ESR5-BWS-31-24VDC

Safety relays for emergency stop, protective door and light grid monitoring

Powering Business Worldwide

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Service

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Contact details
Eaton.com/contacts
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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 2023, publication date 11/23
See change log in chapter "About this manual“

Translation: GlobalDoc
Editors: Antje Nonnen

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 About this manual

This manual contains all the information you will need in order to use the ESR5-BWS-31-24VDC safely and effectively.

The ESR5-BWS-31-24VDC manual is considered an integral part of the device and must always be readily available in the device's close proximity so that users have access to it.

This manual describes all lifecycle stages of the device: transport, installation, commissioning, maintenance, storage and disposal.

It assumes you have electrical engineering knowledge and skills.

Due to the fact that we cannot know the details of your specific application, the information and examples in this document are meant to provide you solely with general assistance in regard to the use of safety control equipment to implement standards, guidelines, and directives.
The information and examples in this document do not claim to be exhaustive or legally binding.
For detailed information, please refer to the standards, guidelines, and directives that apply to your specific application.

0.1 List of revisions

The following significant amendments have been introduced since previous issues:

Publication date	Page	Keyword	New	Modification	Deleted
10/23	–	Initial issue	–	–	–
11/23	–	Second certification EN IEC 62061	–	✓	–

0.2 Target group

This manual is intended for qualified personnel that has appropriate electrical training and:

- Plans and develops safety equipment for machines and systems or
- Installs and commissions this safety equipment and
- Is familiar with the applicable standards and regulations regarding accident prevention and occupational health and safety

The term "qualified personnel" refers to individuals who are authorized, by the party responsible for the system's safety, to perform the required activities and can identify and avoid the corresponding potential hazards as a result of their training, experience, and briefing and their familiarity with the applicable standards, regulations, accident prevention regulations, and operating conditions.

Familiarity with the following is required:

- Machinery Directive/Machinery Regulation and functional safety
- Handling safety components
- Applicable EMC regulations
- Applicable accident prevention and occupational health and safety regulations

0.3 Additional documents

For further information, see the applicable documentation:

- IL049016ZU
- Safety relay data sheet ESR5-BWS-31-24VDC, article no. 401064

ATTENTION

Make sure to always use the latest documentation for your device. The latest edition of this documentation and the applicable documents can be found on the Internet at Eaton.com/esr5.

0.4 Abbreviations and symbols

The following symbols are used throughout this manual:

▶ Indicates instructions to be followed.

Hazard warnings of personal injury

DANGER

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

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.

Hazard warnings of material damages

ATTENTION

Warns about the possibility of material damage.

Tips

Indicates useful tips.

1 Description ESR5-BWS-31-24VDC

1.1 Intended use

The safety relay can be used to monitor electro-sensitive protective devices with a monitored active switching output (OSSD) in conformity with EN 61496, as well as controlled emergency (category 1) stop and protective door interlocks.

The ESR5-BWS-31-24VDC safety relay is used to monitor single-channel signal generators and drive actuators.

With the help of this ESR5-BWS-31-24VDC, circuits are de-energized for safety purposes. When the sensor circuit is broken, the safety relay brings about a safe state.

Any other use must be discussed and agreed upon with the manufacturer in advance.
The ESR5-BWS-31-24VDC is approved for use in control cabinets or enclosures with a minimum degree of protection of IP54..

The ESR5-BWS-31-24VDC must be used only in locations for which the device is approved. Make sure to read and Observe the markings on the device, as well as section Approvals and standards in the appendix.

→ Please note that we assume no liability for damages, consequential damages, and/or accidents caused by the following:

- Failure to follow any applicable occupational health and safety rules, standards, and/or regulations
- Device failures or function disturbances
- Improper use and/or handling
- Not following the instructions or observing the information in the documentation for the device
- Alterations, changes, and repairs to the device

1.2 Possible signal encoders

- Emergency-stop push buttons
- Protective door interlocks
- Solenoid
- Light grid

1.3 Contact type

- 3 instantaneous enable current paths
- 1 instantaneous signaling current path

The enable current paths and the signal current path will drop out without a delay in conformity with Stop category 0 as defined in EN 60204-1.

1.4 Actuation

- Single-channel
- Automatic or manual start

1.5 Achievable level of safety integrity

- Category 4, PL e (EN ISO 13849-1), SIL 3 (EN IEC 62061)
  → Section 5, "Application examples", page33

1.6 Other Features

- Plug-in screw terminals
- 22.5 mm housing width

1.7 Approvals

1.8 Operator control and display elements

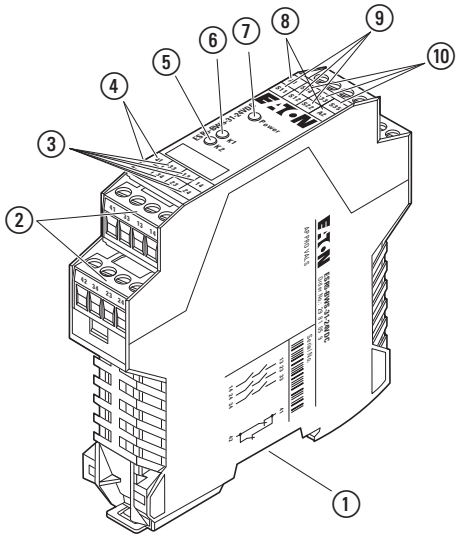


Figure 1: ESR5-BWS-31-24VDC

① Metal lock for installation on the mounting rail
② Plug-in screw terminals COMBICON
③ 13/14, 23/24, 33/34 – non-delayed enable current paths
④ 41/42 – signal current path
⑤ LED status display, green – K2
⑥ LED status display, green – K1
⑦ LED status display, green – Power
⑧ A1, A2 – supply voltage connection
⑨ S11, S12, S22 – input circuits
⑩ S33, S34, S35 – starting circuit (activation circuit)

→ The device's year of manufacture can be found underneath the CE marking on the housing.
XX/XX = calendar week / year

1.9 Function description

Single-channel sensor circuit

The sensor circuit does not have any redundancy.
The safety relay will not detect any short-circuits or cross-faults in the sensor circuit.

Dual-channel sensor circuit

The dual-channel sensor circuit is connected the same.

The following variants are possible:

- Dual-channel without cross-circuit detection
- dual-channel with cross-circuit detection

→ Section 3.4.3, "Terminal models Signal encoder", page28

Automatic start

The device will start automatically after the sensor circuit is closed.

Manual, monitored start

If the sensor circuit is closed, the device will start after the start circuit is closed by pressing the reset button.

A connected reset pushbutton (connection to S34) is monitored.

→ Section 3.4.4, "Connection options Start and feedback circuit", page28
→ Section 1.10, "Function and time diagrams", page10

Safe shut-down

When the sensor circuit is opened, enable current paths S13/14, 23/2, and 33/34 will be opened without delay.

When the enable current paths are open, the device will be in a safe state. The signal current path closes.

