

# Safety Chain solutions, Safety functions

Solutions for efficient machine safety

# Quick access to product information

## Get technical information about your product

References

**Modicon TM3**  
I/O expansion modules for Modicon controllers  
Analog I/O modules

Number and type of channels	Input range	Resolution	Aperture time (typical)	Reference	Weight (kg)
2 voltage inputs	-15...+10 VDC 0...20 mA r.t. 20 mA	16,000 or 10,000 r.s.g.	0.005 s 0.005 s	TM3AI2H TM3AI2HG	0.110 0.100
4 voltage inputs	-15...+10 VDC 0...20 mA r.t. 20 mA	12,000 or 10,000 r.s.g.	0.005 s 0.005 s	TM3AI4 TM3AI4G	0.100 0.100
4 voltage or temperature inputs	-15...+10 VDC 0...20 mA r.t. 20 mA	16,000 or 10,000 r.s.g.	0.005 s 0.005 s	TM3AI4T TM3AI4TG	0.110 0.100
4 differential temperature inputs	0...100 °C 0...200 °C 0...500 °C 0...1000 °C	16,000 or 10,000 r.s.g.	0.005 s 0.005 s	TM3AI4D TM3AI4DG	0.110 0.100
8 voltage inputs	-15...+10 VDC	12,000 or 10,000 r.s.g.	0.005 s	TM3AI8	0.110

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All products Industrial Automation and Control PLC, PAC and Dedicated Controllers Distributed Input/Output (I/O) Modules Modicon TM3

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**TM3AI2H**

Module TM3 - 2 analog inputs high resolution

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Related Software >

Product Datasheet User guide Catalogue CAD Document

Characteristics Documents and Downloads Technical FAQs Additional Information Dimensions Drawings >

Main

range of product Modicon TM3

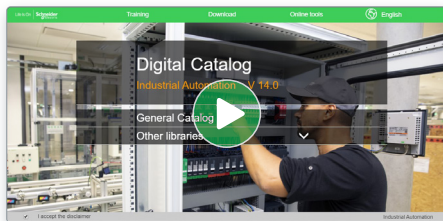
product or component type Analog input module

range compatibility Modicon M251

Each commercial reference presented in a catalog contains a hyperlink. Click on it to obtain the technical information of the product:

- Characteristics, Dimensions and drawings, Mounting and clearance, Connections and schemas, Performance curves
- Product image, Instruction sheet, User guide, Product certifications, End of life manual

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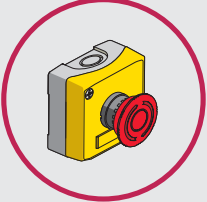

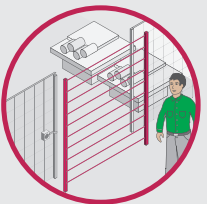
# Content

## Safety chain solutions

<b>Selection guide</b> .....	<a href="#">page 2</a>
<b>Emergency Stop with Embedded safety module</b>	
- Emergency Stop pushbutton / Contactors .....	<a href="#">page 3</a>
- Emergency Stop pushbutton / Contactors .....	<a href="#">page 4</a>
<b>Guard monitoring with Safety module</b>	
- Coded magnetic switches / Contactors .....	<a href="#">page 5</a>
- Coded magnetic switches / Variable speed drive .....	<a href="#">page 6</a>
- Coded magnetic switches / Multifunctional starter .....	<a href="#">page 7</a>
<b>Guard monitoring with Embedded safety module</b>	
- Guard switches / Contactors .....	<a href="#">page 8</a>
<b>Perimeter guarding with Safety module</b>	
- Safety light curtains / Contactors .....	<a href="#">page 9</a>
<b>Perimeter guarding with Embedded safety module</b>	
- Safety light curtains / Contactors .....	<a href="#">page 10</a>
- Safety light curtains / Variable Speed Drive .....	<a href="#">page 11</a>

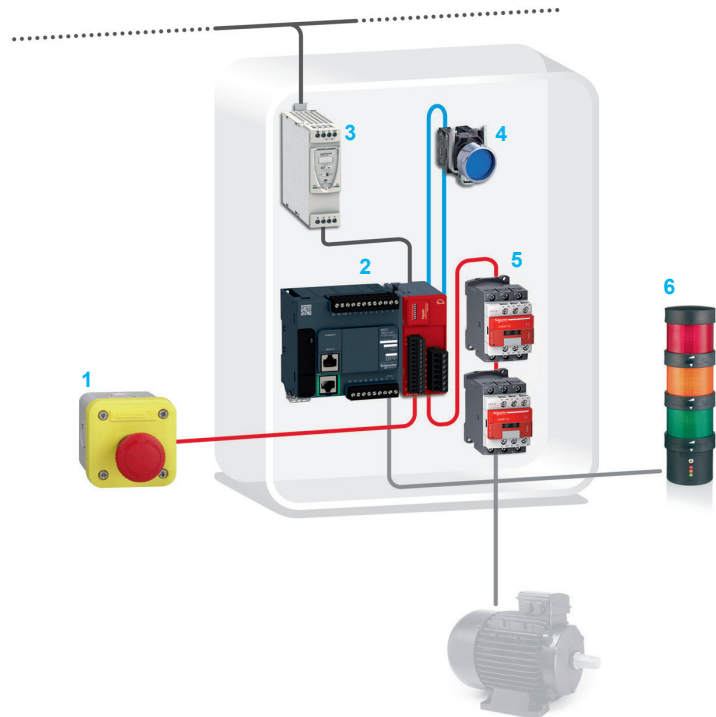
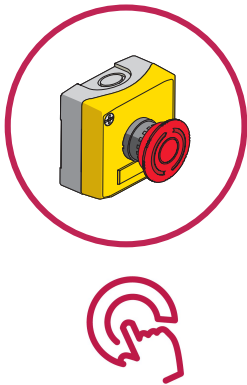
## Safety functions: Detailed description

<b>Emergency stop</b>	
- Stop Category 0, Stop Category 1, Stop Category 2 .....	<a href="#">page 12</a>
<b>Guard monitoring</b>	
- with Guards with/without guard locking device .....	<a href="#">page 13</a>
- with Coded magnetic guard switch and system .....	<a href="#">page 14</a>
<b>Enabling movement</b>	
- with Two-hand control stations .....	<a href="#">page 15</a>
- with Enabling Switch .....	<a href="#">page 15</a>
<b>Speed monitoring</b>	
- Zero speed monitoring .....	<a href="#">page 16</a>
- Safety-limited speed, Safe maximum speed, Safe direction .....	<a href="#">page 16</a>
<b>Perimeter guarding</b>	
- with Safety light curtains .....	<a href="#">page 17</a>
- with Safety mats .....	<a href="#">page 17</a>

