Safety

Good equipment is **safe** equipment, which combines:

- **Safety:** of personnel (equipment that does not pose a hazard),
- **Reliable Operation:** of production machinery (equipment in working order at all times).

Safety is achieved by:

- Simultaneously optimizing safety and reliability,
- Applying fundamental principles: redundancy, and self-testing,
- Making reliability a design consideration (failure potential determining the design of the machine in a specified position, pro-active safety features),
- Ease of maintenance.

Safety and Automation

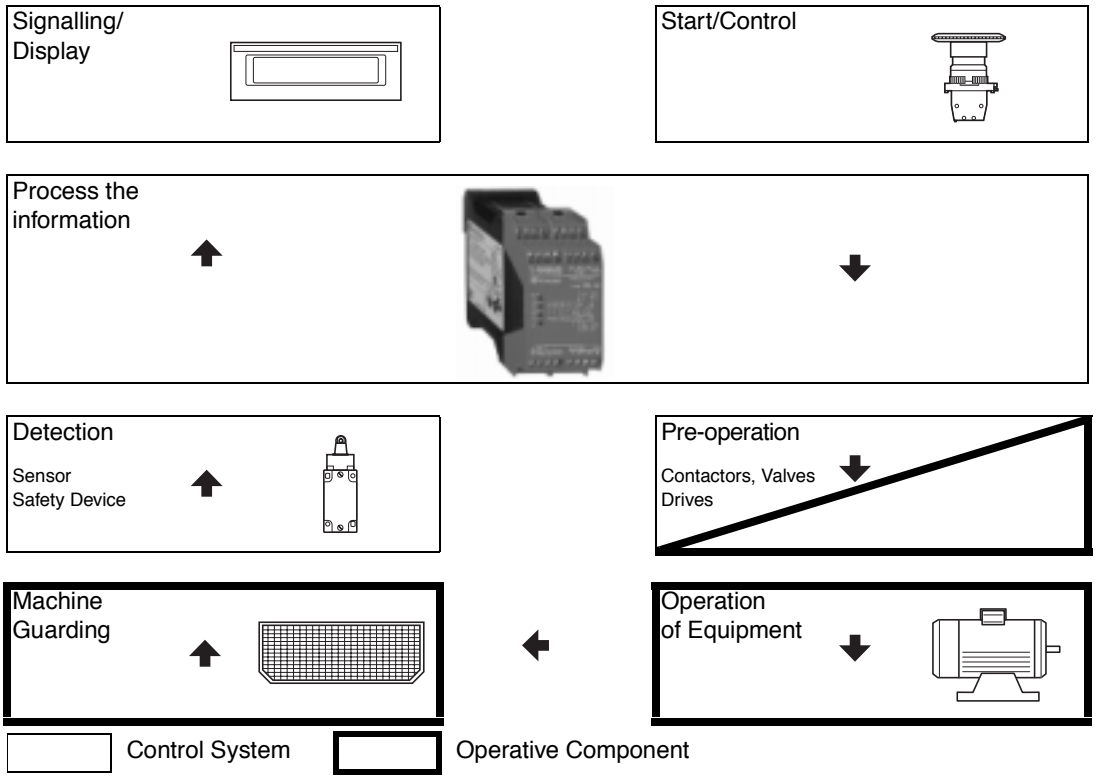
All hazardous areas must be identified and their access restricted and controlled, that is to say that no failure or tampering should render the automated equipment hazardous to personnel.

Please note that the use of safety products does not necessarily assure the equipment is compliant with the European Machinery Safety Directive, OSHA, ANSI, or other USA safety requirements.

Rather, proper use, wiring, connections and planning contribute to the safety of the equipment as a whole.

Safety systems are comprised of many components. No one safety component will ensure the safety of the system. The design of the complete safety system should be considered before you begin. It is very important to follow applicable safety standards when installing and wiring these components.

General Model of an Automated Machine



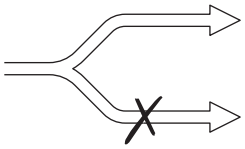
Objective

- Open outputs upon occurrence of the first fault.
- Provide non-hazardous positioning (machine stops in a safe state).
- Enhance the safety of personnel operating industrial machinery.

Basic Principles

Redundancy

To compensate for the failure of one component with another properly operating component, with the assumption that both components will not fail simultaneously.



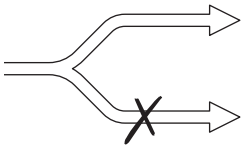
Reliability

If an initial fault is not detected, there is no corrective action, allowing a second fault to occur, thereby compromising safety.

+

Redundancy

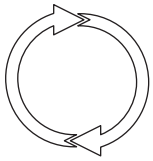
To compensate for the failure of one component with another properly operating component, with the assumption that both components will not fail simultaneously.



+

Self-Testing

To automatically test the operation of each component which changes state with each operating cycle.
The next cycle can be inhibited or enabled.



Reliability + Safety

An initial fault in a safety circuit will be detected before a second fault can occur (next cycle inhibited).

The use of a Preventa™ XPS safety relay module allows a Category 4 control system to be designed in compliance with standard EN 954-1 (for safety-related control system components).

Definitions

Redundancy

This function is achieved by integrating dual circuitry into the design, combined with a test function which authorizes a control action only when at least two output signals are identical.

Self-Test Function

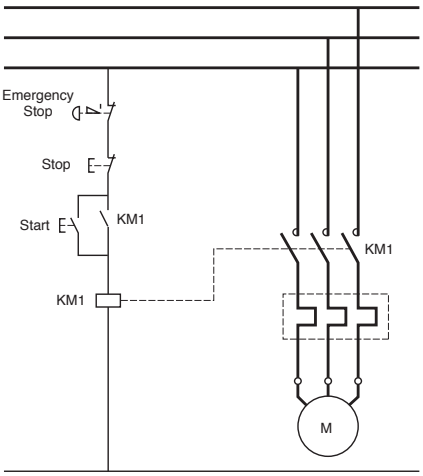
Preventa™ safety relay modules use mechanically-linked N.O. and N.C. contact relays.

These relays ensure the uniform operation of their additional N.C. and N.O. contacts.

The reliability of the self-test function is ensured by verifying the proper operation of the contact relays during the current cycle.

To detect the failure of a mechanically-linked N.O. relay contact requires that the proper operation of its N.C. contacts be tested at the time of their integration into a self-test circuit. This detection is made possible only by using mechanically-linked contact relays.

Effect on the Control Circuit without Interposing Relays/Contactors



The control signal issued by the protective device (emergency stop circuit illustrated to the left) acts directly on the power contactor of the machine.

