ESR5-NO-41-24VAC-DC
Safety relay

Powering Business Worldwide

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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.

1. Edition 2019, publication date 12/19
See revision protocol in the "About this manual" chapter.

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Subject to alteration.

Danger!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally retriggered.
- Verify isolation from the supply.
- Ground and short-circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (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 equalizing. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference do 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 connection so that a cable or wire breakage on the signal side does not result in undefined states in the automation device.
- Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supply units complying with IEC 60364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- Deviations of the mains voltage from the nominal value must not exceed the tolerance limits given in the technical data, 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 switching off devices must not cause restart.
- Built-in devices for enclosures or cabinets must only be run and operated in an installed state, desk-top devices or portable devices only when the housing is closed.
- 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 switching off 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.).
- During operation, and depending on their degree of protection, variable frequency drives may have live, uninsulated, moving, and/or rotating parts, as well as hot surfaces.
- The impermissible removal of the required cover, improper installation or incorrect operation of the motor or variable frequency drive can cause the failure of the device and serious injury and/or material damage.
- Comply with all applicable national accident prevention regulations (e.g. BGV A3) when working with energized variable frequency drives.
- The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross sections, fuses, PE).
- All transport, installation, commissioning and maintenance work must only be carried out by trained personnel (observe IEC 60364, HD 384 or DIN VDE 0100 and national accident prevention regulations).
- If applicable, systems in which variable frequency drives are installed must be equipped with additional monitoring and protective devices in accordance with the applicable safety regulations, e.g., the German Equipment and Product Safety Act, accident prevention regulations, etc. Making changes to the variable frequency drives by using the operating software is allowed.
- Keep all covers and doors closed during operation.
- When designing the machine, the user must incorporate mechanisms and measures that limit the consequences of a drive controller malfunction or failure (an increase in motor speed or the motor?9s sudden stop) so as to prevent hazards to people and property, e.g.:
  - Additional stand-alone devices for monitoring parameters that are relevant to safety (speed, travel, end positions, etc.)
  - Electrical and non-electrical safety devices (interlocks or mechanical locks) for mechanisms that protect the entire system
  - Due to the possibility of there being capacitors that are still holding a charge, do not touch live device parts or terminals immediately after disconnecting the variable frequency drives from the supply voltage. Heed the corresponding labels on the variable frequency drives

Content

0 About This Manual

This manual applies to the ESR5-NO-41-24VAC-DC safety relay.

0.1 List of revisions

The following significant amendments have been introduced since previous issues:

Publication date	Page	Keyword	new	modified	deleted
12/19		First edition	–	–	–

0.2 Target group

This manual is intended for qualified personnel installing, operating, and maintaining the ESR5-NO-41-24VAC-DC safety relay.

CAUTION

Installation requires a qualified electrician

0.3 Additional documents

For further information, see the following documentation:

- Instruction leaflet IL05013028Z2018_06

WARNING

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

0.5 Ordering data

ESR5-NO-41-24VAC-DC safety relay: Catalog No. 118701

1 Safety notes

WARNING

Risk of electric shock
During operation, parts of electrical switching devices carry hazardous voltages.
Before working on the switching device, disconnect the power.
Please 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.
Startup, mounting, modifications, and upgrades should only be carried out by a skilled electrical engineer!

WARNING

Risk of automatic machine restart!
For emergency stop applications, the machine must be prevented from restarting automatically by a higher-level control system.
Protective covers must not be removed when operating electrical switching devices.

WARNING

Danger due to faulty devices!
The devices may be damaged following an error and correct operation can no longer be ensured.
In the event of an error, replace the device immediately.
Repairs to the device, especially if the housing must be opened, may only be carried out by the manufacturer or authorized persons. Otherwise the warranty is invalidated.

CAUTION

Risk of damage to equipment due to incorrect installation
For reliable operation, the safety relay must be installed in housing protected from dust and humidity (IP54).
Carry out wiring according to the application.
Refer to the "Application examples" section for this.

CAUTION

Risk of damage to equipment due to noise emissions
When operating relay modules the operator must meet the requirements for noise emission for electrical and electronic equipment (EN 61000-6-4) on the contact side and, if required, take appropriate measures.

