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GK-2 CATALOG-HANDBOOK FIFTH EDITION



Protect Safety Controllers

Schmersal Safety Controllers

What are Safety Controllers?

Safety controllers are connected between machine guarding devices such as keyed interlocks, non-contact sensors, light curtains, etc. and the machine's stop control elements such as a motor contactor or control relay. These controllers contain redundant, self-checking monitoring circuits and positive-guided relays and/or solid state outputs. Each is designed to detect faults in the safety system's components and interconnection wiring, and their own internal monitoring circuits and output.

Detection of a fault, or of an open machine guard, disables the controller's output signal(s) facilitating machine stoppage, and/or prevents the restarting of the machine until the fault has been corrected. Units are available for use with guard interlock switches, coded-magnet sensors, safety edges, two-hand controls, light curtains, E-stops and emergency cable-pull switches to satisfy a broad range of application requirements.

What are their functions?

In addition to detecting open guards and/or actuated safety input devices, safety controllers are capable of detecting the following types of safety system faults: guard monitoring switch/sensor failure, "open-circuit" in interconnection wiring, "short-circuit" in interconnection wiring, "cross-short" between channels, welded contact in controlled output device (such as positive-guided motor contactor), failure of safety controller's positive-guided relay(s), fault in safety system monitoring circuit, and insufficient operating voltage. Some microprocessor-based safety controllers also feature integrated system diagnostics with visual LED outputs which indicate fault type and location—thus minimizing machine downtime. Safety controllers increase the reliability of the machine guarding safety system. Their ability to detect safety circuit/component faults, and shut down the machine until the fault has been corrected, ensures that the safety system will perform when called upon to do so.

When should they be used?

There are a variety of applications in which the use of safety controllers is recommended. These include (but are not limited to):

- Applications in which the assessed risk level is relatively high
- Applications for which the designer wishes to satisfy requirements for "control reliability"
- Applications having relatively low levels of assessed risk for which the designer wishes to heighten the performance/reliability of the safety system

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*Some features listed may not be available on certain models.

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SELECTING THE OPTIMAL CONTROLLER

Some form of a safety controller is required to meet higher risk categories and to meet the requirements for Control Reliability. This guide is intended to help you properly select and apply Schmersal Safety Controllers.

It is common to want to look at safety issues as "Here is Application Number 116 and I can find the solution in my Safety Handbook under Solution Number 116". Unfortunately, this is seldom possible. In most cases you are forced to re-examine previous solutions for similar safety issues as it is generally application specific. For any given situation, there may be a number of correct solutions depending on the overall system design.

A safe machine is generally achieved through the combination of safety measures incorporated by design and taken by the machine operator. Ideally such measures should be addressed during the design phase. In addition proper training of machine operators and maintenance personnel is critical for safe operation.

While individual component suppliers can provide general guidance and technical information related to their products, it is the responsibility of the machine designer or retrofitter to ensure the safety system is designed to meet the appropriate standards.

To minimize the possibility of worker injury and address industry safety standards/guidelines, it is recommended that the machine designer follow these general steps:

- 1. Become familiarized with the pertinent safety Standards
- 2. Specify the limits of the machine
- 3. Identify the hazards and assess the risks
- 4. Remove the hazards or limit the risk by design
- 5. For remaining hazards, install necessary protective devices
- 6. Inform and warn the operator of any remaining risks/hazards

In designing a machine guarding safety system, the following objectives should be considered:

- Design to suit the working environment
- Achieve the desired degree of protection
- Do not interfere with machine operation
- Do not encourage manipulation/bypassing
- Make it difficult to override
- Do not cause any additional dangers/hazards

It is impossible to correctly select and apply a Safety Controller without performing some type of quantitative risk assessment. "Guesstimating" a control category for a Performance Level may lead to excessive expense and/or to an inadequate or unsafe system. There are a number of approaches to risk assessment, most of which use some form of decision tree to determine the appropriate safety control category. One such approach is discussed in the next section.

Certain factors may be considered when trying to select the optimal controller for an application:

- Supply Voltage Requirements 24VAC, 24VDC, 110VAC, 230VAC, etc.
- Input Monitoring Requirements 1NC, 1NO/1NC, 2NC, PNP, etc.
- Feedback & Reset Requirements Automatic, manual, monitored manual, etc.
- Output Requirements Time delayed, semiconductors, dry contacts, etc.
- Type of Performance Level required

RISK ASSESSMENT

Different machines and processes have different levels of relative risk. Determining this relative risk level involves evaluating three major factors. These include:

- 1. Severity of the potential injury.
- 2. Frequency of exposure to the potential hazard.
- 3. Possibility of avoiding the hazard if it occurs.

One approach to a risk assessment is provided by ISO 14121. This international standard identifies these three factors to evaluate when estimating the level of risk.

Another approach is seen in ISO 13849-1 where it adopts the decision tree from EN 954-1to determine a risk, interpreted as a Performance Level required (PL_r) ranging from "a" (low) to "e" (high); not to be confused with the actual Performance Level (PL) which has to be calculated (Figure 1).

This particular method is depicted in Figure 1, in which the following qualitative definitions apply:

S: Severity of injury

- S1: slight (normally reversible)
- S2: severe (normally irreversible including death)

F: Frequency and/or exposure time to hazard

F1: Seldom to quite often and/or short exposure time F2: Frequent to continuous and/or long exposure time P: Possibility of avoiding the hazard if it occurs (generally related to the speed/frequency of movement of hazard point and distance to hazard point)

P1: Possible under specific conditions

P2: Scarcely possible



Figure 1

One factor to look at when trying to achieve the PL_r is the actual design of the safety circuit. These designs have also been adopted from EN954-1 and are classified as Safety Controls Categories referred to as B, 1, 2, 3 and 4 as defined in Figure 2.

These safety control system categories are not to be regarded as a hierarchy. The goal is to reduce the ultimate risk of all machines to acceptable levels regardless of initial assessed risk.

Safety Cat.	General Safety System Requirements	General Safety System Behavior	Safety Cat.	General Safety System Requirements	General Safety System Behavior
В	Safety system designed to meet operational requirements and withstand expected external influences. (This category is usually satisfied by selecting components compatible with the application conditions e.g. temperature, voltage, load, etc.)	A single fault or failure in the safety system can lead to the loss of the safety function.	3	Safety system must meet the requirements of Category B. In addition the safety control system must be designed such that a single fault will not lead to the loss of the safety function. And, where practical, the single fault will be detected. (This requires redundancy in the safety circuit	Here a single fault or fail- ure in the safety system will not lead to the loss of the safety function and, where possible, will be detected.
1	Safety system must meet the requirements of Category B, but must use "well-tried" safety princi- ples and components. "Well-tried" principles and components include	A single fault or failure in the safety system can lead to the loss of the safety function. However, the use		monitoring of the input and output adoutput devices such as machine guard interlock switches, E-stop pushbut- tons, safety relays, etc.)	
	 those which: avoid certain faults e.g. short circuits. reduce probability of faults e.g. over-rating selected components, over-dimensioning for structural integrity. detect faults early e.g. ground fault protection. assure the mode of the fault e.g. ensure an open circuit when it is vital that power be interrupted should an unsafe condition arise. limit the consequences of the fault. 	of "well tried" safety princi- ples and safety compo- nents results in a higher level of safety system relia- bility.	4*	Safety system must meet the requirements of Category B. In addition the safety control system must be designed such that a single fault will not lead to the loss of the safety function and will be detected at or before the next demand on the safety system. If this is not possible, then the accumulation of multiple faults must not lead to the loss of the safety function. (This also requires redundancy in the safety cir- cuit and the use of dual-channel monitoring of the input and output devices such as machine guard	Here a single fault or fail- ure in the safety system will not lead to the loss of the safety function, and it will be detected in time to pre- vent the loss of the safety function.
2	Safety system must meet the requirements of Category B. In addition the machine shall be pre- vented from starting if a fault is detected upon application of machine power. or upon periodic	Here, too, a single fault or failure in the safety sys- tem can lead to the loss of the safety function between		interlock switches, E-stop pushbuttons, safety relays, etc. Here the number of allowable faults will be determined by the application, technology used, and system structure.)	
	checking during operation. (Single-channel operation is permitted provided that the input devices such as machine guard interlocks, E-stop pushbuttons, et al are tested for proper operation on a regular basis.)	the checking intervals. However, periodic checking may detect faults and per- mit timely maintenance of the safety system.	*Category/Level 4 safety requirements are usually associated with extremely high- applications. Since general machine design practice respects classic safety hierarchy which most machine hazards are either: • designed out, • guarded against (if they cannot be designed out), and, • (as a last resort) warned against, Level 4 requirements may arise relatively infrequently.		

