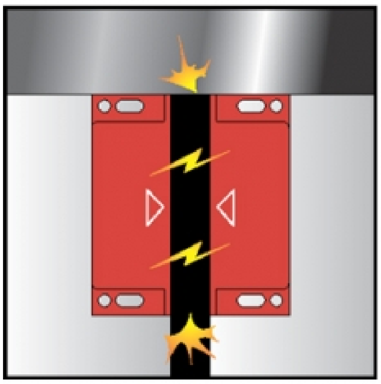
Safety Chain Solution – Magnetic switches

PL e, SIL 3

High diagnostic level with an optimized implementation



Function:

- Safety-related stop function initiated by any of the moveable guards that helps protect the access to the hazardous area.
- The opening of each guard is detected by using magnetic switches, which are checked by the safety module by means of a combination of contacts (normally closed and normally open).
- Opening of any of these guards causes the deactivation of the safety module outputs, which results in the switching-off of the motor power supply by means of the contactors K1 and K2 (stop category 0 according to EN/IEC 60204-1) to help prevent possible hazardous movements or states.
- The main contactors are monitored by the safety module to detect contact welding by means of the mirror contacts.
- The safety module also monitors the consistent actuation of the magnetic switch contacts to detect any failure, before restart of the machine movement is permitted.
- Opening or removal of the protective guard is detected by means of the coded magnetic switches, which are particularly useful for guards without accurate guidance and for use in difficult environments (dust, liquids, etc.).

Typical applications:

- Assembling, packaging or similar compacted machines with a short rundown time and where the access to the hazardous area is very frequent.

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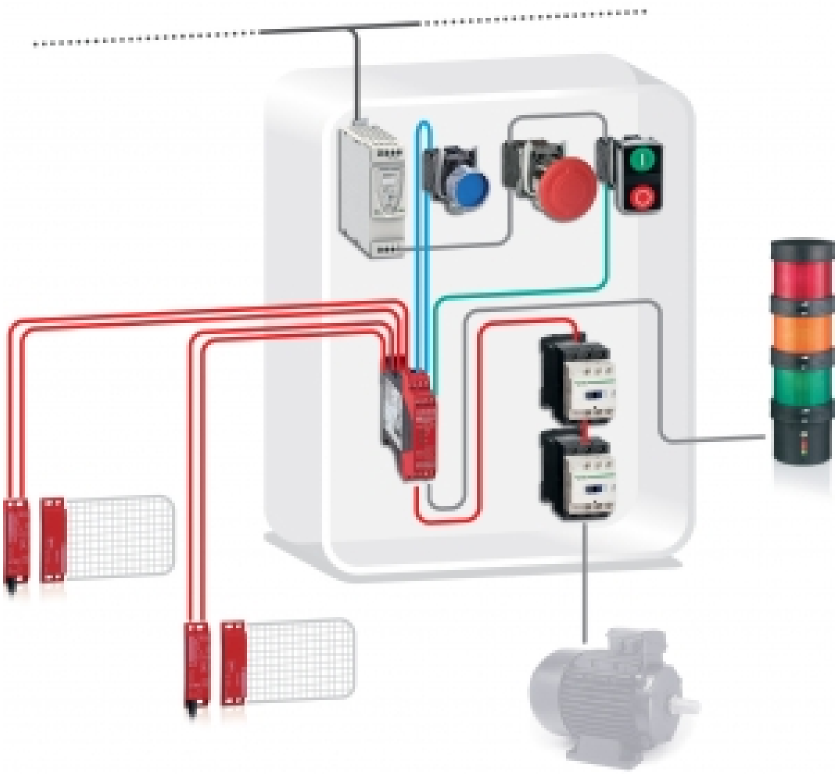
Design:

- The safety function employs well-tried safety principles and is robust in the event of a component failure by means of two redundant contacts on the magnetic switch device and two redundant contactors (K1 and K2).
- The contact synchronization of the magnetic switches and contactor failure are detected by the safety module at the next demand upon the safety function.
- The start (S2) and the restart interlock (S1) pushbuttons must be located outside the hazardous area and at a point from which the potential danger is visible.
- The safety module satisfies the requirements for performance level PL e in accordance with EN ISO 13849-1 and SILCL 3 in accordance with EN/IEC 62061.
- The contactors (K1 and K2) are considered as well-tried components.
- Protection against overcurrent must be provided in accordance with EN/IEC 60947-4-1
- The contactors (K1 and K2) have mirror contacts in accordance with EN/IEC 60947-4-1, which are integrated into the feedback of the safety module L1 for fault detection.

