

## APPLICATION NOTE

# Motor Starting & Protection solutions with functional safety for OEMs & Machine Builders

IEC & UL



Ensure the safety of equipment and personnel. Opt for our Motor Starting & Protection solutions enhanced with functional safety to help you meet all safety requirements in your machinery.

### Why you need Motor Starting & Protection solutions with functional safety

Ensuring the safety and efficiency of operations is of paramount importance in the realm of modern machinery. Original Equipment Manufacturers (OEMs) face the challenge of developing machines that not only deliver optimal performance but also comply with stringent safety regulations. Our Motor Starting & Protection bundles enhanced with functional safety play a crucial role in ensuring the safe and reliable operation of motors, in protecting personnel, equipment and maintaining business continuity, thereby guaranteeing the overall safety, performance and longevity of your machinery.



### Main benefits

#### Enhanced Personnel Safety

Enhance the protection of personnel and significantly reduce the risk of accidents by incorporating safety systems in your machines, such as emergency stop controls, interlocks and safety monitoring systems.



#### Reduced Equipment Damage and Downtime

Reduce equipment damage and downtime by early detection of faults and by rapidly isolating them to enable prompt fault diagnosis and repairs, thanks to remote monitoring.



#### Compliance with Safety Standards and Regulations

Maintain a safe working environment by implementing functional safety in motor starters and complying with safety standards EN ISO 13849-1, ANSI B11.26 and IEC / EN 62061.

## Introduction

Functional safety in machinery is a crucial issue when it comes to ensuring the safe operation of industrial equipment and machinery. It involves designing, implementing and maintaining safety measures to prevent or mitigate risks and hazards associated with the use of machinery in various industrial locations.

The goal of functional safety in machinery is to reduce the likelihood of accidents, injuries and damage caused by faulty machine operation or failures. This is especially important in industries where machines perform complex and potentially hazardous tasks, such as manufacturing, construction, mining and material handling.

By implementing functional safety in machinery, industries can significantly reduce the risk of accidents and injuries, protect personnel and assets, and comply with safety regulations. Investing in robust safety measures not only safeguards human lives but also contributes to increased productivity, reduced downtime and a positive reputation for responsible and safe business practices.



# Functional safety (SIL / PL) for motor starters

Machines and systems are equipped with safety devices to ensure user safety. In order to comply with the safety standards, these devices have specific safety-related parameters. Since Machinery Directive 2006/42/EC became applicable in 2009, machine builders have had to carefully design safety systems and demonstrate their conformity, preferably by using the following harmonized standards:

- **EN ISO 13849-1 Safety of machinery - Performance Level (PL):**

EN ISO 13849-1 defines how to determine the required Performance Level (PL) and how to verify the achieved PL of a safety function. PL specifically describes the ability of safety-related parts of a control system to perform a safety function under foreseeable conditions. There are five PL levels available: a, b, c, d and e, where PLe is the most reliable level and PLa the least. The safety function consists of a number of sub-elements. If, in the assessment, it is established that, for instance, SIL3 shall be used, every individual sub-element in the safety function must fulfil SIL3 requirements while the safety function must, in its entirety, also fulfil SIL3 requirements. The ANSI B11.26 standard refers to ISO 13849-1. It provides general principles for the design of safety control systems using ISO 13849-1, including the determination of the required performance level (PL) for safety functions. This standard is used to assess the general principles for the design of safety control systems. It's part of the ANSI B11 series of standards, which provide a framework to identify and address machinery safety hazards and implement machine guarding through task-based risk assessment.

- **IEC / EN 62061 Safety of machinery - Safety Integrity Level (SIL):**

IEC 62061 is an international standard for the functional safety of electrical, electronic, and programmable electronic control systems. This standard establishes how to determine the Safety Integrity Level (SIL), which represents the reliability of safety functions. There are four possible SIL levels: 1, 2 and 3: 'SIL 3' is the highest level of safety integrity and 'SIL 1' the lowest. IEC 62061 specifies the requirements for designing and implementing the safety-related control systems of machinery. This document is machine sector specific within the framework of IEC 61508. In the United States, electrical and electronic systems standards are mainly governed by the National Fire Protection Association (NFPA) and the Institute of Electrical and Electronics Engineers (IEEE). The relevant U.S. standards for functional safety include NFPA 79.