2 Description

Intended Use

The ESR5-NO-41-24VAC-DC safety relay is used to monitor single-channel signal generators and to control actuators.

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

Possible signal generators

- Emergency stop button
- Door locking mechanisms

Contact type

- 4 undelayed enabling current paths
- 1 undelayed enabling current path

The enabling current paths and the signaling current path drop out without delay according to stop category 0 (EN 60204-1).

Control

- Single-Channel
- Automatic or manual start

A connected reset button is not monitored.

Achievable safety integrity

- Suitable up to category 1, PL c (EN ISO 13849-1), SILCL 1 (EN 62061)
- Depending on the application, suitable up to category 4, PL e (EN ISO 13849-1), SILCL 3 (EN 62061)

Additional features

- Safe isolation
- Screw terminal blocks for plug-in
- 22.5 mm housing width

3 Operating and indication elements

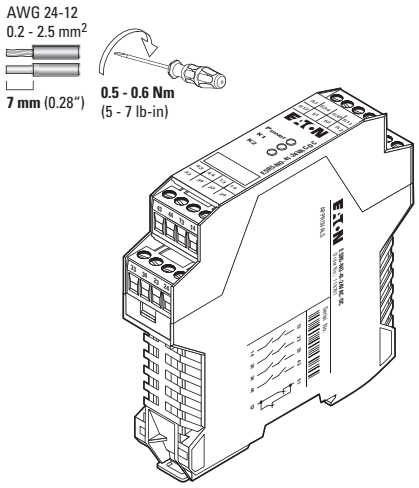
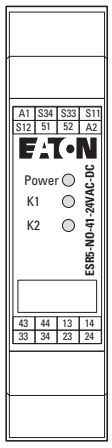


Figure 1: ESR5-NO-41-24VAC-DC

3.1 Connection assignment



A1	24 V AC/DC power supply
S33/S34	Start and feedback circuit
S11	Sensor circuit output
S12	Input sensor circuit
51/52	Signaling current path, undelayed
A2	0 V power supply
Power	Power LED (green)
K1	Status indicator safety circuit; LED (green)
K2	Status indicator safety circuit; LED (green)
13/14	Undelayed enabling current paths
23/24	Undelayed enabling current paths
33/34	Undelayed enabling current paths
43/44	Undelayed enabling current paths

4 Basic circuit diagram

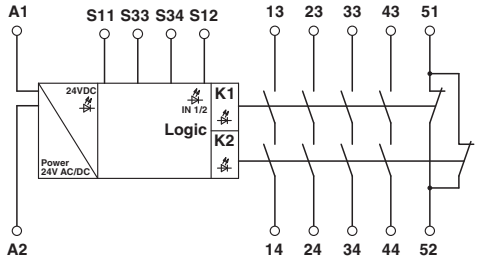


Figure 2: Block diagram

Designation	Explanation
A1	24 V AC/DC power supply
A2	0 V power supply
S11	Sensor circuit output
S12	Input sensor circuit
S33/S34	Start and feedback circuit
13/14, 23/24, 33/34, 43/44	Undelayed enabling current paths
51/52	Signaling current path, undelayed

5 Derating

The derating curve applies for the following conditions:

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

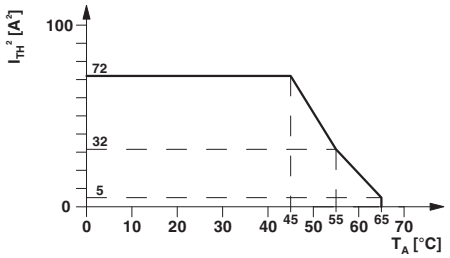


Figure 3: Derating curve - vertical or horizontal mounting position, without spacing

6 Load curve - ohmic load

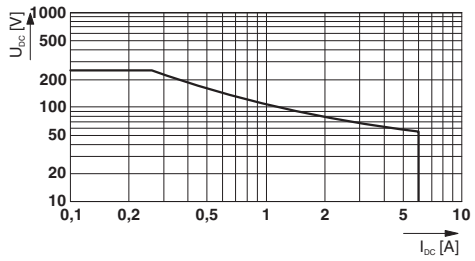


Figure 4: Relay load curve - ohmic load

7 Function description

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.

