagnostic contact is not working correctly. 2. An N/O contact is welded.	External error: check the actuator. Internal error: perform a power down reset with subsequent function test. If the error occurs again after the function test, replace the device.
ON	ON	OFF	OFF	The sensor circuit is active. The reset/start circuit (S34) is/was activated. The safety circuit (K1 and K2) is not picking up.	Error during manual reset S34 (stuck-at at the input).	Remove the error in the reset/start circuit. Then perform a function test.
ON	ON	OFF	ON	The sensor circuit is active. The reset/start circuit (S34 or S35) is/was activated. The safety circuit (K1) is not picking up.	External error: sensor circuit channel 1 was opened and reactivated. Internal error: diagnostics active.	External error: check the sensor circuit. Internal error: perform a power down reset with subsequent function test. If the error occurs again after the function test, replace the device
ON	ON	ON	OFF	The sensor circuit is active. The reset/start circuit (S34 or S35) is/was activated. The safety circuit (K2) is not picking up.	External error: sensor circuit channel 2 was opened and reactivated. Internal error: diagnostics active.	External error: check the sensor circuit. Internal error: perform a power down reset with subsequent function test. If the error occurs again after the function test, replace the device.
OFF	OFF	OFF	OFF	The sensor circuit is active.	1. No supply voltage at A1/A 2. Over- or undervoltage at A1	Check the supply voltage.

15 Application examples

15.1 Emergency stop monitoring/automatic start/ with cross-circuits detection in the input circuit

- Two-channel emergency stop monitoring
- Automatic start
- Monitoring of external, force-guided contactors
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the control to the actuator can be ruled out.



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space.

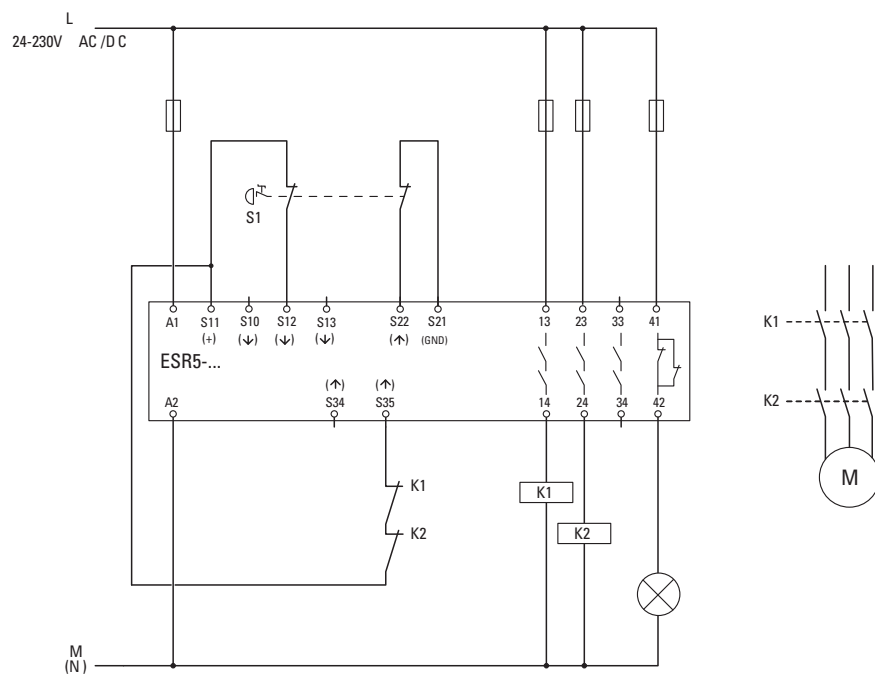


Figure 14: Emergency stop monitoring/automatic start

Key:
 S1 Emergency stop button
 K1/K2 Force-guided contactors

15.2 Emergency stop monitoring / automatic start / without cross-circuit detection

- Two-channel emergency stop monitoring
- Automatic start
- Monitoring of external, force-guided contactors
- No cross-circuit detection in the sensor circuit
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the control to the actuator and the sensor circuit can be ruled out.



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space. For sensor circuits in the field, prevent cross-circuits by using a cable installation that is protected mechanically.