Most customers are used to Performance Level (PL) when it comes to machine safety applications since it has been the only technology-neutral standard for a long time.

On the other hand, SIL is popular among process safety customers, but is sometimes used for machine safety.

The standard a customer decides to use is a matter of preference and choice.

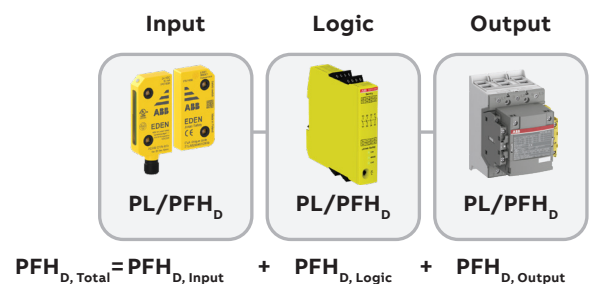
## How to configure the SIL/PL of a safety function

A safety function is a function which can result in an immediate increase in risk should it fail. To put it simply, it is a measure taken to reduce the likelihood of an unwanted event from occurring and exposing a hazard.

A safety function is not part of machine operation. If such a function fails, the machine can still operate normally, but the risk of injury due to such operation increases. To give a general outline, the following chapters provide a rough overview of a possible course of events.

A safety function is formed by three different elements: Input, logic and output. To obtain a certain safety level, all three must reach that level individually.

### Safety function (SF)



## Risk estimation

For the purpose of calculating the performance level required (PL<sub>r</sub>).

### S Severity of injury

S1 slight (normally reversible injury)

S2 serious (normally irreversible injury or death)

### F Frequency and/or exposure to hazard

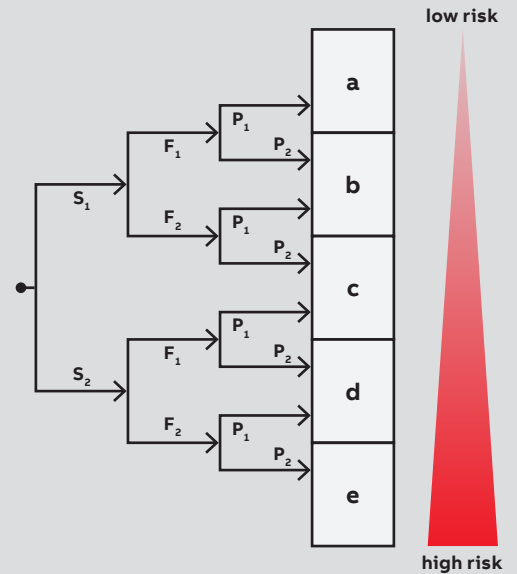
F1 seldom to less often and/or exposure time is short

F2 frequent to continuous and/or exposure time is long

### P Possibility of avoiding hazard or limiting harm

P1 possible under specific conditions

P2 scarcely possible



**S1** bruises, abrasions, puncture wounds and minor crushing injuries | **S2** skeletal injuries, amputations and death

**F1** less frequently than every two weeks | **F2** more often than every two weeks

**P1** slow machine movements, plenty of space, low power | **P2** quick machine movements, crowded, high power

Defining a safety function is a key issue, which always includes two components:

- Intended result (what the safety function performs to reduce the risk).
- Safety performance (SIL or PL – Safety Integrity Level and Performance Level respectively).

The general steps for implementing a functional safety system include (example based on PL level) those described below.

### 1. Definition of safety requirements on the basis of:

- a) Safety Integrity Level SIL (according to IEC / EN 62061), or
- b) Performance Level PL (according to EN ISO 13849-1).

### 2. Selection of system architecture to be used for the safety system:

- a) Determine category B, 1, 2, 3 or 4 as described in EN ISO 13849-1, or
- b) Decide on architecture A, B, C or D as described in IEC / EN 62061. Do this for the sub-systems

### 3. Construction of system using safety-related sub-systems – sensor/switch, input, logic, output and actuator either by:

- a) using certified sub-systems (recommended) or
- b) performing a SIL assessment and safety calculations for each sub-system, or PL assessment and safety calculations for each sub-system

**4. Safety system installation:** the system needs to be installed properly to avoid common failure possibilities due to improper wiring, environmental issues or other such factors. A safety function that does not perform correctly due to careless installation is of little use and may even pose a risk in itself.