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ISO 13849-1:2008 (2006)

Roughly summarized, a Performance Level represents an assessment of several factors in order to measure the safety and reliability of the Safety Related Parts of a Control System.

In contrast to what is now common practice in engineering, a performance level is equivalent to a multi-dimensional assessment. Instead of complex models, however, ISO 13849-1 uses a simplified approach which considers four auxiliary variables.

Note that a Performance Level essentially relates to preventing and controlling random failures and faults. As such, additional basic requirements have to be taken for avoiding and controlling systematic failures and faults.

A PL estimation first starts by determining the various safety functions of a machine or a machine controller.

The Performance Level reflects the degree of measures necessary to reduce risks. A PL always relates to the overall safety function, i.e. the [I] inputs + [L] signal processing/logic and [O] outputs. Safety control modules depict the [L] level and are used for fault diagnosis, when simple safety switching devices on the [I] level and feedback signals on the [O] level are connected to the feedback loop.

The diagnostic coverage is between 60% (for simple 2-channel series circuits on the [I] level) to 99% (with 2-channel non-series wiring on the [I] level and with feedback signals from positive-guided power contactors on the [O] level). For complete breakdown of diagnostic coverage, refer to Appendix E of ISO 13849- 1:2008 (2006).

The effectiveness of the necessary measures is expressed in the form of a PFH_d value (a value of the remaining maximum tolerated average probability of a dangerous failure per hour = Average Probability).

Here, the PFH_d value is also the link to Safety Integrity Levels (SILs), as recognized by IEC 61508:2000 or IEC 62061:2005.

Schmersal specifies a pre-calculated PFH_d value so it is not necessary to carry out calculations for our individual safety controllers.

The assessment (calculation) of a Performance Level is now carried out according to ISO 13849-1 based on the assessment of 4 individual parameters as seen on the following page.



Figure 3

Note: Safety controllers fulfill the requirements for the Logic (L) subsystem. The overall PL of the safety function takes into consideration the type of devices as well as how the Input and Output subsystems are connected to the safety controller.

- The Architecture, essentially identical to the controller categories as they are known from the application of EN 954-1:1996 and has been incorporated in ISO 13849-1;
- Hardware reliability, expressed as Mean Time to dangerous Failure MTTF_d in years (a statistically based assumption over the time during which the hardware will operate without random safety failures);
- Diagnostic Coverage (DC), the assessment (of the probability) of the effectiveness of the diagnostic measures in the SRP/CS expressed as a percentage;
- The assessment of measures against so-called Common Cause Failures (CCF) which could defeat the safety of a multi-channel system.



Figure 4

Using a graphic—a bar chart—or from Appendix K of ISO 13849-1 it is possible to determine the performance level PL and compare and validate it with the PL_r required for the particular safety function.

ACHIEVING "CONTROL RELIABILITY"

"Control Reliability" as defined by ANSI/OSHA essentially states that the safety system be designed, constructed and installed such that the failure of a single component within the device or system should not prevent normal machine stopping action from taking place — but shall prevent a successive machine cycle from being initiated until the failure is corrected.

It is helpful to break down the definition of Control Reliability in order to better understand how it might be achieved:

- Any single fault shall not lead to a loss of the safety function. This is achieved with redundancy in the safety circuit.
- Successive machine cycles shall be prevented until the fault is corrected. This means the fault must be detected. This is achieved by cross-monitoring of the redundant safety circuits.

Assuming the components are selected with appropriate electrical ratings and agency approvals, this system will generally meet category B requirements.

We can improve the safety system reliability by using a safety switch with positive-break contacts. This will generally meet category 1 requirements. However, it does not yet meet the requirements for control reliability.

To increase the reliability, let's next add a test function. Testing of the safety function may be automatic and is done at the machine startup, before initiation of a hazardous condition and/or periodic intervals during operation. Faults may exist in-between testing of this single channel design, thus still not providing the requirements for control reliability. Thus the following are required to achieve "Control Reliability":

- Redundancy
- Fault Detection

Note that this definition closely follows the definitions of a safety control category 3 as defined by EN 954-1 which is mainly used (but not limited) to fulfill the design requirements of Performance Level C and above as defined by ISO 13849.

Let's look at a basic safety system and develop it to a control reliable level.



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Let us now increase the testing cycles, such that a single fault is detected at or before the next demand of the safety function. This can be achieved by using a safety controller that will automatically and continually monitor for system and internal faults. Let us also increase the number of channels of the safety function. A safety controller can also achieve cross-monitoring between these two channels. We now have redundancy and fault detection fulfilling control reliability.

Notice the difference between category 3 and category 4 inputs to the safety controller. Here, we are no longer able to daisy chain devices that monitor multiple entry points and are without selfdiagnostics. This is because the opening and closing of a door can clear a fault downstream of the safety chain. Accumulation of faults downstream in such a system can even lead to the loss of the safety function as it will not be detected.

Figure 10 shows a typical example of a control reliable circuit utilizing a safety controller. Note that redundancy is not only achieved at the input with the safety device, but also at the output level with dual contactors which are being monitored by the safety controller via a feedback loop.

Basic Safety Control System with Redundancy and Fault Protection Can be used in designs up to PLe* (Category 3)



Basic Safety Control System with Redundancy and Fault Protection Can be used in designs up to PLe* (Category 4)





Figure 10

*Other factors besides the control category design need to be considered while trying to obtain a PL; such as the MTTFd, PFHd, Common Cause Failure measures and Dcavg.

BACKGROUND INFORMATION

Safety-related classification

When making an overall assessment of the design for an architecture the peripherals connected upstream and downstream (in particular sensor analysis and actuators as well as the demand frequency/testing) must also be taken into consideration. This may be, for example, signal processing of ON/reset buttons with edge detection in the case of accessible zones.

A maximum overall PL_d to ISO 13849-1 is achieved for series circuits, e.g. series circuits of commercially available EMERGENCY STOP control devices and similar protective devices. This does not refer to safety sensors and protective devices which are classified as PL_e or SIL3 to IEC 62061, due to their inherent monitoring intelligence. This applies, for example, to Schmersal safety sensors of the Pulse Echo and RSS type.

A restriction to PL_d similarly applies to module circuitry which does not have its own control circuits for reasons of functionality, i.e. the safety-oriented sensor analysis is looped in to the supply voltage.