Related products

Switches, pushbuttons, emergency stop - Harmony XB4
Switch mode Power supply - Phaseo ABL8
Safety Module - Preventa XPSDM
Coded magnetic system - Preventa XCSDM
Contactor - TeSys D
Modular beacon and tower light - Harmony XVB



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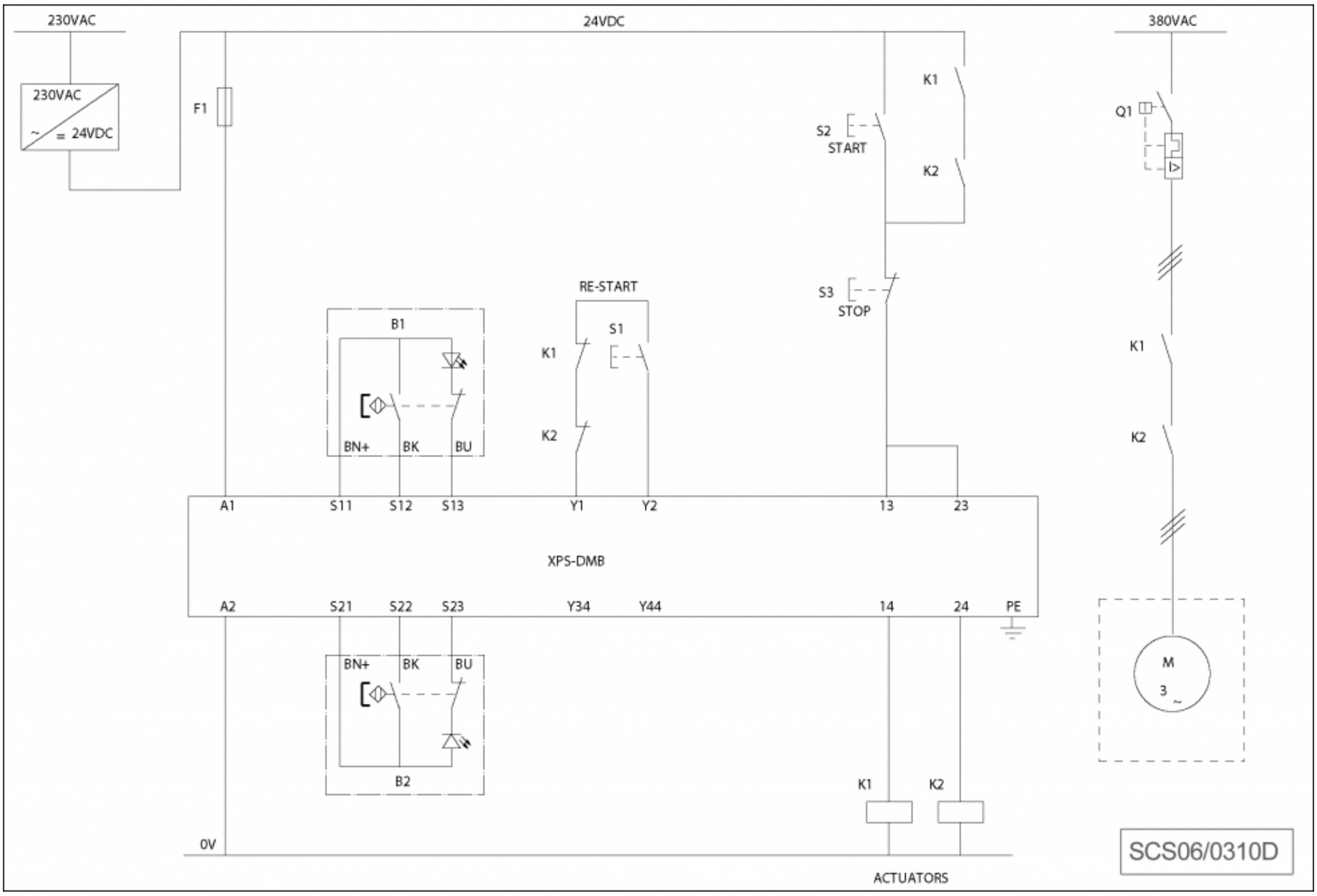

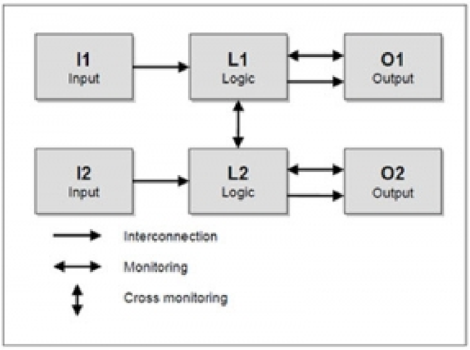

Figure 1

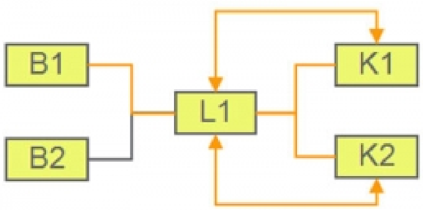

Figure 2

Chain structure:

- The circuit diagram SCS06/0310D is a conceptual schematic diagram and is limited to present the safety function with only the relevant safety components.
- For the designated architecture of the category 4 system, two redundant channels are implemented.
- The circuit arrangement can be divided into three function blocks, input (I), logic (L) and output (O) blocks, on each channel.
- The unbroken lines for monitoring symbolize the higher DCavg assumed for this category (see figure 1)
- Since each protective guard forms part of a dedicated safety function, the calculation of the performance level considers only one of them.
- The functional channel can be represented by a single guard switch device (B1) that corresponds to the input block (see figure 2).
- The safety module (XPSDMB) corresponds to the logic block (L1/2), which maintains the internal redundancy of the safety circuits required for this category.
- The output block is represented by two redundant contactors (K1 and K2) that are monitored by the logic block (safety module) to detect failure.
- The complete wiring must be in accordance to EN 60204-1 and provision to avoid short circuits has to be provided (EN ISO 13849-2 Table D.4).

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Cycle time (s)	300
Number of hours' operation per day (h)	12
Number of days' operation per year	220
Number of operations per year (n_{op})	31680

		Values	
		Channel 1	Channel 2
Input (magnetic switch) XCS	$B10_d$ (operations)	50 000 000	50 000 000
	T10d (years)	1578	1578
	$MTTF_d$ (years)	15782.8	15782.8
	$MTTF_d$ resulting (years)	2500	2500
	PFH_d resulting (1/h)	9.05×10^{-10}	9.05×10^{-10}
	DC (%)	99	99
Logic (safety module) XPSDMB	PFH_d (1/h)	3.92×10^{-9}	3.92×10^{-9}
Output (actuator) LC1	B10 (operations)	1 000 000	1 000 000
	% dangerous failure	73	73
	$B10_d$ (operations)	1 369 863	1 369 863
	$T10_d$ (years)	43	43
	$MTTF_d$ (years)	432.4	432.4
	$MTTF_d$ resulting (years)	432.4	432.4
	PFH_d resulting (1/h)	5.35×10^{-9}	5.35×10^{-9}
	DC (%)	99	99
Safety function	$MTTF_{dC}$	**67.8 (high)**	
	DC_{avg}	**99 (high)**	
	PFH_d resulting (1/h)	**1.02×10^{-8}**	
	PL attained	e	
	SIL attained	3	

Safety level calculation:

- A required performance level (PLr) must be specified for each intended safety function following a risk evaluation. The performance level (PL) attained by the control system must be validated by verifying if it is greater than or equal to the PLr.
- If the protective guard device is assumed to be actuated every 5 minutes during 220 working days per year and 12 working hours, the number of operations (nop) would be 31 680.
- A B10d value of 50 000 000 cycles is stated for the coded magnetic switch. In accordance with the assumed above nop value, the MTTFd would be 15782.8 years for each channel. These values are limited to 2500 years in this case as this is the limit used by the SISTEMA calculation tool for category 4 systems.
- A PFHd value of 3.92×10^{-9} is stated for the safety module (XPSDMB). This value comes directly from the safety device data and it is certified by an accepted standards body.
- For the redundant contactors K1 and K2, the B10 value corresponds under nominal load to an electrical lifetime of 1 000 000 switching cycles. If 73% of failures are assumed to be dangerous, the B10d value is 1 369 863 operations. With the assumed value for nop, it results in a MTTFd of 432.4 years for each component. These values are not limited in this case as this is a category 4 systems and they are under the 2500 year limit used by the SISTEMA calculation tool.
- Measures against common cause failures must attain at least 65 points (i.e. separation (15), diversity (20), over voltage protection etc. (15) and environmental conditions (25+10)).
- Since this is the highest performance level, both the MTTFd of each channel and the DCavg must be high.
- The combination of channel 1 and channel 2 results in a DCavg 99% (high) as we are using magnetic switches with a NO/NC contact combination, and mirror contact monitoring for the contactors.
- The safety-related control system corresponds to category 4 with high MTTFd. The complete functional safety chain results in average probability of dangerous failure (PFHd) of 1.02×10^{-8}.
- This corresponds to PL e and SIL 3.

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Schneider Electric Industries S.A.S
Head Office
35 rue Joseph Monier
CS 30323
92506 Rueil-Malmaison
www.schneider-electric.com

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