### 5. Verification of system functionality:

the Lowest SIL or PL of the sub-system in the safety function will be the highest achievable

- a) SIL or
- b) PL for the safety function.

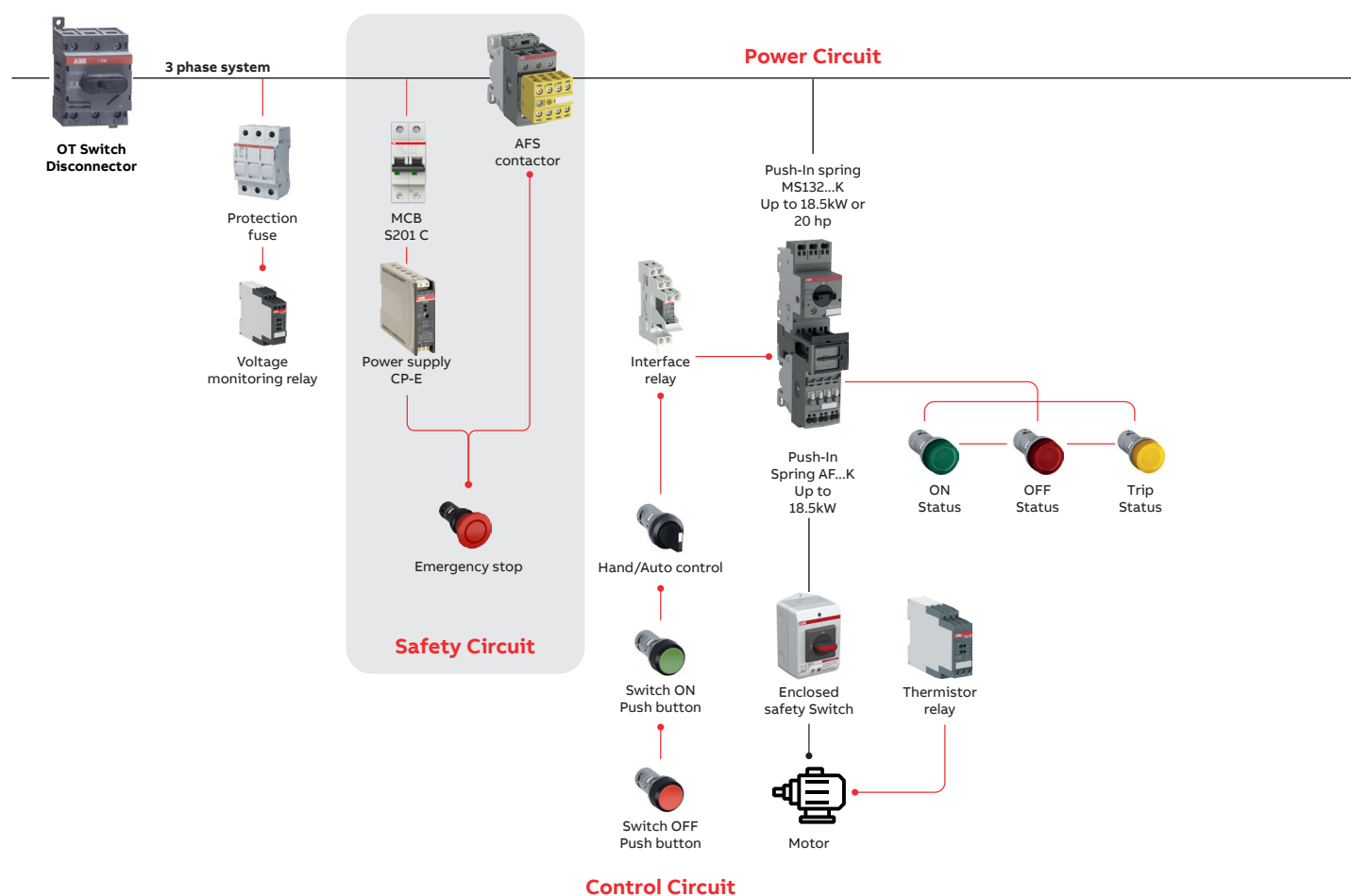


# Motor Starting & Protection solution with functional safety

We will now examine a few example scenarios that demonstrate the use of Safety Integrity Level (SIL) or Performance Level (PL) safety systems in general machinery applications. These cases involve a dedicated safety circuit and include an emergency stop function, along with a dedicated safety relay and safety contactor for ensuring safety.