In this diagram, the possible fault conditions are:

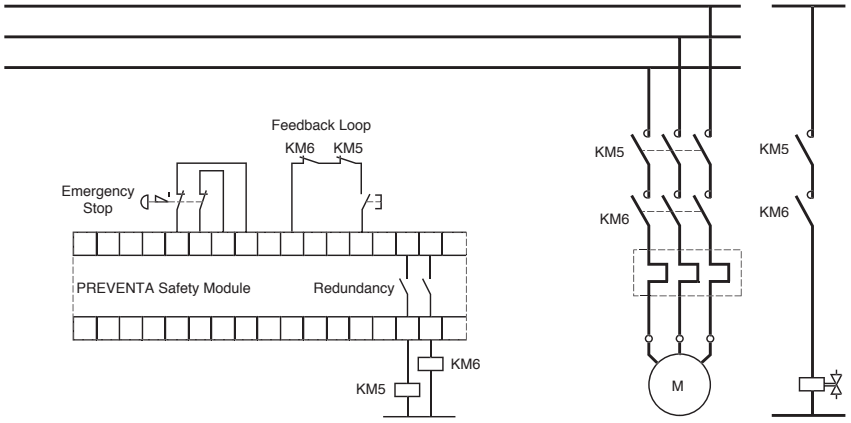
- emergency stop button being shorted or jumpered.
- KM1 contactor sticking or welded.

When the emergency stop is operated, the signal is not recognized, and another sequence can begin following the emergency stop, despite the presence of the fault condition.

In this case of failure, the safety function▲ is compromised. Therefore, reliable interposing relays/ contactors must be used.

▲ A safety function is a function whose non-execution or untimely execution results in the immediate placement of the equipment into a non-hazardous condition.

Effect on the Control Circuit with Interposing Relays/Contactors



KM5 and KM6 Relays/Contactors with Mechanically-Linked Contacts

Independent Safety Circuits

Preventa™ safety relay modules provide **reliable** interposing relaying by eliminating the risks of a:

- control circuit fault (inputs),
- power circuit fault (outputs),
- safety module internal component fault.

The safety function remains operative in all occurrences of one of these faults.

Relays and Contactors in the Safety Circuit

Use relays or contactors with mechanically-linked contacts on the safety outputs of the safety relay such as the Square D or Telemecanique products found in Appendix B, pages 303-306, of this catalog.

Category Requirements

To meet the requirements of Category 3 per EN 954-1 (this standard deals with safety related parts of control systems), the output devices must be redundant - meaning there must be two relays/contactors in series controlling the load which can cause a hazardous movement. Using only one relay/contactor will reduce the control system to a **maximum Category 2**.

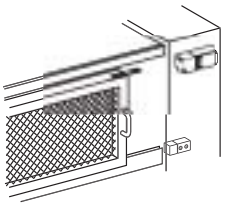
To meet the requirements of Category 4 per EN 954-1, the requirements for Category 3 need to be met, **plus** one of the N.C. auxiliary contacts from **each** of the two relays/contactors in series must be wired in series in the feedback loop. Without both of these N.C. contacts wired in series in the feedback loop, the control system is reduced to a **maximum Category 3.**

Selection Criteria

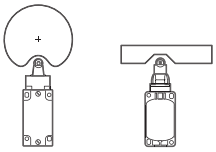
Low Potential of Hazard to Personnel

Locking or interlocking device based on the principle of intrinsically safe design (proven components and principles)

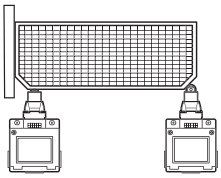
Quick-Stop Machinery. Locking (stop time < access time) ∗



Locking by actuating key



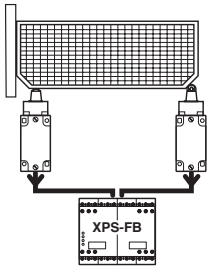
Positive Mode Activation



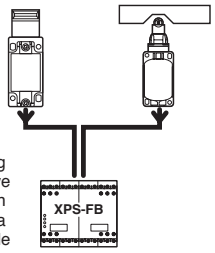
Positive and Negative Mode Activation

High Potential of Hazard to Personnel

Locking or interlocking device based on redundancy and self-testing. The safety relay modules provide these functions.

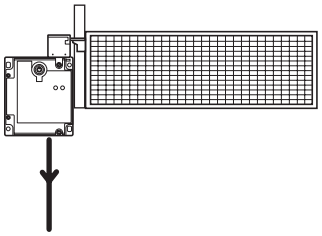


Positive and negative mode activation wired to a safety relay module

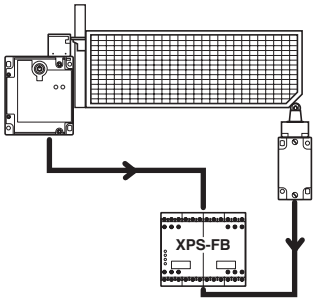


Locking by actuating key with positive mode activation wired to a safety relay module

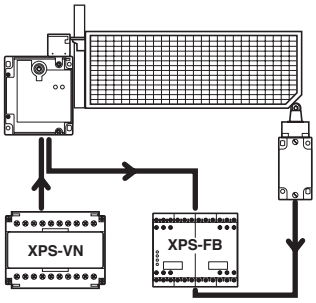
Inertia-Based Machinery; Long Stopping Times. Interlocking (stop time > access time)∗



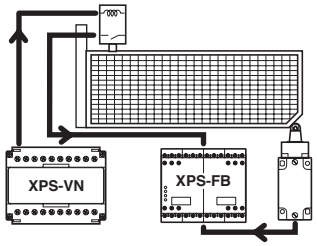
Interlocking Device with Electromagnetic Guard Lock



Interlocking Device with Electromagnetic Guard Lock



Interlocking Device with Electromagnetic Guard Lock and Zero Speed Sensing



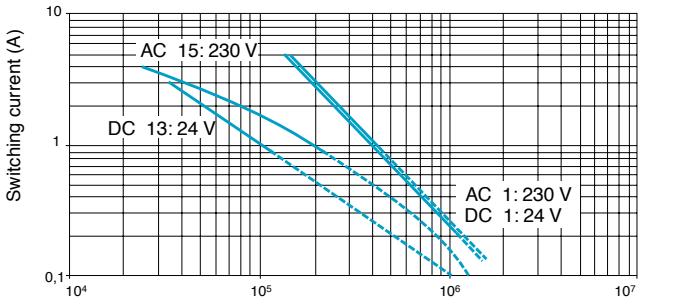
Interlocking Device with Electromagnetic Lock

∗ Stop time: time elapsed between issuance of the machine stop command and the moment at which the machine stops (risk elimination). Access time: time required for a person to access the hazardous area (calculated using an approach speed as the basis).

