

easySafety ES4P  
Safety Relay ESR5

# Safety Logic for Machines and Systems



Safety Technology  
Control the unexpected



**EATON**

Powering Business Worldwide



# Functional safety for persons, machines and the environment



**Safety Technology**  
Control the unexpected



Dangers for people, machine and the environment exist during the entire lifecycle of a machine – from manufacture through to disassembly. It is therefore essential to determine these risks during the construction phase of the machine and to introduce suitable risk reduction measures.

The Machinery Directive 2006/42/EC demands that there is no danger posed by machines. As 100 % safety is impossible to technically implement, the challenge is to reduce the risk to a tolerable level of remaining risk. The overall safety of a machine defines the state which is deemed to be free of unwarranted risks for persons or which is deemed to be danger free. The functional safety describes the fraction of the overall safety of a system that is dependent on the correct function of the safety-related systems and external devices in order to reduce the risks.

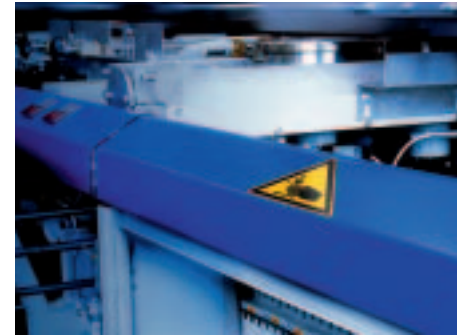
## Reducing the risks associated with a machine

The international standard EN ISO 12100 "Safety of machinery – General principles for design – Risk assessment and risk reduction" provides the constructor with detailed assistance in the identification of dangers and the risks to be examined, and contains design guidelines and methods for safe construction and reduction of risks.

It provides detailed requirements for risk assessment and risk reduction, which are to be implemented methodically in an

iterative process and which are to be comprehensibly documented.

The international standard EN ISO 12100 "Safety of machinery – General principles for design – Risk assessment and risk reduction" provides the constructor with detailed assistance in the identification of dangers and the risks to be examined, and contains design guidelines and methods for safe construction and reduction of risks.



### 1st step: A Avoidance of dangers

Risk elimination and reduction through constructive measures during the planning and development phase of the machine.

### 2nd step: A Protect against dangers

Reduction of the risks by the introduction of necessary protective measures

### 3rd step: A Indicate remaining sources of danger

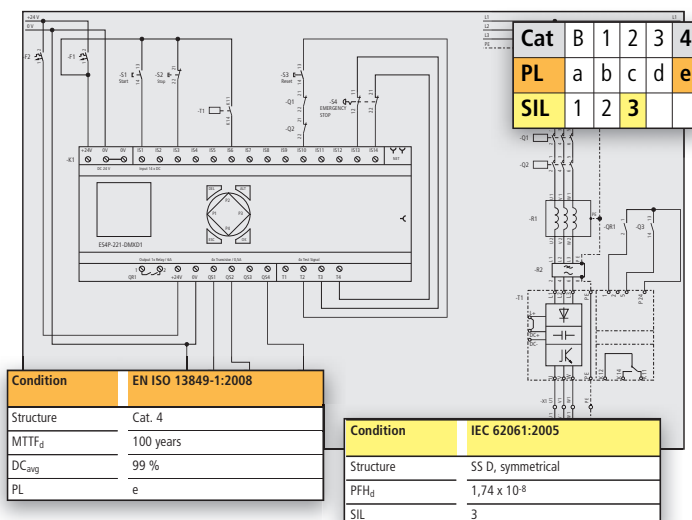
Risk reduction through information/warnings concerning the residual risks

## Safety manual for machines and systems compliant to EN ISO 13849-1 and IEC 62061

Eaton has created a "Safety Manual" on the topic of "Safety of machines and systems" for machine and panel builders, trainers and trainees as well as all who are interested in the issue of safety.

It provides a simple introduction to the extensive subject matter in the field of safety technology. The Eaton safety manual offers an overview of the most important relationships between directives, standards and regulations, which require consideration when employed in the safety equipment and devices used on machines.

The manual shows you how you can achieve functional safety with electrical, electronic and programmable components and systems in safety-relevant applications using circuitry examples.



