# SAFETY RELAY APPLICATION


Application manual for YRB-4EML-31S safety relay

Designation: SAFETY RELAY APPLICATION

Revision: 02 / 13.07.2016

Order No.: 605-000-728

This manual is valid for:

YRB-4EML-31S from Contrinex

# Please observe the following notes

**User group of this manual**

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

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

**Explanation of symbols used and signal words**

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

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

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

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

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

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

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

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# 1 Introduction

The term “safety” derives from Latin and refers to a state that is free from unacceptable risks. This fundamental human requirement is also enshrined in basic EU law.

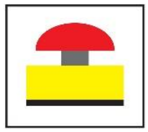
The safety of machines and systems mainly depends on the correct application of standards and directives. In Europe, the basis for this is the Machinery Directive, which provides standard specifications to support companies when designing safety-related machines. The aim is to eliminate barriers to trade within the EU. However, even outside the European Economic Area, many European standards are gaining in importance due to their international status.

The fact that the safety of machines and systems not only depends on the components and technologies used, but is mainly affected by the “human” factor is no surprise.

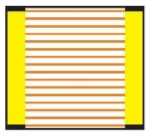
## 1.1 Target group for this application manual

This manual is aimed at all designers of safety controllers. This manual should provide a simple introduction to the technology of safety-related machines and systems and an overview of safety technology basics. You must always ensure you are familiar with the directives, standards, and regulations relevant to the field of application.

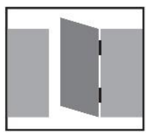
## 1.3 Symbols used



Emergency stop



AOPD light curtain



Movable guard

# 2 Safety of machines and systems

In modern industrial production, the amount of complex technical equipment used is constantly increasing. The purpose of safety technology is to reduce the risk to people, working animals, the environment, and machines as far as possible, and to at least a reasonable degree. The availability of production equipment should not be restricted any more than is absolutely necessary.

Safety is relative. There is no such thing as an absolutely safe machine. However, since the opening of the European single market, manufacturers and operators of machines and technical equipment are legally bound to observe European directives for the design and operation of machines and systems.

When adhering to harmonized standards (assumed effect), which apply to a machine or piece of technical equipment, it is assumed that they comply with legal regulations when launched.

The Machinery Directive is one of the most important single market directives. It is of such importance because machine construction is one of the industrial mainstays of the European Economic Area. The Machinery Directive defines the requirements machinery must meet before it can be placed on the market and operated in the European Economic Area. It also contains essential health and safety requirements for the planning and construction of machinery and safety components.

Every machine or system poses a risk. According to the requirements of the Machinery Directive, a risk assessment must be carried out for every machine.

If the risk is greater than the level of risk that can be tolerated, risk reduction must be implemented.

Standard EN ISO 12100 “Safety of machinery - General principles for design - Risk assessment and risk reduction” describes the risks to be considered and the general principles for design to reduce risk, and describes risk assessment and risk reduction as a repetitive process to achieve safety. All phases in the life of the machine are therefore assessed.

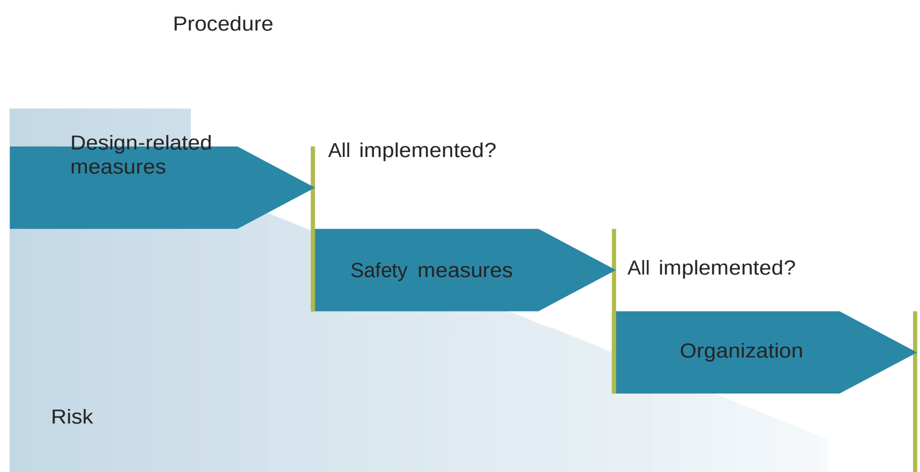



Figure 1 Risk reduction in machines

## 2.1 Functional safety

Safety-related parts of machine control systems are frequently assigned to provide safety functions. The contribution to the overall risk reduction of machinery by the safety-related parts of a control system is determined according to EN ISO 12100.

In order to achieve the necessary functional safety of a machine or system, it is essential for the safety-related parts of the safety equipment and control devices to operate correctly and, in the event of failure, for the system to remain in the safe state or enter a safe state. The requirements for achieving functional safety are based on the following objectives:

– Avoidance of systematic errors
– Control of systematic errors
– Control of random faults or failures

The requirements of the safety-related parts of a machine control system are specified in EN ISO 13849 (and EN 62061). The standard specifies the various safety levels in the form of the “performance level” (and “safety integrity level” (SIL)) for the safety-related parts according to the degree of risk and describes the characteristics of the safety functions.

## 2.2 Practical procedure according to EN ISO 13849

In practice, the following steps have proven effective when designing safe controllers according to EN ISO 13849.

### 2.2.1 Definition of the safety function

The safety functions must be defined first. This information is derived from the risk assessment.

Example:

| | |
|---|---|
| Trigger event: | Opening the safety door. |
| Response: | The robot drive is set to a safe stop state. The power semiconductor pulses are disabled. |
| Safe state: | Power circuit has no power. |

### 2.2.2 Determination of the required performance level ($PL_r$)

The $PL_r$ is determined in combination with the safety function within the framework of the higher-level risk assessment. For each safety function, the required $PL_r$ is estimated using the risk graph below.