Safety function and Processing device	Input/Output	Cat. PL, SIL / Stop Cat.
 <p><b>Emergency Stop with Embedded safety module</b></p>	Emergency Stop pushbutton / Contactor	<b>Cat.3 PL d, SIL 2 / Stop Category 0</b> > <a href="#">page 3</a>
	Emergency Stop pushbutton / Contactor	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> > <a href="#">page 4</a>
 <p><b>Guard monitoring with safety module</b></p>	Coded magnetic switch / Contactor	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> <b>Cat.3 PL d, SIL 2 / Stop Category 0</b> > <a href="#">page 5</a>
	Coded magnetic switch / Variable speed drive	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> > <a href="#">page 6</a>
	Coded magnetic switch / Multifunctional starter	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> <b>Cat.3 PL d, SIL 2 / Stop Category 0</b> > <a href="#">page 7</a>
<p><b>Guard monitoring with Embedded safety module</b></p>	Guard switch / Contactor	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> > <a href="#">page 8</a>
 <p><b>Perimeter guarding with safety module</b></p>	Safety light curtain / Contactor	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> > <a href="#">page 9</a>
	Safety light curtain / Contactor	<b>Cat.4 PL e, SIL 3 / Stop Category 0</b> > <a href="#">page 10</a>
	Safety light curtain / Variable speed drive	<b>Cat.3 PL d, SIL 2 / Stop Category 1</b> > <a href="#">page 11</a>

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Emergency Stop with Embedded safety module  
 Emergency Stop pushbutton / Contactor  
 Cat.3 PL d, SIL 2 / Stop Category 0



### Related Products

- 1 Emergency Stop push button [Harmony XB5](#) on Control station [Harmony XALK](#)
- 2 Logic controller [Modicon M221](#) and Safety module [Modicon TM3S](#)
- 3 Switch mode power supply [Modicon ABL8](#) (1)
- 4 Pushbutton [Harmony XB4](#)
- 5 Contactor [TeSys D](#)
- 6 Modular beacon and tower light [Harmony XVB](#)

### Function

Safety-related stop function initiated by Emergency Stop push button to minimize the consequences of possibly harmful event.

The pushing of Emergency Stop push button is detected from opening contacts, which are checked by the safety module.

Opening these contacts causes the deactivation of the safety module outputs (stop category 0 according to EN/IEC 60204-1), which results in a switch-off of the motor power supply to minimize hazard in case of emergency by means of the contactors (K1 and K2).

### Typical applications

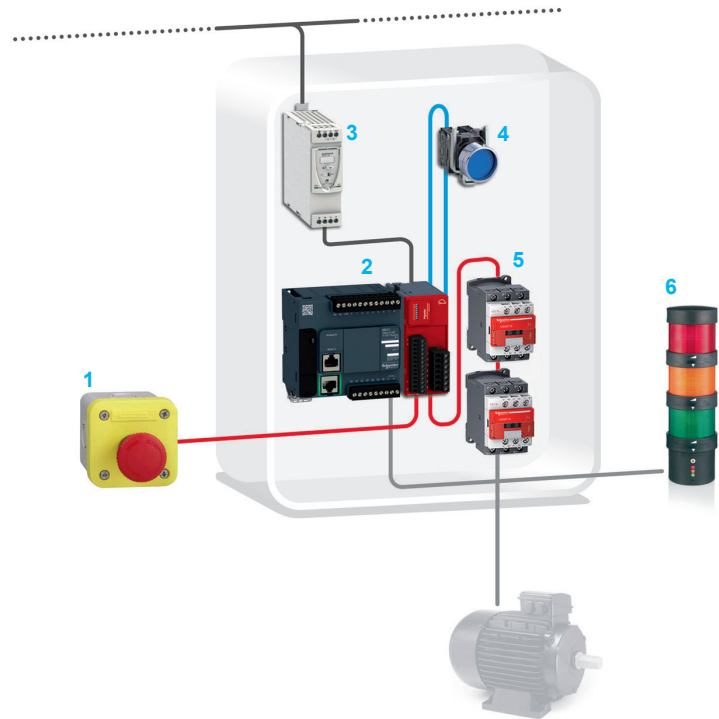
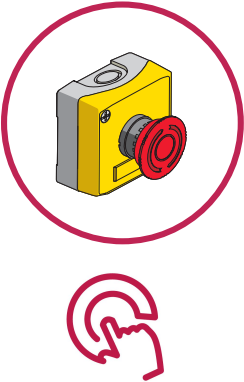
- > Machine-tools or similar machines with low inertia (no rundown time), where the access to the hazardous area is limited to maintenance interventions.

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# Safety chain solutions

## Emergency Stop with Embedded safety module

Emergency Stop with Embedded safety module  
 Emergency Stop pushbutton / Contactors  
 Cat.4 PL e, SIL 3 / Stop Category 0



**Related Products**

- 1 Emergency Stop push button [Harmony XB5](#) on Control station [Harmony XALK](#)
- 2 Logic controller [Modicon M221](#) Safety module [Modicon TM3S](#)
- 3 Switch mode power supply [Modicon ABL8](#) (1)
- 4 Pushbutton [Harmony XB4](#)
- 5 Contactor [TeSys D](#)
- 6 Modular beacon and tower light [Harmony XVB](#)

**Function**

Safety-related stop function initiated by Emergency Stop push button to minimize the consequences of possibly harmful event.

The pushing of Emergency Stop push button is detected from opening contacts, which are checked by the safety module.

Opening these contacts causes the deactivation of the safety module outputs (stop category 0 according to EN/IEC 60204-1), which results in a switch-off of the motor power supply to minimize hazard in case of emergency by means of the contactors (K1 and K2).

The main contactors are monitored by the safety module to detect e.g. contact welding, by means of their mirror contacts.

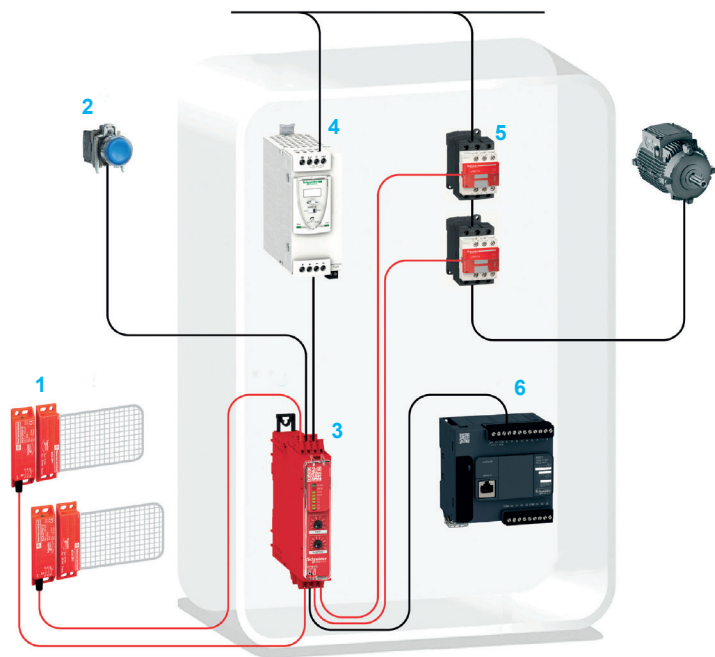
**Typical applications**

- > Machine-tools or similar machines with low inertia (no rundown time), where the access to the hazardous area is limited to maintenance interventions.

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Guard monitoring with Safety module  
 Coded magnetic switches / Contactors  
 Cat.4 PL e, SIL 3 / Stop Category 0  
 Cat.3 PL d, SIL 2 / Stop Category 0



### Related Products

- 1 Coded magnetic switches [XCSDM](#)
- 2 Pushbutton [Harmony XB4](#)
- 3 Safety module [Preventa XPSUS](#)
- 4 Switch mode power supply [Modicon ABL8](#) (1)
- 5 Contactor [TeSys D](#)
- 6 Logic controller [Modicon M221](#)

### Function

This Safety Chain Solution monitors movable guards as per ISO 14119/14120 to restrict access to the zone of operation of a machine while the machine is in operation. This Safety Chain Solution implements a safety-related stop function as per ISO 13849-1. This safety-related stop function is triggered if a guard is opened.