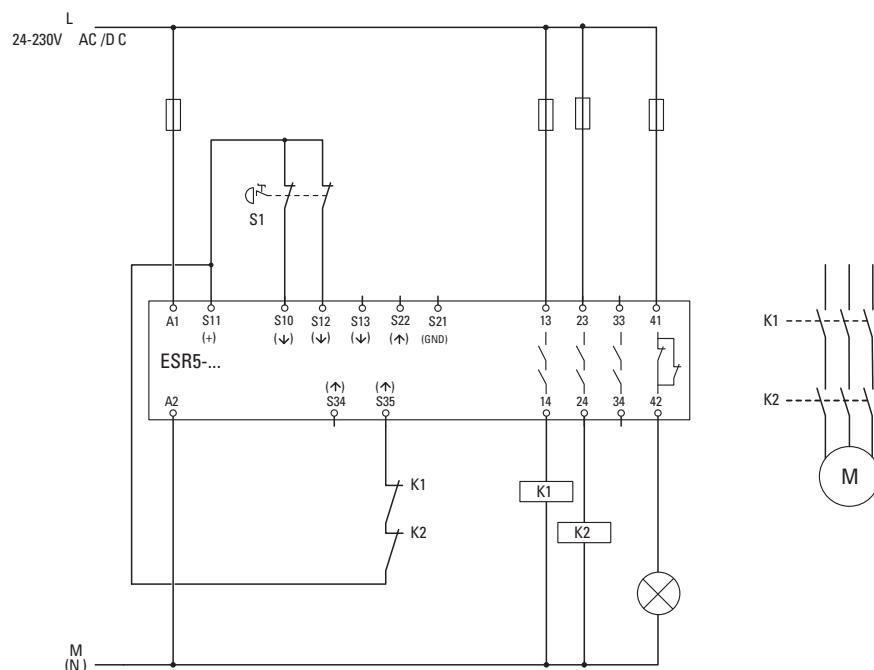


Figure 15: Emergency stop monitoring / automatic start / without cross-circuit detection

Key:

S1 Emergency stop button

K1/K2 Force-guided contactors

15.3 Emergency stop monitoring/manual, monitored start/with cross-circuit detection in the input circuit

- Two-channel emergency stop monitoring
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the cable installation to the actuator can be ruled out



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space.

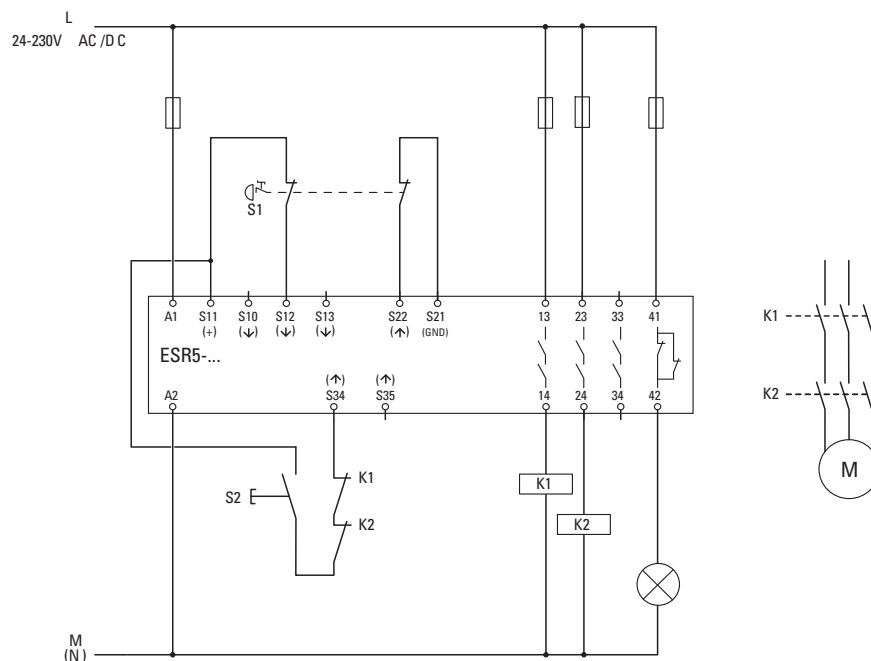


Figure 16: Emergency stop monitoring/manual, monitored start

Key:

S1	Emergency stop button
S2	Manual reset device
K1/K2	Force-guided contactors

15.4 Emergency stop monitoring / manual, monitored start / without cross-circuit detection

- Two-channel emergency stop monitoring
- Manual, monitored start
- Monitoring of external, force-guided contactors
- No cross-circuit detection in the sensor circuit
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the control to the actuator and the sensor circuit can be ruled out



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space. For sensor circuits in the field, prevent cross-circuits by using a cable installation that is protected mechanically.