Design

A common feature of the Schmersal safety modules is a housing design with installation widths of 22.5 mm and 45 mm, offering the following functional advantages in particular:

- 1. Plug-in terminals and optionally coded screw terminals (0.25 mm2 ... 2.5 mm2) so that preassembled cable harnesses can be used and the unit can be maintained guicker.
- 2. EN 292-compliant, front accessible adjustment which is also protected from tampering by a cover.
- 3. Snap-on item designations.
- 4. Air vents in the housing for applications under even higher operating temperatures.







Figure 11

SELECTED RELAYS WITH SPECIAL FUNCTIONALITIES

Input Extension Modules

Additional visualization and diagnostic signals as well as time savings in the wiring of series connections in safety circuits: these are the main advantages of the input extension modules in the PROTECT-SRB range.

Up to 4 (2-channel) E-STOP control devices, safety switches / sensors and/or other protective devices with floating contacts can be connected the PROTECT IE and PROTECT PE modules (installed width 48 mm) by means of 1:1 wiring of the safety contacts. Up to 20 modules (80 sensors) can be cascaded together.

Multiple Evaluation

Up to six sensors can be directly connected to these safety relay modules. With the same advantages as the input extension modules, but restricted to 6, an additional terminal signals the state of every device connected for visualization and diagnostic purposes. The module type SRB 206ST/SQ is intended for NC contacts and the module type SRB 207AN and AES 2285 for NC/NO contact combinations.

Dual Zone Monitoring

The special circuitry feature of these models (SRB 202 and SRB 400) is to be found in the dual functionality. "Dual functionality" means that two protective devices can be parallel connected to one module and the safety enabling outputs shut down in a differentiated manner, depending on which protective device has requested a safety function. If, for example, an EMERGENCY STOP control device and a guard interlock unit have been connected on the sensor level, the EMERGENCY STOP control device will act on all safety enabling outputs and the interlocking device on only one part.

The module SRB 202 has a total of 2 safety enabling outputs (plus two signaling contacts) and the module SRB 400 a total of 4 safety enabling outputs. One or two enabling outputs can then be shut down separately, depending on module.



Figure 12

Differentiated shut-down shown here using the circuitry of the module SRB 202: If, for example, an EMERGENCY STOP control device and a guard interlock act on the sensor level, all safety enabling outputs are opened if a protective function of the EMERGENCY STOP control device is requested (entire range A and B) and the corresponding actors reliably brought to a standstill, but only that of part B if an interlocking function is requested.

For complete technical information, please visit www.usa.schmersal.net

Multifunctional

The claim of multifunctional is reflected in the module SRB 308IT and SRB 219IT and refers to different aspects and in particular to the following possibilities compared to other commercially available modules:

- Diagnosis and visualization Virtually every status in the safety circuit (8 in the SRB 308IT and 9 in the SRB 219IT) can be incorporated in the error management of a machine control system via the signaling outputs provided especially for this purpose.
- Potential versatility On the input level virtually all known types of sensors can be connected, i.e. in addition to EMERGENCY STOP control devices, safety switches, interlocking devices and other protective devices with floating contacts, safety sensors and opto-electronic protective devices (AOPD's) and also electromagnetic safety switches due to a current and voltage restriction.
- Circuitry All known selections, including the possibility of mandatory start-up testing, are optionally available.

Muting Modules

This special safety relay module serves to temporarily automatically bridge one (several) safety function(s) during the normal operation of a machine. This means that the module bridges the output signal of a protective device in order to travel within a secured hazard area, for example, with safety light barrier or safety light grids, with a driver-free automated transport system. The distinction as to whether a person approaches the hazard area or a transport system travels in the hazard area or leaves it is recognized by a detection sensor system in the form of commercially available proximity switches, light barriers or position switches.

While a muting function is already an integrated part of safety light grids today, not all areas of application can be covered by them. For example, it may be more favorable to realize muting functions with several individual safety light barriers. The module SRB 202MSL is available for tasks of this nature. The special features here are as follows:

- A lamp current monitoring of the muting indicator light with signaling output as well as
- A signaling output "simultaneity" of the connected muting sensors.







For complete technical information, please visit www.usa.schmersal.net

Two-Hand Control Monitors

The two-hand safety control monitors are intended for the connection of two actuators each equipped with an NC contact and an NO contact. Both actuators must be operated simultaneously in accordance with EN 574 type III C requirements within a time of ≤ 0.5 s. If the time is exceeded, both actuators must be released before a restart can be initiated.

Double reset with time monitoring

As a pre-switching device in safety-related parts of machine control systems, this module provides additional safety for operating staff required to perform work in machine areas in integrated production systems, for example. The circuitry has an additional precautionary measure to prevent an unintended restart of the machine control system while an operator could be in the area of the machine.

The function of the SRB 100DR ensures that it is first possible to restart the machine control system

- Once a restart button has been actuated by the operator which is located in the interior of the plant and, after he has left the accessible room and a separating protective device has been interlocked again,
- Then a reset button 2 has been actuated which is outside the accessible area of the machine.

An adjustable time window of 3 ... 30 seconds (via DIP switches) is provided to execute the so-called double reset, whereby the two buttons must be actuated exclusively in the order of 1 and 2. The time window is to be geared to the operational sequences.

The double reset must be repeated if the operator does not actuate button 1 at all or does not actuate button 2 within the time window, because the process of restarting the machine could not be performed quickly enough, for example.

Correct acceptance creates an enabling signal in the module SRB 100DR which is then further processed as a start signal by a commercially available safety relay module.

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The button signals are processed by means of the additional safety-related feature of edge detection, i.e. the trailing edge is analyzed after resetting device so that errors from a welded contact or manipulations cannot bring about a hazardous state.





Sensor-less Standstill Monitor

Safety-related standstill monitors of the type AZR31S1 and SSW 301HV form a constituent element of the safety-related parts of machine control systems and technologically belong to the group of relay-based safety circuits.

The special advantage is the recognition of standstill without an additional sensor by connecting the devices directly to a three-phase alternating current motor. Monitoring makes use of the principle of operation of 1 or 3-phase current motors by recording and analyzing a frequency which is proportionate to speed depending on the phase which is generated as voltage as the machine slows down (i.e. after the mains voltage has been switched off). A switching signal is generated once a limit value <30 mV is reached and there are no zero sequences of the alternating current thereafter at certain temporal monitoring intervals. The modules do not need to be individually set due to this additional frequency analysis.

Other features in brief:

• Suitable for the connection of three-phase current motors with the following interfaces:

AZR31S1

- Motor voltage range 0 ... 400 V
- For frequency inverters
- Speed frequency 0 ... 1,000 Hz
- Switching frequency of the end stages \leq 16 kHz

SSW 301HV

- Motor voltage range 0 ... 690 V
- For frequency inverters
- Speed frequency 0 ... 1,000 Hz
- Switching frequency of the end stages ≤16 kHz
- 3 safety enabling outputs STOP 0
- 1 signaling contact (NC contact)
- No setpoint adjustment necessary
- Wire break monitoring of the measuring inputs
- Self-test with error memory
- Cyclical self-monitoring
- 5 LEDs to display the operating states
- \bullet SIL3 to IEC 62061 and PLe to ISO 13849-1



Safe Speed Monitoring

With the modular system DNDS, there are new possibilities for a user to monitor any drive systems.

This system enables the machine builder monitoring the speed of, for instance, spindle or axle drives in a safe manner. The system monitors the signals from rotary and linear movements and can be individually programmed.