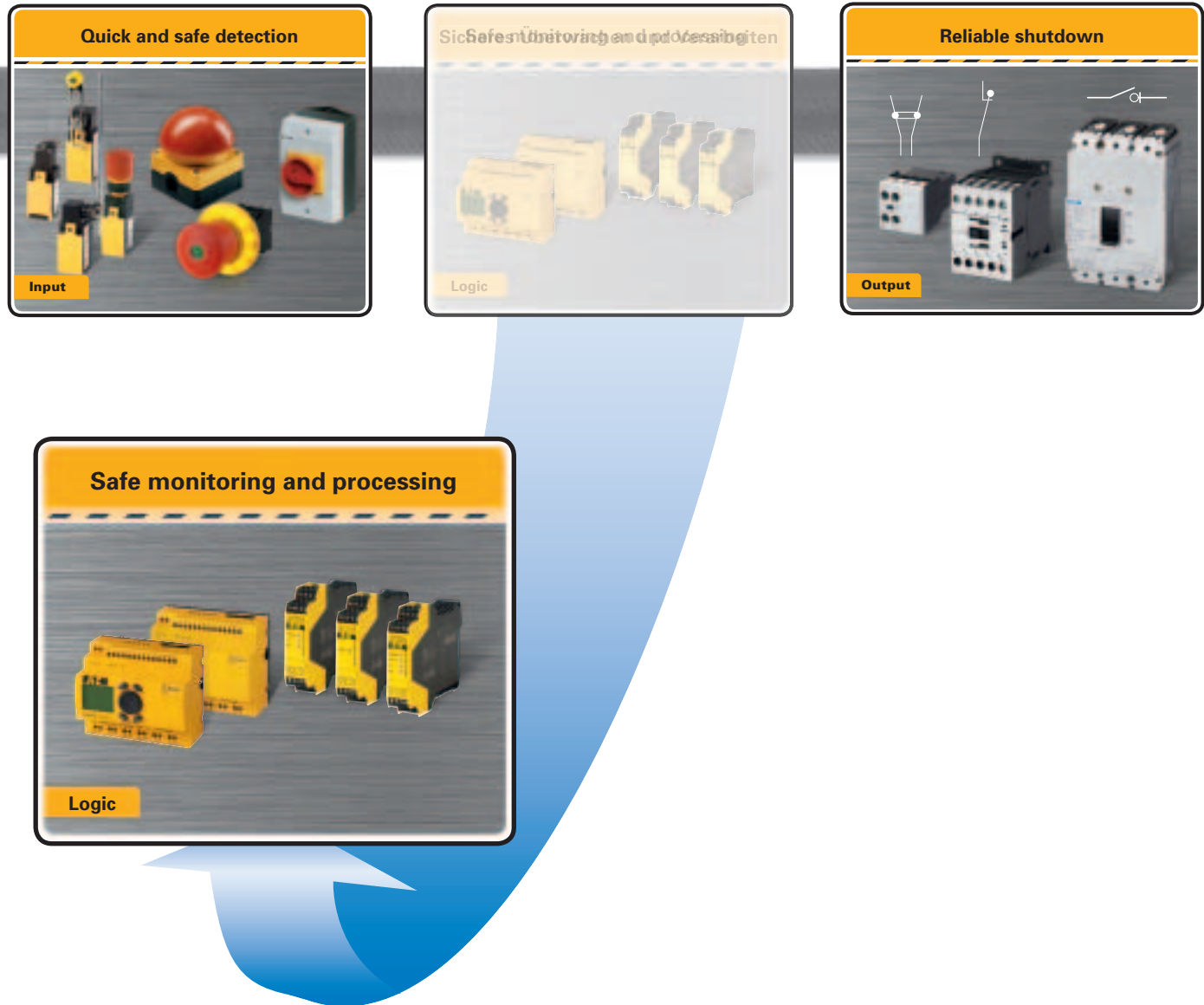
Furthermore, you will find a description of the function as well as a representative overview of a possible assessment for each circuitry example in the Safety Manual. The calculated characteristic values apply for the assumptions made in safety-related applications and the safety-oriented switchgear used.

Simply register online at [www.eaton.eu/shb](http://www.eaton.eu/shb) and work online with the safety manual or download the safety manual free-of-charge.