Each guard is equipped with a coded magnetic switch. The outputs of the coded magnetic switches are connected to the inputs of a safety module. The outputs of the safety module are connected to two motor contactors. As long as the guards are closed, access to the zone of operation is restricted as provided by your risk assessment and the corresponding design of your specific application.

When one of the guards is opened, for example, to allow for machine operator access to the zone of operation, the outputs of the coded magnetic switch mounted to this guard change state. The changed signal state of the coded magnetic switch is detected by the safety module. In response, the safety module deactivates its outputs.

This causes the motor contactors connected to the safety module to trigger a stop with stop category 0 of the motor as per IEC 60204-1. If the safety module detects errors such as indeterminable signal states, or short circuits or cross circuits at the inputs, the stop is triggered, or the stop remains activated if it had already been triggered before the error was detected.

Two types of the Safety Chain Solution are available:

- Type A monitors two movable guards with two coded magnetic switches. One coded magnetic switch is connected to each of the two safety-related inputs of the safety module. This type of the Safety Chain Solution reaches Performance Level e.
- Type B monitors six movable guards. Three coded magnetic switches each are interconnected. Such a combination of three interconnected coded magnetic switches is connected to each of the two safety-related inputs of the safety module. This type of the Safety Chain Solution reaches Performance Level d.

### Typical applications

- > Assembly machines, packaging machines and similar compact machines that require frequent access to the zone of operation at multiple access points. Such machines need to be suitable for stops with stop category 0, that is, the time after removal of power to the motor and coasting of the load to standstill is sufficiently short.

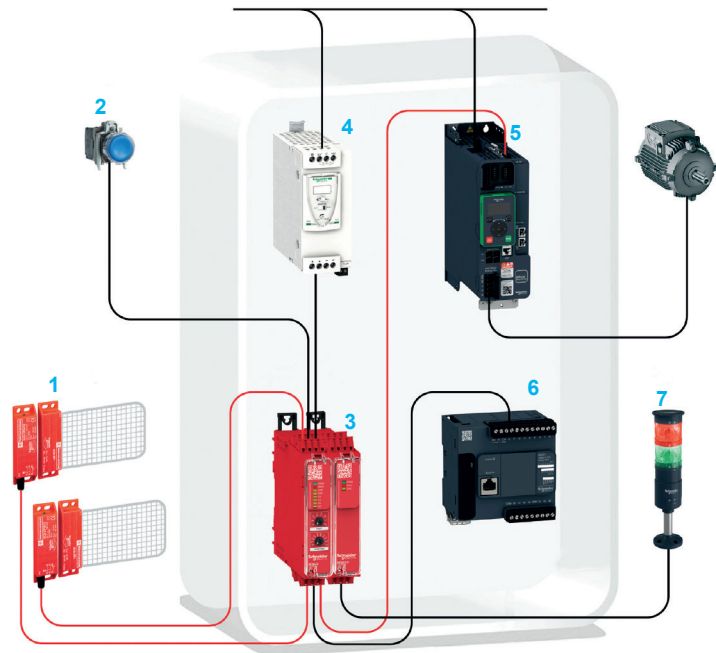
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# Safety chain solutions

## Guard monitoring with Safety module

**Guard monitoring with safety module**  
**Coded magnetic switches / Variable speed drive**  
**Cat.4 PL e, SIL 3 / Stop Category 0**



**Related Products**

- 1 Coded magnetic switches [XCSDM](#)
- 2 Pushbutton [Harmony XB4](#)
- 3 Safety module [Preventa XPSUS](#) and Safety extension module [Preventa XPSUEP](#)
- 4 Switch mode power supply [Modicon ABL8 \(1\)](#)
- 5 Variable speed drive [Altivar Machine ATV340](#)
- 6 Logic controller [Modicon M221](#)
- 7 Modular beacon and tower light [Harmony XVU](#)

**Function**

This Safety Chain Solution monitors two movable guards as per ISO 14119/14120 to restrict access to the zone of operation of a machine while the machine is in operation. This Safety Chain Solution implements a safety-related stop function as per ISO 13849-1. This safety-related stop function is triggered if a guard is opened.

Each guard is equipped with a coded magnetic switch. The outputs of the coded magnetic switches are connected to the inputs of a safety module. The outputs of the safety module are connected to two safety-related inputs of a variable speed drive. As long as the guards are closed, access to the zone of operation is restricted as provided by your risk assessment and the corresponding design of your specific application.

When one of the guards is opened, for example, to allow for machine operator access to the zone of operation, the outputs of the coded magnetic switch mounted to this guard change state. The changed signal state of the coded magnetic switch is detected by the safety module. In response, the safety module deactivates its outputs.

This causes the variable speed drive connected to the safety module to trigger a stop with stop category 0 of the motor as per IEC 60204-1 via its integrated safety-related sub-function Safe Torque Off (STO). If the safety module or the variable speed drive detect errors such as indeterminable signal states, or short circuits or cross circuits at the inputs, STO is triggered or STO remains activated if it had already been triggered before the error was detected.

**Typical applications**

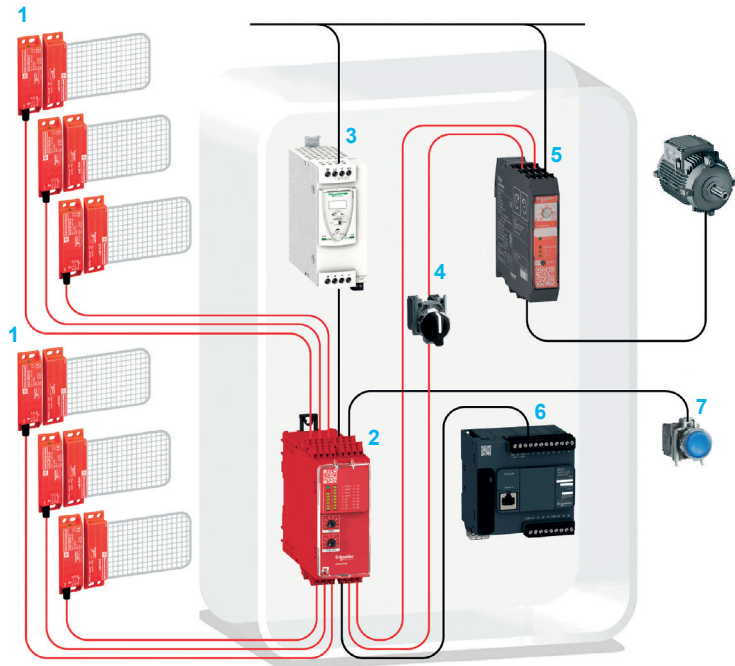
- > Assembly machines, packaging machines and similar compact machines that require frequent access to the zone of operation. Such machines need to be suitable for stops with stop category 0, that is, the time after removal of power to the motor and coasting of the load to standstill is sufficiently short.