- Mentoring with encoders, resolvers or proximity sensors
- Up to four individual modes can be monitored
- SIL3 to IEC 62061 and PLe to ISO 13849-1



For complete technical information, please visit www.usa.schmersal.net

SAFETY CONTROLLER SELECTION CRITERIA

It helps the selection process to view a safety controller as having four basic characteristics, each determined by the application requirements. This approach can be applied to any safety controller.





Supply Voltage Requirements

Select your supply voltage. While many voltages are possible (24VDC, 24VAC, 24VAC/DC, 115VAC and 230VAC), 24 VDC gives the most flexibility since virtually all controllers are available in this voltage. Also, since a transformer and rectifier are not required, this unit generally is less expensive and smaller than a 115VAC model.

Regardless of supply voltage, it is always converted by the controller electronics to 24VDC for internal operation and for powering monitored input devices. Hence monitored devices only need to be rated for 24VDC.

Input Monitoring Requirements

The first step is to determine whether you need single channel (up to control category 2 designs used for safety functions up to PLd) or dual channel (control category 3 & 4 designs used for safety functions of PL_d and PL_e) operation.

Single-channel systems must monitor one NC positivebreak contact. Dual-channel systems can monitor 1NO/1NC or 2NC contacts. Generally, these need to be isolated drv contacts since most controllers will view C-form contacts as a short circuit. Remember that 24VDC is supplied by the safety controller for monitoring these contacts.

Safety controllers are available for monitoring nonpotential free contacts (such as PNP outputs from light curtains). Models are also available that allow users to field select the monitored contact configuration.

Another consideration is crossed wire detection (a short between channels). This requires special circuitry in the safety controllers and is required for category 4 designs.

Feedback & Reset Circuit Requirements



monitor control relays and motor contactors with positive-guide contacts. Such feedback is required for safety control category 3 & 4 designs. A NC auxiliary contact is wired into the feedback loop (with or without a reset (start) button) to detect welded contacts in these external control devices. The safety controller detects the existence of a weld when the relay shuts down due to a power loss or open machine guard and prevents a restart.

In order to reset the controller, the feedback loop must be closed (at least temporarily). If the NC auxiliary contact stays open due to a contact weld, the controller cannot be reset.

Reset can be automatic or be manual. With automatic reset the controller will automatically reset (outputs close) when the machine guard is closed. A reset or start button can be added to the feedback loop if desired. The controller only needs to momentarily see a 24VDC signal at the feedback terminals to reset.

With a manual monitored/trailing edge reset, some type of manual pushbutton is required. The feedback loop circuitry is designed so that it needs to see a 24V to 0V transition (trailing edge) in order to reset. This method of reset is generally required when a person can actually get inside a machine guard (where they would be at risk if the equipment should automatically restart when the guard closes).

Output Requirements

Determine the number and type of safety controller outputs required for machine control elements and signaling.

Following are the types of safety controller outputs:

- A. NO safety enable circuits instant or timed.
- B. NO or NC auxiliary relay contacts not to be used for safety functions, but only for annunciation

Safety controllers with feedback capability can also C. Semiconductor outputs for annunciation. Courtesy of Steven Engineering, Inc. - (800) 258-9200 - sales@steveneng.com - www.stevenengineering.com

	INPUT			OUTPUT		
Input Contacts	No. of Independent Dual Channel Devices	Operating Voltage	Output Type	Safety Outputs Instant (Delayed)	Auxiliary Output Dry Contact (Semiconductor)	Model Code
		041/DC	Instant	1 (0)	0 (2)	AES 1135
		24000	Instant	2 (0)	0 (0)	AES 1235
						SRB 301 MC
						SRB 301 MA
			Instant	3 (0)	1 (0)	SRB 301 ST
			instant			SRB 301 LC(I)
		24VAC/DC				SRB 301 LC/B
	1			5 (0)	1 (3)	SRB 504 ST
				2 (1)	0 (1)	SRB 211 ST
2NC			Delayed	3 (2)	1 (3)	SRB 324 ST
				0 (3)	1 (0)	SRB 031 MC
		24-230VAC/DC	Instant	1 (0)	0 (2)	AES 2135
			motant	3 (0)	0 (2)	AES 2335
		48.000///0	Instant	2 (0)	1 (0)	SRB 301 ST-230
		40-230 VAC	Instant	3 (0)	1 (0)	SRB 301 SQ
			Instant	2 (0)	0 (6)	SRB 206 ST
	6	24VAC/DC	Instant	2 (0)	0 (8)	SRB 206 SQ
	0	48-230VAC	Instant	2 (0)	0 (6)	SRB 206 ST-230
			Instant	2 (0)	0 (0)	SRB 206 SQ-230
				1 (0)	0 (2)	AES 1135
		24VDC	Instant	2 (0)	0 (0)	AES 1235
				3 (0)	0 (1)	AES 1337
	1	24\/AC/DC	Instant	3 (0)	1 (0)	SRB 301 AN
		24VAC/DC	Delayed	2 (1)	0 (1)	SRB 211 AN
1NO/1NC		24-230\/AC/DC	Instant	1 (0)	0 (2)	AES 2135
(Isolated)1		24-230 (AC/DC	motant	3 (0)	0 (2)	AES 2335
	2	241/00	Instant	1 (0)	0 (0)	AES 1165
	۲	24000	motant	2 (0)	0 (2)	AES 1265
		241/00	Instant	2 (0)	1 (6)	SRB 207 AN-24VDC
	6	24000	motant	2 (0)	1 (0)	AES 2285
		48-230VAC	Instant	2 (0)	1 (6)	SRB 207 AN-230
	1	24VAC/DC	Instant	1 (0)	0 (0)	AES 1102-24VAC(DC)
1NO/1NC	1	110VAC	Instant	1 (0)	0 (0)	AES 1102.1
(C-Form) ²	2	24VAC/DC	Instant	1 (0)	0 (0)	AES 1112-24VAC(DC)
	۷	110VAC	Instant	1 (0)	0 (0)	AES 1112.1
1NC	1	24VAC/DC	Instant	4 (0)	1 (0)	SRB 401 LC

¹ Isolated Contacts: Galvanically separated contacts

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 $^{\rm 2}\mbox{C-Form}$ Contacts: Contacts having a common contact between them