## Risk reduction by the use of safety-related parts of control systems

The components of machine controls that are responsible for safety tasks are referred to in international standards as "safety-related parts of control systems" (SRP/CS). Safety-related control parts each involve the entire functional chain of a safety function, consisting of the input level (sensors), the logic (safe signal processing) and the output level (actuator).

The general objective is to design these parts so that the safety of the control functions as well as the reaction of the control during a malfunction corresponds with the degree of risk reduction as determined in the risk analysis. The higher the level of risk reduction to be provided by the safety-related parts of control system, the higher the safety level of the technical safety performance level demanded of the control section.



## Logic units for safety functions

Safety-related control parts require the use of special components defined in the Machinery Directive 2006/42/EC as "safety components". The directive defines them as components,

- which serve to fulfil a safety function,
- the failure and/or malfunction of which endangers the safety of persons,
- which are independently placed on the market and
- for which normal components may be substituted in order for the machinery to function.

Furthermore, the Machinery Directive permits the use of logic units to ensure safety functions, which are established state of the art. As the central control unit, the safe logic not only assumes the detection and monitoring of sensor signals, but also frequently offers the opportunity to detect faults on the input level using integrated diagnostic devices. At the same time, the output unit is controlled reliably and monitored for faults with the assistance of diagnostic functions.

## Safe processing of logic

Machines and systems pose many potential hazards with their movement sequences that must be mastered. Safety devices such as Emergency-Stop buttons, safety guards, light curtains and control devices for safe setting operations must be controlled, monitored and the system must be brought to a safe operating state if required. Traditionally, these functions were elaborately implemented using hardware. The safe logic units from Eaton considerably reduce this hardware effort and expense and are mostly limited to the sensor/actuator level. Eaton provides you with two safe logic series for this purpose;

the electronic safety relay series ESR5 and the safety-oriented control relay easySafety. Safety relays of the ESR5 series offer the optimum solution for every application through tailor-made safety functions. The safety-oriented control relay easySafety integrates a host of safety relays in the form of safety function components in a single device and accordingly offers the highest level of flexibility with significant space advantages.



Applications can be implemented with the safety relay ESR or the safety-related control relay easySafety providing the highest levels of safety compliant to the international standards:

- up to Performance Level PL e to EN ISO 13849-1
- up to Safety Integrity Level SILCL 3 to IEC 62061
- up to Safety Integrity Level SIL 3 to IEC 61508

Whether it's in a simple or complex machine, the necessary personnel and process protection are guaranteed by TÜV Rheinland certified safety products from Eaton.





## Economic monitoring with ESR5 safety relays

The electronic safety relays ESR5 provide many safety switching contacts and up to 5 enable and 2 signal current paths on a very narrow width. In fault-free operation, the safety-relevant circuits are monitored by the electronics, after the switch on command and the enable paths are enabled via the relay. The enable paths are interrupted immediately (Stop category 0) or after a time-delay (for Stop category 1), and the motor is disconnected from the mains, when the switch-off command is received, as well as during a fault. If more contacts are required, a contact extension module can provide them. In redundantly designed safety circuits, a short-circuit will not cause danger, so that a renewed switch-on will lead to detection of the fault and switch on is safely prevented.



### Safely monitored Emergency-Stop circuits

The electronic safety relays ESR from Eaton switch several enable paths for immediate or time-delayed disconnection of the energy supply as soon as the EMERGENCY-STOP button is pressed. Depending on the configuration, they detect faults such as cross-shorts, short-circuits, open circuits and bridging in safety circuitry. After successful elimination of the dangers / faults, the ESR safety relays are acknowledged and the enable paths are re-enabled.

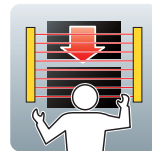
### Monitoring mobile protective mechanisms

The monitoring of protective screens on machines and processing centres is another important function of the electronic safety relay ESR from Eaton. Depending on the safety level, one or two position switches signal that the protective door is in the closed position. Instead of restart-monitoring, you can also implement an automatic start with the safety relays. Thus, you reduce the cycle times in production without dispensing with safety.