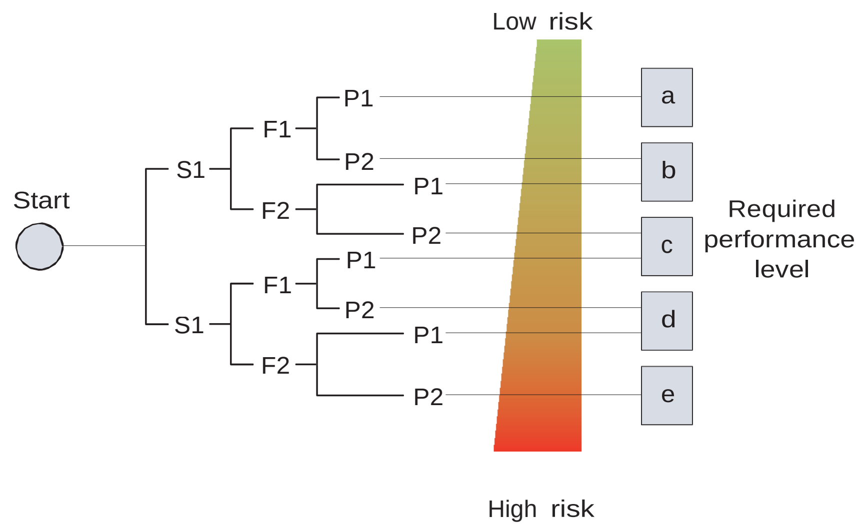



Figure 2 Risk graph (according to EN 13849-1)

Meaning of individual parameters:

S: severity of injury

- S1 Slight (normally reversible) injury
- S2 Serious (normally irreversible) injury

F: frequency and duration of exposure to the hazard

- F1 Seldom to not very frequent or exposure to hazard is brief
- F2 Frequent to continuous or exposure to hazard is long

P: possibility of avoiding or limiting damage

- P1 Possible under specific conditions
- P2 Scarcely possible

### 2.2.3 Technical implementation

This step involves the technical pre-planning of the safety function, taking possible technologies and components into account. The safety-related components and parts must then be identified for later verification.

### 2.2.4 Dividing the safety function into subsystems

In the next step, a safety-related block diagram must be created for further evaluation. As a rule, a safety function consists of sensor - logic - actuator. In the simplest case, each one is a subsystem. These subsystems are connected in series to form the overall safety function.

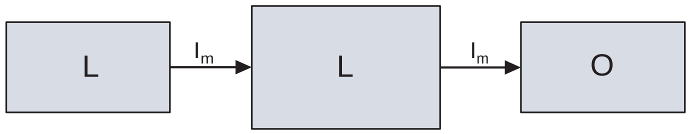



Figure 3 Safety-related block diagram (according to EN 13849-1)

### 2.2.5 Determination of the achieved PL for each subsystem

A characteristic value when determining the performance level is the $PFH_d$ value, the statistical "probability of a dangerous failure per hour". The safety characteristics can be found in the FUNCTIONAL SAFETY CHARACTERISTICS data sheet or the SISTEMA library.

The diagram below shows the basic relationship between PL and the safety characteristics category, DC, and $MTTF_d$.

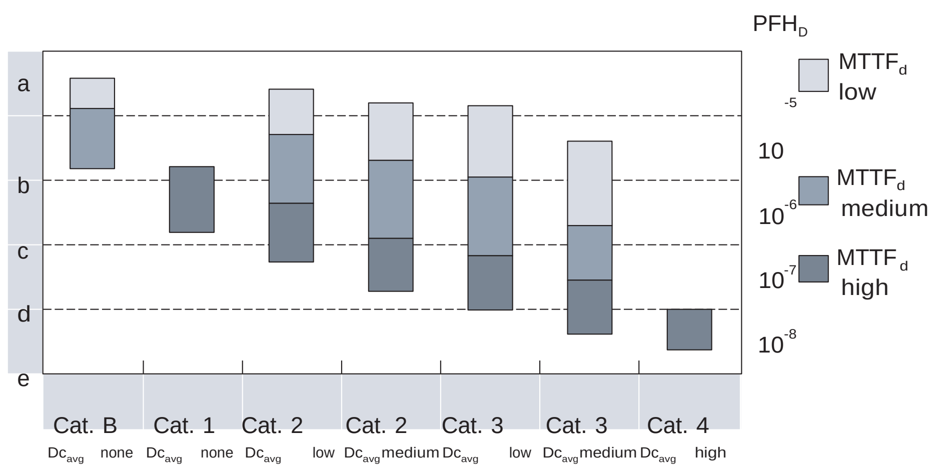



Figure 4 Relationship between PL, category, DC, and MTTFd (according to EN 13849-1)

The category is an important parameter when determining the PL. The category term has been taken from the previous standard EN 954-1. The requirements for the categories are listed below.

Table 1 Explanation of categories

| Category | Summary of requirements | System behavior | Principle to achieve safety |
|---|---|---|---|
| B | Safety-related parts of control systems and/or their protective equipment, as well as their components, shall be designed, constructed, selected, assembled, and combined in accordance with relevant standards so that they can withstand the expected influences. Basic safety principles must be used. | The occurrence of a fault can lead to the loss of the safety function. | Mainly characterized by the selection of components. |
| 1 | The requirements of category B must be met. Proven components and proven safety principles must be used. | The occurrence of a fault can lead to the loss of the safety function but the probability of occurrence is lower than that for category B. | Mainly characterized by the selection of components. |
| 2 | The requirements of category B and the use of proven safety principles must be met. The safety function must be tested by the machine control system at suitable intervals. | The occurrence of a fault can lead to the loss of the safety function between the tests. The loss of the safety function is detected by the test. | Mainly characterized by the structure. |
| 3 | The requirements of category B and the use of proven safety principles must be met. Safety-related parts must be designed so that:<br>– A single fault in<br>any of these parts does not lead to the loss of the safety function; and<br>– the single fault is detected, whenever this is feasibly possible. | When the single fault occurs, the safety function is always performed. Some but not all faults are detected. An accumulation of undetected faults can lead to the loss of the safety function. | Mainly characterized by the structure. |
| 4 | The requirements of category B and the use of proven safety principles must be met. Safety-related parts must be designed so that:<br>– A single fault<br>in any of these parts does not lead to the loss of the safety function; and<br>– the single fault is detected on or before the next demand of the safety function. If detection is not possible, an accumulation of undetected faults must not lead to the loss of the safety function. | When the single fault occurs, the safety function is always performed. The detection of accumulated faults reduces the probability of the loss of the safety function (high DC). The faults are detected in time to prevent a loss of the safety function. | Mainly characterized by the structure. |

### 2.2.6 Determination of the achieved PL for the overall safety function

For subsystems with integrated diagnostic functions such as safety devices and safety controllers, the achieved $PFH_d$ and PL are provided by the manufacturer with the specification of the category.

For subsystems consisting of discrete components (e.g., switches, contactors, valves, etc.), the $PFH_d$ value is determined from the category, DC, and $MTTF_d$. For components that are subject to wear, the $MTTF_d$ is determined based on the number of operating cycles using the B10d value provided by the component manufacturer.

In addition, for category 2 or higher the effect of common cause failure (CCF) must also be considered.