Automatic start

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

Manual start

The device starts with closed sensor circuit once the start circuit has been closed by pressing the reset button.

A connected reset button is not monitored.

Safe shutdown

When the sensor circuit is opened, the enabling current paths 13/14, 23/24, 33/34 and 43/44 open without delay.

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

The signaling current path closes.

8 Function and time diagrams

Time diagram for automatic start

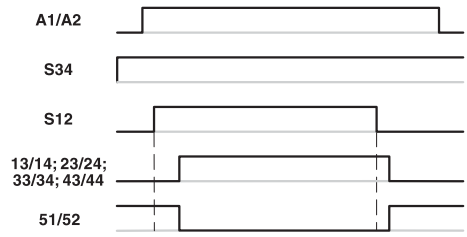


Figure 5: Time diagram for automatic start

Time diagram for manual start

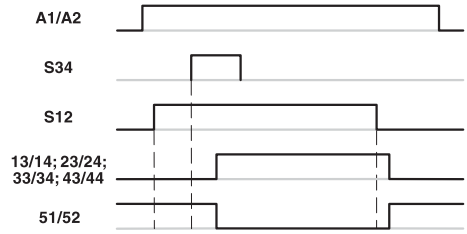


Figure 6: Time diagram for manual start

Designation	Explanation
A1/A2	Power supply
S34	Start circuit
S12	Input sensor circuit
13/14, 23/24, 33/34, 43/44	Undelayed enabling current paths
51/52	Signaling current path, undelayed

9 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.

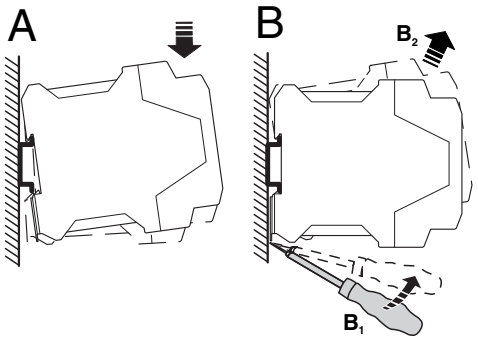


Figure 7: Mounting and removing

10 Wiring

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

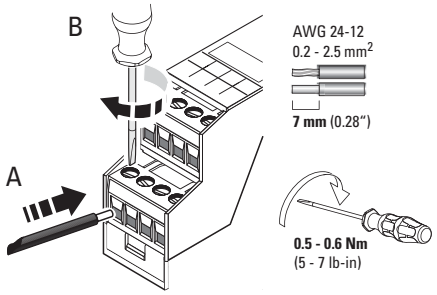


Figure 8: Connecting the cables

→ 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.

10.1 Signal generator connection versions

▶ Connect suitable signal generators to S11/S12.

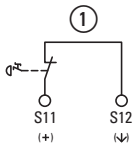


Figure 9: Signal generator connection versions

① Single-channel connection

10.2 Start and feedback circuit connection variants

Automatic start

▶ Bridge the contacts S33/S34.

Manual start

▶ Connect a reset button to contacts S33/S34.

A connected reset button is not monitored.

Start and feedback circuit

▶ Place the relevant N/C contact in path S33/S34 to monitor external contactors or extension devices with force-guided contacts.

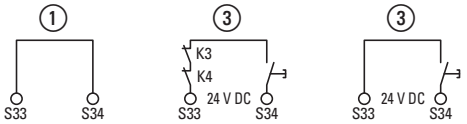


Figure 10:Start and feedback circuit connection variants

① Automatic start

② Manual start with monitored contact extension

③ Manual start

11 Startup

▶ Apply the nominal input voltage U_N (24 V AC/DC) at terminal blocks A1/A2. → The **Power** LED lights up.

▶ Close contacts S11/S12 as follows.

Automatic start

→ The enabling current paths 13/14, 23/24, 33/34, and 43/44 close.

→ Signaling current path 51/52 opens.

→ The K1 and K2 LEDs light up.

Manual start

▶ Press the reset button.

→ The enabling current paths 13/14, 23/24, 33/34, and 43/44 close.

→ Signaling current path 51/52 opens.

→ The K1 and K2 LEDs light up.