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Guard monitoring with safety module  
 Coded magnetic switches / Multifunctional starter  
 Cat.4 PL e, SIL 3 / Stop Category 0  
 Cat.3 PL d, SIL 2 / Stop Category 0



### Related Products

- 1 Coded magnetic switches [XCSDM](#)
- 2 Safety module [Preventa XPSUDN](#)
- 3 Switch mode power supply [Modicon ABL8 \(1\)](#)
- 4 Selector switch [Harmony XB4](#)
- 5 Multifunctional starter for asynchronous motor [TeSys H](#)
- 6 Logic controller [Modicon M221](#)
- 7 Pushbutton [Harmony XB4](#)

### Function

This Safety Chain Solution monitors movable guards as per ISO 14119/ISO 14120 to restrict access to the zone of operation of a machine while the machine is in operation. This Safety Chain Solution implements a safety-related stop function as per ISO 13849-1. This safety-related stop function is triggered if a guard is opened.

Each guard is equipped with a coded magnetic switch. The outputs of the coded magnetic switches are connected to the inputs of a safety module. The outputs of the safety module are connected to the safety-related inputs of a motor starter. As long as the guards are closed, access to the zone of operation is restricted as provided by your risk assessment and the corresponding design of your specific application.

When one of the guards is opened, for example, to allow for machine operator access to the zone of operation, the outputs of the coded magnetic switch mounted to this guard change state. The changed signal state of the coded magnetic switch is detected by the safety module. In response, the safety module deactivates its outputs.

This causes the motor starter connected to the safety module to trigger a stop with stop category 0 of the motor as per IEC 60204-1. If the safety module detects errors such as indeterminable signal states, or short circuits or cross circuits at the inputs, the stop is triggered, or the stop remains activated if it had already been triggered before the error was detected.

Two types of the Safety Chain Solution are available:

- Type A monitors six movable guards with six coded magnetic switches. One coded magnetic switch is connected to each of the six safety-related inputs of the safety module. This type of the Safety Chain Solution reaches Performance Level e.
- Type B monitors 18 movable guards with 18 coded magnetic switches. Three coded magnetic switches each are interconnected. Such a combination of three interconnected coded magnetic switches is connected to each of the six safety-related inputs of the safety module. This type of the Safety Chain Solution reaches Performance Level d.

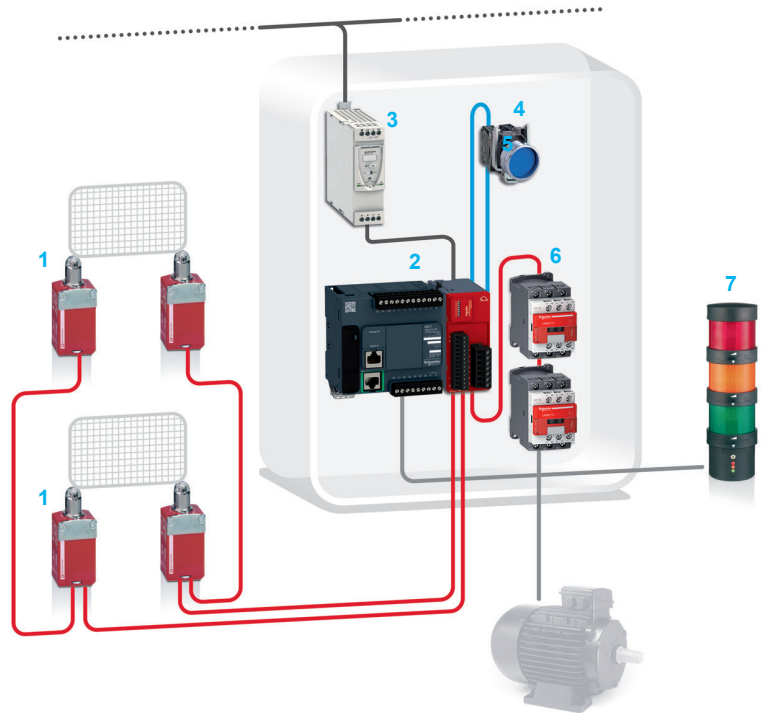
### Typical applications

- > Assembly machines, packaging machines and similar compact machines that require access to the zone of operation at multiple access points. Such machines need to be suitable for stops with stop category 0, that is, the time after removal of power to the motor and coasting of the load to standstill is sufficiently short.

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Guard monitoring with Embedded safety module  
 Guard switches / Contactors  
 Cat.4 PL e, SIL 3 / Stop Category 0



**Related Products**

- 1 Safety limit switches [XCSPM](#)
- 2 Logic controller [Modicon M221](#) Safety module [Modicon TM3S](#)
- 3 Switch mode power supply [Modicon ABL8](#) (1)
- 4 Pushbutton [Harmony XB4](#)
- 5 Coded magnetic switches [XCSDM](#)
- 6 Contactor [TeSys D](#)
- 7 Modular beacon and tower light [Harmony XVB](#)

**Function**

Safety-related stop function initiated by a movable guard designed to help protecting from the access to a hazardous zone.

The opening of this guard is detected by using a guard switch, which is checked by the safety module allowing detection of the opening or the removal of the protective guard.

Opening of this guard causes the deactivation of the safety module outputs (stop category 0 according to EN/IEC 60204-1), which results in a switch-off of the motor power supply to prevent possible hazardous movements or states by means of the contactors (K1 and K2).

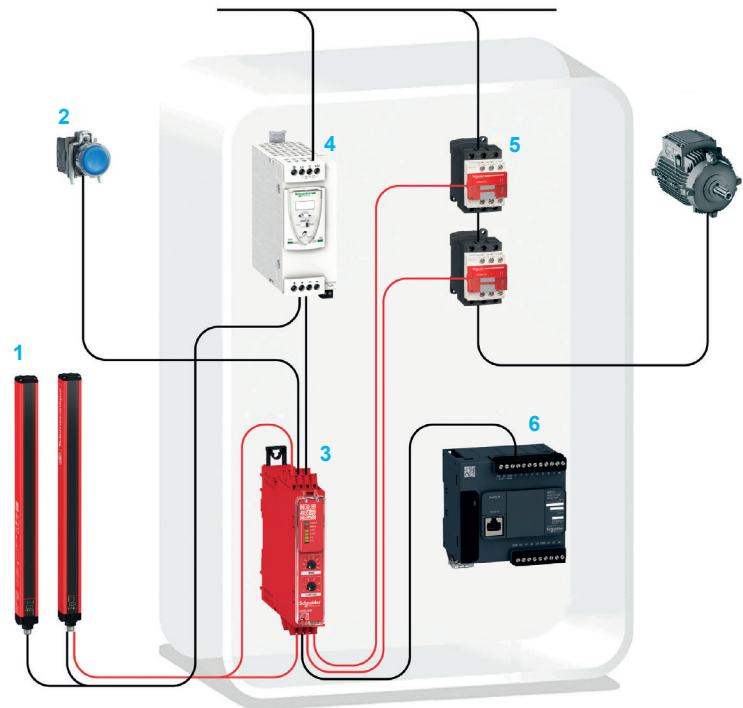
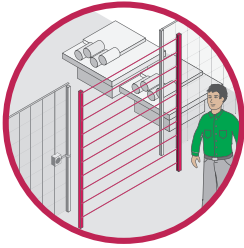
The main contactors are monitored by the safety module to detect e.g. contact welding, by means of their mirror contacts.

**Typical applications**

> Assembling, machining centers or similar machines tools, where the access to the hazardous area is frequent or with long exposure time.