### 2.2.7 Verification of the achieved PL

Each individual subsystem and the entire safety chain must both meet the requirements of the necessary $PL_r$. This includes both the quantitative evaluation and the consideration of systematic aspects, such as proven components and safety principles.

The systematic aspects include:
- Correct dimensioning of components
- Consideration of expected operating conditions and ambient conditions
- Use of basic and proven safety principles
- Avoidance of specification errors and software errors through testing

### 2.2.8 Validation

The last step should check whether the selected measures achieve the necessary risk reduction and therefore the protection objectives of the risk assessment. The result of the validation process is included in the final risk assessment.

The purpose of the validation process is to confirm the specification and level of conformity of the design of safety-related parts of the control system (SRP/CS) within the overall specifications for the safety requirements of the machinery. Before validation of the design of the SRP/CS or the combination of SRP/CS that contains the safety function, the specification requirement for the safety function must be confirmed. Validation involves performing analysis and function tests under normal conditions in accordance with the validation plan.

EN ISO 13849-2 contains detailed requirements and describes the basic procedure for the individual validation processes.

## 2.3 Practical procedure according to EN ISO 62061

In practice, the following steps have proven effective when designing safe controllers according to EN 62061.

### 2.3.1 Specification of requirements for the safety-related control function (SRCF)

The safety function must be defined first. This information is derived from the risk assessment.

Example:

| | |
|---|---|
| Trigger event: | Opening the safety door. |
| Response: | The robot drive is set to a safe stop state. The power semiconductor pulses are disabled. |
| Safe state: | Power circuit has no power. |

### 2.3.2 Determination of the required safety integrity level (SIL)

The required SIL is determined in combination with the safety function within the framework of the higher-level risk assessment.

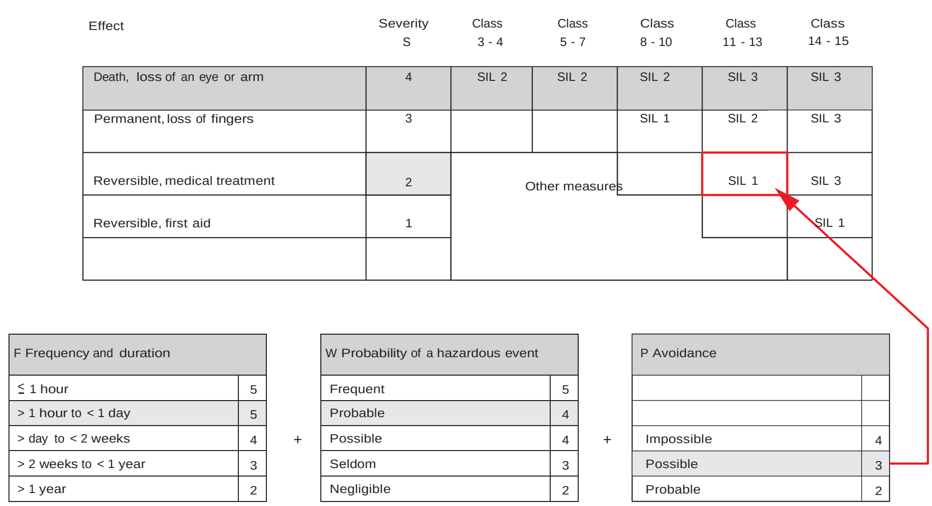



Figure 5 Example of specifying the SIL (according to EN 62061)

### 2.3.3 Drafting the safety-related electrical control system (SRECS)

This step involves the technical pre-planning of the safety function, taking possible technologies and components into account. The safety-related components and parts must then be identified for later verification.

### 2.3.4 Determination of the achieved safety integrity for the entire SRECS

To determine the achieved safety integrity level, the $PFH_d$ values of the individual subsystems must now be added together. The result must lie within the SIL required for the safety function.

Table 2 Determination of the safety integrity level (according to EN 62061)

| Safety integrity level | Probability of a dangerous failure per hour ($PFH_D$) |
|---|---|
| 3 | $\geq 10^{-8}$ to $< 10^{-7}$ |
| 2 | $\geq 10^{-7}$ to $< 10^{-6}$ |
| 1 | $\geq 10^{-6}$ to $< 10^{-5}$ |

Furthermore, the SIL CL of an individual subsystem determines the maximum achievable SIL for the SRECS. For safety components with integrated diagnostics, this is provided by the manufacturer. For subsystems consisting of discrete components, this value must be determined using the table below.

Table 3 Determination of the safety integrity level for a subsystem with discrete components (according to EN 62061)

| Safe failure fraction | Hardware fault tolerance [1)] | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| < 60% | Not permitted [2)] | SIL 1 | SIL 2 |
| 60% to < 90% | SIL 1 | SIL 2 | SIL 3 |
| 90% to < 99% | SIL 2 | SIL 3 | SIL 3 |
| ≥ 99% | SIL 3 | SIL 3 | SIL 3 |

[1)] A hardware fault tolerance of N means that N + 1 faults can lead to a loss of the SRCF.

[2)] See EN ISO 62061, Section 6.7.7

### 2.3.5 Verification of the achieved SIL

Each individual subsystem and the entire safety chain must both meet the requirements of the necessary SIL. This includes both the quantitative evaluation and the consideration of systematic aspects.

The systematic aspects include:

- Correct dimensioning of components
- Consideration of expected operating conditions and ambient conditions
- Use of basic and proven safety principles
- Avoidance of specification errors and software errors through testing

### 2.3.6 Validation

The last step should check whether the selected measures achieve the necessary risk reduction and therefore the protection objectives.

The result of the validation process is included in the final risk assessment.

The purpose of the validation process is to confirm the specification and level of conformity of the design of safety-related parts of the control system (SRP/CS) within the overall specifications for the safety requirements of the machinery. Before validation of the design of the SRP/CS or the combination of SRP/CS that contains the safety function, the specification requirement for the safety function must be confirmed. Validation involves performing analysis and function tests under normal conditions in accordance with the validation plan.

EN ISO 13849-2 contains detailed requirements and describes the basic procedure for the individual validation processes.

# 3 Safety technology basics

## 3.1 Cross-circuit detection

In both category 3 and category 4, a first fault must never lead to the loss of the safety function. This often makes it necessary to provide redundancy in the control structure.

Cross-circuit detection has the ability to detect short circuits, bridges or short circuits to ground between two channels either immediately or within the framework of cyclic self-monitoring.