12 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

$P_{Input} = U_B^2 / (U_N/I_N)$

Contact power dissipation

With the same load currents:

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

With different load currents:

$P_{Contact} = (I_{L1}^2 + I_{L2}^2 + \ldots + I_{Ln}^2) \times 200\ m\Omega$

Total power dissipation

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

therefore

$P_{Total} = U_B^2 / (U_N/I_N) + n \times I_L^2 \times 200\ m\Omega$

or

$P_{Total} = U_B^2 / (U_N/I_N) + (I_{L1}^2 + I_{L2}^2 + \ldots + I_{Ln}^2) \times 200\ m$

P	Power dissipation in mW
U_B	Applied operating voltage
U_N	Nominal input voltage
I_N	Input current
n	Number of enabling current paths used
I_L	Contact load current

13 Diagnostics

○ – LED off

● – LED on

Table 1: Diagnostic description

	Power	K1	K2	Fault	Remedy
Connection/ voltage error	○	○	○	Supply voltage not present.	Apply supply voltage.
	●	○	●	Supply voltage too low.	Adjust supply voltage.
	●	○	○		
	●	○	○	The enable circuits are connected incorrectly or not connected at all.	Check the connection of the enable circuits.
Short circuit	○	○	○	Fault between contact points A1 and A2.	Remove short circuit.
Fault in reset circuit	●	○	●	Faulty reset button. Short circuit between S33 and S34. No fault detection on initial start, only on first new demand.	Remove short circuit.
Fault with internal cause	●	○	●	Enable contact(s) of K1 faulty.	Replace safety relays.
	●	●	○	Enable contact(s) of K2 faulty.	
	●	○	○	Enable contact(s) of K1 and K2 faulty.	

Function test/proof test

→ Use the function test to test the safety function.
To do this, request the safety function once via the basic device by pressing the emergency stop button, for example.
Check whether the safety function is executed correctly by then switching the basic device and thereby also the contact extension on again.

14 Application examples

14.1 Single-channel safety door monitoring

- Manual start
- Monitoring of external contactors
- Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)

→ Contactor K4 is not essential in order to achieve category 1.

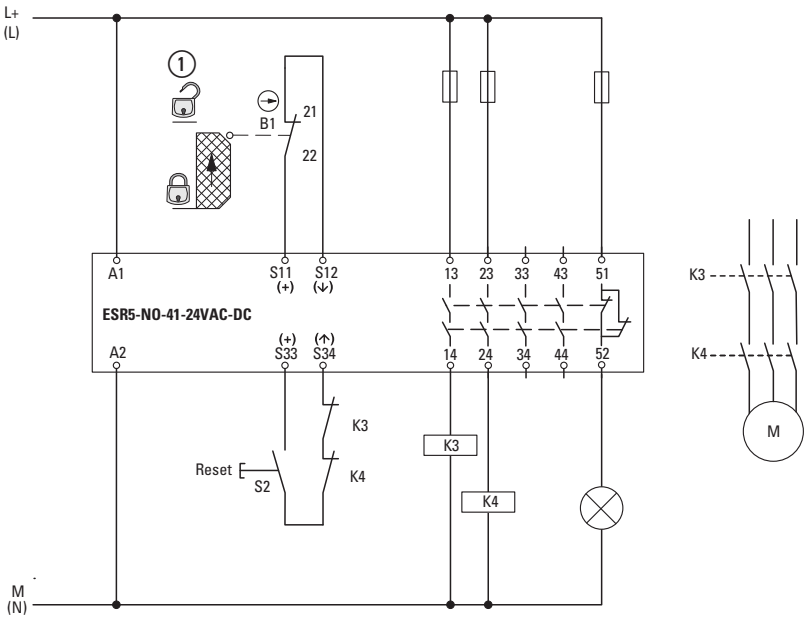


Figure 11:Single-channel safety door monitoring/manual start

① B1 - Mechanical safety door switch

S2 - Reset button

K3, K4 - Contactors

14.2 Single-channel emergency stop monitoring

- Manual start
- Monitoring of external contactors
- Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN 62061)

→ Contactor K4 is not essential in order to achieve category 1.