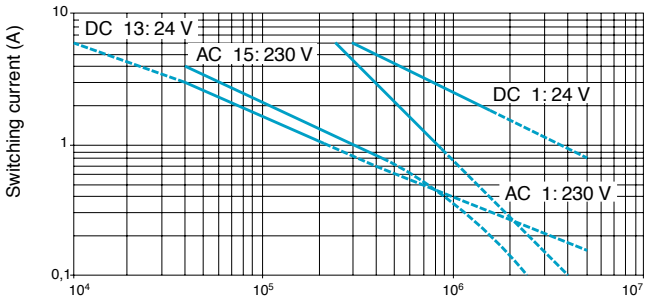
Lifetime Curve and Switching Capability with N.O. Contacts

Determined by EN 60947-5-1 Table C2

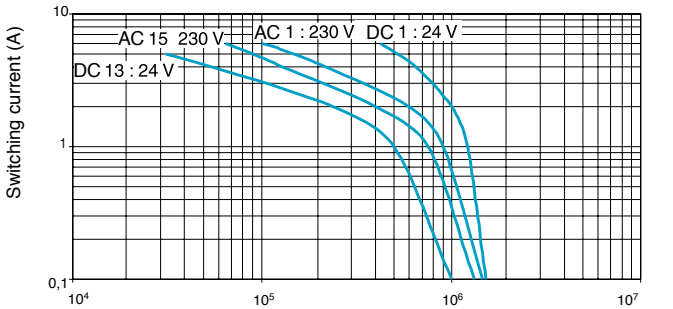
XPSAC, **XPSAT** (time delay contacts), **XPSTSA, XPSTSW, XPSBA**, **XPSBC**, **XPSCM**, **XPSDA, XPSFB, XPSNS, XPSOT, XPSPVK**, **XPSPVT**, **XPSVN, GNKL**



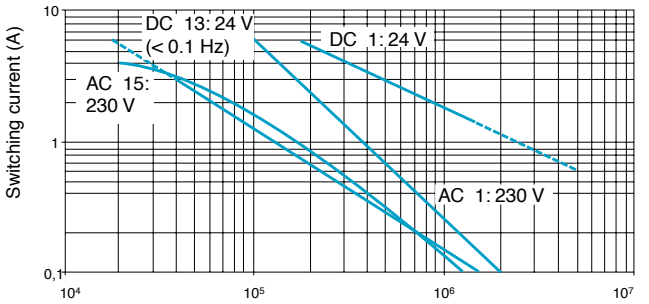
XPSAT (instantaneous contacts), **XPSECM**, **XPSECP, GBS**



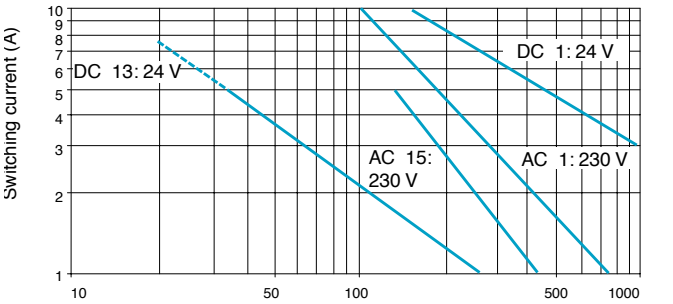
XPSAF, **XPSAK**, **XPSAFL**



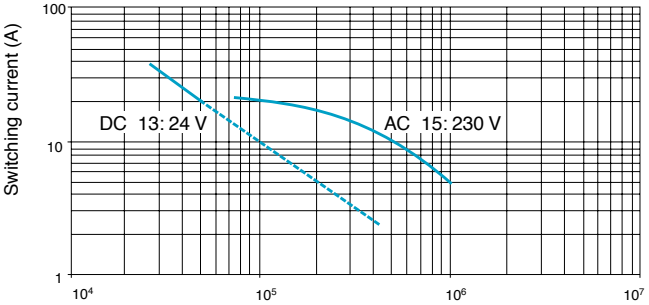
XPSAV, **XPSMP, XPSBF**



XPSAR



XPSDMB/DME



The product life expressed above is based on average usage and normal operating conditions.
Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any express or implied warranties as to product operation or life. For information on the limited warranty offered on this product please refer to the Square D terms and conditions of sale found in the Square D Digest.

Determining the Electrical Life According to EN 60947-5-1 (Table C2)

Type of Current	Utilization Category	Start-up			Breaking		
		Current	Voltage	Cos φ	Current	Voltage	Cos φ
AC supply	AC-15	10 x Ie	Ue	0.7	Ie	Ue	0.4
Type of Current	**Utilization Category**	**Start-up**			**Breaking**		
		Current	**Voltage**	**T 0.95**	**Current**	**Voltage**	**T 0.95**
DC supply	DC-13	Ie	Ue	50 ms	Ie	Ue	50 ms

Ie: Operational current measured. Cos φ: Power factor.
Ue: Operational voltage measured. T 0.95: Time taken to reach 95% of rated current.

The tests are carried out with a frequency of 6 switching operations per minute and with no additional protection of the components connected to the safety outputs.

The use of additional protection for the components connected to the safety outputs significantly increases the life of the safety outputs.

Determining the Breaking Capacity According to EN 60947-5-1 (Table 4)

Utilization cat.	Start-up			Breaking			Total No. of Switching Ops.	Switching Ops. per minute for 1-1000 Switching Ops.	Switching Ops. per minute for 1001-6050 Switching Ops.	Minimum Duration of Switching Operation
	Current	Voltage	Cos φ	Current	Voltage	Cos φ				
AC-15	10 x Ie	Ue	0.3	Ie	Ue	0.3	6050	60	6	50 ms
Utilization cat.	**Start-up**			**Breaking**			**Total No. of Switching Ops.**	**Switching Ops. per minute for 1-1000 Switching Ops.**	**Switching Ops. per minute for 1001-6050 Switching Ops.**	**Minimum Duration of Switching Operation**
	Current	**Voltage**	**T 0.95**	**Current**	**Voltage**	**T 0.95**				
DC-13	Ie	Ue	50 ms	Ie	Ue	50 ms	6050	60	6	50 ms

Ie: Operational current measured. Cos φ: Power factor.
Ue: Operational voltage measured. T 0.95: Time taken to reach 95% of rated current.

Comments:

The maximum values for the breaking capacity of the safety outputs in the various utilization categories are not fixed and depend on the power factor and on the switching frequency. The test definition for the “breaking capacity” and “electrical life” tables in European standard EN 60947-5-1 uses different values for the power factor and the switching frequency.

The switching frequency of the safety outputs is higher in the “breaking capacity” table (60 switching operations per minute for the first 1000 switching operations) than in the “electrical life” table (6 switching operations per minute).

Consequently, the maximum breaking capacity values determined using the “breaking capacity” table are lower than those in the “electrical life” table.