A cross circuit may be due to one of the following reasons:

– Squeezing
– High temperatures
– Chips
– Acids

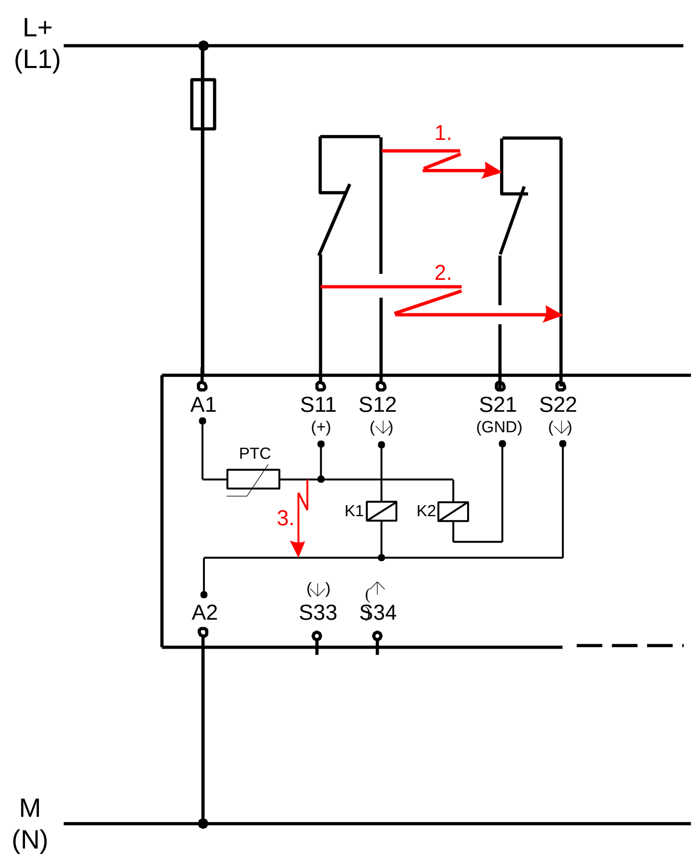



Figure 6 Cross-circuit detection

## 3.2 Maximum cable lengths

Depending on the size of the machine or system, a considerable amount of cabling may be required to wire the sensors.

Make sure that the specified cable lengths are not exceeded, so as to ensure error-free operation of the safety relay.

## 3.3 Stop

**Stop categories according to EN 60204-1**

Every machine must be fitted with emergency stop equipment.

As per EN 60204-1, this must be implemented in stop category 0 or stop category 1 and must be able to function independently of the operating mode.

In order to stop a machine, three stop categories are defined in EN 60204-1, which describe the stop control sequence independently of an emergency situation.

**Stop category 0**

- Stopping by immediate removal of power to the machine drives (i.e., an uncontrolled stop).

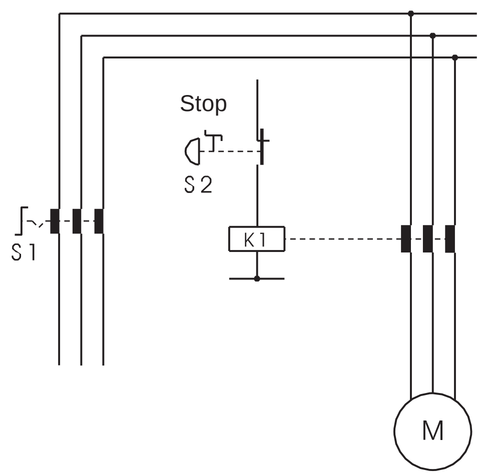



Figure 7 Stop category 0 example

**Stop category 1**

- A controlled stop with power available to the machine drives to achieve the stop; power is removed only when the stop is achieved.

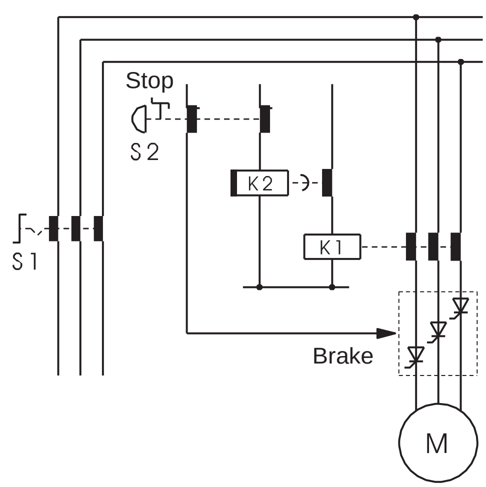



Figure 8 Stop category 1 example

**Stop category 2**

- A controlled stop with power available to the machine drives.

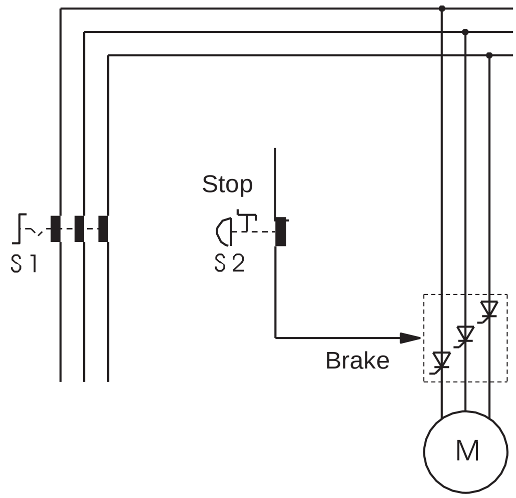



Figure 9 Stop category 2 example

# 4 Application examples for YRB-4EML-31S safety relay

## 4.1 Emergency stop

**Emergency stop (according to EN ISO 13850, EN 60204-1)**

An emergency operation intended to stop a process or a movement that would become hazardous (stop).

The emergency stop function is triggered by a single operator operation. This function must be available and operational at all times according to EN ISO 13850. In this case, the operating mode is not taken into consideration.

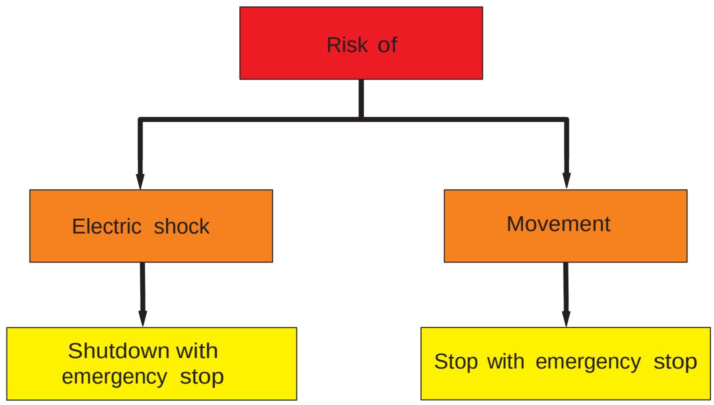
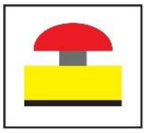



Figure 10 Emergency stop

The emergency stop function should not be used as a substitute for safety equipment or other safety functions, but should be designed as additional safety equipment. The emergency stop function must not adversely affect the effectiveness of safety equipment or equipment with other safety functions.