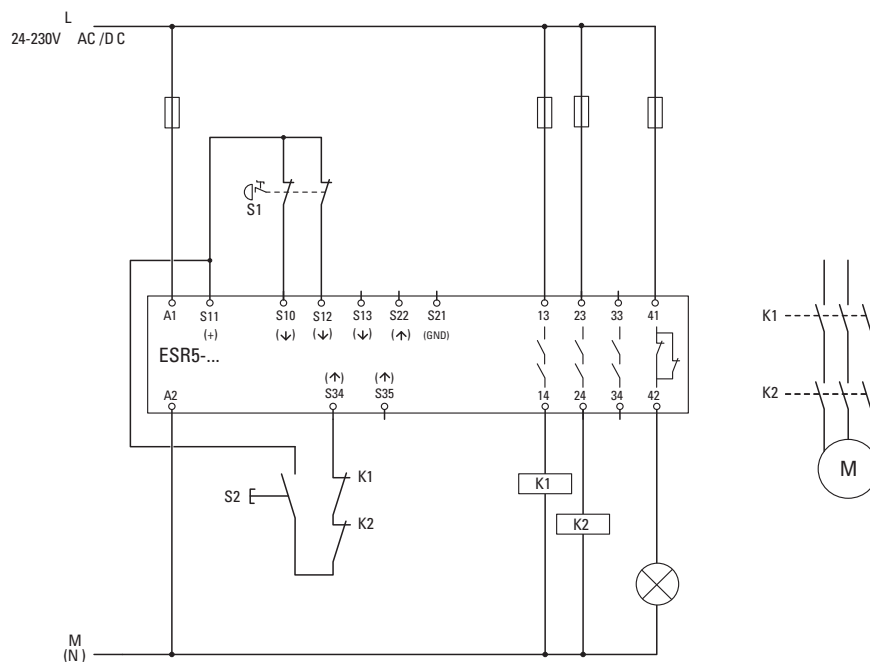


Figure 17: Emergency stop monitoring / manual, monitored start / without cross-circuit detection

Key:

S1	Emergency stop button
S2	Manual reset device
K1/K2	Force-guided contactors

15.5 Single-channel emergency stop monitoring

- Single-channel emergency stop monitoring
- Manual, monitored start
- Monitoring of external contactors (optional)
- No cross-circuit detection in the sensor circuit
- Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)



Feedback from contactor K1 is not essential in order to achieve category 1.