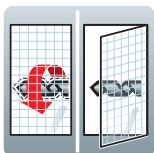
## Safety functions of the ESR5 range



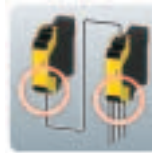
Stopping in an emergency (EMERGENCY-STOP disconnection) – Safely stopping a hazardous movement with Emergency-Stop devices



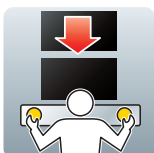
Safe operation with two-hand controls – Applied with hazardous machine movements such as with pressing, punching, shearing



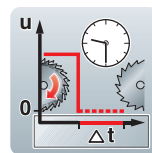
Monitoring of movable guards – Reliable detection of door, guard or flap positions



Delayed and non-delayed contact expansions – Increasing the number of enabling contacts



Monitoring open hazardous areas – Protecting hazardous areas with electro-sensitive protective equipment (ESPE) such as light curtains



Off-delayed shutdown – Delaying the shutdown time of enabling contacts

# Circuitry example with safety relay ESR5 for emergency-stop disconnection

## Application

The Emergency-Stop function is an additional safety function and is not permissible as a sole means of protection. In accordance with Machine Directive 2006/42/EC, a device for stopping in an emergency (Emergency-Stop) has to be provided on every machine. The degree of risk safeguarding by the Emergency-Stop device has to be determined by the risk assessment.

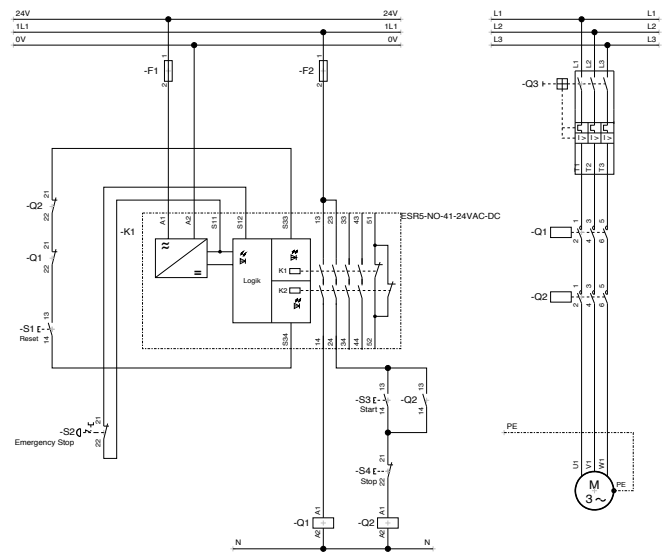
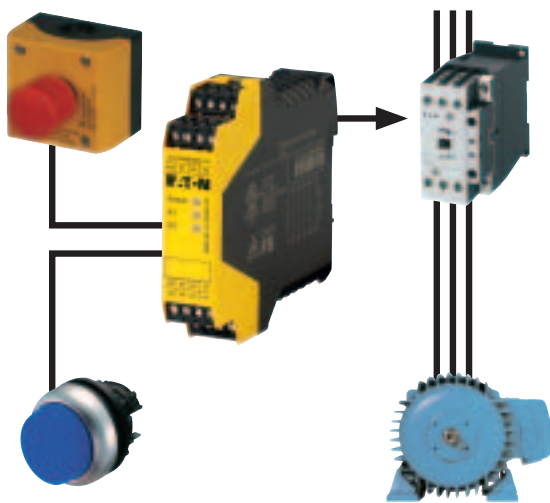
## Function

On single-channel applications, an input circuit is available, to which the sensors (e.g. Emergency-Stop switching device) are connected. The start response (automatic/manual) of the ESR5 is determined via a reset circuit. The shutdown level is connected to the enable paths and activated when the Reset button is actuated.