AC Voltage and Current Ratings 50-60 HZ

Contact Rating Designation	Thermal Continuous Test Current, Amperes	Maximum Current, Amperes				Volt amperes	
		120 Volts		240 Volts			
		Make	Break	Make	Break	Make	Break
B300	5	30	3.00	15	1.50	3600	360
C300	2.5	15	1.50	7.5	0.75	1800	180

Technical Data

Module Type		**XPSAV11113** and **AV11113P**	**XPSAT●●●●**
Product designed for max. use in safety related parts of control systems (conforming to EN 954-1)		Category 4	Category 4 (instantaneous safety outputs) Category 3 (time delay safety outputs)
Power Supply			
voltage	V	24 Vdc	24 Vac/dc, 115 Vac, 230 Vac
voltage limits		- 20 to + 20 %	- 20 to + 10 % (24 V) / - 15 to + 15 % (115 V) / - 15 to + 10 % (230 V)
frequency	Hz	–	50/60
Power Consumption	W	< 5	< 8
Module Fuse Protection		Internal, electronic	Internal, electronic
Adjustable Time Delay	s	0 to 300	0 to 30
Start Button Monitoring		Yes/No (configurable by terminal connection)	Yes/No (configurable by terminal connection)
Control Unit Voltage (at nominal supply voltage)		Between terminals S21-S22, S31-S32 or S11-S12	Between terminals S11-S12, S21-S22 or S11-B1
24 V version	Vdc	24	24
115 V and 230 V versions	Vdc	–	48
Calculation of Wiring Resistance RL between input terminals	Ω	100 max. Maximum cable length: 6,562 ft. (2000 m)	RL max. = $\frac{\text{U int - U min.}}{\text{I min.}}$ Ue = true voltage applied to terminals A1-A2 U int (terminals S11-S21) = supply voltage Ue - 3 V (24 V version) U int between 42 V and 45 V, with typical value = 45 V (115 V, 230 V version) Calculated max. RL must be equal to or greater than the true value
Synchronization Time Between Inputs	s	For guard: 1.5 / For emergency stop: unlimited	Approx. 0.075 (automatic start, terminals S33-Y2 and Y3-Y4 linked)
Outputs			
voltage reference		Relay hard contacts	
number and type of instantaneous opening safety circuits		3 N.O. (03-04, 13-14, 23-24)	3 N.O. (13-14, 23-24, 33-34)
number and type of time delay opening safety circuits		3 N.O. (37-38, 47-48, 57-58)	2 N.O. (57-58, 67-68)
number and type of additional circuits		3 solid state	1 N.C. (41-42)
breaking capacity in AC-15			
-- instantaneous outputs	VA	C300: inrush 1800, maintained 180	B300: inrush 3600, maintained 360
-- time delay outputs	VA	C300: inrush 1800, maintained 180	C300: inrush 1800, maintained 180
breaking capacity in DC-13			
-- instantaneous outputs		24 V/1.25 A L/R = 50 ms	24 V/1.5 A L/R = 50 ms
-- time delay outputs		24 V/1.25 A L/R = 50 ms	24 V/1.5 A L/R = 50 ms
breaking capacity of solid state outputs		24 V/20 mA	–
max. thermal current (the)			
-- instantaneous outputs	A	3.3 for all 3, or 6 for 1 and 2 for 2, or 4 for 2 and 2 for 1	5
-- time delay outputs	A	3.3 for all 3, or 6 for 1 and 2 for 2, or 4 for 2 and 2 for 1	2.5
max. total thermal current	A	20	8
output fuse protection conforming to IEC EN 60947-5-1. DIN VDE 0660 part 200			
-- instantaneous outputs	A	4 gG or 6 fast acting	6 gG
-- time delay outputs	A	4 gG or 6 fast acting	4 gG
minimum current	mA	10	10
minimum voltage	V	17	17
Electrical Life		See page 156	
Response Time on Instantaneous Opening Inputs	ms	< 30	< 20
Rated Insulation Voltage (Ui)	V	300 (degree of pollution 2 conforming to IEC EN 60947-5-1, DIN VDE 0110 parts 1 and 2)	
Rated Impulse Withstand Voltage (Uimp.)	kV	4 (over voltage category III, conforming to IEC EN 60947-5-1, DIN VDE 0110 parts 1 and 2)	
LED Display		11	4
Operating Temperature	°F(°C)	+ 14 to + 130 (- 10 to + 55)	
Storage Temperature	°F(°C)	- 13 to + 185 (- 25 to + 85)	
Degree of Protection conforming to IEC EN 60529			
Terminals		IP 20	
Enclosure		IP 40	

Connection	Type	**XPSAV11113** Captive screw clamp terminals	**XPSAV11113P** Captive screw clamp terminals, separate removable block	**XPSAT●●●●** Captive screw clamp terminals
- 1-wire connection	Without cable end	Solid or stranded wire: 26-14 AWG (0.14 - 2.5 mm^2)	Solid or stranded wire: 24-14 AWG (0.2 - 2.5 mm^2)	Solid or stranded wire: 1 x 12 AWG (1 x 4 mm^2)
	With cable end	Without bezel, stranded wire: 24-14 AWG (0.25 - 2.5 mm^2)	Without bezel, stranded wire: 24-14 AWG (0.25 - 2.5 mm^2)	Stranded wire: 2 x 14 AWG (2 x 2.5 mm^2)
	With cable end	With bezel, stranded wire: 24-16 AWG (0.25 - 1.5 mm^2)	With bezel, stranded wire: 24-14 AWG (0.25 - 2.5 mm^2)	–
- 2-wire connection	Without cable end	Solid or stranded wire: 26-20 AWG (0.14 - 0.75 mm^2)	Solid wire: 24-18 AWG (0.2 -1.0 mm^2) Stranded wire: 24-16 AWG (0.2 - 1.5 mm^2)	–
	With cable end	Without bezel, stranded wire: 24-18 AWG (0.25 - 1.0 mm^2)	Without bezel, stranded wire: 24-18 AWG (0.25 - 1.0 mm^2)	–
	With cable end	Double, with bezel, stranded wire: 22-14 AWG (0.5 - 1.5 mm^2)	Double, with bezel, stranded wire: 22-14 AWG (0.5 - 1.5 mm^2)	–
Recommended Terminal Clamp Torque		4.4 – 5.3 in.lbs (0.5 – 0.6 Nm)		

XPSAV11113

XPSAV11113P

XPSAT●●●●

Operating Principle

Preventa™ XPSAV safety relays conform to Category 4 of standard EN 954-1.

Preventa™ XPSAT safety relays conform to Category 4 of standard EN 954-1 when instantaneous break contacts are used and Category 3 of standard EN 954-1 when time delay break contacts are used.

They are used for monitoring:

- Emergency stop circuits (Emergency stop push buttons or cable pull switches) that conform to standards EN 418 and EN 60204-1
- Limit switches or safety interlocks mounted on guards or doors that conform to standard EN 1088.

Instantaneous vs. Time Delay Contacts

Instantaneous contacts (stop category 0) are used for applications where immediate removal of power is desired. These instantaneous contacts are used for most safety applications.

Time delay contacts (stop category 1) allow for controlled deceleration of motor driven components until a complete stop is achieved (i.e.: motor braking with a variable speed drive or mechanical brake). At the end of the time delay, these outputs open, removing power and drop out the motor.