1.10 Function and time diagrams

Designation	Explanation
A1/A2	Power Supply
S33/S35	Automatic start
S33/S34	Manual start
S12	Sensor circuit 1 input
S22	Sensor circuit 2 input
13/14, 23/24, 33/34	Enable current path, non-delayed
41/42	Signal current path, non-delayed

Time diagram automatic start

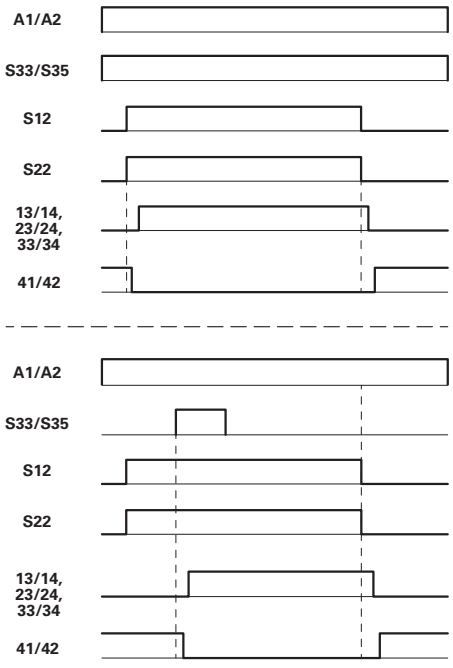


Figure 2: Time diagram automatic start

Time diagram manual start

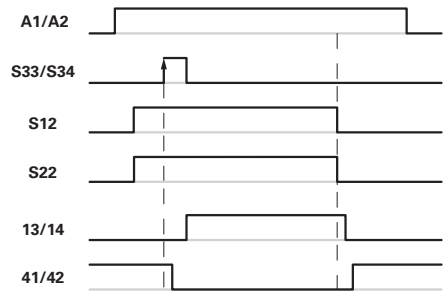


Figure 3: Time diagram manual start

Time diagram manual, monitored start with fault scenario

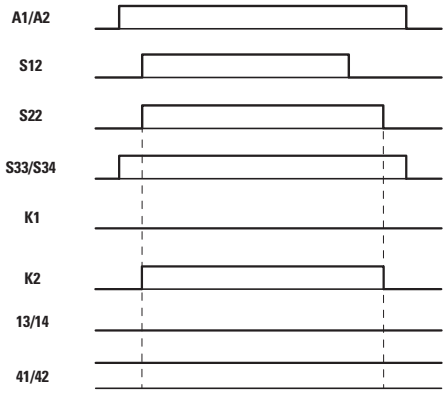


Figure 4: Time diagram manual, monitored start with fault scenario

1.11 Heat dissipation calculation

The safety relay's total heat dissipation is yielded by the input heat dissipation and the contact heat dissipation with equal or different load currents.

Input heat dissipation

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

Contact heat dissipation

At equal load currents.

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

At different load currents:

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

Total heat dissipations

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

now then

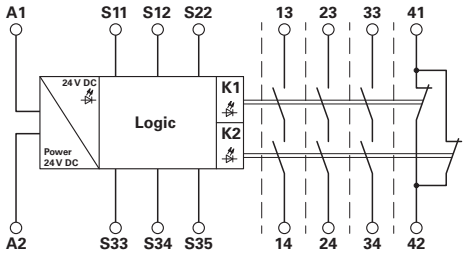
$P_{Total} = U_B^2 / (U_N/I_N) + n \times I_L^2 \times 200\ m\Omega$

or

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

P	Heat dissipation in mW
U_B	Applied operating voltage
U_N	Input rated voltage
I_N	Input current
n	Number of enable current paths used
I_L	Contact load current

1.12 Block diagram



Designation	Explanation
A1	Power supply 24 VDC
A2	Power supply 0 V
S11, S12, S22	Sensor circuit input
S33, S34, S35	Start circuit
13/14	Enable current paths, non-delayed 1
23/24	Enable current paths, non-delayed 2
33/34	Enable current paths, non-delayed 3
41/42	Signal current path, non-delayed

Figure 5: Block diagram

Isolation co-ordination

	Enclosure material	A1/A2, Logic	13/14	23/24	33/34	41/42
Enclosure material	-	4 kV BI	4 kV BI	4 kV BI	4 kV BI	4 kV BI
A1/A2, Logic	-	-	6 kV ST	6 kV ST	6 kV ST	6 kV ST
13/14	-	-	-	4 kV BI	4 kV BI	4 kV BI
23/24	-	-	-	-	4 kV BI	4 kV BI
33/34	-	-	-	-	-	4 kV BI
41/42	-	-	-	-	-	-
Legend: BI - basic insulation, ST - safe isolation						

Basic insulation
(rated surge voltage 4 kV)
Mixing low voltage and SELV is not permissible. Connect 250 VAC to one of the enable contacts only if the neighboring contact/enable current path is also carrying the same potential.

Safe isolation / reinforced insulation
(rated surge voltage 6 kV)
The reinforced insulation is designed one overvoltage category higher than the basic insulation (e.g., with greater clearances and creepage distances for the conductors). Accordingly, mixing SELV circuits with V ≤ 25 VAC or V ≤ 60 VDC and circuits with a higher voltage is possible.

1.13 Derating

The derating curves apply under the following conditions:

- Mounting on vertical or horizontal mounting rail
- Devices mounted without distance to each other
- with U_N up to max. 26.4 V DC
- $I_{max}^2 = I_1^2 + I_2^2 + I_3^2$

Horizontal mounting position

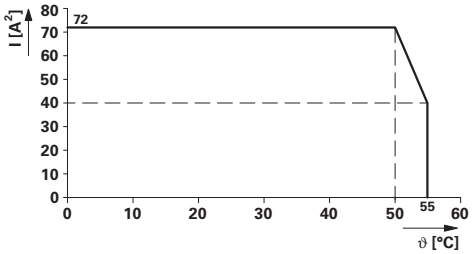


Figure 6: Derating curve – horizontal mounting positions, without distance

Vertical mounting position

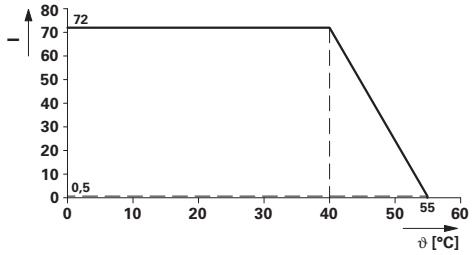


Figure 7: Derating curve – vertical mounting positions, without distance

1.13.1 Use at altitudes greater than 2000 m above sea level. NN

The following section describes the special conditions for the use of an ESR5-BWS-31-24VDC at altitudes greater than 2000 m abovesea level.
Make sure to observe the corresponding device-specific specifications (technical data, derating, etc.).

The use of the device ESR5-BWS-31-24VDC at altitudes **higher than 2000 m above sea leveland up to a maximum of 4500 mabove sea level** is allowed provided that:

1. Rated input voltage V_N: 24 VDC (-15%/+10%) is maintained and
2. The maximum switching voltage at the relay outputs for enable current paths 13/14, 23/24, 33/34, 43/44: min. 10 V, max. 250 VAC and signal current path 51/52: min 5 V, max. 250 VAC is not exceeded.

▶ 1.Reduce the maximum ambient temperature for operation by the corresponding temperature derating factor as per the following table.

Altitude above sea level	Temperatur-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

▶ 2.If derating is required, shift all the points in the derating curve by the temperature derating factor.