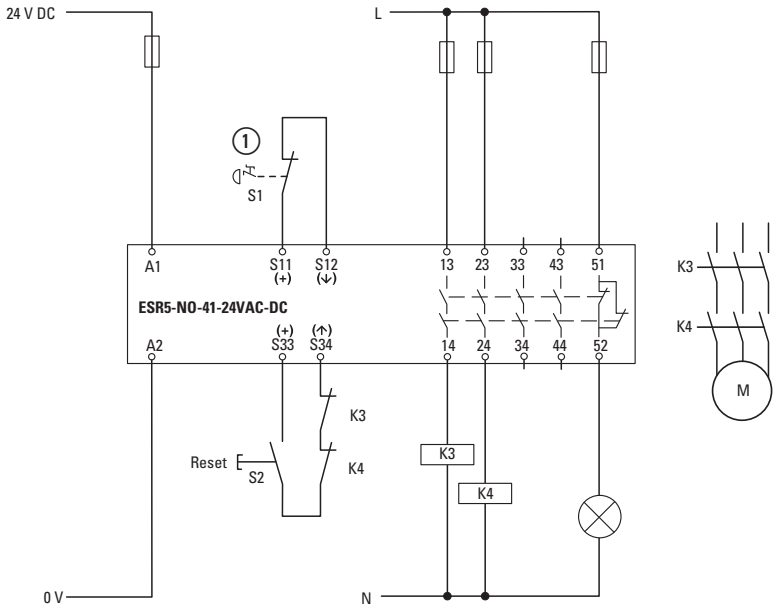


Figure 12:Single-channel emergency stop monitoring/manual start

① S1 - Emergency stop button

S2 - Reset button

K3, K4 - Contactors

15 Attachment - using devices at altitudes greater than 2000 m above sea level

The following section describes the special conditions for using ESR5-NO-41-24VAC-DC 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 nominal 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 when 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 factor**
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.

Figure 13: Example of a suspended derating curve (red)

27 °C x 0,906 = 24 °C
55 °C x 0,906 = 49 °C

16 Technical data

Input data	
Nominal input voltage U_N	24 V AC/DC -15 % / +10 %
Typical input current I_N	140 mA AC 65 mA DC
Typical inrush current	2A (Δt = 10 ms at U_N) < 40 mA (at U_N/I_x to S34)
Current consumption	< 50 mA (at U_N/I_x to S12) 0 mA (at U_N/I_x to S34)
Power consumption at U_N	3.36 W (AC) 1.56 W (DC)
Voltage at input/start and feedback circuit	24 V DC 15 % / +10 %
Max. permissible overall conductor resistance	~ 22 Ω (Input and start circuits at U_N)
Typical response time at U_N	< 65 ms (automatic start) < 40 ms (manual start)
Typical starting time at U_N	< 65 ms (when controlled via A1)
Typical release time at U_N	< 45 ms (when controlled via S12) < 200 ms (when controlled via A1)
Recovery time	1 s
Operating voltage display	1 x LED, green
Status display	2 x LEDs, green
Protective circuit	Surge protection Suppressor diode Protection against polarity reversal for rated control circuit supply voltage
Output data	
Contact type	4 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 (observe the load curve)
Limiting continuous current	6 A (N/O contact, pay attention to the derating) 6 A (N/C contact)
Maximum inrush current	20 A ($\Delta t \leqq 100$ ms)
Minimum inrush current	10 mA
Sq. Total current $(I_{TH})^2 = (I_1)^2 + (I_2)^2 + \ldots + (I_n)^2$	72 A^2 (see derating curve, → Figure 3, page 9)
Interrupting rating (ohmic load) max.	144 W (24 V DC, τ = 0 ms) 288 W (48 V DC, τ = 0 ms) 110 W (110 V DC, τ = 0 ms) 88 W (220 V DC, τ = 0 ms) 1500 VA (250 V AC, τ = 0 ms)
Maximum interrupting rating (inductive load)	42 W (24 V DC, τ = 40 ms) 42 W (48 V DC, τ = 40 ms) 42 W (110 V DC, τ = 40 ms) 42 W (220 V DC, τ = 40 ms)
Switching capacity min.	50 mW