## Technical safety evaluation

cat	B	1	2	3	4
PL	a	b	c	d	e
SIL	1	2	3		

Cat., PL to EN ISO 13849-1  
SIL to IEC 62061



Example 1 – Single channel shutdown with ESR5-NO-41-24VAC-DC

## Selection via functions and properties

Part No.	Article No.	Emergency-Stop	Safety door	Light curtain/OSSD	Two-hand control	Contact expansion	Off-delayed	1-channel	2-channel	Cross circuit recognition
ESR5-NO-41-24VAC-DC	118701	x	x	-	-	-	-	x	-	-
ESR5-NO-21-24VAC-DC	118700	x	x	-	-	-	-	x	x	x
ESR5-NO-31-24VAC-DC	118702	x	x	-	-	-	-	x	x	x
ESR5-NO-31-230VAC	119380	x	x	-	-	-	-	x	x	x
ESR5-NOS-31-230VAC*	153152	x	x	-	-	-	-	x	-	-
ESR5-NO-31-AC-DC	118704	x	x	-	-	-	-	x	x	x
ESR5-NV3-30	118705	x	x	x	-	-	x	x	x	x
ESR5-NV3-300	171858	x	x	x	-	-	x	x	x	x
ESR5-NZ-21-24VAC-DC	118703	-	x	-	x	-	-	-	x	x
ESR5-NE-51-24VAC-DC	118707	-	-	-	-	x	-	x	-	-
ESR5-VE3-42	118706	-	-	-	-	x	x	x	-	-

\* approved for EN50156-1



# Circuitry example with safety relay ESR5 for safety guard monitoring

## Application

Movable safety devices such as safety doors, grilles or flaps can be used for protection of accessible hazardous areas. The position of the movable safety device is detected using position switches or non-contact sensors, which are monitored and evaluated by a secure logic unit. A risk assessment provides the necessary degree of risk reduction through the safety device.

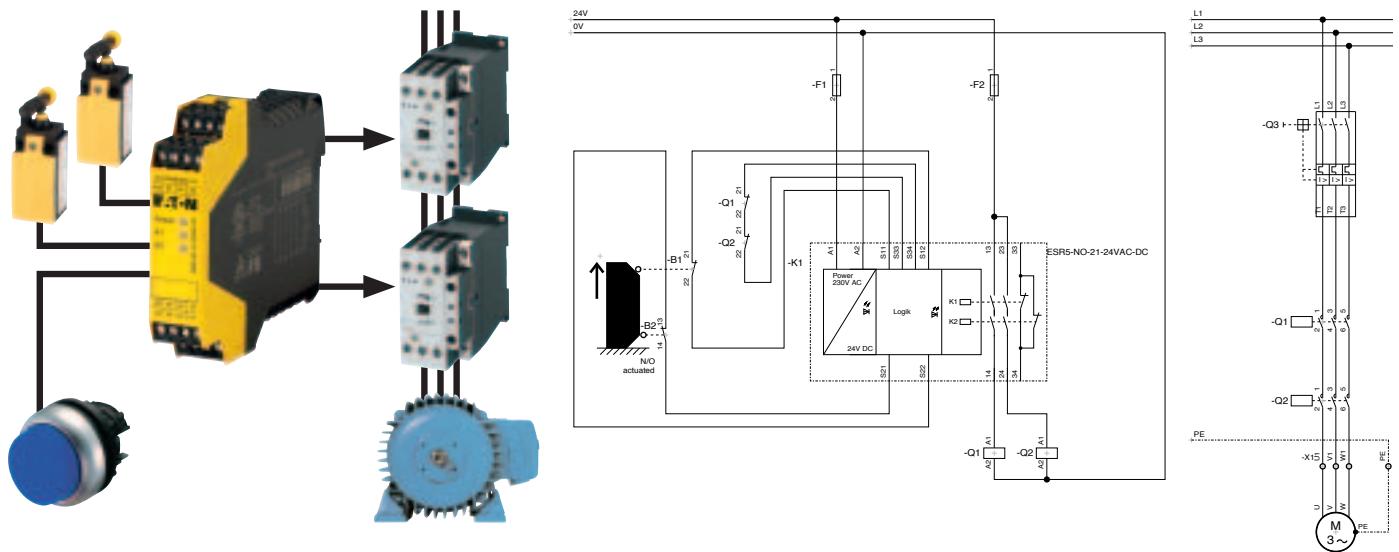
## Function

Two input circuits, which monitor the sensors (e.g. position switches of an interlocking device) are made available for two-channel applications. The ESR5 can be started using a Reset button after the input circuits are closed. Accordingly, the enable and signal current paths are activated and the actuators connected to them are switched on. The safety relay diagnoses possible fault states using forced-operated auxiliary contacts on the actuators.