Calculation example for shifting the derating curve

→ Carry out the calculation and shift the derating curve as required for your application
→ Section 1.13, "Derating"

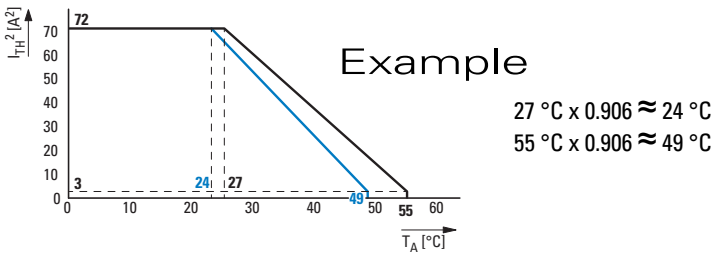


Figure 8: Example: Shifted derating curve (blue) at altitude of 3000 m above sea level

1.14 Load curve – resistive load

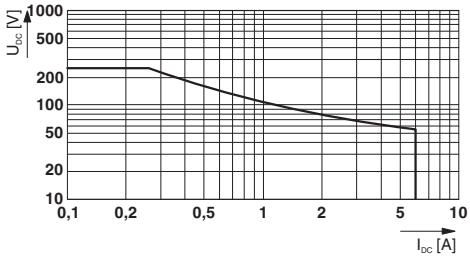


Figure 9: Load curve of the relay – resistive load

1.15 Electrical lifespan

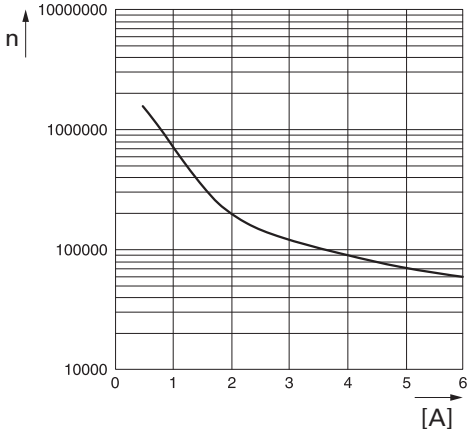


Figure 10: Number of switching cycles AC-1

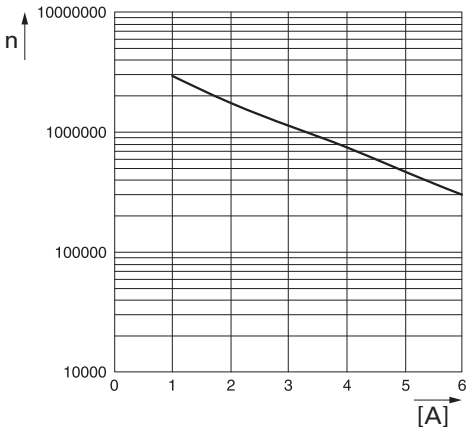


Figure 11: Number of switching cycles DC-1

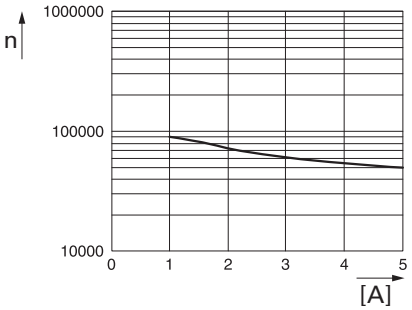


Figure 12: Number of switching cycles AC-15

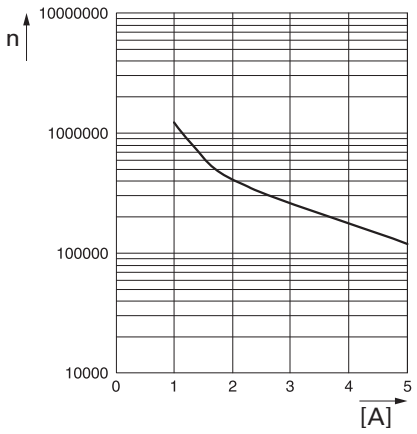


Figure 13: Number of switching cycles DC-13

2 Safety regulations

2.1 Basics

The device has been designed according to the state of the art and all generally accepted safety rules and standards. However, this alone cannot eliminate all potential hazards, which is why it is necessary for you to be aware of all hazards and residual risks.

Do not run the device unless it is in perfect technical condition. Make sure to always operate it as specified in this document and for the intended purpose.

WARNING

Danger due to electric voltage!
Disregarding safety regulations may result in death, serious personal injury or damage to equipment!
Depending on the specific application in question, the improper use of the device may pose serious hazards to the user or result in serious property damage.
Please observe all safety standards, regulations, and instructions regarding electrical equipment, as well as those established by the applicable employers' liability insurance association!

WARNING

Danger posed by the machine restarting automatically!
When dealing with controlled emergency (category 1) stop applications, make sure that the higher-level control system will not cause the machine to restart automatically!
Do not remove any protective covers from electrical switchgear during operation!

WARNING

Danger posed by faulty devices!
After a fault , the devices may be damaged, in which case proper operation can no longer be guaranteed!
Turn off the device without fail after the first fault!
Repairs to the device, especially those involving opening the housing, must be carried out exclusively by the manufacturer or by a person authorized by the manufacturer to do so. Failure to observe this requirement will void any and all warranties!

WARNING

Danger due to electric voltage!
During operation, parts of electrical switching devices carry hazardous voltages!

During operation, the protective covers must not be removed from the electric switchgear!

CAUTION
UV LIGHT

Plastics will become brittle when exposed to UV light.
This artificial aging will reduce the device's lifespan. Protect the device from direct sunlight and other sources of UV radiation.

ATTENTION

Risk of property damage posed by improper installation
In order to ensure safe operation, install the safety relay in an enclosure protected from water sprays and limited dust ingress (IP54).
Wire the device as required for the intended use.
→ Section 5, "Application examples", page33.

ATTENTION

Risk of property damage posed by emitted interference
When operating relay modules, the company operating the system must ensure that the requirements for emitted interference for electrical and electronic equipment (EN 61000-6-4) are met on the contact side.
If necessary, corresponding measures must be taken.

ATTENTION

Follow the safety instructions for the ESR5-BWS-31-24VDC!
The section on safety instructions must be read and understood by everyone who will be working with the ESR5-BWS-31-24VDC before the actual work is performed Safety relays for emergency stop, protective door and light grid monitoring.

2.2 Mandatory requirements, personnel requirements

2.2.1 Occupational safety

All generally accepted occupational health and safety rules and standards (internal and national) must be complied with, as must be all applicable laws and regulations in the relevant country.

2.2.2 Personnel qualifications

The personnel responsible for installation, operation, maintenance, and repairs must have the necessary qualifications for the work they will be performing. They must be appropriately trained and/or briefed and be informed of all hazards and risks associated with the device.

2.2.3 Device documentation

This manual is considered an integral part of the ESR5-BWS-31-24VDC and must always be readily available in the device's close proximity so that users have access to it.

Additional applicable documents and information on ESR5-BWS-31-24VDC, including the installation instructions, can be found on the Internet, in the Eaton Download Center - Documentation and on the product pages.

Eaton.com/documentation
Eaton.com/esr5

WARNING

INCOMPLETE OPERATOR MANUAL COPIES.

Working with individual pages taken out from the manual may lead to bodily injury and property damage due to missing safety information.

▶ Always work with the complete documentation.