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Perimeter guarding with safety module  
 Safety light curtains / Contactors  
 Cat.4 PL e, SIL 3 / Stop Category 0



### Related Products

- 1 Safety light curtains [XUSL](#)
- 2 Pushbutton [Harmony XB4](#)
- 3 Safety module [Preventa XPSUAF](#)
- 4 Switch mode power supply [Modicon ABL8 \(1\)](#)
- 5 Contactor [TeSys D](#)
- 6 Logic controller [Modicon M221](#)

### Function

This Safety Chain Solution monitors a type 4 light curtain as per IEC 61496-1 to restrict access to the zone of operation of a machine while the machine is in operation. This Safety Chain Solution implements a safety-related stop function as per ISO 13849-1. This safety-related stop function is triggered if a beam of the light curtain is interrupted.

The outputs of the safety light curtain are connected to the inputs of a safety module. The outputs of the safety light curtain are connected to two motor contactors.

When a beam of the safety light curtain is interrupted, the outputs of the safety light curtain change state. The changed signal state of the outputs of the safety light curtain is detected by the safety module. In response, the safety module deactivates its outputs.

This causes the motor contactors connected to the safety module to trigger a stop with stop category 0 of the motor as per IEC 60204-1. If the safety module detects errors such as indeterminable signal states, or short circuits or cross circuits at the inputs, the stop is triggered, or the stop remains activated if it had already been triggered before the error was detected.

### Typical applications

The Safety Chain Solution is typically used in the following types of machines:

- > Robot cells
- > Transfer lines
- > Assembly lines
- > Mechanical and hydraulic presses
- > Palletizers
- > Welding stations
- > Coilers, decoilers
- > Machine tools
- > Packaging machines
- > Food and beverage machines

Such machines need to be suitable for stops with stop category 0, that is, the time after removal of power to the motor and coasting of the load to standstill is sufficiently short.

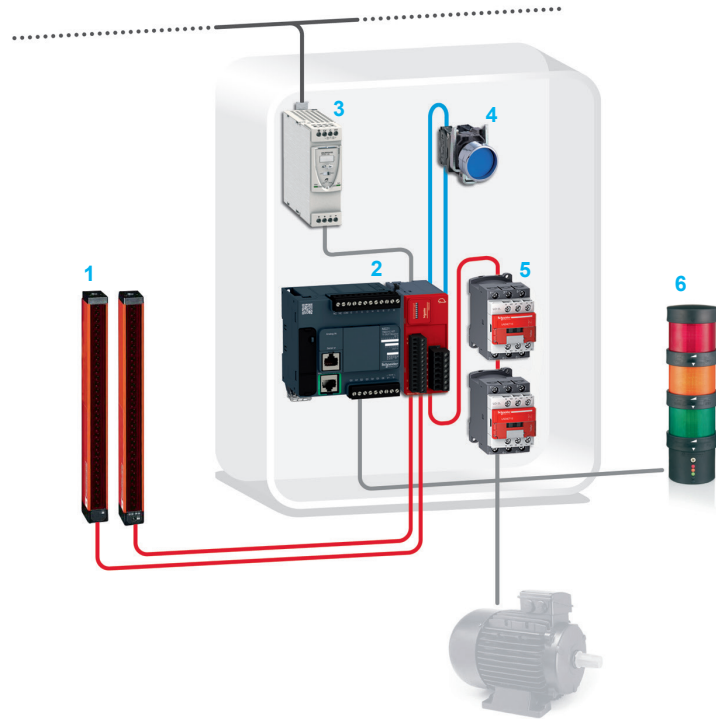
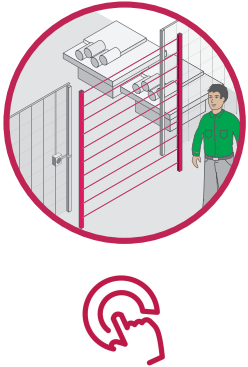
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# Safety chain solutions

## Perimeter guarding with Embedded safety module

Perimeter guarding with Embedded safety module  
 Safety light curtains / Contactors  
 Cat.4 PL e, SIL 3 / Stop Category 0



**Related Products**

- 1 Safety light curtains [XUSL](#)
- 2 Logic controller [Modicon M221](#) Safety module [Modicon TM3S](#)
- 3 Switch mode power supply [Modicon ABL8 \(1\)](#)
- 4 Pushbutton [Harmony XB4](#)
- 5 Contactor [TeSys D](#)
- 6 Modular beacon and tower light [Harmony XVB](#)

**Function**

Safety-related stop function initiated by safety light curtain (ESPE Type 4 according to EN/IEC 61496-1 and EN/IEC 61496-2).

An interruption of the detection field causes the safety outputs to open. The deactivation of the safety outputs results in the switching-off of the motor power supply by means of the contactor (K1) to help to prevent possible hazardous movements or states.

The safety light curtain receivers and outputs are cyclically tested and monitored by the safety light curtain to detect possible failures.

**Typical applications**

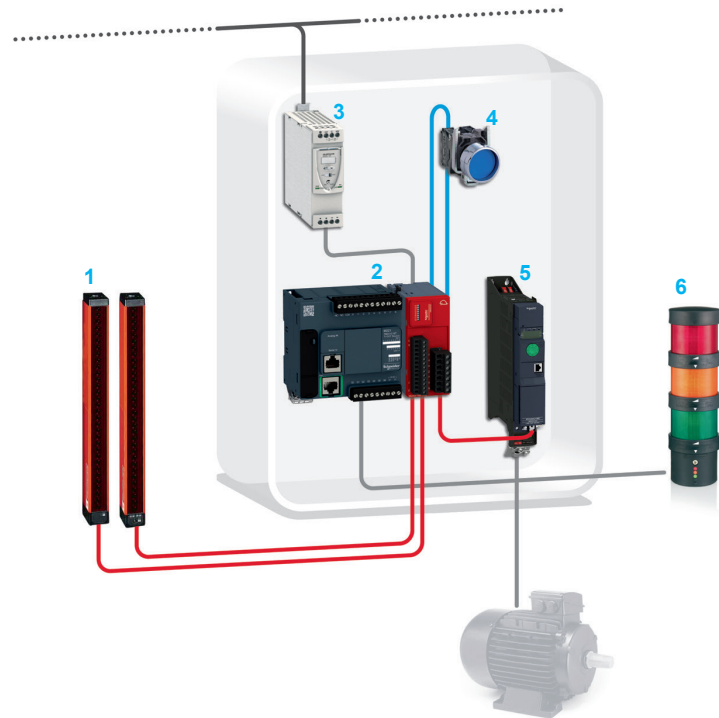
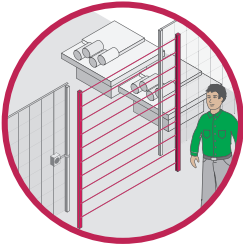
- > Palletizing stations with automatic control system where pallets would pass frequently through the hazardous area.

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Perimeter guarding with Embedded safety module

Safety light curtains / Variable speed drive

Cat.3 PL d, SIL 2 / Stop Category 1



#### Related Products

- 1 Safety light curtains [XUSL](#)
- 2 Logic controller [Modicon M221](#) Safety module [Modicon TM3S](#)
- 3 Switch mode power supply [Modicon ABL8](#) (1)
- 4 Pushbutton [Harmony XB4](#)
- 5 Variable speed drive [Altivar Machine ATV320](#)
- 6 Modular beacon and tower light [Harmony XVB](#)

#### Function

Safety-related stop function initiated by a safety light curtain (ESPE Type 4 according to EN/IEC 61496-1 and EN/IEC 61496-2). Controlled stopping with power maintained to the drive to achieve stopping (i.e. braking), then cut-off of power when standstill is reached (Safe Stop 1).