## Technical safety evaluation

Cat	B	1	2	3	4
PL	a	b	c	d	e
SIL	1	2	3		

Cat., PL to EN ISO 13849-1  
SIL to IEC 62061



Example 2 – Two channel safety door monitoring with ESR5-NO-21-24VAC-DC

Reset button monitoring	Feedback circuit	Enable current paths, non-delayed	Enable current paths, delayed, delay time	Signal current paths	Feedback current paths	Enclosure width (mm)	Input voltage	Achievable PL	Achievable SIL	Control category
-	x	4	-	1	-	22.5	24V AC/DC	PL c	SIL 1	1
-	x	2	-	1	-	22.5	24V AC/DC	PL e	SIL 3	4
-	x	3	-	1	-	22.5	24V AC/DC	PL e	SIL 3	4
x	x	3	-	1	-	45	230V AC	PL e	SIL 3	4
x	x	3	-	1	-	22.5	230V	PL c	SIL 1	1
x	x	3	-	1	-	45	24V–230V AC/DC	PL e	SIL 3	4
x	x	2	2/0.1–30 s	-	-	22.5	24V DC	PL e	SIL 3	4
x	x	3	2/0.2–300	1	-	45	24V DC	PL e	SIL 3	4
-	x	2	-	1	-	22.5	24V AC/DC	PL e	SIL 3	4
-	-	5	-	1	1	22.5	24V AC/DC	PL e	SIL 3	4
-	-	-	4/0.3–3 s	1	1	22.5	24V DC	PL d	SIL 2	3

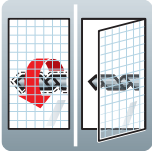


## All in one – Safety and control relay combined in a single device

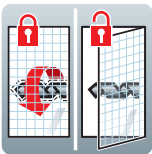
The safety-oriented control relay easySafety integrates not only safety, but also standard functions in just a single device – all in one. The safety control relay easySafety certified by TÜV-Rheinland features a standard circuit diagram in addition to a safety circuit-diagram, which incorporates the safety configuration. This circuit diagram can be used for standard tasks such as the processing of diagnostics messages or general control tasks of a machine. The simplicity of the easy circuit diagram philosophy has been continued, so that every one of today's easy users will immediately be at home. Users are thus provided with a wide range of application options in a single device thanks to the large number of safety function blocks available. In this way, users stay flexible and are able to respond immediately to current and future changes in application requirements. This saves financial resources and offers future security, whilst also reducing stock-keeping costs for special safety relays. Whether it's in a simple or complex system, the necessary personnel and process protection are guaranteed by the compact easySafety.

**Circuits for stopping in an emergency**

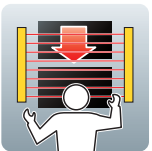
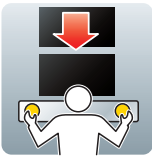
Makes it possible to safely stop dangerous movements; for immediate stops for stop category 0 and for delayed disconnection for stop category 1 as defined in EN 60 204-1; application: single-channel or dual-channel safety monitoring mechanisms for emergency stop circuits

**Guard door monitoring with and without interlocking/guard locking**

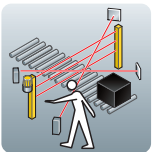
Used with moving guards such as doors, barriers or flaps. Positions are reliably detected, monitored and enabled to safety-related requirements – optional interlock device with guard locking when increased personal and process protection are required. This securely keeps the guard closed until the next machine standstill.

**Safe operation with two-hand control**

Type III to EN 574. Used for hazardous machine movement such as presses, punching, shearing – the safe enabling of hazardous movement only if both hands of the operator are outside of the hazardous area and the two-hand control switches are actuated synchronously within 0.5 seconds.

**Electro-sensitive protective equipment (ESPE)**

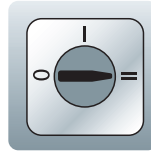
Protection of the hazardous location or area in the vicinity of machines by means of contactless guards such as light grids/light barriers/light curtains.