For complete technical information, please visit www.usa.schmersal.net

	Control								
Model Code	Category (Performance Level)	E-Stop Monitoring	Safety Switch⁴	Coded Magnetic Sensor	AOPD⁵	Pulse Echo Compatible	Method of Reset ⁶	Cross Short Monitoring	
AES 1135	3 (d)	\checkmark	\checkmark	\checkmark	—	\checkmark	Automatic	—	
AES 1235	3 (d)	\checkmark	\checkmark	\checkmark	-	\checkmark	Leading Edge	_	
SRB 301 MC	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Leading Edge	Dipswitch Selectable	
SRB 301 MA	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Trailing Edge	Dipswitch Selectable	
SRB 301 ST	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Trailing Edge	Dipswitch Selectable	
SRB 301 LC(I)	4 (e)	\checkmark	\checkmark		—	—	Leading Edge	Hardwire Selectable	
SRB 301 LC/B	3 (d)/4 (e) ³	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Leading Edge	—	
SRB 504 ST	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	—	Trailing Edge	Hardwire Selectable	
SRB 211 ST	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Trailing Edge	Dipswitch Selectable	
SRB 324 ST	4 (e)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Trailing Edge	Hardwire Selectable	
SRB 031 MC	3 (d)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	Leading Edge	Dipswitch Selectable	
AES 2135	3 (d)	\checkmark	\checkmark	\checkmark	—	_	Automatic	—	
AES 2335	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Leading Edge	—	
SRB 301 ST-230	4 (e)	\checkmark	\checkmark	—	—	—	Trailing Edge	—	
SRB 301 SQ	4 (e)	\checkmark	\checkmark		—	_	Trailing Edge		
SRB 206 ST	3 (d)	\checkmark	\checkmark		—	—	Trailing Edge	—	
SRB 206 SQ	3 (d)	\checkmark	\checkmark	—	—	—	Trailing Edge	\checkmark	
SRB 206 ST-230	3 (d)	\checkmark	\checkmark		—	_	Trailing Edge	—	
SRB 206 SQ-230	3 (d)	\checkmark	\checkmark	—	—	—	Trailing Edge	\checkmark	
AES 1135	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Automatic	\checkmark	
AES 1235	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Leading Edge	\checkmark	
AES 1337	4 (e)	\checkmark	\checkmark	\checkmark	—	_	Trailing Edge	\checkmark	
SRB 301 AN	4 (e)	—	\checkmark	\checkmark	—	—	Trailing Edge	\checkmark	
SRB 211 AN	4 (e)	\checkmark	\checkmark	\checkmark	—	_	Leading Edge	Dipswitch Selectable	
AES 2135	3 (d)	\checkmark	\checkmark	\checkmark	—	_	Automatic		
AES 2335	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Leading Edge	\checkmark	
AES 1165	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Automatic	—	
AES 1265	3 (d)	\checkmark	\checkmark	\checkmark	—	_	Leading Edge	\checkmark	
SRB 207 AN-24VDC	3 (d)	\checkmark	\checkmark	\checkmark	—	_	Trailing Edge		
AES 2285	3 (d)	\checkmark	\checkmark	\checkmark	—	—	Trailing Edge	\checkmark	
SRB 207 AN-230	3 (d)	\checkmark	\checkmark	\checkmark	—	_	Trailing Edge		
AES 1102-24VAC(DC)	1 (c)		\checkmark	\checkmark	—	_	Automatic	_	
AES 1102.1	1 (c)		\checkmark	\checkmark	_	_	Automatic		
AES 1112-24VAC(DC)	1 (c)	—	\checkmark	\checkmark	—	—	Automatic	—	
AES 1112.1	1 (c)	_				_	Automatic	_	
SRB 401 LC	3 (d)	\checkmark	\checkmark	—	—	—	Leading Edge	—	

³SRB 301LC/B: Performance Level e (Control Category 4) when used with a PL_e device which features self-monitoring

⁴ Devices having dry contacts, e.g., keyed interlock switches with and without guard locking, limit switches, cable pulls, hinge switches, foot switches, etc.

⁵ AOPD: Active Optical Protective Device, e.g. safety light curtain

⁶ Automatic: Safety outputs close as when inputs are satisfied

Leading Edge: Safety outputs close when inputs are satisfied and reset circuit is closed

Trailing Edge: Safety outputs close when inputs are satisfied and reset circuit is closed and reopened

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Input Expansion Modules

A majority of standard safety controllers used in the industry today will monitor 1 discrete device with 2 channels. Depending on the safety level to be obtained, wiring multiple switches in series to one safety controller can be a solution to scenarios such as an expanding application. This form of "daisy-chaining" however will not allow for individual diagnostics for low level safety device (i.e., limit switches) and can increase installation time and costs. Input expanders allow multiple devices to be wired to one safety controller while still having the ability of individual diagnostics. Multiple PROTECT input expanders can be used to wire a maximum of 80 dual channel devices.

	No. of 2 Channel Devices Monitored	Type of Monitored Input	Output Configu- ration	Input Configu- ration	Terminal Connec- tion	Model Code	E-Stop Monitoring	Safety Switch ¹	Coded Magnetic Sensor	AOPD ²	Pulse Echo Compat- ible	Module Indicator ³ (PNP Out)
					Cage	PROTECT-IE-11	\checkmark	\checkmark	V	—	—	—
				100/100	Clamps	PROTECT-PE-11	\checkmark	\checkmark	\checkmark	—	—	V
			2NC	ino/ino	Screw	PROTECT-IE-11-SK	\checkmark	\checkmark	√	—	—	
	4	Dry Contacts	5		Terminals	PROTECT-PE-11-SK	\checkmark	\checkmark	\checkmark	—	—	\checkmark
Input				2NC	Cage Clamps	PROTECT-IE-02	\checkmark	\checkmark	\checkmark	—	—	—
Expander	7				Screw Terminals	PROTECT-IE-02-SK	\checkmark	\checkmark	\checkmark	—	—	—
					Cage Clamps	PROTECT-PE-11-AN	\checkmark	\checkmark	\checkmark	_	—	\checkmark
			TNO/TNC	ino/ino	Screw Terminals	PROTECT-PE-11-AN-SK	\checkmark	\checkmark	\checkmark	—	—	\checkmark
		Dry/Non- Floating	/Non- pating 2NC	2NC 2NC	Cage Clamps	PROTECT-PE-02	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
					Screw Terminals	PROTECT-PE-02-SK	V	\checkmark	V		V	V

¹ Devices having dry contacts, e.g., keyed interlock switches with and without guard locking, limit switches, cable pulls, hinge switches, foot switches, etc.

² AOPD: Active Optical Protective Device, e.g. safety light curtain

³Module Indication: +24VDC PNP auxiliary signal indicating that all inputs are satisfied on the expansion unit.



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Output Expansion Modules

Output expanders allow a safety controller to increase the number of safe signals that can be delivered. Each SRB-EM module will provide an additional 4 dry contact safety outputs, 2 dry contact auxiliary contacts and a connection to the main monitoring safety controller to complete an external feedback monitoring loop for the safety function.

	Additional Safety Outputs	Additional Auxiliary Outputs	Terminal Connection	Operating Voltage	Model
	4	0		24VAC/DC SRB 402 EM	SRB 402 EM
Output Expanders	4	2	Screw Terminals	115VAC	SRB 401 EM

Dual Zone Monitoring

The SRB 202C and SRB 400C safety controllers allow for dual zone monitoring without adding the complexity of using a safety PLC. No software or programming tool is required for zone setup. Input 1 is reserved for a global shutdown (the release of all safety outputs) such as an E-Stop actuation. Input 2 is reserved for dropping out only half of the safety outputs of the relay. (More information can be found on Page 9.)

Safety Outputs	Auxiliary Outputs	Input 1 Contacts	Input 2 Contacts	Input 1 Reset	Input 1 Cross Short Monitoring ¹	Model Code	Control Category (Performance Level)	E-Stop Monitoring	Safety Switch ²	Coded Magnetic Sensor	AOPD ³	Pulse Echo Compatible
					No	SRB202CA	4 (e)	\checkmark	\checkmark	V	_	—
			1NO/1NC	Auto or Manual	Yes	SRB202CA/Q	4 (e)	\checkmark	\checkmark	\checkmark	—	—
2	2	2NC		Trailing Edge	No	SRB202CA/T	4 (e)	\checkmark	\checkmark	V	—	_
L	2	2NC			Yes	SRB202CA/QT	4 (e)	\checkmark	\checkmark	V	—	—
			2NC	Auto or Manual	No	SRB202CS	4 (e)	\checkmark	\checkmark	V	—	—
				Trailing Edge		SRB202CS/T	4 (e)	\checkmark	\checkmark	\checkmark	—	_
				Auto or Manual	No	SRB400CA	4 (e)	\checkmark	\checkmark	V	_	—
					Yes	SRB400CA/Q	4 (e)	\checkmark	\checkmark	\checkmark	—	_
4	0	2NC	1NO/1NC	Trailing False	No	SRB400CA/T	4 (e)	\checkmark	\checkmark	\checkmark	_	_
4	0	2110		Trailing Edge	Yes	SRB400CA/QT	4 (e)	\checkmark	\checkmark	\checkmark	—	_
			010	Auto or Manual		SRB400CS	4 (e)	\checkmark	\checkmark	\checkmark	_	_
			2100	Trailing Edge	INO	SRB400CS/T	4 (e)	\checkmark	\checkmark	1	—	—

¹Cross short monitoring and trailing edge not available for Input device 2.