2.2.4 Installation, maintenance, and disposal

Make sure that the device is connected, installed, serviced, and disposed of professionally and in line with all relevant standards and safety rules.

CAUTION

Installation requires qualified electrician
A ESR5-BWS-31-24VDC may only be fitted and connected by a qualified electrician or a person who is familiar with electrical installations.

Dispose of recyclables as required by your local recycling regulations.
Devices no longer being used must be professionally disposed of as per local regulations. To learn more, please visit: Eaton.com/recycling.

2.2.5 Prerequisites for proper operation

In order for the device to be able to meet the contractually stipulated terms, the following must be observed:

- Only qualified personnel should be allowed to work with the device.
- The personnel working with the device must have read and understood all documents for the device and must follow all the instructions in them.
- The required ambient conditions must be met.
- Maintenance work must be carried out correctly.

Make sure to read the → disclaimer, → Section 1.1, "Intended use", page6

We assume no liability for damages, consequential damages, and/or accidents caused by the following:

- Failure to follow any applicable occupational health and safety rules, standards, and/or regulations
- Device failures or function disturbances
- Improper use and/or handling
- Not following the instructions or observing the information in the documentation for the device
- Alterations, changes, and repairs to the device

2.3 Device-specific hazards

CAUTION
MALFUNCTION

The values specified in the technical data, as well as the device's electromagnetic compatibility (EMC), cannot be guaranteed if the following are used: unsuitable cables, improperly assembled and terminated cables, and/or wiring that does not conform to the applicable standards.
Only use cables assembled and terminated by professionals.
The cables being used must be assembled according to the wiring specifications in this document.
All general Directives and standards must be complied with.

2.3.1 Direct/indirect contact

- For all the components connected to the system, ensure protection against direct and indirect contact in conformity with VDE 0100 Part 410.

No cases of hazardous accidental energization must occur in the event of a fault (safety under single-fault conditions!).

2.3.2 Power supply units for 24 V supply

- Only use power supplies with safe isolation and SELV / PELV voltage.
- Protect the 24 V system with a suitable external fuse.
- Make sure that the power supply can deliver **four times** the rated current of the external fuse so as to ensure that the fuse will blow reliably in the event of a fault.
- Make sure that the output voltage of the power supply does not exceed 24 VDC -15%/+10% even in the event of a fault.

2.3.3 Mismatching and polarity reversal of connections

- Take measures to prevent mismatching, polarity reversal, and manipulation of connections.

2.4 In operation

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

- Do not remove any protective covers from electrical switchgear during operation!

In controlled emergency (category 1) stop applications, serious hazards to the user can be posed by the machine starting automatically.

- Make sure that the higher-level control system will not cause the machine to restart automatically.

In conformity with DIN EN ISO 13849-1, the manual monitored resetting device must not trigger a machine start.
Inductive loads can result in sticky relay contacts.

- Provide a suitable and effective protective circuit for inductive loads.
- Have the suppressor circuit be parallel to the load, not parallel to the switching contact.

Magnetic fields can affect the device. The surroundings' magnetic field strength must not exceed 30 A/m.

- Do not use the device in the proximity of strong magnetic fields (e.g., transformers or magnetite).

Emitted interference is possible when operating relay modules. Radio reception in residential areas can experience interference as a result.
The device is a class A product.

- Observe the requirements regarding emitted interference for electrical and electronic equipment (DIN EN IEC 61000-6-4).
- Take appropriate measures against emitted interference.

2.5 Defective devices

The devices may be damaged after a fault, in which case they are considered faulty.
Proper operation can no longer be guaranteed in this case.

- Replace the ESR5-BWS-31-24VDC without fail after the first fault!

CAUTION
DESTRUCTION

Repairs to the device, especially those involving opening the housing, must be carried out exclusively by the manufacturer.

2.6 Ensuring the safety of machinery or equipment

2.6.1 Elaborating and implementing a safety concept

The machine/system manufacturer and the company operating the machine/system are responsible for the safety of the machine/system and the application in which the machine/system is used. In order to use the device described here, you must have first elaborated a suitable safety concept for your machine or system. This includes a risk assessment in conformity with the Directives and standards specified in the EU Declaration of Conformity, etc.

2.6.2 Risk assessment, validation, and functional test

- Before using the device, carry out a risk assessment on the machine or system.
- Validate your overall safety system.
- After every change that is relevant to safety, carry out a new validation.
- Carry out functional tests on a regular basis.

2.6.3 Achievable level of safety integrity

Functional safety is ensured for the device as an individual component. However, this does not guarantee the functional safety of the whole machine or system. In order to be able to achieve the desired safety level for the entire machine or system, define the safety requirements for the machine or system and how they need to be implemented technically and organizationally.

3 Installation

CAUTION

Installation requires qualified electrician
A ESR5-BWS-31-24VDC may only be fitted and connected by a qualified electrician or a person who is familiar with electrical installations.

WARNING

Danger due to electric voltage!
All installation work must be carried out with the entire installation in a de-energized state.

Always comply with all applicable country-specific safety rules and regulations:

▶ 1.Switch off and isolate

▶ 2.Secure against retriggering

▶ 3.Verify isolation from the supply

▶ 4.Earthing and short-circuiting

▶5. Cover or enclose any neighboring live parts.

What to do before turning the device back on

▶ 1.Remove all tools and materials

▶ 2.Leave the danger zone

▶ 3.Remove the short-circuiting and grounding at the area where work was performed and then elsewhere

▶ 4.Disconnect the ground wire from the system components first, then from the ground

▶ 5.Do not touch system components or cables without a ground wire (if there was one previously) anymore

▶ 6.Reinstall all safety covers, safety enclosures, safety labels, and safety signs.

▶ 7.Do not remove safety measures at switching points until you get the all-clear for the areas where work was performed

▶8. If carrying out work that involves more than one worker, make absolutely sure that nobody is still in the danger zone

3.1 Prerequisites for the location of use

The supply voltage must be guaranteed and must conform to the relevant specifications-

The devices are intended to be flush mounted in control cabinets, control panels, service distribution boards, or control consoles on a mounting rail.

The device can be installed in a horizontal or vertical position.

3.2 Unpacking and checking the equipment supplied

The device is delivered in a package together with the document IL049016ZU.

- Check the ESR5-BWS-31-24VDC's packaging for transit damage.
- Carefully remove the packaging in order to avoid damaging the device.
- Check the package contents for visible transit damage.
- Keep the original packaging so that you will be able to use it in the future if you need to transport or ship the device.
- Carefully read the document IL049016ZU
- Make sure to also keep the document IL049016ZU and/or to give them to the end customer.

Missing parts or damage

If you notice anything wrong, please contact your distributor or Eaton Service +1 877-386-2273 (en) / 877-ETN-CARE (877-386-2273).

3.3 Mounting and disassembly

▶ Mount the device on a 35 mm mounting rail according to EN 60715.
▶ To remove it, release the locking base with a screwdriver.