The hazardous movement is interrupted either if the stop push button or the Emergency Stop device is actuated. An interruption of the detection field initiates the functional stopping of the drive, i.e. by a braking ramp (stop category 1 in accordance with EN/IEC 60204-1).

After the delay time monitored by the drive has elapsed, the drive is halted, by the "safe torque off" (STO) safety function integrated within it, which prevents the motor from restarting unintentionally.

The switching of the LI3 input is monitored by the drive. The power stage is disabled when the time offset is exceeded.

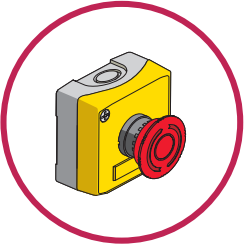
#### Typical applications

- > Machines that use drives in their movements due to high speed and precision needed (i.e. textile, wood-working or simple packaging machines), when the delayed initiation of the stopping in the event of a fault must not involve an unacceptably high residual risk.

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### Emergency stop

### Explanation of function



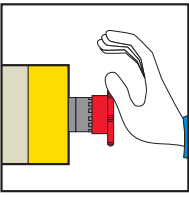
International standard EN/ISO 13850 (replaces standard EN 418) specifies the functional requirements and design principles of emergency stop devices.

**Stop types:**  
Stop category 0 and/or stop category 1 and/or stop category 2 stop functions shall be provided as indicated by the risk assessment and the functional requirements of the machine:

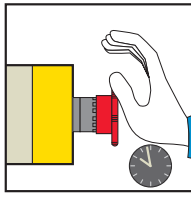
**Stop Category 0:**  
Stopping by immediate removal of power to the machine actuators (i.e. an uncontrolled stop – stopping of machine motion by removing electrical power to the machine actuators)

**Stop Category 1:**  
A controlled stop (stopping of machine motion with electrical power to the machine actuators maintained during the stopping process) with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved

**Stop Category 2:**  
A controlled stop with power left available to the machine actuators



Stop category 0: Emergency stop function



Stop category 1

For the Emergency stop function either Stop Category 0 or Stop Category 1 is chosen according to the risk assessment results.

It applies to all machines, whatever type of energy is used to control this function. When the emergency stop instruction ceases, the effect must be maintained until it is reset. Manual resetting must only be possible in the location where the instruction was given. Resetting must not start the machine, but simply enable the starting cycle.

Restarting of the machine must not be possible until the emergency stop has been reset.

Where required, facilities to connect protective devices and interlocks shall be provided. If such a protective device or interlock causes a stop of the machine, it may be necessary for that condition to be signalled to the logic of the control system. The reset of the stop function shall not initiate any hazardous situation.

Where more than one control station is provided, stop commands from any control station shall be effective when required by the risk assessment of the machine.

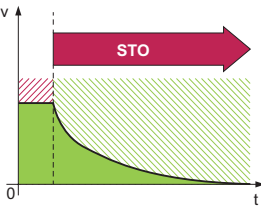
In addition to the requirements for the emergency stop function has the following requirements:

- It shall override all other functions and operations in all modes
- Power to the machine actuators that can cause a hazardous situation(s) shall be either removed immediately (stop category 0) or shall be controlled in such a way to stop the hazardous motion as quickly as possible (stop category 1) without creating other hazards
- Reset shall not initiate a restart

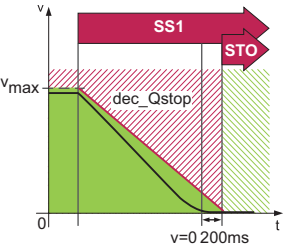
The choice between these two stopping methods is determined by an evaluation of the machine-related risks.

This function includes several sub-functions either Safe Torque off (stop category 0), Safe Stop 1 (stop category 1) or Safe Stop 2 (stop category 2) and is represented by the drawings opposite.

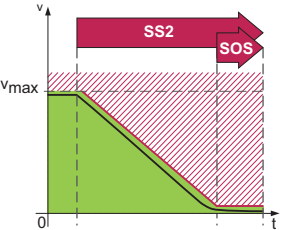
- The operator interface may be:
- Pushbutton equipped with a mushroom head
  - Cable actuated switch
  - Foot switch



STO: Safe Torque Off



SS1: Safe Stop 1, STO: Safe Torque Off



SS2: Safe Stop 2, SOS: Safe Operating Stop

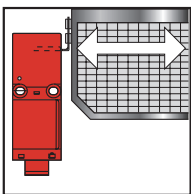
### Typical architecture

- Safety chain solution:**
- > Emergency Stop with Embedded Safety Module / Emergency Stop Pushbutton / Contactor / Cat.3 PL d, SIL2, Stop Category 0
  - > Emergency Stop with Embedded Safety Module / Emergency Stop Pushbutton / Contactor / Cat.4 PL e, SIL3, Stop Category 0

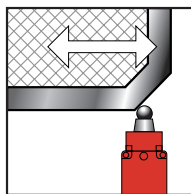
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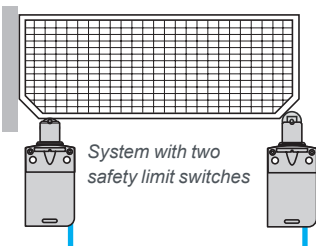
### Guard monitoring



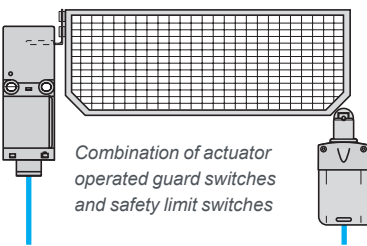
Guard with guard locking device



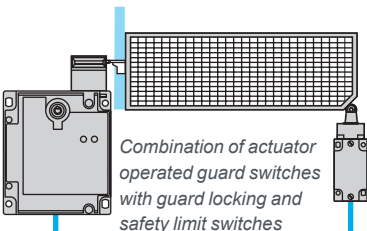
Guard without guard locking device



System with two safety limit switches



Combination of actuator operated guard switches and safety limit switches



Combination of actuator operated guard switches with guard locking and safety limit switches

### Explanation of function

#### Guards without guard locking device

On a large number of potentially dangerous machines, the operator must be kept at a distance during operation, but needs to take action when the machine is stopped to position a part, remove a product or adjust a tool.

An effective means of protection is to install a guard which, according to the type of installation, will cut-off the power to the motor if an attempt is made to open it during the machine operating phase.

In all cases, it must not be possible to restart the machine until the guard is closed.

Depending on the level of protection required, the system will comprise two conventional limit switches or a combination of protected, actuator operated guard switches to prevent tampering.

#### Guards with guard locking device

This type of guard is necessary for potentially dangerous machines with high inertia (long rundown time).

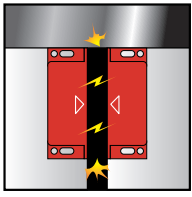
The guard is interlocked (by a solenoid for example); it cannot be opened until the machine has come to a complete standstill.