² Devices having dry contacts, e.g., keyed interlock switches with and without guard locking, limit switches, cable pulls, hinge switches, foot switches, etc.

³ AOPD: Active Optical Protective Device, e.g. safety light curtain

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Safe Speed Monitoring

Monitored Speeds	Monitored Method	Operating Voltage	Model Code	Control Category (Performance Level)	Safety Outputs
		24VDC	AZS 2305-24VDC	4 (d)	3
	Timer	110VAC	AZS 2305-110VAC	4 (d)	3
		230VAC	AZS 2305-230VAC	4 (d)	3
		24VDC	FWS 1206	3 (d)	2
	1 PNP Impulse Sensor		FWS 2106	3 (d)	1
	Concor	24-230VAC/DC	FWS 2506	3 (d)	4
	2 PNP Impulse Sensors		FWS 1205	3 (d)	2
Standstill		24000	DNDS	4 (e)	Selectable
			FWS 2105	3 (d)	1
		24-230VAC/DC	FWS 2505	3 (d)	4
		24VDC(VAC)	AZR 31 S1-24VDC(AC)	4 (e)	3
	400VAC Back EMF	110VAC	AZR 31 S1-110VAC	4 (e)	3
		230VAC	AZR 31 S1-230VAC	4 (e)	3
	600VAC Book EME	115VAC	SSW 301 HV-115VAC	4 (e)	3
	090VAC BACK EIVIF	230VAC	SSW 301 HV-230VAC	4 (e)	3
Safe Speeds	Safe Speeds Encoders/Resolver 2 PNP Impulse Sensors		DNDS	4 (e)	Selectable

Mats/2-Hand Controls

Operating Voltage	Type of Reset	Model	E-Stop	Safety Switch1	Safety Mat ²	Two-Hand Control
	Monitored Rest	SRB 301HC/R-24	\checkmark	\checkmark	\checkmark	\checkmark
24VAC/DC		SRB 301HC/T-24	\checkmark	√		—
	Auto Rest	SRB 201 ZH	—	—	—	
48-230VAC	Monitored Rest	SRB 301HC/R-230		\checkmark		
	Auto Rest	SRB 301HC/T-230	\checkmark	\checkmark	\checkmark	

¹ Devices having dry contacts, e.g., keyed interlock switches with and without guard locking, limit switches, cable pulls, hinge switches, foot switches, etc.

²Safety mats operating with an electrical cross-short principle to detect actuation.

Safety Edges Monitors

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Operating Voltage	Maximum Number of Edges Monitored	Model	Control Category (Performance Level)	Method of Reset
24\/DC	1	SE-400C	4 (e)	Trailing Edge
24000	2	SE-100C	1 (c)	Method of Reset Trailing Edge — Trailing Edge
24VAC/DC	4	SE-304C	3 (d)	Trailing Edge

For complete technical information, please visit www.usa.schmersal.net

Safety Relay Modules with Intrinsically Safe Monitoring Circuits Ex i

PROTECT SRB-Exi

- ATEX certified
- For emergency stop and guard monitoring

The new generation of safety relay modules SRB EXi combines the approved safety technique with the demands of the explosion protection.

The SRB EXi modules are developed on the basics of the ATEX directive 94/9/EG and the European standards EN 60 079 et seq. The intrinsically safe monitoring guards Ex i are designed for equipment of the category 2GD. Therewith emergency stop devices and safety door monitorings may be used in gas- and dust-explosive atmosphere.

Explosion protection — ATEX

- ATEX category (2)GD for connection of devices from zones 1 or 21
- ATEX category 3G allows installation of SRB EXi's in gas-zone 2

Dimension of intrinsic safety circuits Ex i [Ex i]



	0.5 mm ²	72 ohm/km	
Resistance (bidirectional)	0.75 mm ²	48 ohm/km	
	1.5 mm²	24 ohm/km	
Capacity*		180–200 nF/km	
Inductivity*		0.8–1 mH/km	

*Approximate values

Safety-related function SRB 101EXi-1R

- 1 safety enabling output Stop 0
- 1 auxiliary contact
- Cross-short detection (optional)
- Monitored reset function

SRB 101EXi-1A

- 1 safety enabling output Stop 0
- 1 auxiliary contact
- Cross-short detection (optional)
- Automatic and manual reset function

SRB 200EXi-1R

- 2 safety enabling outputs Stop 0
- Cross-short detection (optional)
- Monitored reset function

SRB 200EXi-1A

- 2 safety enabling outputs Stop 0
- Cross-short detection (optional)
- Automatic and manual reset function



Ga	s		Du	Dust		
category ¹	Zone ²	Definition explosive atmosphere	Zone ²	category ¹		
1G	0	Continuous, long periods, frequent	20	1D		
2G	1	Occasional	21	2D		
3	2	Normally not, only for short periods	22	3D		

¹Manufacturer: 94/9/EG = ATEX directive

²User: 1999/92/EG = ATEX directive

For complete technical information, please visit www.usa.schmersal.net

3 SCHMERSAL

SCHMERSAL PROGRAMMABLE SAFETY CONTROLLER (PSC)

PROTECT-PSC

The programmable PROTECT-PSC modular safety control system is mainly used in modern production systems or on complex stand-alone machines.

PROTECT-PSC is suitable both for reliable analysis and interconnection of several safety-related signals, such as those from EMERGENCY-STOP command devices, guard door monitoring, safety multiple infrared beam barriers (AOPDs) or Schmersal CSS or MZM or AZM 200 series safety sensors.

The modular design of the PROTECT-PSC is a major advantage which makes it very versatile. As far as cost is concerned, the user can provide the optimum solution to each requirement without leaving too many inputs or outputs unused unnecessarily. The very high density of terminals also helps save space in the cabinet.

With PROTECT-PSC, it is possible to realize control category 4 applications according to EN 954-1, Performance Level "e" according to EN 13849-1 and SIL 3 according to EN IEC 61508.

A special feature of PROTECT-PSC is that it also offers the possibility of operational (non-safe) signal processing in addition to safe signal processing.

If programming is abandoned entirely, with PROTECT-PSC, a safe zone area-disconnection must be realized according to the order of the modules on the top-hat rail alone, like a system of safety control modules.