Furthermore, it must be designed so that when faced with the decision to activate the manual emergency stop control, the operator does not have to consider the resulting effects.



### 4.1.1 YRB-4EML-31S up to PL c/SIL 1

**Single-channel emergency stop monitoring with manual reset**

| | |
|---|---|
| **Order No.** | 605-000-728 with screw connection |
| **Technical data** | – 24 V AC/DC<br>– 3 enabling current paths, 1 signaling current path<br>– Monitored manual or automatic start<br>– Basic insulation<br>– Stop category 0<br>– Cat. 4/PL e according to EN ISO 13849-1, SIL CL 3 according to EN 62061 |

**Application example**

- Single-channel emergency stop monitoring
- Manual reset (S33, S34)
- Stop category 0
- Safety level of the example up to PL c (EN ISO 13849-1) and SIL 1 (EN 62061)

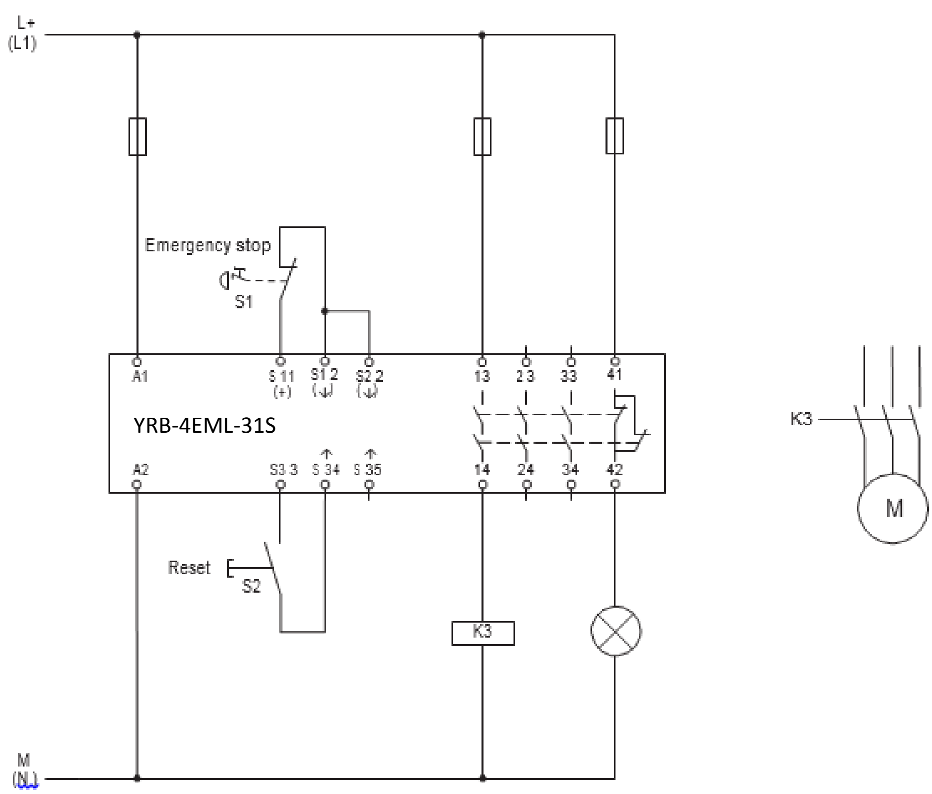
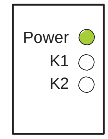
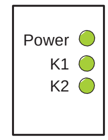
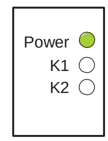


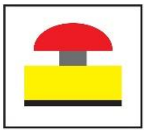

Figure 11 Single-channel emergency stop monitoring with manual reset

**Function description**

| **Start** | Action | Result | Diagnostics |
|---|---|---|---|
| | 1. Unlock emergency stop button S1. | The emergency stop button closes enable circuit S11 and S12 of the safety relay.<br>The circuit is enabled via the reset button. |  |
| | 2. Press reset button S2. | Contactor K3 is activated. |  |
| **Stop** | Action | Result | Diagnostics |
| | 1. Press emergency stop button S1. | The safety function is triggered and contactor K3 is opened. |  |

**Notes on the application example**

1. The emergency stop control device is positive opening according to EN 60947-5-1.
2. Stop category 0 describes an immediate stop by removal of power by interrupting a machine or drive element according to EN 60204.
3. Proven components and proven safety principles according to EN ISO 13849-2 must be used when applying category 1.
4. The occurrence of a fault can lead to the loss of the safety function.
5. The connecting cables for the emergency stop control device should either be laid separately or protected against mechanical damage.
6. When using the safety relay, take into consideration the maximum permissible number of cycles for observing the SIL/PL safety characteristics in the specific application. The safety characteristics can be found in the FUNCTIONAL SAFETY CHARACTERISTICS data sheet or the SISTEMA library.



### 4.1.2 YRB-4EML-31S up to PL d/SIL 2

**Two-channel emergency stop monitoring with manual reset**

| | |
|---|---|
| **Order No.** | 605-000-728 with screw connection |
| **Technical data** | – 24 V AC/DC<br>– 3 enabling current paths, 1 signaling current path<br>– Monitored manual or automatic start<br>– Basic insulation<br>– Cat. 4/PL e according to EN ISO 13849-1, SIL CL 3 according to EN 62061 |

**Application example**

– Two-channel emergency stop monitoring
– Manual reset (S33, S34)
– Feedback of contactor contacts K3 and K4 at S33 and S34
– Stop category 0
– Monitoring of external contactors
– Safety level of the example up to PL d (EN ISO 13849-1) and SIL 2 (EN 62061)