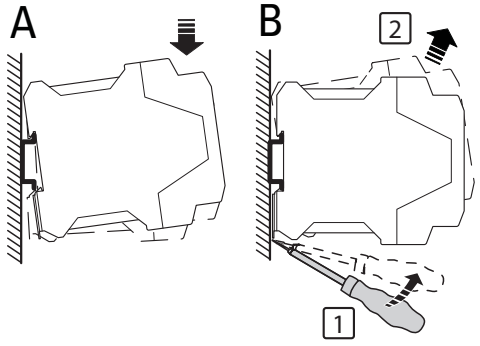
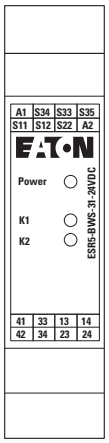


Figure 14: Mounting A and disassembly B

3.4 Connection

3.4.1 Pin assignment



A1	Power supply 24 VDC
A2	Power supply 0 V
S11	Sensor circuit output
S12	Input circuit safety sensor / switch 1
S22	Input circuit safety sensor / switch 2
S33/S34	Start circuit manual
S33/S35	Start circuit automatic
Power	Power LED (green)
K1	Safety sensor circuit status display: LED (green)
K2	Safety sensor circuit status display: LED (green)
13/14	Enable current path, non-delayed 1
23/24	Enable current path, non-delayed 2
33/34	Enable current path, non-delayed 3
41/42	Signal current path, non-delayed

3.4.2 ?Wiring topic

▶ Connect the cables to the connection terminals with the help of a screwdriver.

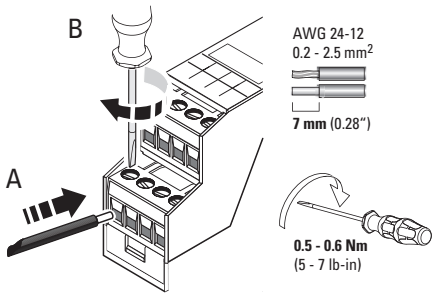


Figure 15: Connection of the cables

→ Ferrules are recommended when connecting flexible cables.

→ Use copper wire approved for temperatures of up to 60 °C/ 75 °C in order to meet the requirements for the UL listing.

Apply the nominal input voltage U_N (24 V DC) to terminals A1/A2. → The Power LED is lit.

Connect the sensor circuit as per the wiring to S11/S12/S22.

Automatic start

→ The signal current path 41/42 opens.

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

→ The K1 and K2 LEDs are lit.

3.4.3 Terminal models Signal encoder

▶ Connect suitable signal encoders to S11/S12/S22.

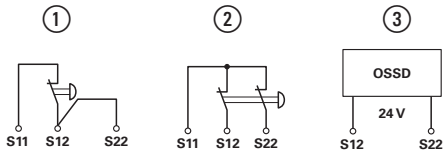


Figure 16: Terminal models Signal encoder

① Single-channel connection
② Dual-channel connection without cross-circuit detection
③ Dual-channel connection with **external** cross-circuit detection by the signal encoder

If single-channel driving via a PLC is used, then the PLC's digital output must meet the requirements for the required safety integrity.

3.4.4 Connection options Start and feedback circuit

Automatic start

▶ Connect the contacts S33/S35.

Manual, monitored start

▶ Connect a reset pushbutton to contacts S33/S34.

A connected reset pushbutton is monitored.

Start and feedback circuit

▶ To monitor external contactors or expansion devices with positively driven contacts, connect the respective N/Cs to path S33/S34 or S33/S35.

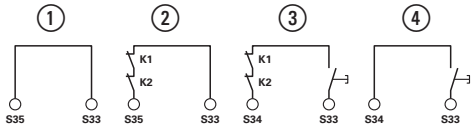


Figure 17: Connection options Start and feedback circuit

① Automatic start
② Manual start with monitored contact expansion module
③ Manual, monitored start with monitored contact expansion module
④ Manual, monitored start

4 Maintenance

4.1 Maintenance

The device is maintenance-free within its permissible service life of 240 months.
If required, carry out proof tests within the specified proof test interval
→ Section , "Technical safety data", page41.

Depending on the application and the connected peripherals, check the proper operation of the peripheral devices and of the safety chain on a regular basis.

→ Observe the manufacturer specifications concerning maintenance for the connected peripheral devices.

4.1.1 Proof-Test

The functional test is used to test the device's safety function.
To verify the device's function, follow the steps below:

- Activate the safety function
  by activating the corresponding protective device, e.g., the emergency stop button.
- Check whether the safety function runs correctly
  by switching the device back on with the sensor circuits.

If the ESR5-BWS-31-24VDC does not switch back on, the device has failed the proof test. The device is considered defective. → Section 2.5, "Defective devices", page22

.

WARNING
LOSS OF FUNCTIONAL SAFETY AS A RESULT OF MALFUNCTION

If the device fails the proof test, the device's proper operation is no longer guaranteed.
Replace the device.

4.2 Storage and transport

The device is delivered in cardboard packaging.

- Observe the handling instructions on and in the packaging.

→ Transport the device exclusively in its original packaging or in packaging suitable for transportation.

- For transportation and storage, observe the specifications regarding climatic ambient conditions in the technical data for the temperature range, humidity, and air pressure → Page 41

4.2.1 Decommissioning and disposal

For decommissioning, make sure to observe the requirements of the machine or system manufacturer.
When decommissioning the system or parts of the system, make sure to handle the used devices as follows.

If you will continue to use the device in conformity with its intended use:

- Store and transport the device in conformity with the corresponding specifications → Section 4.2, "Storage and transport", page30

The device is no longer used:

ATTENTION

Devices no longer being used must be professionally disposed or returned to the manufacturer or relevant sales department. For more information, see Eaton.com/recycling.

▶ Dispose of recyclables as required by your local recycling regulations.

4.2.2 Device replacement and repair

The device can be replaced if necessary.

If replacing the device:

- Use the same device type
- Use the same or a higher hardware/firmware version.

CAUTION
DESTRUCTION

Repairs to the device, especially those involving opening the housing, must be carried out exclusively by the manufacturer.

4.3 Diagnostics

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

→ If an error or fault scenario that is not listed occurs, please contact Eaton through Eaton.com/contact.

4.3.1 General states

Table 1 Diagnostics - general states

LED			State	Remark
Power	K1	K2		
●	○	○	All relays are not actuated. The sensor circuit is inactive.	-
			Only channel 1 or channel 2 of the sensor circuit is active.	-
			The sensor circuit is active. Relays K1 and K2 are ready to start and wait for reset/start command (S34).	Possible error see error messages.
●	●	●	The sensor circuit is active. All relays are energized.	-

Legend: ○ – LED off, ● – LED on

4.3.2 Error Messages

Table 2 Diagnostics - error messages

LED			State	Possible cause	Remedy
Power	K1	K2			
○	○	○	The sensor circuits are active.	No supply voltage or undervoltage at A1/A2.	Check the supply voltage
●	○	○	The sensor circuit is being actively driven, but the input LEDs is not lit.	Possible short circuit in sensor circuit between S12 and S22. The module does not detect the error (e.g., when using light curtains).	Turn off the operating voltage and fix the cross-fault. Then carry out a functional test.
			The sensor circuit is active. The reset/start circuit (S34) is/was activated. The safety circuit (K1 and K2) does not pick up	External error: The read-back contact (external actuator) in the reset circuit is open. Internal error: 1. the diagnostic contact is not working correctly. 2. one NO contact is welded.	External error: Check the actuator. Internal error: Power down reset with subsequent test of the safety function (function test). **If the error occurs again after the function test, please replace the device.**