Connectable devices (sensor level)

- EMERGENCY STOP devices with floating contacts
- Safety switches with floating contacts, ditto locking devices (with and without interlock) and enabling switches etc.
- Safety magnetic switches, e.g. Schmersal BNS
- Safety devices with floating contacts, such as optoelectronic safety devices (AOPDs) etc.
- Schmersal series CSS safety sensors and Schmersal series non-contact interlocks AZM 2xx

The main features summarized:

- Modular design
- Integration of safe and operational signals
- Free programming according to IEC 61 131 via standard USB interface
- Or
 - Signal combination via external wiring without programming
 - Connection option for external gateway (Profibus, DeviceNet or CC-Link)
 - Response time 22 ms (semiconductor outputs) or 37 ms (relay outputs)
 - Visualization and status display on module or PC
 - Simple DIN top-hat rail mounting



Gateway

Diagnostic status via gateways to the following bus systems:

- Profibus DP
- DeviceNet
- CC-link
- Modbus RTU
- CANopen
- EtherCat
- Profinet IO
- EtherNet IP
- Modbus TCP

SYSTEM OVERVIEW OF PROTECT-PSC



The PSC power and PSC-CPU-MON modules with 8 safe inputs and 6 safe outputs form the basic configuration for PROTECT-PSC. (For description, see next page.) Expand safety with:

- Safe input modules PSC-S-IN-E and PSC-S-IN-LC
- Safe output modules
 PSC-S-IN-OUT and PSC Relay
 Safe input/output modules
- PSC-SUB-MON, PSC-STP-E, PSC-S-STP-LC and PSC-S-STP-ELC

Expand operationally

- (right, gray terminals) with:Operational input modules
 - PSC-NS-IN
- Operational output modules PSC-NS-OUT

CE	Number of si	ngle channe	l inputs		Number of single channel outputs			
Module	Standard Safe				Standard	Safe		
	signals with dry contacts	Dry	Non- floating	Selectable*	signals with dry contacts	Transistor Rel		Relay
					0.3 A**	0.5 A**	0.3 A**	4 A**
PSC-CPU-MON		4		4	_	6	—	—
PSC-SUB-MON	—	4	_	4	_	6	—	
PSC-S-STP-E	_	4		2	—	4	—	—
PSC-S-STP-LC	—	-	4	2	—	4	—	—
PSC-S-STP-ELC	—	2	2	2	—	4	—	—
PSC-S-Relay	_	—		_	—	—	—	2 × 2
PSC-S-IN-E	—	16	—	—	—	—	—	_
PSC-S-IN-LC	—	—	16	—	—	—	—	—
PSC-S-OUT	_	—		—	—	—	16	_
PSC-NS-IN	16	<u> </u>	—	—	—	_	<u> </u>	—
PSC-NS-OUT	_	_			16	_	_	_

* The dry or non-floating information refers to the technical properties of the input signals:

• Dry-contacts input signals, e.g. from emergency stop control devices, safety switches, interlocking devices, safety solenoid switches and similar.

• Non-floating input signals, e.g. PNP outputs from optoelectronic protective devices such as safety light curtains, laser scanners etc., but also from safety sensors from Schmersal CSS or AZM200 ranges.

• Selectable, input signals are monitored without cross short recognition. Outputs from optoelectronic protective devices can be directly connected, or dry contacts can be monitored up to a PL_d.

** Maximum current per output with resistive load.

For complete technical information, please visit www.usa.schmersal.net

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Schmersal Innovations



PROTECT-SELECT

To protect machinery and plants with different safety requirements, either a combination of safety-monitoring modules or a programmable safety controller was installed.

The Schmersal Group introduces PROTECT SELECT (or PROTECT SELECT WL with safe radio link), a component, which features the same level of performance as a safety controller and can be handled as smoothly as a safety-monitoring module.

- 12 standard safety program selectable through a password-protected selection menu
- Suitable for up to 9 safety functions
- Program selection through toggle switches

UNDERSTANDING SCHMERSAL SAFETY CONTROLLER SCHEMATICS



Contact arrangement is for the guards closed (e.g. key inserted into the interlock switch). All power line are shown in the de-energized condition.

KEY TO SYMBOLS USED IN THE CATALOG

Symbol	Description	Symbol	Description
Symbol C C C C C C C C C C C C C	Description Guard device closed Guard device open Machine Guard (Open-Close) Control Category 1 to EN 954-1 Control Category 3 to EN 954-1 Control Category 3 to EN 954-1 Control Category 4 to EN 954-1 Stop category 0 to IEC 60204-1 Stop category 1 to IEC 60204-1 Control Category 1 to IEC 60204-1 Contact Control Category 1 to IEC 60204-1 Contact Control Category 1 to IEC 60204-1 Contact Control Category 1 to IEC 60204-1 Contact Contact Contact Control Category 1 to IEC 60204-1 Contact Conta		Description Descriptint Descriptint Descriptint Descriptint Descripti
(H1)	After releasing interlock it is not		Reset Push button
(H2) (H7) (U) (SD) Ue	Feedback circuit improves safety . but does not increase Control Category Additional standstill signal required UL recognized CSA listed Integrated System Diagnostics Input Voltage		Annunciator Lamp

KEY TERMS

Authorized Output: an output from a safety controller's positive-guided relays (used to "authorize" or "enable" a machine's start circuit when safety system conditions exist). Also known as "safety output."

Automatic Reset: a safety controller reset circuit that automatically resets the safety controller when safe system conditions (no system faults) exist. A manual reset button is optional.

Auxiliary output: a non-safety related contact closure or semiconductor output primarily used for signaling component or system status to a PL_c, audible alarm or visual indicator (such as a stack light). Also called a "signaling contact" or "auxiliary monitoring contact".

ANSI (American National Standards Institute): an association of industry representatives who, working together, develop safety and other technical standards. Auxiliary monitoring contact: See "auxiliary output".

BG (Berufgenossenschaft): see "IFA (Institut für Arbeitsschutz)"

CE (Conformité Europeéne) mark: a symbol (CE) applied to finished products and machinery indicating it meets all applicable European Directives. For electrical and electronic "finished products", such as a safety relay module, these include the Low Voltage Directive and, where relevant, the Electromagnetic Compatibility (EMC) Directive.

Coded-Magnet Sensor: a two-piece position sensor consisting of an array of reed switches and a multiple magnet array-actuating element. Such devices will only deliver an output signal when the reed switch element is in the presence of a matched, multiple-magnetic field array. Coded-magnet sensors cannot be actuated using a simple magnet. Hence they are far more difficult to defeat/bypass than a simple magnetic switch or proximity sensor.

Control Reliability: A term applied to safety devices or systems which are designed constructed and installed such that the failure of a single component within the device or system does not prevent normal machine

stopping action from taking place...but does prevent a successive machine cycle from being initiated.

CSA (Canadian Standards Association): an independent Canadian testing and standards-making organization similar to Underwriters Laboratories (UL) in the U.S. "CSA-certified" products meet relevant CSA electrical and safety standards.

Declaration of Conformity: a manufacturer's selfcertified document, signed by a highly-positioned technical manager, which lists all the Standards and Directives to which a product conforms. A Declaration of Conformity is mandatory for all CEmarked products, and for machine components which, if they fail, could lead to a dangerous or hazardous situation on a machine.

Defined Area: a predetermined area scanned by a light beam within which the presence of an opaque object of specified minimum size will result in the generation of a control signal.

Direct-Action Contacts: See "positive-break" contacts.

Diverse Redundancy: the use of different components and/or different microprocessor instruction sets written by different programmers in the design and construction of redundant components/circuits. Its purpose is to increase system reliability by minimizing the possibility of commonmode failure (the failure of like components used in redundant circuits).

Dual-Channel Safety System: a safety control system characterized by two inputs; each connected to one of two independent safety circuits. Dualchannel systems are typically capable of detecting interconnection wiring faults such as open circuits, short-circuits and ground faults. As such they provide a higher level of safety than single-channel systems.

E-Stop (Emergency Stop): the stopping of a machine by actuation of an "emergency stop" switch (such as a safety interlock switch, emergency push button switch, rope-pull switch, foot switch, or other actuating device.

European Machinery Directive (EMD) 2006/42/EC:

a set of machine safety design requirements which must be satisfied to meet the Essential Health and Safety standards established by the European Economic Community. This Directive, and other relevant European Directives (such as the Low Voltage Directive, EMC Directive, et al) must be satisfied for the machine to bear the CE mark.