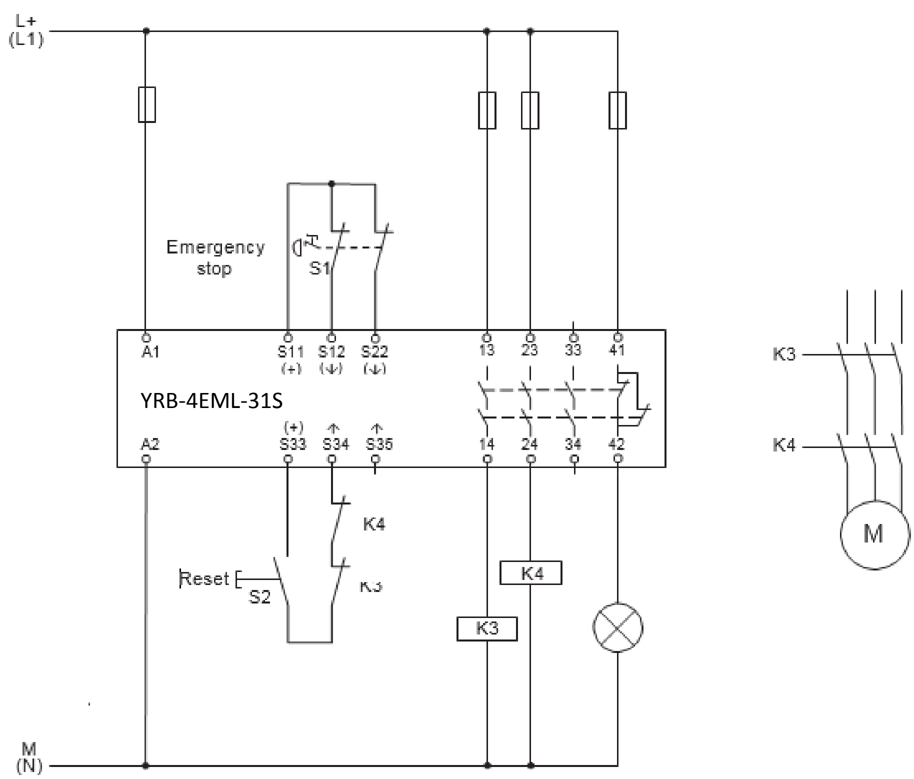
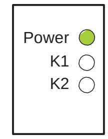
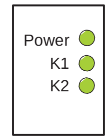
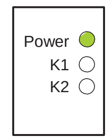



Figure 12 Two-channel emergency stop monitoring with manual reset YRB-4EML-31S

**Function description**

| **Start** | Action | Result | Diagnostics |
|---|---|---|---|
| | 1. Unlock emergency stop button S1. | The emergency stop button closes enable circuit S11, S12, and S22 of the safety relay.<br>The circuit is enabled via the reset button. |  |
| | 2. Press reset button S2. | Contactors K3 and K4 are activated and the mirror contacts (N/C contacts of K3 and K4) in the reset circuit are opened. |  |
| **Stop** | Action | Result | Diagnostics |
| | 1. Press emergency stop button S1. | The safety function is triggered and contactors K3 and K4 are opened.<br>In the reset circuit, the mirror contacts of K3 and K4 are closed. |  |

**Notes on the application example**

1. The emergency stop control device is positive opening according to EN 60947-5-1.
2. Contactors K3 and K4 have mirror contacts according to EN 60947-4-1.
3. Stop category 0 describes an immediate stop by removal of power by interrupting a machine or drive element according to EN 60204.
4. When using the safety relay, take into consideration the maximum permissible number of cycles for observing the SIL/PL safety characteristics in the specific application. The safety characteristics can be found in the FUNCTIONAL SAFETY CHARACTERISTICS data sheet or the SISTEMA library.

## 4.2 Light curtain (ESPE)

**Light curtains**

Light curtains consist of a transmit and receive unit and have a two-dimensional monitoring range. Light curtains are electrosensitive protective elements used to protect operating personnel working on or in the vicinity of dangerous machines. Compared to mechanical systems, they offer the advantage of contact-free and therefore wear-free operation.

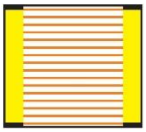
Please note the following factors when using light curtains:

– The light curtains must be installed in such a way that it is impossible to access the protected field from above, below or behind. If this is not guaranteed, additional safety equipment must be installed.
– The machine control system must be capable of being influenced electrically and permit dangerous states to be exited immediately in each operating phase.
– The ambient conditions must not adversely affect the effectiveness of the light protective system.
– Electrosensitive protective equipment (ESPE) does not provide protection from flying parts.

**Relevant standards**

EN 61496-1, EN 61496-2: Requirements for electrosensitive protective systems

EN ISO 13855: Positioning of safeguards with respect to the approach speeds of parts of the human body



### 4.2.1 YRB-4EML-31S up to PL e/SIL 3

**Two-channel light curtain monitoring with manual reset (ESPE type 4)**

| | |
|---|---|
| **Order No.** | 605-000-728 with screw connection |
| **Technical data** | – 24 V AC/DC<br>– 3 enabling current paths, 1 signaling current path<br>– Monitored manual or automatic start<br>– Basic insulation<br>– Cat. 4/PL e according to EN ISO 13849-1, SIL CL 3 according to EN 62061 |

**Application example**

- Two-channel light curtain monitoring
- Cross-circuit detection via the light curtain
- Manual reset (S33, S34)
- Feedback of contactor contacts K3 and K4 at S34
- Stop category 0
- Monitoring of external contactors
- Safety level of the example up to PL e (EN ISO 13849-1) and SIL 3 (EN 62061)

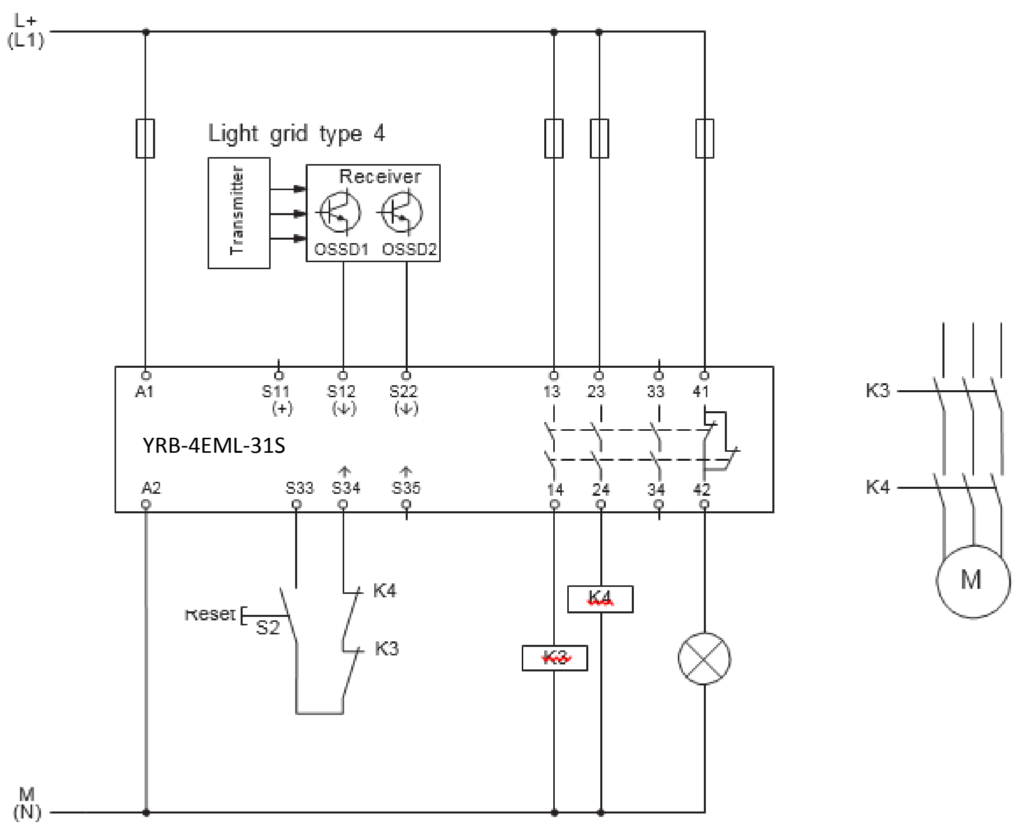
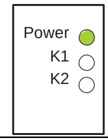
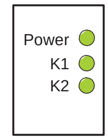
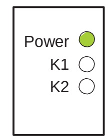