The starting motor method remains the same in both examples. However, based on the safety devices incorporated, variations can be observed in the safety level ranging from low to high and even easy achievement of the maximum level.

## SIL 1 / PL-c with dedicated safety contactor



**Note:** Ensure that the motor is unable to start automatically once the emergency stop has been activated and released again.



# Bill of materials

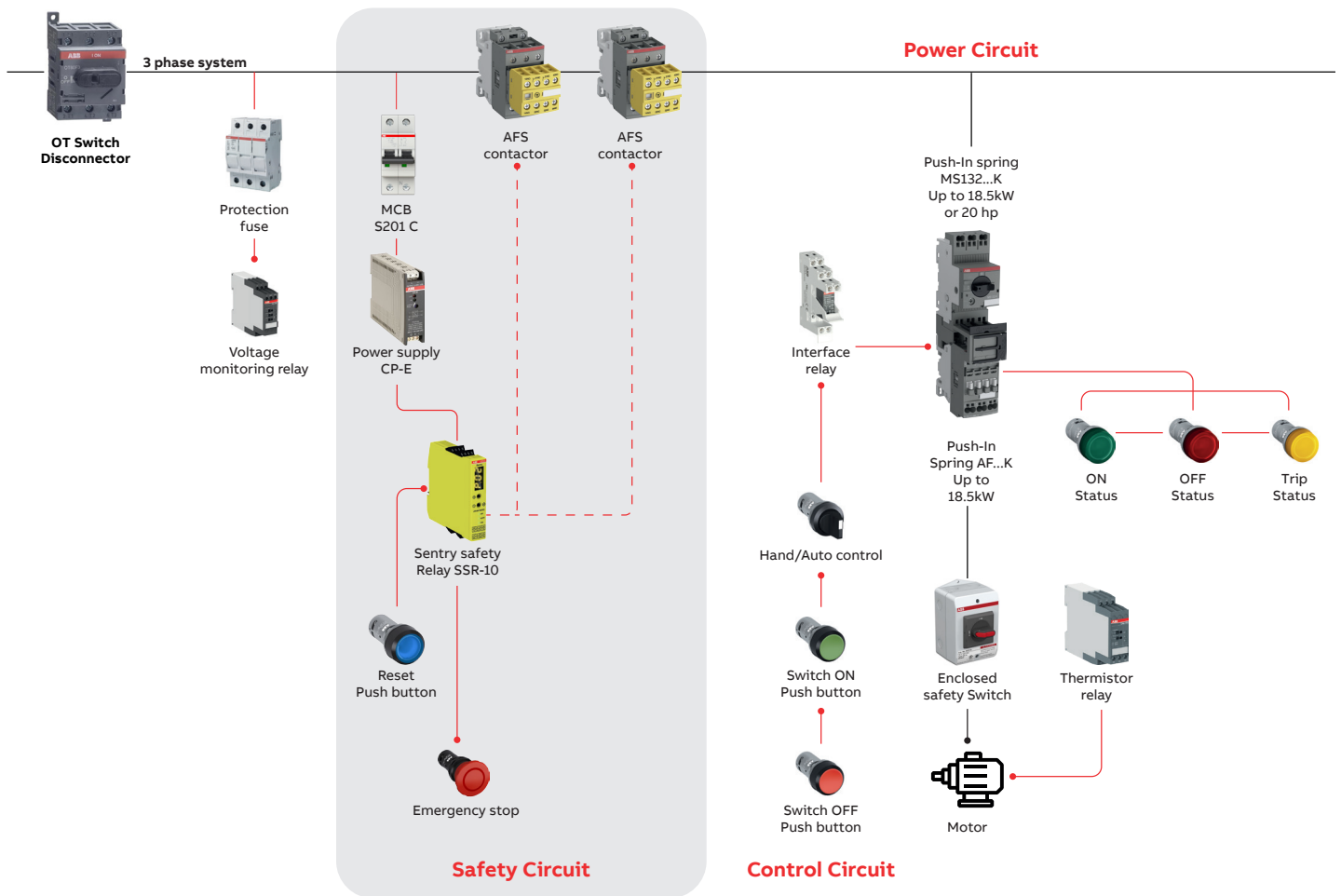
## SIL-1 / PL-c with dedicated safety contactor