LED			State	Possible cause	Remedy
Power	K1	K2			
●	○	●	The sensor circuit is active. The reset/start circuit (S34) is/was activated. Both safety circuits K1 and K2 are not picking up	S34 manual reset error (stuck-at on input).	Fix the problem in the reset/start circuit. Then carry out a functional test.
			The sensor circuit is active. The reset/start circuit (S34) is/was activated. The safety circuit (K1) does not pick up.	External error: The sensor circuit channels were not both opened / requested. Internal error: Diagnostics active.	External error: Check whether the second channel is opened with the sensor's request. Internal error: Perform a power-down reset followed by a function test. **If the error occurs again after the function test, replace the device.**
●	●	○	The sensor circuit is active. The reset/start circuit (S34) is/was activated. The safety circuit (K2) does not pick up.	External error: The sensor circuit channels were not both opened / requested. Internal error: Diagnostics active.	External error: Check whether the second channel is opened with the sensor's request. Internal error: Perform a power-down reset followed by a function test. **If the error occurs again after the function test, replace the device.**

Legend: ○ – LED off, ● – LED on

5 Application examples

5.1 Dual-channel light grid monitoring (shunted connection recognition by light grid)

- Manual activation
- Automatic activation with jumper at S33-S35
- Suitable up to category 4, PL e (EN ISO 13849-1), SIL 3 (EN IEC 62061)

→ Contactor K4 is not absolutely necessary to achieve Category 1.

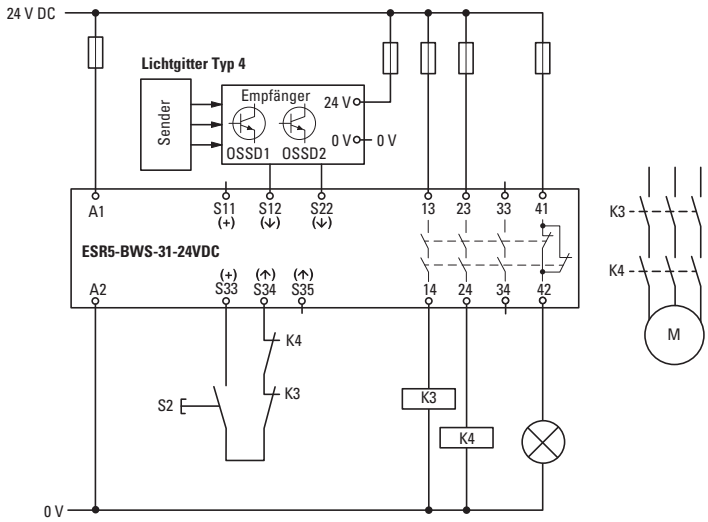


Figure 18: Dual-channel light grid monitoring
Reset S2 - manual reset device
K3, K4 - interlocked opposing contactors

5.2 Single-channel EMERGENCY STOP monitoring without shunted connection recognition, with monitored Reset pushbutton

- Manual activation
- Automatic activation with jumper at S33-S35
- Suitable up to category 3, PL d (EN ISO 13849-1), SIL 2 (EN IEC 62061)

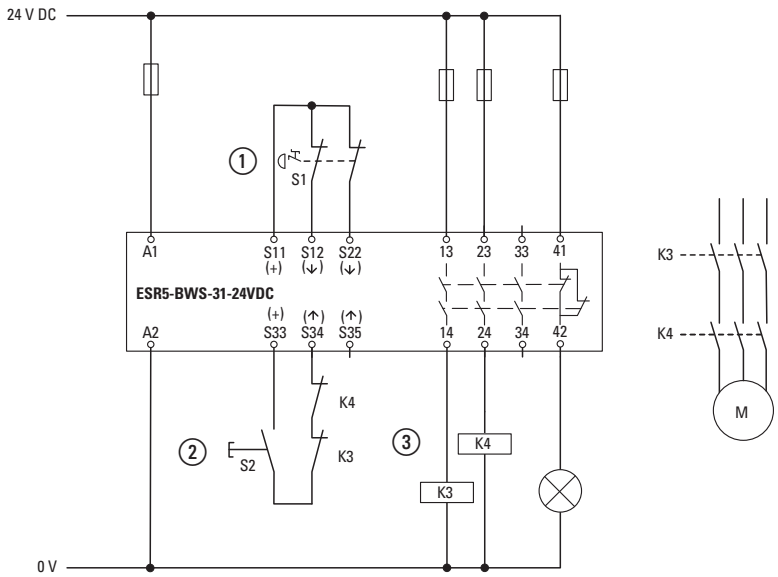


Figure 19: Single-channel EMERGENCY STOP monitoring / manual activation

① S1 – EMERGENCY-STOP pushbutton

② S2 – manual reset device

③ K3, K4 - interlocked opposing contactors

5.3 Single-channel EMERGENCY STOP monitoring

- Manual activation
- Automatic activation with jumper at S33-S35
- Suitable up to category 1, PL c (EN ISO 13849-1), SIL 1 (EN IEC 62061)

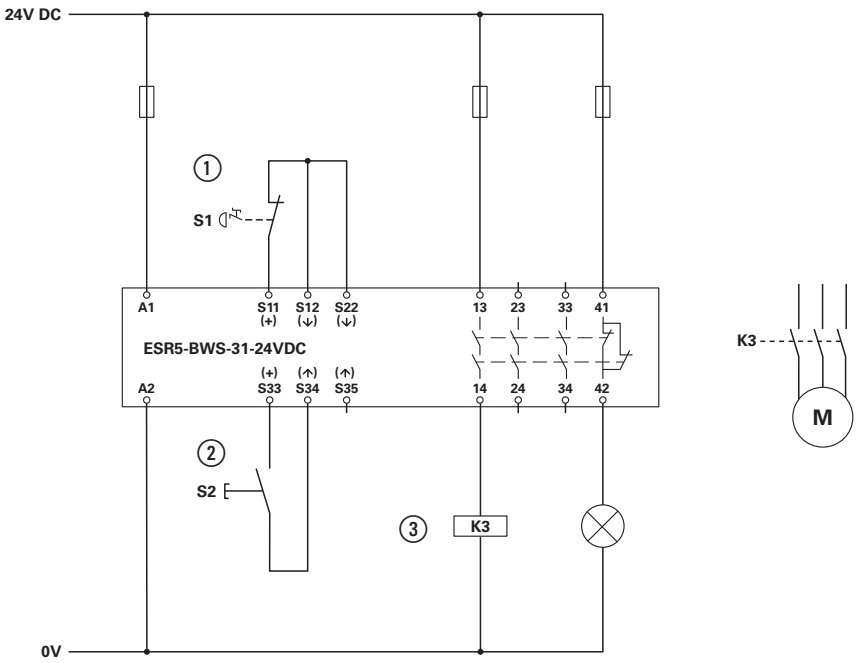


Figure 20: Single-channel EMERGENCY STOP monitoring with monitored Reset pushbutton

① S1 – EMERGENCY-STOP pushbutton
② S2 – manual reset device
③ K3, K4 - interlocked opposing contactors

5.4 Two-channel protective door monitoring without shunted connection recognition, with monitored Reset pushbutton

- Manual activation
- Automatic activation with jumper at S33-S35
- Suitable up to category 3, PL d (EN ISO 13849-1), SIL 2 (EN IEC 62061)

→ Contactor K4 is not absolutely necessary to achieve Category 1.