The XPSAV modules have:

— A 1.77"/45mm wide enclosure.
— 3 N.O. safety outputs, 3 N.O. timed outputs, and 3 solid state outputs for signaling to the PLC.
— Two versions are available: one has non-removable terminal block mounting, which is an integral part of the module, the other has removable terminal blocks to reduce maintenance time and replacement.
— Eleven LEDs on the cover to provide status information for easier troubleshooting

The XPSAT modules have:

— A 3.54"/90mm wide enclosure.
— 3 N.O. safety outputs, 2 N.O. timed outputs, and 1 N.C. output.
— All the terminals are an integral part of the module (non-removable).
— Four LEDs on the cover to provide status information for easier troubleshooting

Ordering Information

Type of connection terminal block	Number of safety circuits	Additional outputs	Power supply	Catalog number	Weight oz (kg)
Non-removable	6 N.O. (3 N.O. time delay)	3 solid state	24 Vdc	**XPSAV11113**	11.29 (0.320)
Removable	6 N.O. (3 N.O. time delay)	3 solid state	24 Vdc	**XPSAV11113P**	11.29 (0.320)
Non-removable	5 N.O. (2 N.O. time delay)	1 N.C.	24 Vac/dc	**XPSAT5110**	22.93 (0.650)
			115 Vac	**XPSAT3410**	29.98 (0.850)
			230 Vac	**XPSAT3710**	29.98 (0.850)

File E164353
CCN NKCR

File LR44087
Class 3211 03

Preventa™ XPSAV safety relays are suitable for use in circuits through Category 4 per EN 954-1.

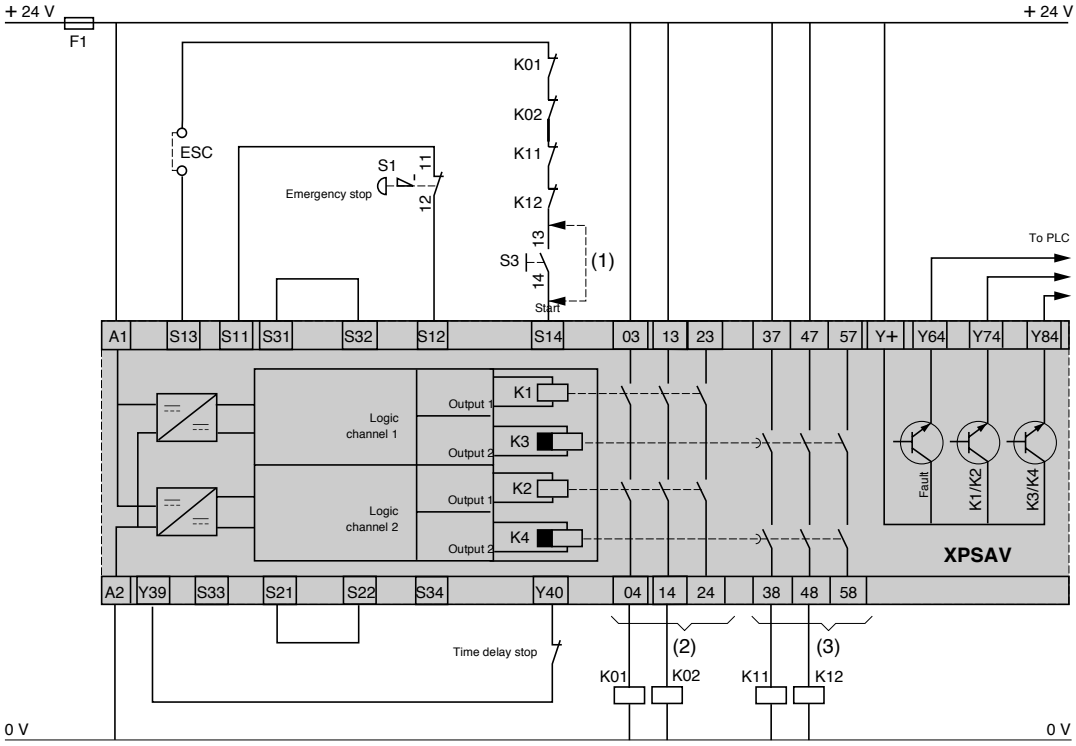
Preventa™ XPSAT safety relays are suitable for use in circuits through Category 4 per EN 954-1 when instantaneous break contacts are used.

Preventa™ XPSAT safety relays are suitable for use in circuits through Category 3 per EN 954-1 when time delay break contacts are used.

See page 258 for dimensions.

Wiring Diagrams

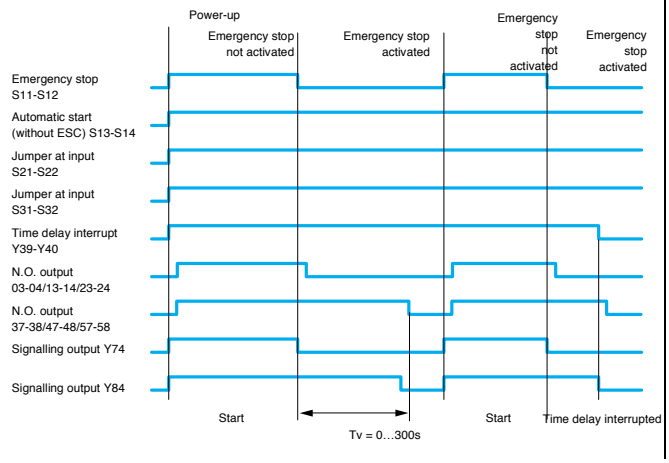
XPSAV module with an Emergency stop push button with 1 N.C. contact, automatic start or unmonitored start



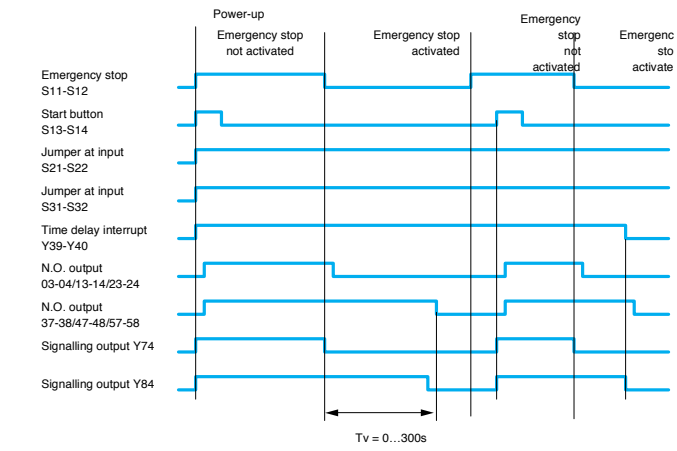
(1) Jumper for automatic start.
(2) Instantaneous opening safety outputs (stop category 0).
(3) Time delay opening safety outputs (stop category 1).
ESC = External start conditions.