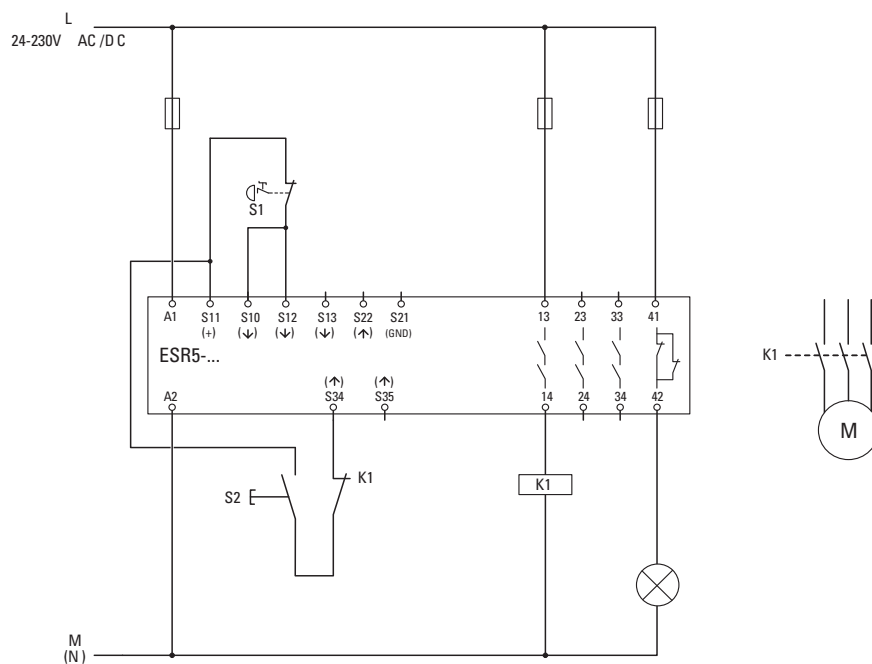


Figure 18: Single-channel emergency stop monitoring/manual, monitored start

Key:

S1 Emergency stop button

S2 Manual reset device

K1 Contactor

15.6 Magnetic switch monitoring/automatic start

- Two-channel, non-equivalent magnetic switch monitoring
- Automatic start
- Monitoring of external, force-guided contactors
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the cable installation to the actuator can be ruled out



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space.

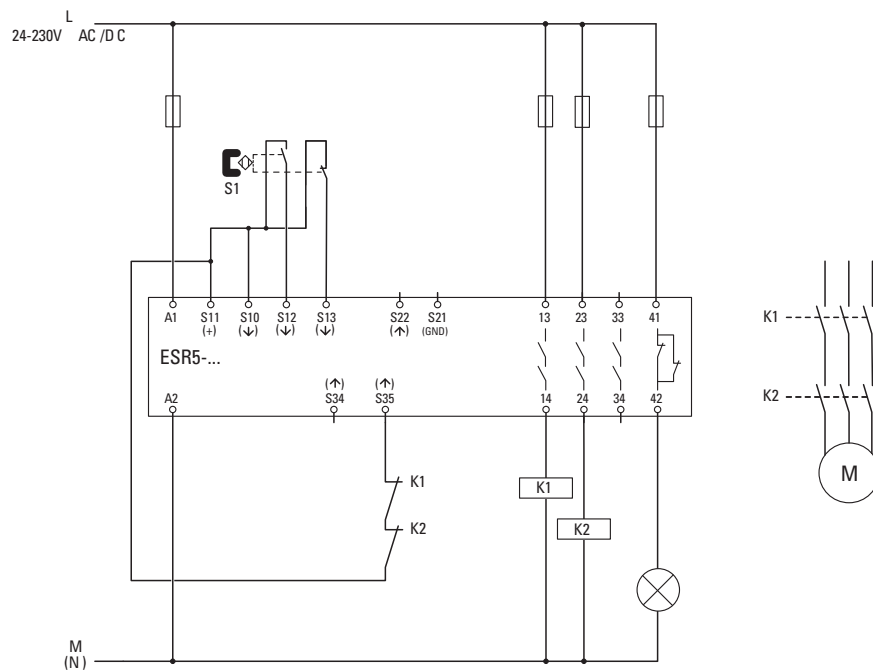


Figure 19: Magnetic switch monitoring/automatic start

Key:

S1	Solenoid switch
K1/K2	Force-guided contactors

15.7 Magnetic switch monitoring/manual, monitored start

- Two-channel, non-equivalent magnetic switch monitoring
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the control to the actuator can be ruled out



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space.