Figure 13 Two-channel light curtain monitoring with manual reset YRB-4EML-31S

**Function description**

| **Start** | Action | Result | Diagnostics |
|---|---|---|---|
| | 1. The light curtain is active, there is no object in the protected field. | Both OSSD signals from the light curtain provide high signals to enable circuit S12 and S22 of the safety relay.<br>The circuit is enabled via the reset button. |  |
| | 2. Press reset button S2. | Contactors K3 and K4 are activated and the mirror contacts (N/C contacts of K3 and K4) in the reset circuit are opened. |  |
| **Stop** | Action | Result | Diagnostics |
| | 1. The light curtain is interrupted, there is an object in the protected field. | The safety function is triggered by the interruption of the light curtain and contactors K3 and K4 are opened.<br>In the reset circuit, the mirror contacts of K3 and K4 are closed. |  |

**Notes on the application example**

1. The light curtain (ESPE) must meet type 4 requirements from standard EN 61496-1.
2. Contactors K3 and K4 have mirror contacts according to EN 60947-4-1.
3. Stop category 0 describes an immediate stop by removal of power by interrupting a machine or drive element according to EN 60204.
4. When using the safety relay, take into consideration the maximum permissible number of cycles for observing the SIL/PL safety characteristics in the specific application. The safety characteristics can be found in the FUNCTIONAL SAFETY CHARACTERISTICS data sheet or the SISTEMA library..

## 4.3 Movable guards

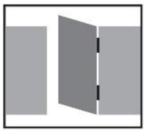
Guards with an interlocking device are designed for executing the following functions together with the machine control system:

– The hazardous machine functions “covered” by the guard cannot be performed until the guard is closed.
– If the guard is opened while the hazardous machine functions are operating, a stop command is triggered.
– The hazardous machine functions “covered” by the guard can be performed as soon as the guard is closed. Closing the guard does not automatically initiate the hazardous machine functions.

Interlocking devices can combine various functions and have a position monitoring function for guards. The interlocking device detects whether or not the guard is closed and issues a stop command. Some interlocking devices have a guard locking function which locks the guard while the hazardous machine functions are performed. A separate status monitoring function for guard locking devices monitors whether the guard locking device is locked and generates a corresponding output signal.

Relevant standards:

– EN 1088 Safety of machinery - Interlocking devices associated with guards.
– prEN 14119 Safety of machinery - Interlocking devices associated with guards.



### 4.3.1 YRB-4EML-31S up to PL d/SIL 2

**Two-channel non-equivalent safety door monitoring with manual reset**

| | |
|---|---|
| **Order No.** | 605-000-728 with screw connection |
| **Technical data** | – 24 V DC<br>– 3 enabling current paths, 1 signaling current path<br>– Monitored manual or automatic start<br>– Basic insulation<br>– Cat. 4/PL e according to EN ISO 13849-1, SIL CL 3 according to EN 62061 |

**Application example**

- Two-channel non-equivalent safety door monitoring with two position switches
- Manual reset (S33, S34)
- Feedback of contactor contacts K3 and K4 at S33 and S34
- Stop category 0
- Monitoring of external contactors
- Safety level of the example up to PL d (EN ISO 13849-1) and SIL 2 (EN 62061)

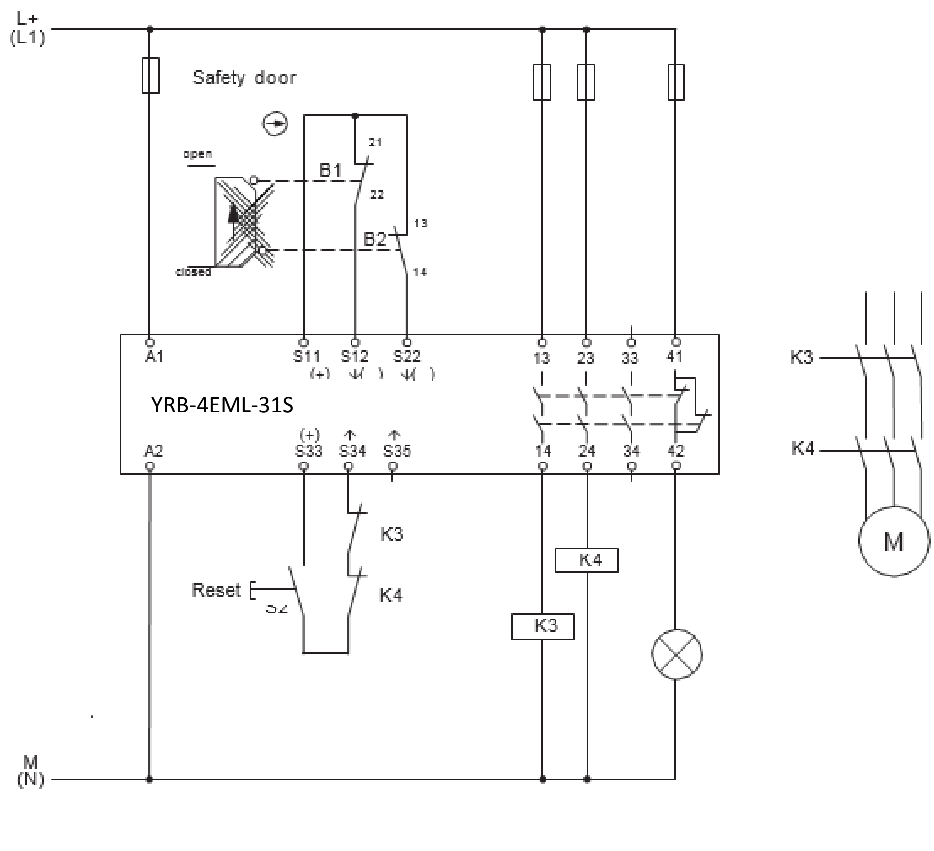
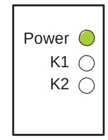
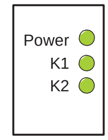
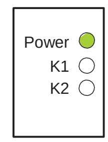