Functional Diagrams

Automatic start



Unmonitored start



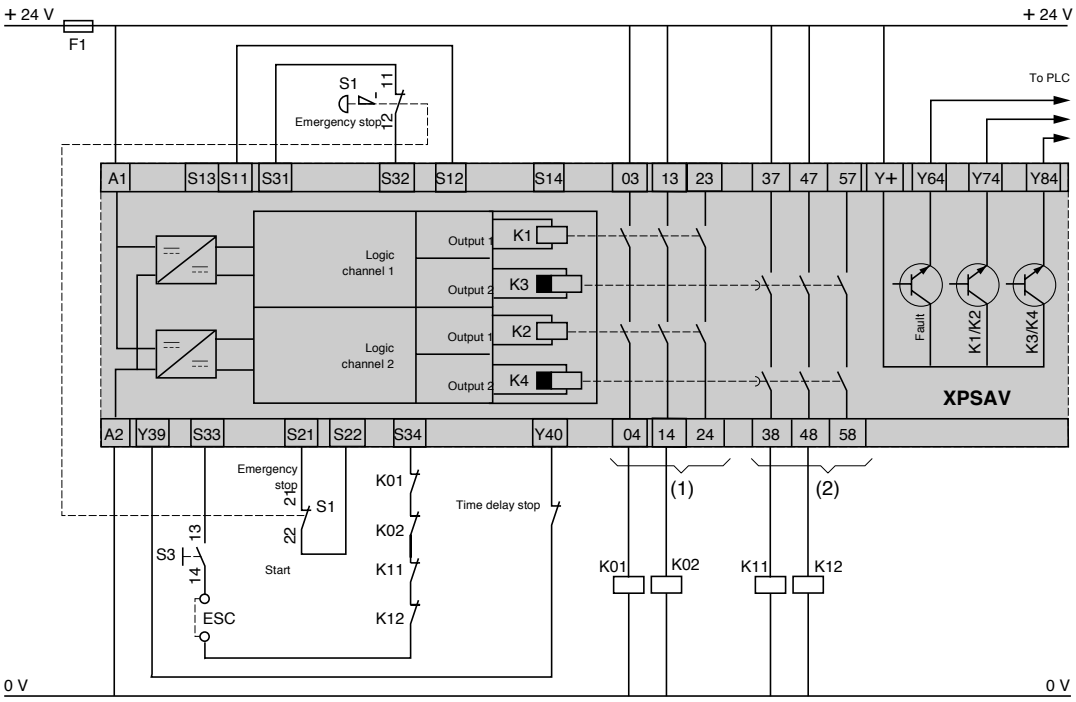
Automatic Start
There is no start contact or it is jumpered (wiring between terminals S13-S14).
Note: Automatic start function is not available with 2 channel wiring on the inputs. Automatic start function is only available on single channel wiring on the inputs.

Unmonitored Start
The output is activated on closing of the start contact (wiring between terminals S13 - S14).

Monitored Start
The start input is monitored so that there is no start-up in the event of the start contact being jumpered or the start circuit being closed for more than 10 seconds.
Start-up is triggered following activation of the start button (push-release function) on opening of the contact (wiring between terminals S33-S34).

Wiring Diagrams

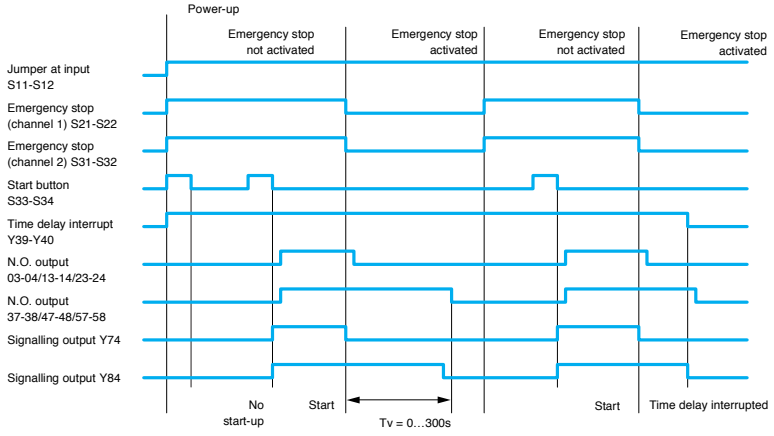
XPSAV module with an Emergency stop button with 2 N.C. contacts, monitored start.



(1) Instantaneous opening safety outputs (stop category 0).
(2) Time delay opening safety outputs (stop category 1).
ESC = External start conditions.
Note: Automatic start function is not available with 2 channel wiring on the inputs.