List of parameters considered for development of the bill of materials		
	IEC Standard	UL Standard
System Design	Main Voltage 400V, 3 phase, 50 Hz	Main Voltage 480Y/277V AC (3-Ph), 50 Hz
Starter type	Direct-online starter with standard Screw version	Direct-online starter with standard Screw version
Co-ordination type	Type-2, 50kA	Construction Type F, 50kA
System Power	1.5 kW	2 hp

Product	Part Number	Description	Quantity
Power circuit products			
MMS	1SAM350000R1008	MS132-4.0 Manual Motor Starter current range 2.50-4.0A	1
MS116/132 SIGNAL/TRIP ALARM, 1NO/1NC	1SAM201903R1001	SK1-11	1
Connecting links	1SBN082306T1000	BEA26-4	1
Contactor	1SBL237001R1300	AF26-30-00-13 100-250V50/60HZ-DC Contactor	1
Side mounting accessories	1SBN010120R1011	CAL4-11	1
Front mounting accessories	1SBN010110R1010	CA4-10	1
3P, 16A enclosed Disconnect Switch	IEC 1SCA022400R9910	OTP16T3M	1
	UL 1SCA022792R2700	EOT16U3M1-S	1
Command and signalling products			
PILOT LIGHT for OFF status indication	1SFA619403R5231	CL2-523R	1
PILOT LIGHT for ON status indication	1SFA619403R5232	CL2-523G	1
PILOT LIGHT for Trip Indication	1SFA619403R5233	CL2-523Y	1
40MM TW-REL RED, 1 NC	1SFA619550R1041	CE4T-10R-01	1
SELECTR 2 POS. MAINT. BLACK 1NO	1SFA619200R1016	C2SS1-10B-10	1
COMPACT FLUSH PB MOM. RED, 1NC	1SFA619100R1041	CP1-10R-01	1
COMPACT FLUSH PB MOM. GREEN 1NO	1SFA619100R1012	CP1-10G-10	1
Interface relay 4 c/o	1SVR405601R3000	CR-P230AC2	1
Interface relay - socket	1SVR405650R1000	CR-PSS	1
Accessories for pilot devices (optional)	SK615550-44	Legend plate "Start", 22mm	1
Accessories for pilot devices (optional)	SK615552-31	Legend plate "Stop", 22mm	1
Accessories for pilot devices (optional)	SK615552-21	Legend plate "Off", 22mm	1
Accessories for pilot devices (optional)	SK615552-22	Legend plate "On", 22mm	1
Accessories for pilot devices (optional)	1SFA619930R1026	Legend plate, black on yellow aluminium, "Emergency stop"	1
Emergency stop safety function products (PL c / SIL1 )			
AFS contactor for 1.5 kW low consumption coil	1SBL136082R3022	AFS09Z-30-22-30 24VDC Contactor	1
Emergency stop button	1SFA619550R1051	EMERGENCY STOP CE4T-10R-02	1
Optional products			
Control MCB for primary & secondary side	2CDS252001R0024	S202-C2 Miniature Circuit Breaker - 2P - C - 2 A	2
Power supply for DC supply	1SVR320361R1000	CP-S.1 24/3.0 Power supply In:100-240VAC/100-250VDC Out:DC 24V/3A	1

**Note:** The above-mentioned products only fulfill the basic safety function and a detailed risk assessment must be done for other safety aspects of the machinery.