Fail-to-Danger: a component or system failure which allows a machine to continue operating, exposing personnel to a hazardous or unsafe condition.

Fail-to-Safe: "Fail-to-Safe" safety devices are designed such that a component failure causes the device/system to attain rest in a safe condition.

Fault Detection: the monitoring of selected safety system components whose failure would compromise the functioning of the safety system. The detection of such failures is known as "fault detection." Examples are:

- A short-circuit in the safety circuit's interconnection wiring
- An open-circuit in the safety circuit's interconnection wiring
- A welded contact in the safety controller's positive guided relays
- An open machine guard

Fault Exclusion: the ability to minimize known possible component failures ("faults") in a safety system by design criteria and/or component selection. Simple examples of "excluded faults" are:

- The use of an overrated contactor to preclude the possibility of contact welding.
- Design of a machine guard such that the safety interlock switch actuator cannot be damaged.
- Selection of a suitable safety interlock switch.
- Use of positive-break safety interlock switches together with a self-monitoring safety relay module, such that the possibility of a contact weld resulting in the loss of the safety function is eliminated.

The elimination of such faults are generally a compromise between the technical safety requirements and the theoretical probability of their occurrence. Design engineers are permitted to exclude such faults when constructing the machine's safety system. However, each "fault exclusion" must be identified, justified, and documented in the Technical File submitted to satisfy the European Machinery Directive.

Feedback Loop: an auxiliary input on a safety controller designed to monitor and detect a contact weld in the primary machine-controlled device (e.g. motor contactor, relay, et al) having positive-guided contacts.

Force-Guided Contacts: See "Positive-Guided Contacts".

Fixed Barrier Guard: See "Hard Guarding".

Guard: a barrier that prevents entry of an individual's hands or other body parts into a hazardous area.

Hard Guarding: the use of screens, fences, or other mechanical barriers to prevent access of personnel to hazardous areas of a machine. "Hard guards" generally allow the operator to view the point-ofoperation.

Hazardous Area: an area of a machine or process which presents a potential hazard to personnel.

IFA (Institut für Arbeitsschutz): Formally known as BG (Berufgenossenschaft), is an independent German insurance agency whose legislative arm recommends industry safety practices. One of many "notified bodies" authorized to certify that safety products comply with all relevant standards.

Interlock: an arrangement in which the operation of one device automatically brings about or prevents the operation of another device.

Interlocked Barrier Guard: a fixed or movable guard which, when opened, stops machine operation.

Machine Primary Control Element (MPCE): an electrically powered component which directly controls a machine's operation. MPCE's are the last control component to operate when a machine's motion is initiated or stopped. Machine Secondary Control Element (MSCE): a machine control element (other than an MPCE) capable of removing power from the hazardous area (s) of a machine.

Manual Start-Up Test: a term applied to safety controllers designed such that at least one of the system's interlocked machine guards must be manually-opened and closed (after applying power) before machine operation is authorized. All SCHMERSAL'S even numbered Series AES microprocessor-based safety controllers (e.g. AES 1136, AES 1146, AES 1156, AES 3366, et al) are designed to require a manual start-up test.

Manually-monitored Reset: a safety controller reset circuit requiring the presence of a discrete "trailingedge" signal (24V to 0V) to activate the controller's authorized outputs. A reset button is mandatory.

Muting: the ability to program a monitoring and/or control device to ignore selected system conditions.

OSHA (Occupational Safety Health Administration):

a U.S. Department of Labor Federal agency responsible for monitoring and regulating workplace safety. OSHA enforcement may reference their own regulations, as well as those of other industry standards-making groups (e.g. ANSI, NFPA, UL, et al).

Performance Level: outlined in EN ISO 13849-1, a required level of safety for SRP/CS. Designated PL_a through PL_e .

Point-of-Operation: the area(s) of a machine where material or the workpiece is positioned and a process is performed.

Positive-Break Contacts: normally-closed (NC) contacts which, upon actuation, are forced to open by a non-resilient mechanical drive mechanism. Also called "positive-opening" or "direct-action" contacts. Positive-Opening Contacts: See "Positive-Break Contacts".

Redundancy: the duplication of control circuits and/or components such that if one component/circuit should fail the other (redundant) component/circuit will ensure safe operation.

Risk Assessment: a systematic means of quantifying the relative level of danger for different types of machine hazards present to the machine operator and/or maintenance personnel. This assessment is usually done in the early stages of the machine's design to permit such hazards to be designed-out or alternatively determine the scope of the safety system needed to protect personnel from possible injury.

Safeguarding: protecting personnel from hazards using guards, barriers, safety devices and/or safe working procedures.

Safety Controller: an electronic and/or electromechanical device designed expressly for monitoring the integrity of a machine's safety system. Such controllers are designed using positiveguided (force-guided) relays. Depending upon the model, SCHMERSAL's safety controllers are capable of detecting the following types of potential safety system faults:

- Machine guard(s) open
- Guard monitoring switch/sensor failure
- Interconnection wiring "open circuit"
- Interconnection wiring "short circuit"
- Interconnection wiring "short-to-ground"
- Welded contact in controlled output device
- Failure of one of the safety controller's positive guided relays
- Fault in the safety controller's monitoring circuit
- Insufficient safety controller operating voltage

Upon detection of a system fault, the safety controller will initiate a "machine stop" command and/or prevent the restarting of the machine until the fault has been corrected. The "stop" command may be immediate or time-delayed depending upon the model safety controller selected.

Safety Enable: (See "Authorized Output.")

Safety Output: (See "Authorized Output.")

Safety Relay: an electromechanical relay designed with positive-guided contacts.

Self-Checking: the performing of periodic selfdiagnostics on the safety control circuit to ensure that critical individual components are functioning properly Self-Monitoring: see "Self-Checking"

Single-Channel Safety System: a safety control system characterized by one safety interlock switch whose normally-closed contact is the sole input to a safety controller or a motor contactor. Such systems are unable to detect a short circuit failure in the interconnection wiring and are only recommended for addressing Safety Categories B, 1 and 2 (see "Risk Assessment").

SRP/CS: Safety Related Parts of Control Systems— (sub)systems which perform a safety function

Stop Categories:

"0" Requires immediate removal of power from the controlled devices.

"1" Allows for a time delay for removal of power. This is commonly used with drive systems where immediate removal of power may result in a longer stop time.

Time-delayed Authorized Outputs: a safety

controller's authorized outputs whose activation is delayed (up to 30 seconds) to satisfy Stop Category 1 requirements.

Trailing-edge Reset: (See "Manually-monitored Reset.")

Two-Hand Control: a machine control system which requires "simultaneous" use of both of the operator's hands to initiate a machine cycle.

UL (Underwriters Laboratories): an independent testing and standards-making organization. UL tests products for compliance to relevant electrical and safety standards/requirements.

NOTES



Machine Guard Safety Systems Need Regular Check-Ups.



Protect Safety Controllers are just what the doctor ordered.

Regardless of the type of man-machine safety components or safety control system being used in any given application, a safety system needs to be monitored in order to meet safety standard requirements where the operator of the machine is exposed to a safety hazard.

Safety monitoring devices are used to continually monitor the integrity of the existing safety circuit for fault modes such as cross shorts, voltage variations, welded or damaged contacts. All of the faults mentioned can potentially compromise the safety system operation required to protect workers from injury.



Why risk life, limb and liability when there are affordable safety controllers with which to meet ANSI and OSHA "control reliability" requirements? Schmersal ProtectsM safety controllers ... the best preventive medicine when system faults occur.



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