Figure 14 Two-channel safety door monitoring with manual reset YRB-4EML-31S

**Function description**

| Start | Action | Result | Diagnostics |
|---|---|---|---|
| | 1. Close the safety door. | The safety door circuit closes enable circuit S11, S12 and S11, S22 of the safety relay.<br>The circuit is enabled via the reset button. |  |
| | 2. Press reset button S2. | Contactors K3 and K4 are activated and the mirror contacts (N/C contacts of K3 and K4) in the reset circuit are opened. |  |
| **Stop** | Action | Result | Diagnostics |
| | 1. Open the safety door. | The safety function is triggered and contactors K3 and K4 are opened.<br>In the reset circuit, the mirror contacts of K3 and K4 are closed. |  |

**Notes on the application example**

1. The connecting cables for the position switches in the sensor circuit (safety door switch) should either be laid separately or protected against mechanical damage.
2. The position switch is positive opening according to EN 60947-5-1.
3. Contactors K3 and K4 have mirror contacts according to EN 60947-4-1.
4. Stop category 0 describes an immediate stop by removal of power by interrupting a machine or drive element according to EN 60204.
5. When using the safety relay, take into consideration the maximum permissible number of cycles for observing the SIL/PL safety characteristics in the specific application. The safety characteristics can be found in the FUNCTIONAL SAFETY CHARACTERISTICS data sheet or the SISTEMA library.

## 4.6 Contact extension/forcibly guided contacts

Often more contacts are required than are available as standard. For these applications, the forcibly guided contact extension modules are used. They can be connected as modules as required.

**Forced guidance**

Standard EN 50205 makes a distinction between two groups of relays with forcibly guided contacts:

- Application type A: relay with forcibly guided set of contacts
- Application type B: relay with a forcibly guided set of contacts and other contacts which are not forcibly guided, as well as a contact set with PDTs

The definition of "forced guidance" according to EN 50205 is:

The relay must be designed so that none of the mechanically connected N/C contacts can close if a N/O contact is closed and none of the mechanically connected N/O contacts can close if a N/C contact is closed.

These requirements apply for the entire service life of the relay and for reasonably foreseeable failure conditions.

The effects of reasonably foreseeable breaks and/or wear on parts of the elementary relay must not cause the (mechanical) forced guidance to fail.

During the entire relay service life specified by the manufacturer, the contact distances of opened contacts must be greater than 0.5 mm for a single N/C contact and greater than 0.3 mm each for a double interrupt. (Mechanical) forced guidance of contacts means that none of the N/C contacts can close if a N/O contact does not open for the non-activated relay. In addition, none of the N/O contacts can close if a N/C contact does not open when the relay is activated.

# A Appendix for document lists

## A 1 Explanation of terms

| | |
|---|---|
| **Performance level (PL)** | Classification of the ability of safety functions to meet a safety requirement. |
| **Category** | Classification of the resistance to faults according to EN ISO 13849-1. |
| **Safety integrity level claim limit (SIL CL)** | SIL claim limit (suitability) |
| **Probability of a dangerous failure per hour ($PFH_d$)** | Probability of a dangerous failure per hour. |
| **Mission time $t_M$** | Duration of use |
| **Probability of failure on demand (low demand) (PFD)** | Probability of failure, relative to the number of demands. |

| | |
|---|---|
| **DC** | Diagnostic coverage |
| **MTTF** | Mean time to failure |
| **AOPDDR** | Active optoelectronic protective device responsive to diffuse reflection<br>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. |
| **AOPD** | Active optoelectronic protective device<br>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 an optical data link 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. |
| **SRCF** | Safety-related control function - safety function |
| **SRECS** | Safety-related electric, electronic, programmable electronic control system |

# A 1 Case studies – connection to a PLC

Depending on the request, Contrinex is able to test if one or the other use of the YRB-4EML-31S safety relay is possible or not. Contrinex is not responsible for the assembly of the relay into the application, and it is always the responsibility of the end user to test that the setup is operating in accordance with the various safety standards.

In that particular case, it was requested to connect to PLC together and ensure that PLC 2 (blue below) can work together with PLC 1 (red below), thus creating a redundant and dependent installation on the PLC side. This principle is theoretically based on the same kind of wiring than when an emergency stop button is used.
However, it is also up to the end user to check what will be the final PL or SIL level acquired with this setup.

The most important is to connect the inputs S11, S12 and S22 together (green below) and bridge the restart mode into automatic with a jumper (yellow below) between S33 and S35.

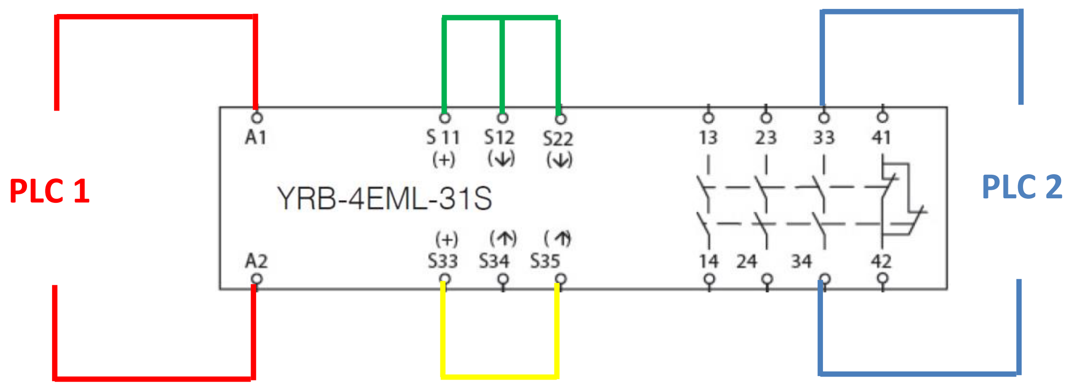



Fig 15 – Wiring with 2 PLCs

This setup has been checked at Contrinex with a Siemens S1 PLC as PLC1. The goal was first to check if the contactors react to the PLC1 or not. The result was positive, thus meaning such setup would be technically feasible.