## SIL-3 / PL-e with dedicated safety relay and safety contactor



# Bill of materials

## SIL-3 / PL-e with dedicated safety relay and safety contactor

### List of parameters considered for development of the bill of materials

	IEC Standard	UL Standard
System Design	Main Voltage 400V, 3 phase, 50 Hz, control voltage -230V AC	Main Voltage 480Y/277V AC (3-Ph), 50 Hz
Starter type	Direct-online starter with Push-In spring version	Direct-online starter with Push-In spring version
Co-ordination type	Type-2, 50kA	Construction Type F, 50kA
System Power	1.5 kW	2 hp

Product	Part Number	Description	Quantity
Products for power circuit			
MMS	1SAM350010R1008	MS132-4.0K Manual Motor Starter current range 2.50-4.0A	1
MS116/132 SIGNAL/TRIP ALARM, 1NO/1NC	1SAM201903R1201	SK1-11K	1
Connecting links	1SBN082325T2000	BEA38-4KF	1
Contactor	1SBL237005R1300	AF26-30-00K-13 100-250V50/60HZ-DC Contactor	1
PI SIDE MNT AUX 1NO1NC AF09K-96K/NF	1SBN010134R1011	CAL4-11K	1
Front mounting accessories	1SBN010160R1010	CA4-10K	1
3P, 16A enclosed Disconnect Switch	IEC 1SCA022400R9910	OTP16T3M	1
	UL 1SCA022792R2700	EOT16U3M1-S	1
Products for command and signalling			
PILOT LIGHT CL2 RED 110-130V AC	1SFA619403R5131	CL2-513R	1
PILOT LIGHT CL2 GREEN 110-130V AC	1SFA619403R5132	CL2-513G	1
PILOT LIGHT CL2 YELLOW 110-130V AC	1SFA619403R5133	CL2-513Y	1
40MM TW-REL RED, 1 NC	1SFA619550R1041	CE4T-10R-01	1
SELECTR 2 POS. MAINT. BLACK 1NO	1SFA619200R1016	C2SS1-10B-10	1
COMPACT FLUSH PB MOM. RED, 1NC	1SFA619100R1041	CP1-10R-01	1
COMPACT FLUSH PB MOM. GREEN 1NO	1SFA619100R1012	CP1-10G-10	1
Interface relay 4 c/o	1SVR405601R2000	CR-P120AC2	1
Interface relay - socket	1SVR405650R1000	CR-PSS	1
Accessories for pilot devices	SK615550-44	Legend plate "Start", 22mm	1
Accessories for pilot devices	SK615552-31	Legend plate "Stop", 22mm	1
Accessories for pilot devices	SK615552-21	Legend plate "Off", 22mm	1
Accessories for pilot devices	SK615552-22	Legend plate "On", 22mm	1
Accessories for pilot devices	1SFA619930R1026	Legend plate, black on yellow aluminium, "Emergency stop"	1
Products for			
Sentry safety relay	2TLA010050R0000	Sentry SSR10 Safety relay	1
AFS contactor for 1.5 kW low consumption coil	1SBL136082R3022	AFS09Z-30-22-30 24VDC Contactor	2
Illuminated Reset push button	1SFA619100R1114	PUSHBUTTON CP1-11L-10	1
Emergency stop button	1SFA619550R1051	EMERGENCY STOP CE4T-10R-02	1
Optional products			
Control MCB for primary & secondary side	2CDS252001R0024	S202-C2 Miniature Circuit Breaker - 2P - C - 2 A	2
Power supply for DC supply	1SVR320361R1000	CP-S.1 24/3.0 Power supply In:100-240VAC/100-250VDC Out:DC 24V/3A	1

Note: The above-mentioned products only fulfill the basic safety function and a detailed risk assessment is to be done for other safety aspects of the machinery.

### APPLICATION FINDER

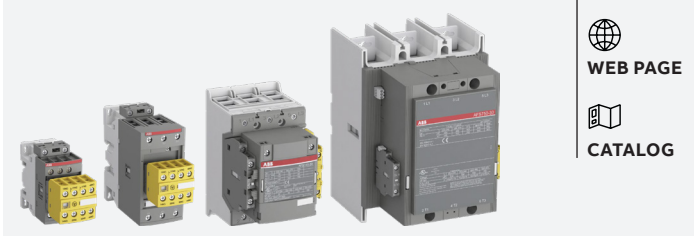
We've made it simpler for you to set up your project!  
Click here to find the reference architecture that best fits your needs and download the Bill of Materials.