### Typical architecture

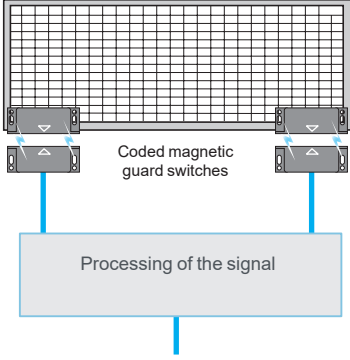
#### Safety chain solution:

- > Guard Monitoring with Embedded Safety Module / Guard switch / Contactor / Cat.4 PL e, SIL 3 / Stop Category 0

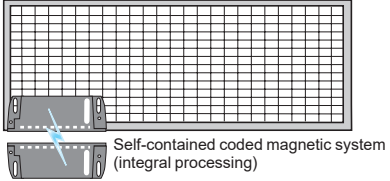
### Guard monitoring



Coded magnetic guard switch



Functions of coded magnetic guard switches



Functions of a coded magnetic guard switch system

### Explanation of function

#### Coded magnetic guard switch and system

A non-contact solution is often used on industrial machines fitted with a door or guards with imprecise guiding.

It is particularly suitable for machines subjected to frequent washing or splashing of liquids as well as small machines with a single guard for self-contained systems.

Depending on the models used, the sensing distance will be between 5 and 10 mm.

The reed contacts used for the coded magnetic switches cannot withstand short circuits and the switches always incorporate a resistor in series. Their operation can therefore only be guaranteed with the associated processing module.

The Hall-effect self-contained systems with integral processing do not require any further processing of the signal.

The illustrations opposite show the functions of coded magnetic guard switches and of a system.

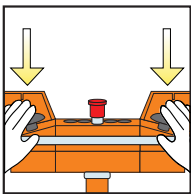
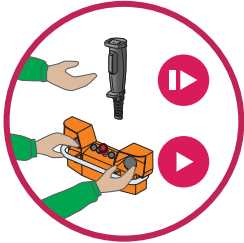
### Typical architecture

#### Safety chain solution:

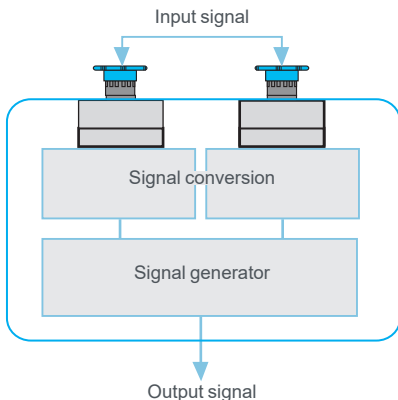
- > Guard monitoring with Safety module / Coded magnetic switches / Contactors / Cat.4 PL e, SIL 3 / Stop Category 0
- > Guard monitoring with Safety module / Coded magnetic switches / Contactors / Cat.3 PL d, SIL 2 / Stop Category 0
- > Guard monitoring with safety module / Coded Magnetic switches / Variable speed drive / Cat.4 PL e, SIL 3 / Stop Category 0
- > Guard monitoring with safety module / Coded Magnetic switches / Multifunctional starter / Cat.4 PL e, SIL 3 / Stop Category 0
- > Guard monitoring with safety module / Coded magnetic switches / Multifunctional starter / Cat.3 PL d, SIL 2 / Stop Category 0

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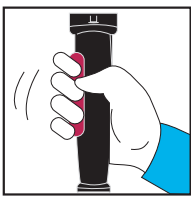
### Enabling movement



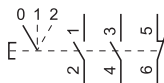
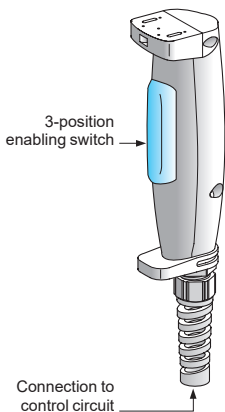
Two-hand control stations



Functions of a two-hand control station



Enabling Switch



Enabling switch XY2 AU1:  
2 enabling functions, 3 positions + 1 N/C

### Explanation of function

#### Two-hand control stations

Standards ISO 13851 and EN 574 define this device. It requires simultaneous operation by both hands in order to start and maintain operation of a machine. It therefore provides protection exclusively for the person operating it.

A diagram representing the function is given opposite; it must meet the following requirements:

- > Concurrent, maintained operation of the two input controls for the same period of time
- > Synchronous operation; the delay between the two signals must not exceed 0.5 s
- > Prevention of accidental operation (mechanical guard)
- > Protection against tampering

Enabling switches, allow authorized personnel to carry out maintenance, adjustment or programming operations within hazardous zones of machines, provided certain conditions are met. These devices conform to standards EN/IEC 60947-5-8 and EN/IEC 60204-1. In effect, to gain access, these operations, often performed at reduced speed, must be selected by authorized personnel using selectors with key or equivalent.

Important note: the enabling switch alone must not lead to the actuation of any dangerous movements associated with the machine; a secondary, intentional, control action is required from the operator. All devices which conform to the standard must be identified by the marking scheme shown opposite.

#### Enabling Switch

##### Operating principle

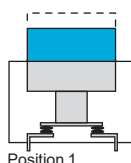
The three possible states are:

- > Position 0: contact open (control operator at rest)
- > Position 1: contact closed (control operator depressed to normal enabling position)
- > Position 2: contact open (control operator fully depressed)

When the switch is depressed in position 1, it must return to position 0 when released. The switch must change from position 1 to position 2 when pressed more firmly. When it is released from position 2 to position 0, the switching contact must not close.



Position 0

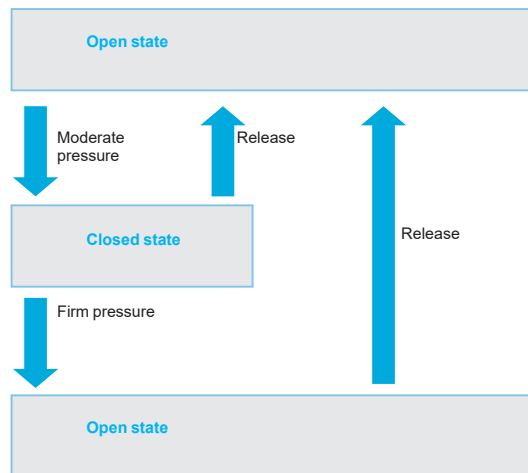


Position 1

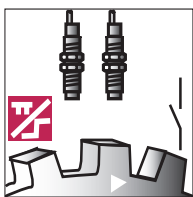
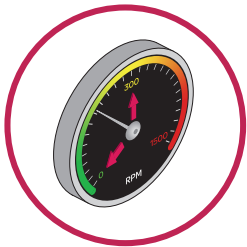


Position 2

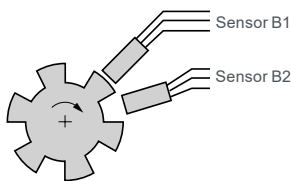
Operating principle of an enabling switch



### Speed monitoring



Speed monitoring

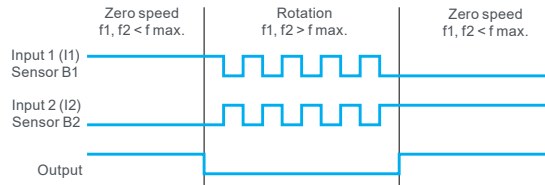


Sensor control

### Explanation of function

#### Zero speed monitoring

##### Detection principle



The two sensors to be arranged that only one sensor is activated at any given time. If the inputs are in the low state, the zero speed signal will disappear after  $t=1/f$  seconds and an open-circuit will be indicated. If the 2 inputs are in the high state, the zero speed signal will disappear after  $t=1/f$  seconds and a short-circuit will be indicated. If the 2 inputs are in the high or low state after starting, no enabling will take place.