**Optional with muting function**

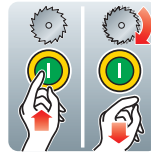
that temporarily bypasses the protective function of a guard such as a light grid. Typical application for the material feed of a machine without interrupting the working process.

**Enabling switch**

The manual or foot operated enabling device allows the temporary enabling of a guard, such as a safety door, by continuous actuation. This may be necessary for setting or servicing a machine.

**Mode switch**

Used for the safe selection and acceptance of a preselected operating mode on an external control device.

**Start element**

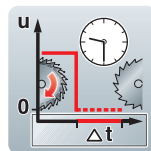
Used for the safe starting of an application by an external start actuator or a start condition from the safety circuit diagram.

**Zero monitoring**

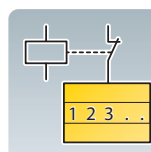
Used when the entry or access to the hazardous area is not permitted until the hazardous driving force has come to a standstill.

**Overspeed monitoring**

Used for safety-related overspeed monitoring of a motor or shaft. The drive is disabled if the maximum speed is exceeded.

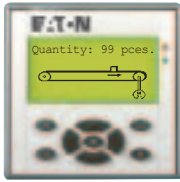
**Safety-related timing relay**

Used for changing the switch duration and the on or off switch points of an enable contact in the safety circuit. Safety-related timing relay with on and/or off delayed or single pulse function.

**Feedback loop monitoring (EDM)**

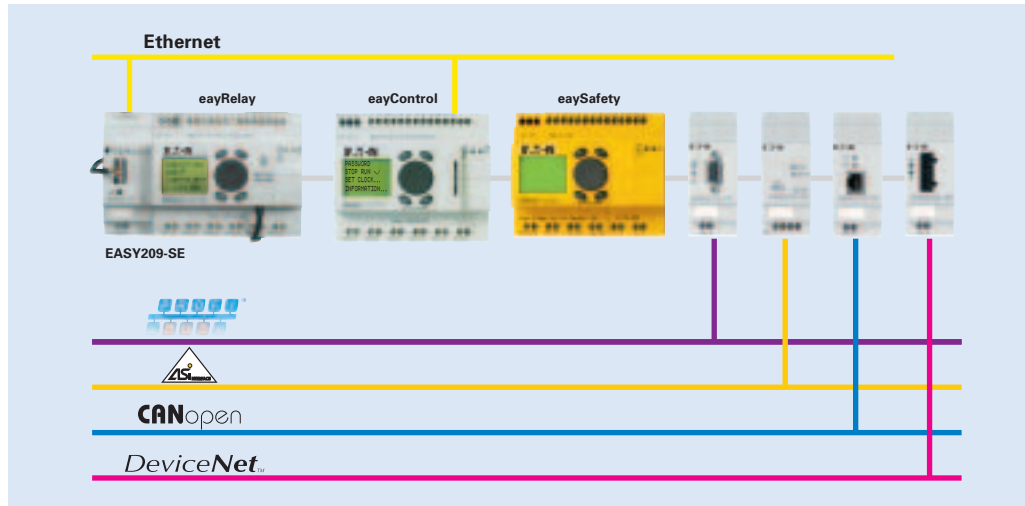
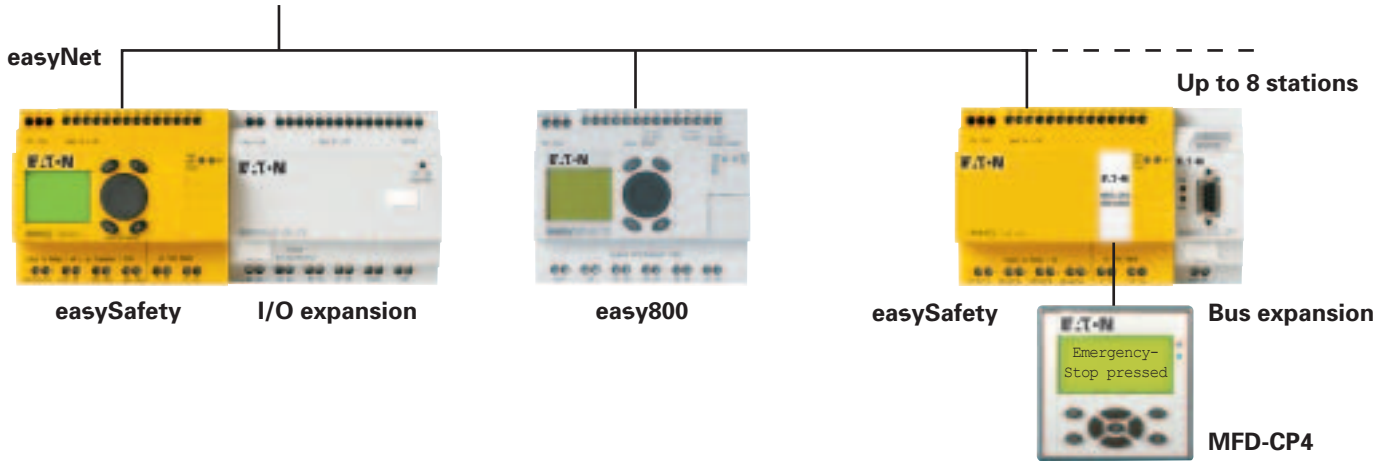
Used for the safety-related monitoring of externally connected actuators, e.g. contactors, relays or valves.