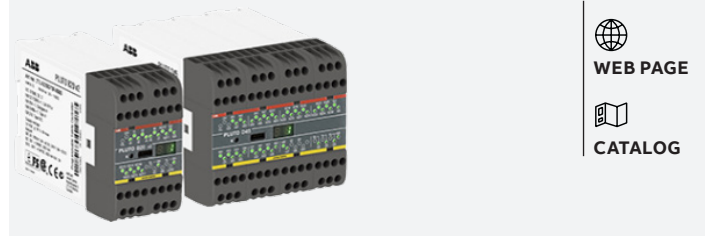


# Product offering

AFS Contactors:



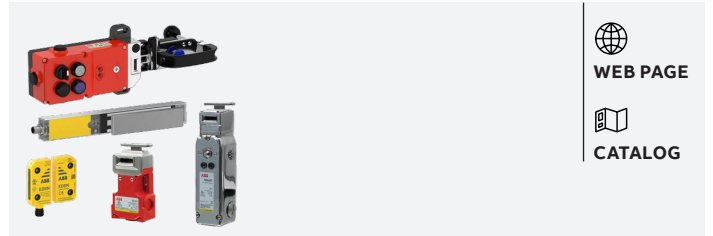
Pluto programmable safety controller:



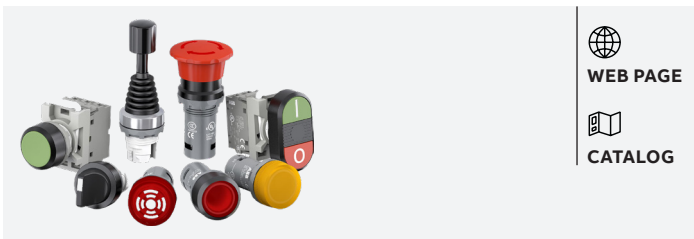
Emergency stops and pilot devices:



Safety sensors, switches and locks:



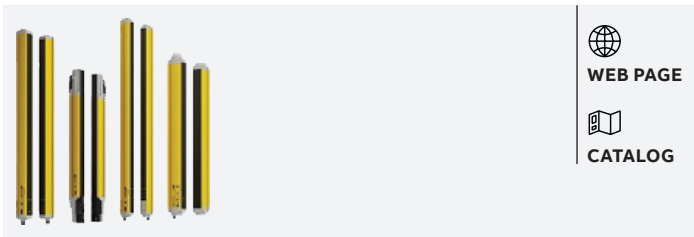
Pilot devices:



Safety relays:



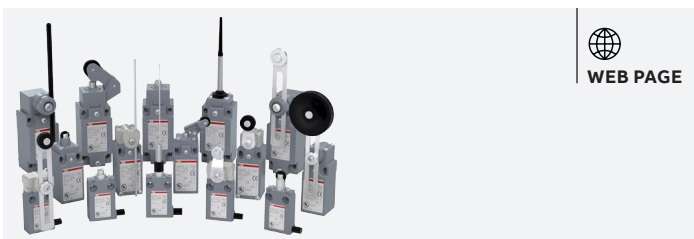
Optical safety devices:



Safety control switches:



Limit switches:



**Contactors:**



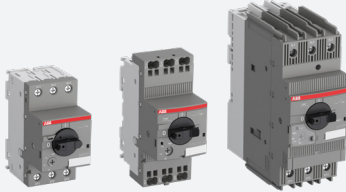



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**Manual motor starters:**



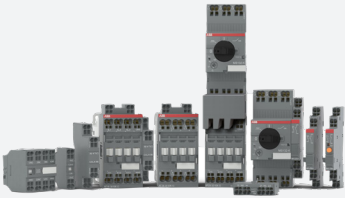



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**Push-In Spring Motor Starting solution:**





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**Softstarters:**







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**Electronic compact starter:**





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**Time relays:**







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**Three phase monitoring relays:**



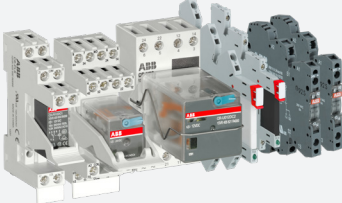



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**Pluggable Interface Relays:**





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**Primary switched mode power supplies:**







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**Temperature monitoring relay:**





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**Switch Fuse Units & Switch Disconnectors:**





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**Miniature circuit breakers (MCBs):**





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Tmax XT:




  
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Motor starting and protection solution




  
DOCUMENT

Application guide for OEM & Machine builders


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APPLICATION FINDER




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