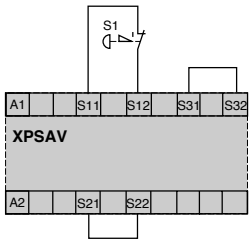
Functional Diagrams

Monitored start

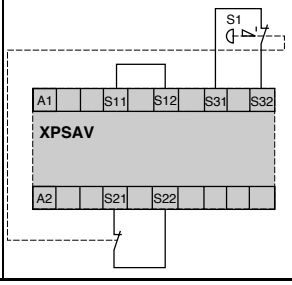


Emergency stop monitoring function configuration

1-channel wiring

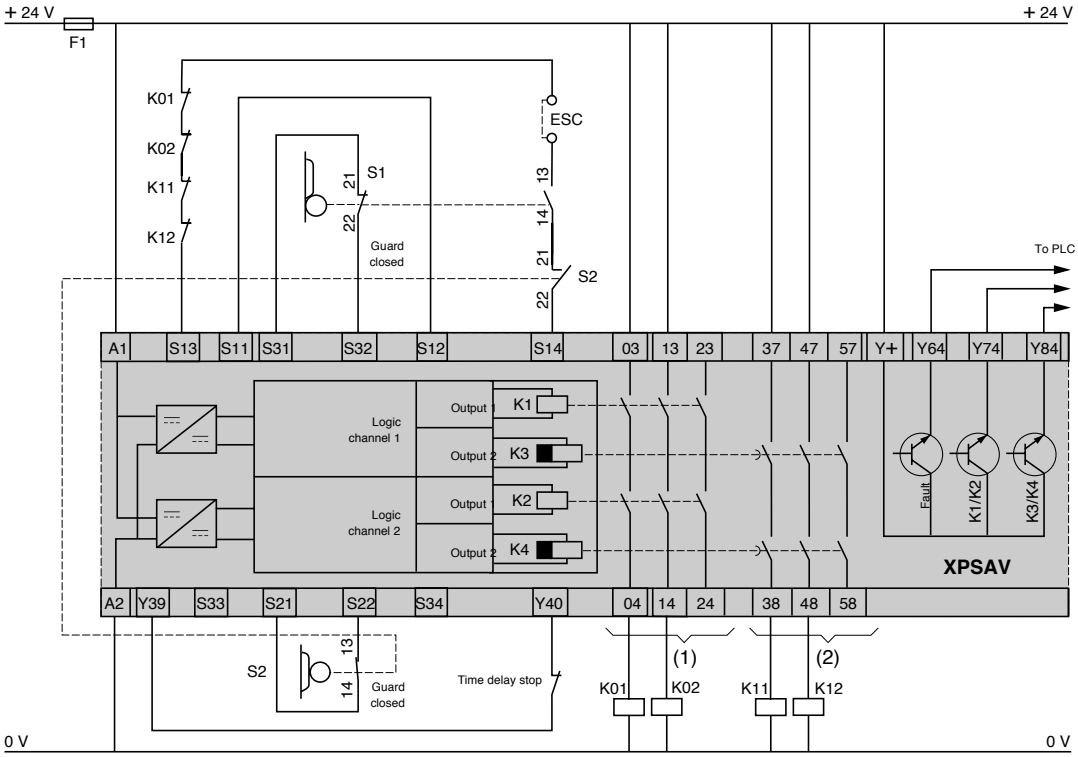


2 channel wiring, with short-circuit detection



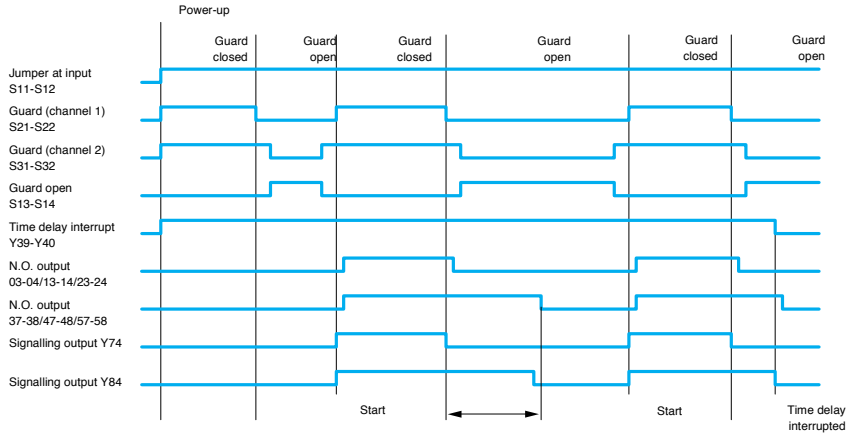
Wiring Diagrams

XPSAV
Monitoring of a movable guard associated with 2 switches
Automatic start (diagram shown for guard closed)
Synchronization time between switches S1 and S2 is 1.5 seconds.

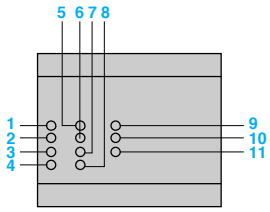


(1) Instantaneous opening safety outputs (stop category 0).
(2) Time delay opening safety outputs (stop category 1).
ESC = External start conditions.
Note: Automatic start function is not available with 2 channel wiring on the inputs.

Functional Diagrams



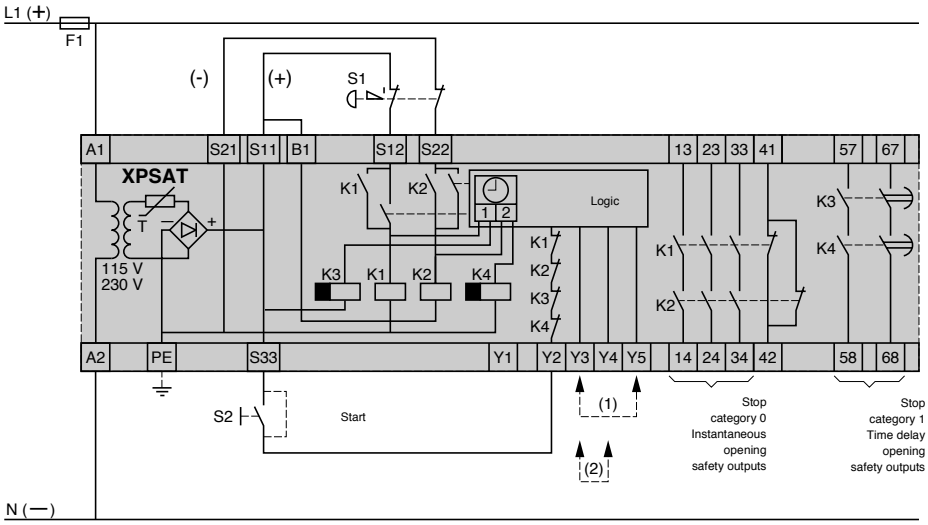
Key to LEDs



(1) S12 input state
(2) S22 input state
(3) S32 input state
(4) S34 input state
(5) S14 input state
(6) Y40 input state (time delay stop)
(7) K1/K2 state (N.O. instantaneous opening safety outputs)
(8) K3/K4 state (N.O. time delay opening safety outputs)
(9) A1-A2 supply voltage
(10) Fault
(11) Configuration mode

Wiring Diagrams

XPSAT module with an Emergency stop push button

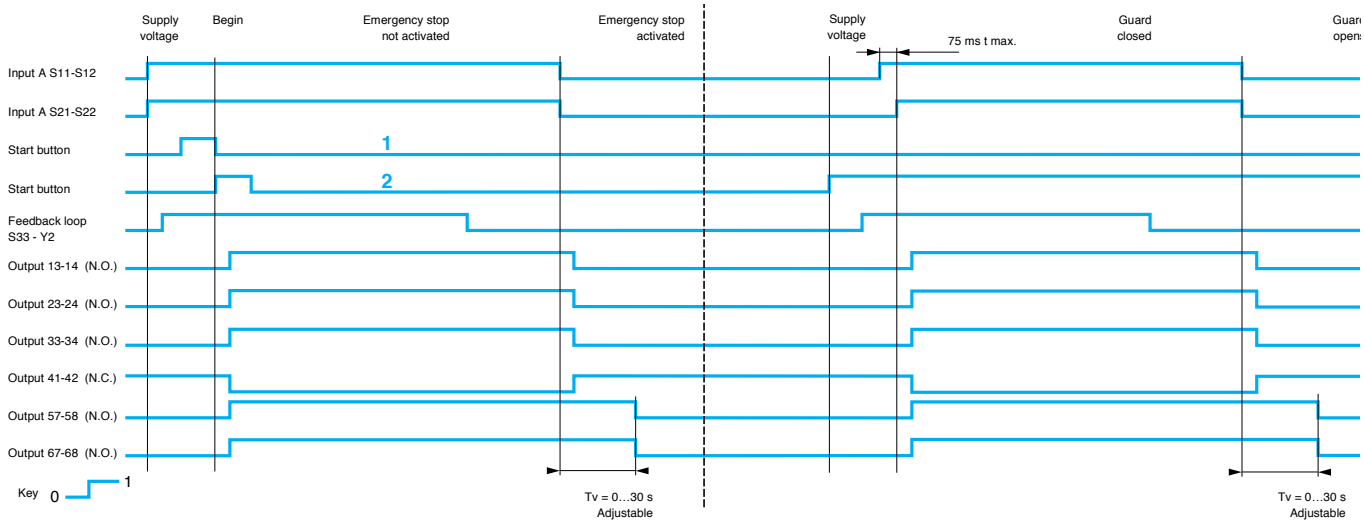


S1: Emergency stop button with 2 N.C. contacts (recommended application).
Output 41-42 must not be used as a safety circuit.
(1) With Start button monitoring
(2) Without Start button monitoring
(3) Dashed line around S2 (N.O. start button between terminals S33-Y2) indicates wiring for automatic start. This is only feasible when configured without start button monitoring. If S2 is jumpered and the module is configured for start button monitoring, the N.O. safety contacts will not close.