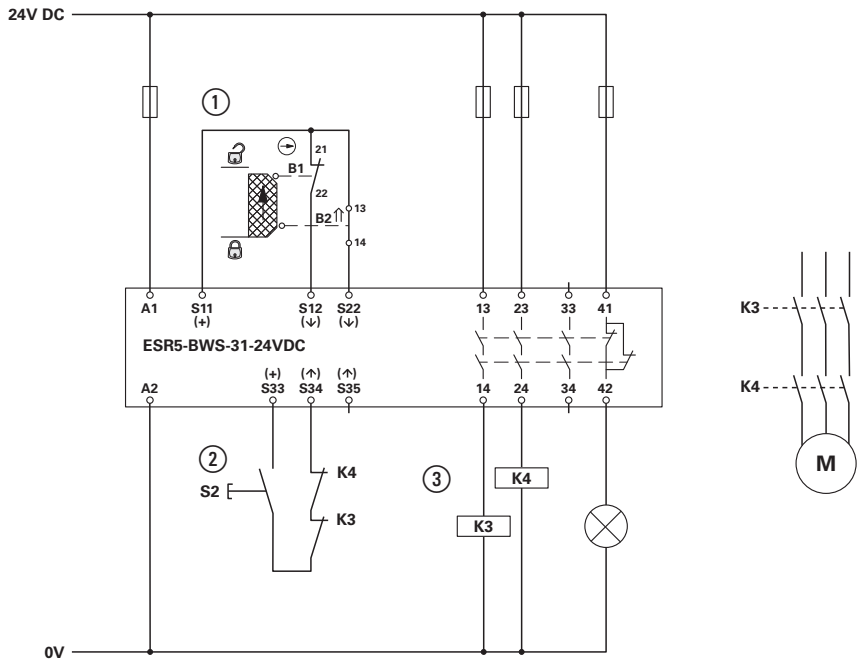


Figure 21: Two-channel protective door monitoring without shunted connection recognition

① B1/B2 – mechanical protective door switches
② S2 – manual reset device
③ K3, K4 - interlocked opposing contactors

6 Appendix

6.1 Data sheet and ordering data

The current specifications for the device can be found in the corresponding data sheet at Eaton.com/esr5

Article no. and type	Description
401064 ESR5-BWS-31-24VDC	ESR5 Safety relays for emergency stop, protective door and light grid monitoring, 24VDC, 3 enable paths

6.2 Technical specifications

Hardware/Firmware version	
HW/FW	≥ 08/-- The technical data and safety parameters are valid as of the specified HW/FW version.

→ The specifications in the technical data applied to the ESR5-BWS-31-24VDC at the time of this manual's publication and can accordingly differ from the specifications for the product found on the Internet.

Supply	
Rated control circuit supply voltage U_S	24 V DC -15 % / +10 %
Rated control supply current I_S	normally 70 mA (at U_S)
Power consumption at U_S	normally 1.68 W
Inrush current	< 3.5 A (normally at U_S, Δt = 3 ms)
Filter time	5 ms (for voltage dips at U_s, no test pulses allowed)
Suppressor circuit	Serial reverse voltage protection, suppressor diode

Supply data	
Conductor cross-section, rigid	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
Strip length	7 mm
Screw thread	M3
Tightening torque	0.5 Nm ....0.6 Nm

Digital inputs : Logic S12, S22	
Number of inputs	2
Input description	safety-related
Input voltage range "0"-signal	0 V DC ... 5 V DC
Input current range "0"-signal	0 mA ... 2 mA
Input voltage range "1"-signal	20.4 V ... 26.4 V
Inrush current	max. 110 mA (normally at U_S, Δt = 3 ms)
Current consumption	38 mA (normally at U_S)
Filter time	max. 2 ms (test pulse width for low test pulses) min. 100 ms (test pulse rate for low test pulses) No light test pulses / high test pulses allowed..
Maximum permissible total cable resistance	50 Ω
Simultaneity	∞
Suppressor circuit	Suppressor diode

Digital inputs : start circuit S34, S35	
Number of inputs	2
Input description	not safety related
Input voltage range "1"-signal	20.4 V ... 26.4 V
Inrush current	< 6 mA (normally with U_S at S34/35, Δt = 70 ms)
Current consumption	0 mA (normally with U_S at S34) 1 mA (normally with U_S at S35)
Filter time	No test pulses allowed
Maximum permissible total cable resistance	50 Ω
Simultaneity	
Suppressor circuit	Suppressor diode

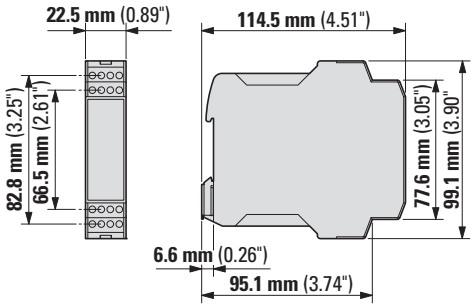
Relay outputs : enable current paths 13/14, 23/24, 33/34	
Number of outputs	3
Output description	2 NO contacts in series each, safety-related, potential-free
Contact material	$AgSnO_2$
Switching voltage	min. 10 V max. 250 V AC
Limiting continuous current	6 A (observe derating and load limit curve)
Inrush current	min. 10 mA max. 6 A
Square total current $I_{TH}^2 = I_1^2 + I_2^2 + ... + I_N^2$	72 A^2 (observe derating)
Switch capacity	min. 100 mW
Switching Frequency	max. 0.5 Hz
Lifespan, mechanical	10x 10^6 switching operations
Switching capacity, to IEC 60947-5-1	5 A (AC-15) 6 A (DC-13)
Output fuse	10 A gL/gG 4 A gL/gG (for low-demand applications)

Relay outputs: signal current path 41/42	
Number of outputs	1
Output description	2 NC in parallel, not safety-related, potential-free
Contact material	$AgSnO_2$
Switching voltage	min. 10 V AC/DC max. 250 V AC
Limiting continuous current	6 A
Inrush current	min. 10 mA max. 6 A
Square total current $I_{TH}^2 = I_1^2 + I_2^2 + ... + I_N^2$	36 A^2
Switch capacity	min. 100 mW
Switching Frequency	max. 0.5 Hz
Lifespan, mechanical	10x 10^6 switching operations
Switching capacity, to IEC 60947-5-1	1.5 A (AC15) 2 A (DC13)
Output fuse	6 A gL/gG

Times	
Normal pick-up time at U_s	100 ms (if actuated via A1)
Normal response time at U_s	100 ms (automatic start) 100 ms (manual, monitored start)
Normal reset time at U_s	10 ms (when requested via the sensor circuits) 45 ms (when requested via A1)
Restart time	< 1 s (boot time)
Recovery time	1 s (according to the requirement of the safety function)
Start pulse duration	≥ 500 ms (manual start)