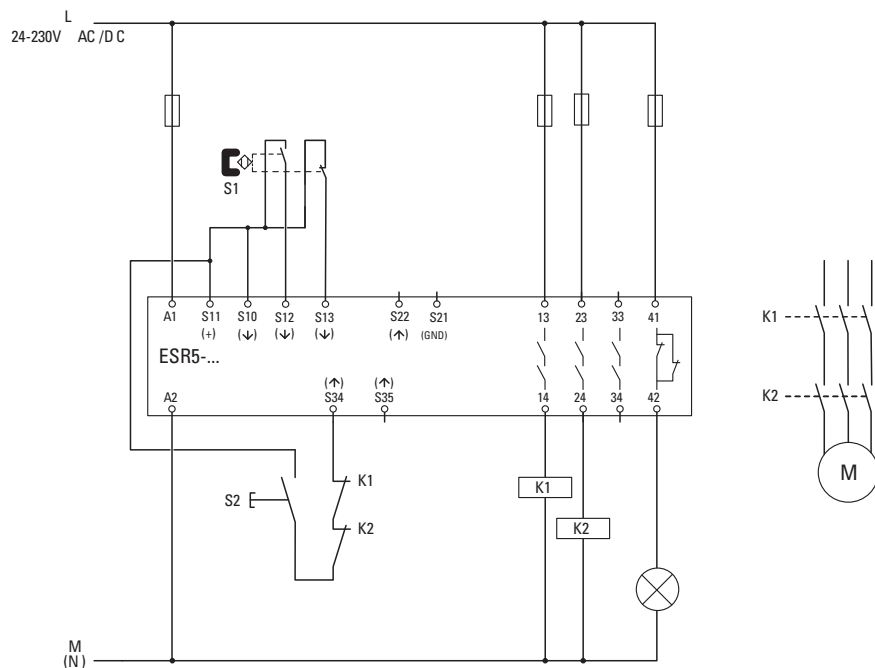


Figure 20: Magnetic switch monitoring/manual, monitored start

Key:

S1	Solenoid switch
S2	Manual reset device
K1/K2	Force-guided contactors

15.8 Light grid monitoring/manual, monitored start

- Two-channel light grid monitoring
- Manual, monitored start
- Monitoring of external, force-guided contactors
- Cross-circuit detection via light grid
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN 62061), if cross-circuits in the control to the actuator can be ruled out



WARNING

LOSS OF FUNCTIONAL SAFETY!

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



According to EN ISO 13849-2, cross-circuits in the cable installation can be excluded if the safety relay and external contactors K1 and K2 are located in the same electrical installation space.

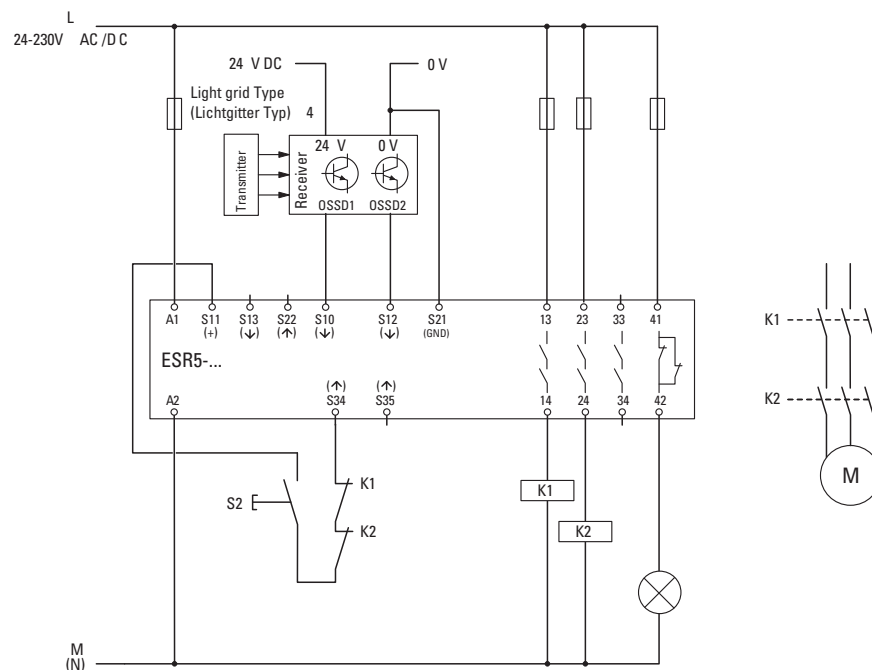


Figure 21: Light grid monitoring/manual, monitored start

Key:

S2 Manual reset device

K1/K2 Force-guided contactors

16 Attachment

16.1 Using at altitudes greater than 2000 m above sea level



The following section describes the special conditions for using PSR devices at altitudes greater than 2000 m above sea level. Observe the relevant device-specific data (technical data, derating, etc.) according to the product documentation for the individual device.