Functional Diagram

XPSAT with Emergency stop button monitoring

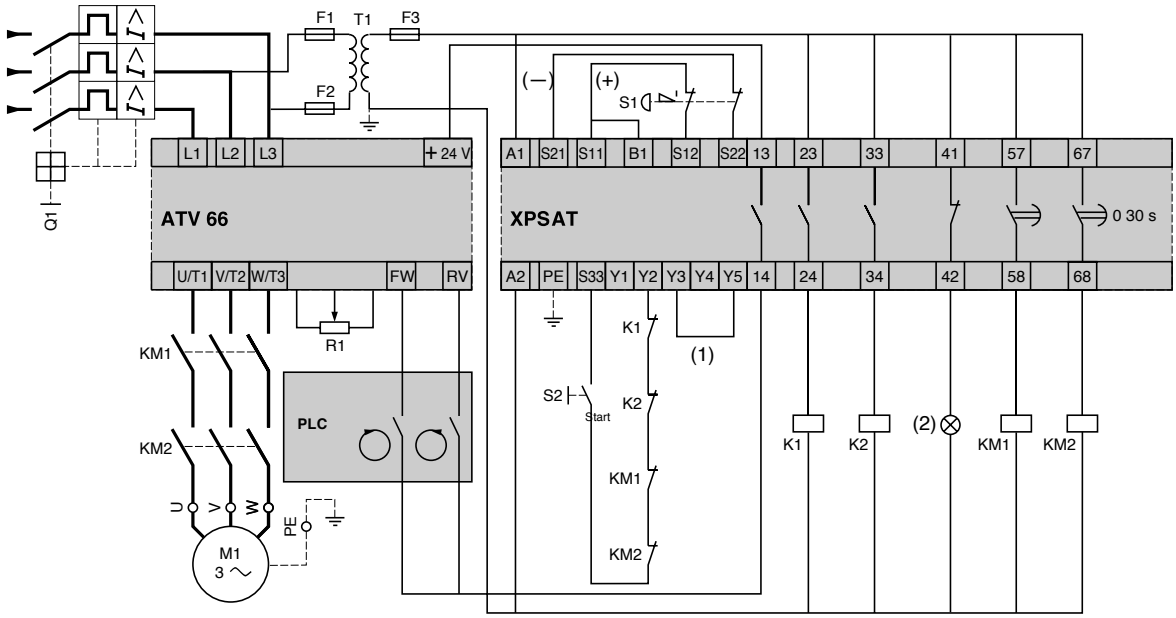
XPSAT with limit switch monitoring



(1) With Start button monitoring (connection Y3-Y5)
(2) Without Start button monitoring (connection Y3-Y4)

Wiring Diagrams

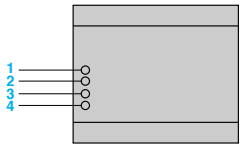
XPSAT: Example of a safety circuit combining an Emergency stop module with a variable speed drive



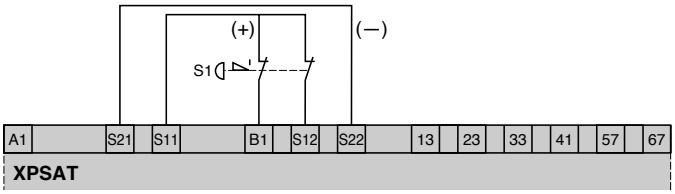
(1) With Start button monitoring
(2) “Emergency stop” signalling
S1: Emergency stop button with 2 N.C. contacts (recommended application)

XPSAT: Key to LEDs

(1) Supply voltage A1-A2, internal electronic fuse status
(2) S12 (A) input state
(3) S22 (B) input state
(4) Stop category 1 outputs closed

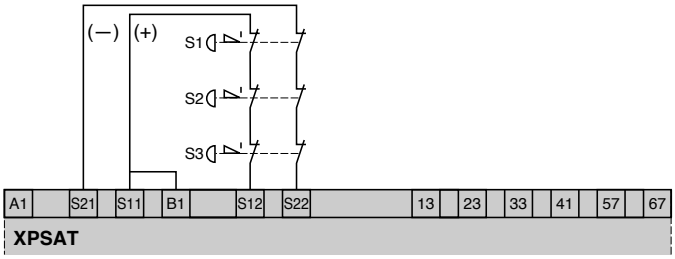


XPSAT: Connection with 1 Emergency stop push button



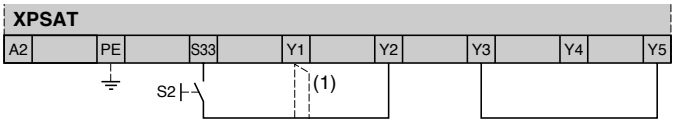
Both input channels are supplied on the same polarity.
S1: Emergency stop push button with 2 N.C. contacts.
(a short-circuit between the 2 inputs is not detected)

XPSAT: Connection with multiple Emergency stop push buttons

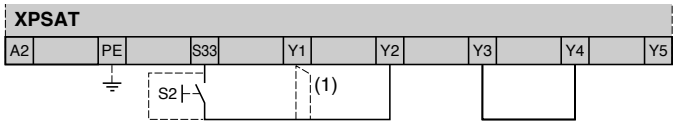


Connection of multiple Emergency stop push buttons with 2 N.C. contacts (recommended application).
The 2 input channels are supplied on different polarity.
A short-circuit between the 2 inputs is detected.

Configuration with Start button monitoring (functional diagram for Start button 1, see page 166)

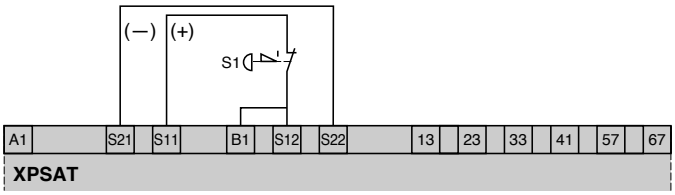


Configuration without Start button monitoring (functional diagram for Start button 2, see page 166)



(1) Auxiliary terminal
(to be used to separate the feedback loop from the wiring to the Start button)

Monitoring an Emergency stop push button with 1 N.C. contact



S1: Emergency stop button with 1 N.C. contact
Not all faults are detected: a short-circuit on the Emergency stop push button is not detected