Mechanical service life	10^7 cycles
Switching capacity (360 cycles/h)	4 A (24 V DC) 4 A (230 V AC)
Switching capacity (3600 cycles/h)	2.5 A (24 V (DC-13)) 3 A (230 V (AC-15))
Output fuse	10 A gL/gG NEOZED (N/O contact) 6 A gL/gG NEOZED (N/C contact)
General data	
Relay type	Electromechanical relay with forcibly guided contacts in accordance with EN 50205
Nominal operating mode	100 % operating factor
Degree of protection	IP20
Min. degree of protection of inst. location	IP54
Mounting position	any
Mounting type	DIN rail mounting
Type of housing	PBT yellow/black
Air and creepage distances between the power circuits	according to DIN EN 50178/VDE 0160
Rated insulation voltage	250 V
Rated surge voltage / insulation	Basic insulation 4 kV: between all current paths and housing Safe isolation, reinforced insulation 6 kV: between A1/A2 and 13/14, 23/24, 33/34, 43/44 between S11/S12/S33/S34 and 13/14, 23/24, 33/34, 43/44 between 51/52 and 13/14, 23/24, 33/34, 43/44
Pollution degree	2
Surge voltage category	III
Dimensions	
W x H x D	22.5 x 99 x 114.5 mm
Connection data	
Conductor cross section, solid	0.2 mm^2 - 2.5 mm^2
Conductor cross section, stranded	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)	-20 °C - 65 °C (observe derating)
Ambient temperature (storage/transport)	-40 °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)
Maximum altitude	≦ 2000 m (above sea levelNN)
Shock	15 g
Vibration (operation)	10 Hz - 150 Hz, 2 g

Conformance / Approvals	
Conformance	CE-compliant
Approvals	  
Safety data	
Stop category according to IEC 60204	0
Safety parameters for IEC 61508 - High demand	
SIL	1 (up to SIL 3 depending on the application)
PFH_d	4.05×10^{-10} per hour
Demand rate	< 12 months
Proof test interval	240 months
Duration of use	240 months
The specifications apply assuming the following calculation basis:	
B_{10d}	230000 (at 3 A AC-15)
Cycles	8760 per year
Safety parameters for IEC 61508 - Low demand	
SIL	1 (up to SIL 3 depending on the application)
PFD_{avg}	1.49×10^{-4}
Proof test interval	78 months
Duration of use	240 months
Safety characteristic data according to EN ISO 13849	
Category	1 (up to Cat. 4 depending on the application)
Performance Level	c (up to PL e depending on the application)
Duration of use	240 monts
For applications in PL e, the required demand rate for the safety function is once per month. Calculation basis:	
B_{10d}	230000 (at 3 A AC-15)
Cycles	8760 per year
Safety parameters for EN 62061	
SILCL	1 (up to SILCL 3 depending on the application)

17 Glossary

Abbreviation	Explanation
AOPD	**Active optoelectronic protective device** Device with a sensor function that is generated by optoelectronic transmit and receive elements, which detects the interruption of optical radiation generated in the device by an opaque object located in the specified protective field (or for a photoelectric barrier on the axis of the light beam). In DIN EN 692 (mechanical presses), DIN EN 693 (hydraulic presses), and EN 12622 (hydraulic trimming presses), the abbreviation AOS is used as a synonym for AOPD.
AOPDDR	**Active optoelectronic protective device responsive to diffuse reflection** Device with a sensor function that is generated by optoelectronic transmit and receive elements, which detects the diffuse reflection of optical radiation generated in the device by an object located in a protective field specified in two dimensions.
Cat. / Category	Classification of the resistance to faults according to EN ISO 13849-1.
CCF	**Common cause failure**
DC	**Diagnostic coverage**
ESPE	**Electro-sensitive protective equipment**
Mission Time T_M	Duration of use
MTTF / $MTTF_d$	**Mean time to failure** / **mean time to dangerous failure**
PFD	**Probability of failure on demand (low demand)**
PFH_d	**Average frequency of a dangerous failure per hour**
PL	**Performance level** Classification of the ability of safety functions to meet a safety demand
SIL	**Safety integrity level**
SILCL	**SIL claim limit**
SRCF	**Safety-related control function**
SRECS	**Safety-related electrical control system** (Safety-related electrical, electronic, and programmable electronic control system)
SRP	**Safety-related part**
SRP/CS	**Safety-related parts of control system**