Using the device at altitudes greater than 2000 m above sea level up to max. 4500 m above sea level is possible under the following conditions:

- ▶1. Limit the Rated input voltage U_N in accordance with the table below. Observe the technical data for the device.

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

- ▶2. Limit the maximum switching voltage in accordance with the table below. Observe the technical data for the device.

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

- ▶3. Reduce the maximum ambient temperature for operation by the corresponding factor in accordance with the table below.
- ▶4. If derating is specified, offset all the points of the derating curve by the corresponding factor in accordance with the table below.

Altitude above sea level	Temperature derating faktor
2000 m	1
2500 m	0,953
3000 m	0,906
3500 m	0,859
4000 m	0,813
4500 m	0,766

Example calculation for 3000 m



The following calculation and the illustrated derating curve are provided as examples.
 Perform the actual calculation and offset the derating curve for the device used according to the technical data and the "Derating" section.

$27\text{ °C} \cdot 0,906 \approx 24\text{ °C}$
 $55\text{ °C} \cdot 0,906 \approx 49\text{ °C}$

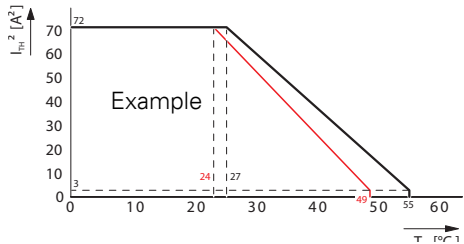


Figure 22: Example of a suspended derating curve (red)

17 Glossary

Abbreviation	Description
AC-15, DC-13	Standardized utilization categories and load cases from standard IEC 60947-5-1 that are used to test switching elements, i.e., switching on and off with defined voltages, currents, and loads (electromagnetic loads in particular in this case).
AOPD	Active Opto-electronic Protective Device Device with a sensor function that is implemented with optoelectronic transmission and reception elements that detect when an opaque object in the defined area of protection (or in the way of the light beam axis in the case of light barriers) is blocking the beams generated by the device. AOS is used as an abbreviation synonymous with AOPD in DIN EN 692 ("Machine tools - Mechanical presses - Safety"), DIN EN 693 ("Machine tools - Safety - Hydraulic presses"), and EN 12622 ("Safety of machine tools - Hydraulic press brakes").
AOPDDR	Active Opto-electronic Protective Device responsive to Diffuse Reflection Device with a sensor function that is implemented with optoelectronic transmission and reception elements that detect when an object in the area of protection defined with two dimensions diffusely reflects the beam generated by the device.
ESPE	Electro-sensitive protective equipment
CCF	Common Cause Failure Common cause failure
DC	Diagnostic Coverage Diagnostic coverage
ESR	Electronic safety relay
DF	Duty factor
PL	Performance Level Classification of safety functions used to meet a safety requirement.
HFT	Hardware Fault Tolerance
Cat. / category	Classification of resistance to errors as defined in EN ISO 13849-1
Mission Time T_M	Lifetime
MTTF / $MTTF_d$	Mean Time To Failure Mean time to failure / mean time to dangerous failure
NC	Normally Closed contact, break contact An NC breaks a circuit when it is energized.
NO	Normally-Open contact An NO closes when it is energized.
PFD	Probability Failure on Demand (Low-Demand) Probability of failure relative to the number of requests
PFH_d	Probability of a Dangerous Failure per Hour Probability of dangerous Failures per Hour
SIL	Safety Integrity Level Safety integrity level
SRCF	Safety-Related Control Function Safety-related control function
SRECS	Safety-Related Electrical Control System Safety related electrical, electronic, programmable electronic control system
SRP	Safety-Related Part Safety-related part
SRP/CS	Safety-Related Parts of Control System Safety-related part of a control system

Eaton is an intelligent power management company dedicated to protecting the environment and improving the quality of life for people everywhere. We make products for the data center, utility, industrial, commercial, machine building, residential, aerospace and mobility markets. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power – today and well into the future.

By capitalizing on the global growth trends of electrification and digitalization, we're helping to solve the world's most urgent power management challenges and building a more sustainable society for people today and generations to come.

For more information, visit Eaton.com.