#### Sensor States and Behavior

##### Switch-on Sequence

State of Sensor 1	0	0 (1)	1
State of Sensor 2	0	1 (1)	1
Behavior	Error Message	Zero Speed	Notification (2)
Output	0	1	0
<b>Operation</b>			
State of Sensor 1	0	0 (1)	1
State of Sensor 2	0	1 (1)	1
Behavior	Error Message	Zero Speed	Notification
Output	0	1	1

(1) If the state of the sensors is inverse (0/1, 1/0), the behavior is identical.

(2) If the firmware version is earlier than 2.34 an error message (short circuit between inputs) appears instead of a notification. This error message must be acknowledged with the reset button.

##### Detection principle 2

Preventa safety modules XPSVNE for zero speed detection are used to detect the stop condition of electric motors. Their most common applications include: providing the unlock signal for electrically interlocked sliding or removable machine guards, controlling rotation direction signals for reversing motors and engaging locking brakes after a motor has come to a standstill.

As electric motors run down, a remanent voltage is produced in the windings of the motor due to residual magnetism. This voltage is proportional to the speed of the motor and, therefore, decreases as the motor comes to a standstill.

This remanent voltage is measured in a redundant manner so as to detect the stop condition of the motor. The cabling between the motor windings and the inputs of the XPSVNE module is also monitored to prevent a cabling breakage or fault being seen as a stopped motor.

A transformer should not be used to connect the motor to terminals Z1, Z2 and Z3 since there is no monitoring of the connection with the motor winding via the resistance monitoring.

Modules XPSVNE are suitable for detecting the stop condition of all types of AC or DC motor driven machines which, when the motor runs down, produce a remanent voltage in the windings due to residual magnetism. These machines can be controlled by electronic devices, such as variable speed drives or DC injection brakes. The input lters for standard XPSVNE modules are designed for a frequency of up to 60 Hz.

For motors operating at a frequency higher than 60 Hz, which therefore produce a high frequency remanent voltage, special modules XPSVNE●●●HS should be used.

Modules XPSVNE have  $t_2$  potentiometers mounted on the front face of the module which allow independent adjustment of the switching threshold for each input circuit. This allows adjustment for different types of motors and application requirements. To aid diagnostics, modules XPSVNE have 4 LEDs and 2 solid-state outputs to provide information on the status of the zero speed detection circuit.

#### Safety-limited speed

The SLS function prevents the motor from exceeding the specified speed limit.

When this function is initiated the machine starts to decelerate to the specified safe speed  $v_2$  with in the specified time  $t_2$ . Once the machine reaches the safe speed  $v_2$  then the function will monitor the speed stays below safe speed  $v_2$ .

In case of speed exceeding specified speed during time  $t_2$  and further, safety function will initiate either SS1 or STO to stop the machine in minimum time.

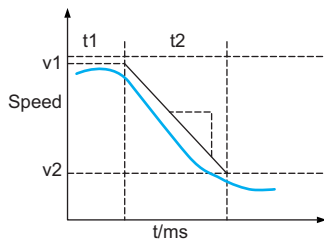
#### Safe maximum speed

The SMS function provides a safe output signal to indicate whether the motor speed is below a specified limit.

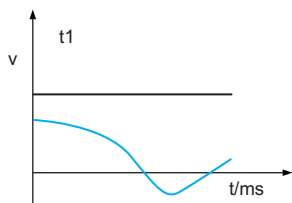
This safety function is an optional function to set an upper limit parameter for continuous monitoring. If the speed of the machine exceeds the specified value then specified safe output will change its state.

#### Safe direction

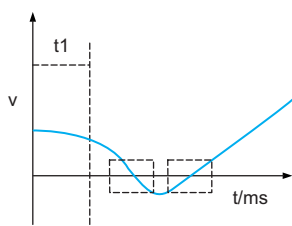
The SDI function prevents the motor shaft from moving in the unintended direction.



Safety-limited speed



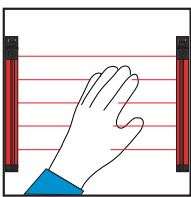
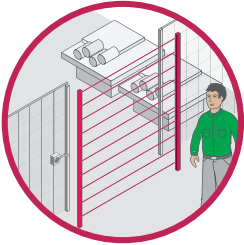
Safe maximum speed



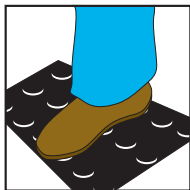
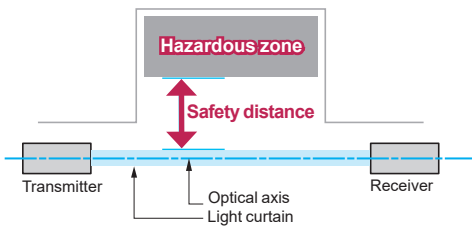
Safe direction

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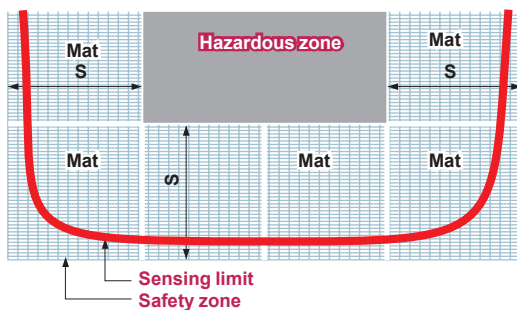
### Perimeter guarding



Safety light curtain



Safety mat



Example of a safety mat application

### Explanation of function

#### Safety light curtains

Safety light curtains are electro-sensitive systems (Electro-Sensitive Protective Equipment) designed to protect persons working in the vicinity of machinery, by stopping dangerous movements when a light beam is broken.

The absence of a door or guard reduces loading, inspection or tool changing times.

This type of system, defined by standards EN/IEC 61496-1 and EN/IEC 61496-2, is frequently used with machines such as:

- presses
- machine tools
- assembly lines, etc.

The machine must be designed so that it is impossible to gain access to dangerous movements without breaking one or more of the light beams.

In addition, the movement must be stopped whatever the entry speed of the operator into the hazardous zone.

The diagram opposite illustrates the operation of a safety light curtain.

### Typical architecture

#### Safety chain solution:

- > Perimeter guarding with safety module / Safety light curtains / Contactors / Cat.4 PL e, SIL 3 / Stop Category 0
- > Perimeter guarding with Embedded safety module / Safety light curtains / Contactors / Cat.4 PL e, SIL 3 / Stop Category 0
- > Perimeter guarding with Embedded safety module / Safety light curtains / Variable speed drive / Cat .3 PL d, SIL 2 / Stop Category 1

### Explanation of function

#### Safety mats

Safety mats are used to detect persons walking across or standing on the mat or objects falling onto the mat.

Standards EN 1760-1/ISO 13856 define their performance.

Any detection of an object on the mat initiates stopping of any dangerous machine movement.

Restarting can be controlled manually or automatically, depending on the configuration of the associated processing unit.

When pressure is applied, the mat distorts locally and the integrated sensors are short-circuited.

The special design of these sensors requires that the mat and the detection module be matched.

In general, several mats are used to cover the safety zone.

The safety distance  $S$ , defined by the standard, takes into account the speed at which a person can cross the safety zone to reach the hazardous zone.

Life Is On



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