General data	
Relay type	Electromechanical relay with forcibly guided contacts according to IEC/EN 61810-3
Rated operating mode	100 % DF
Protection type	IP20
Protection type Installation location minimum	IP54
Mounting type	Rail mounting
Mounting position	Vertical or horizontal
Mounting instruction	See derating curve
Type of housing	
Operating voltage indication	1x LED green
status display	2x LED green
Clearances and creepage distances between circuits	according to DIN EN 60947-1
Rated insulation voltage	250 V
Rated surge voltage / insulation	4 kV / basic insulation (safe isolation, reinforced insulation and 6 kV between A1-A2 / logic / enable and signal current paths.) See section "Isolation co-ordination"
Pollution degree	2
Overvoltage category	III
Maximum power loss at nominal condition	16.44 W (at U_S = 26.4 V, I_L^2 = 72 A^2; $P_{Total\ max}$=2.04 W+14.4 W)
Note on heat dissipation	See chapter "Heat dissipation calculation"

Dimension	
W x H x D	22.5 mm x 99.1 mm x 114.5 mm



Weight	210 gr

Conformity/approvals	
Conformity	CE
Approvals	c UL us LISTED; EAC; TÜVRheinland CERTIFIED Product Safety Functional Safety www.tuv.com ID 0000000000

Ambient conditions	
Ambient temperature (operation)	-20 °C - 55 °C (observe derating)
Ambient temperature (storage/transport)	-40 °C - 70 °C
Max. permissible relative humidity (operation)	75% (on average, 85% occasionally, no condensation)
Max permissible relative humidity (storage/transport)	75% (on average, 85% occasionally, no condensation)
Applicable height	≦ 2000 m (above sea level)
Notes on applicable height	See section "Use at altitudes greater than 2000 m above sea level"
Impact resistance	15 g
Vibration (operation)	10 Hz - 150 Hz, amplitude 0.15 mm, 2 g

Technical safety data	
Stop category according to EN60204	0
Technical safety parameters for IEC 61508 – High Demand	
The specifications apply only if the safety function is requested at least once a year.	
Device type (static)	Type A
HFT (Hardware Fault Tolerance)	1
SIL	1 (up to SIL 3 – depending on the application)
PFH_d	5.56×10^{-10} (5 A DC-13; 5 A AC-15; 8760 switching operations/year)
Demand level	< 12 months
Proof test interval	240 months
Lifetime	240 months
Technical safety parameters for IEC 61508 – Low Demand	
Device type (static)	Type A
HFT (Hardware Fault Tolerance)	1
SIL	1 (up to SIL 3 – depending on the application)
PFD_{avg}	1.50×10^{-4}
Proof test interval	75 months
Lifetime	240 months
Technical safety parameters according to EN ISO 13849	
Category	1 (up to category 4 – depending on the application)
Performance Level	c (up to PL e – depending on the application) e (5 A DC-13; 5A AC-15; 8760 switching operations/year)
Lifetime	240 months
For applications with PL e, a demand mode for the safety function of once per month is required.	
Technical safety parameters for EN IEC 62061	
SIL	1 (up to SIL 3 – depending on the application)

6.3 Interface type (ZVEI classification)

Digital inputs : Logic S12, S22				
Source/drain	**Interface type**	**Additional measure**	**Source/drain**	**Suitable interface type**
Drain	A	M	Source	A

Interface type A - drain			
Parameter	**min.**	**normally**	**max.**
Input current I_i (in ON state)	27 mA	-	110 mA (Δt = 150 ms)
Output voltage U_i	19 V	-	26 V
Input capacity C_i	-	-	-
Additional measure M	The inputs are not types according to IEC 61131-2. T_G is S11 for S12 (24 V without clock)		

Digital inputs : start circuit S34, S35				
Source/drain	**Interface type**	**Additional measure**	**Source/drain**	**Suitable interface type**
Drain	A	M	Source	A
Drain	C0	M	Source	C1, C2, C3

Interface type A - drain			
Parameter	**min.**	**normally**	**max.**
Input current I_i (in ON state)	0 mA (S34) 1 mA (S35)	-	6 mA (Δt = 70 ms)
Output voltage U_i	19 V	-	26 V
Input capacity C_i	-	-	-
Additional measure M	The inputs are not types according to IEC 61131-2. T_G is S33 (24 V without clock)		

Interface type C0 - drain			
Parameter	**min.**	**normally**	**max.**
Test pulse duration t_i	-	-	-
Test pulse interval T	-	-	-
Input resistance R	3.9 kΩ	-	10.7 kΩ
Input capacity C_L	-	-	-
Inductive load L_L	-	-	-
Additional measure M	The inputs are not types according to IEC 61131-2. Switch-on pulses should be switched off for safety applications.		

Relay outputs : enable current paths 13/14, 23/24, 33/34				
Source/drain	**Interface type**	**Additional measure**	**Source/drain**	**Suitable interface type**
Source	A	M	Drain	A
Source	C0	M	Drain	-

Interface-type A - source			
Parameter	**min.**	**normally**	**max.**
Switching current I_i (in ON state)	10 mA	-	6 mA
Switching voltage U_i	10 V	-	250 V AC
Internal resistance R_i (in switched state)	Load ≥ 1 A ≤ 200 mΩ	-	Load ≥ 10 mA ≤ 40 Ω
Load capacity C_L	-	-	See switching capacity
Inductive load L_L	-	-	See switching capacity
Potential free	Yes	-	-
Additional measure M	The inputs are not types according to IEC 61131-2.		

Interface type C0 source			
Parameter	**min.**	**normally**	**max.**
Test pulse duration t_i	-	-	-
Test pulse interval T	-	-	-
Rated operational current I_N	-	-	6 A
Load capacity C_L	-	-	See switching capacity
Inductive load L_L	-	-	See switching capacity
Additional measure M	The inputs are not types according to IEC 61131-2. No test pulses are output at the output.		

Relay outputs : signal current path 41/42				
Source/drain	**Interface type**	**Additional measure**	**Source/drain**	**Suitable interface type**
Source	A	M	Drain	A
Source	C0	M	Drain	-

Interface-type A - source			
Parameter	**min.**	**normally**	**max.**
Switching current I_i	10 mA	-	6 mA
Switching voltage U_i	5 V	-	250 V AC
Internal resistance R_i (in switched state)	Load ≥ 1 A ≤ 100 mΩ	-	Load ≥ 10 mA ≤ 20 Ω
Load capacity C_L	-	-	See switching capacity
Inductive load L_L	-	-	See switching capacity
Potential free	Yes	-	-
Additional measure M	The outputs are not types according to IEC 61131-2.		

Interface type C0 source			
Parameter	**min.**	**normally**	**max.**
Test pulse duration t_i	-	-	-
Test pulse interval T	-	-	-
Rated operational current I_N	-	-	6 A
Load capacity C_L	-	-	See switching capacity
Inductive load L_L	-	-	See switching capacity
Additional measure M	The inputs are not types according to IEC 61131-2. No test pulses are output at the output.		

7 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	**E**lectro-**s**ensitive **p**rotective **e**quipment
CCF	**Common Cause Failure** Common cause failure
DC	**Diagnostic Coverage** Diagnostic coverage
ESR	**E**lectronic **s**afety **r**elay
DF	Duty factor
PL	**Performance Level** Classification of safety functions used to meet a safety requirement.
HFT	**H**ardware **F**ault **T**olerance
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	**N**ormally **C**losed contact, break contact An NC breaks a circuit when it is energized.
NO	**N**ormally-**O**pen 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

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Eaton Industries GmbH
Hein-Moeller-Str. 7–11
D-53115 Bonn

1123 MN049020EN (PMCC)

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