### MFD-CP8



### Expansion and communication options built-in

easySafety offers a wide range of expansion options via the integrated easyNet for remote expansion using devices from the easy family such as easyRelay, MFD-Titan or easyControl and for local expansion via easyLink with I/O modules.



### Fieldbus communication using standard extension modules

Data exchange with the PLC is supported directly via the fieldbus coupling module. It facilitates the cost-effective and simple exchange of standard information.

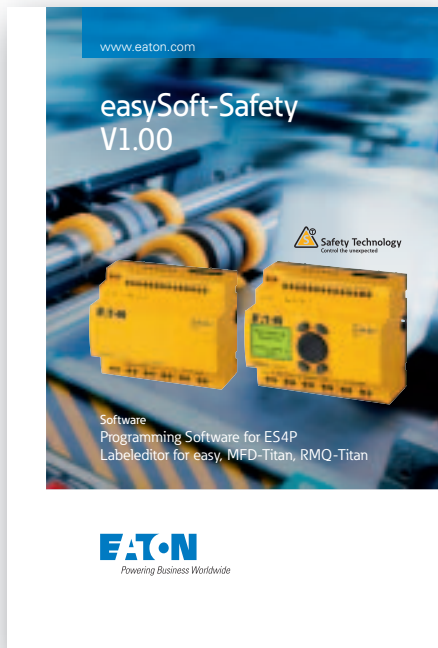
Basic units	Article No.	Inputs/outputs						Expansion/communication			Circuit diagram	
		Safety inputs	Safety relay outputs	Safety tran. outputs	Rednt. safety relay outputs	Test signals	Display	easyNet	easyLink	Open fieldbuses	Safety	Standard
ES4P-221-DMXX1	111016	14	–	4	1	4	–	up to 8 Net stations	digital I/O Standard expansions	Profibus DP CanOpen DeviceNet AS-i	yes	yes
ES4P-221-DMXD1	111017	14	–	4	1	4	yes				yes	yes
ES4P-221-DRXX1	111018	14	4	–	–	4	–				yes	yes
ES4P-221-DRXD1	111019	14	4	–	–	4	yes				yes	yes

Accessories		
ES4A-MEM-CARD1	111461	Memory module
ESP-Soft	111460	easySoft-Safety
EASY800-PC-CAB	256277	Standard easy USB programming cable
EASY800-USB-CAB	106408	Standard easy serial programming cable
ES4A-221-DMX-SIM	116953	I/O-Simulator



**Memory module for reliable data storage and program transfer**

# All in One – User-Friendly Software for Safety and Standard Circuits



easySoft-Safety is a user-friendly configuration environment for creating safety applications and also general control tasks in the conventional easy circuit diagram language.

- Manipulation protection for the machine builder: protects the safety application from manipulation and/or unauthorised access
- Know-how protection for the designer: prevents the undesired transfer or application know-how
- Flexibility for the operator: enables the safe paramterisation of the standard application and a wide range of diagnostic options at any time

## Circuit diagram view

Separate circuit diagrams ensure a strict separation between safety tasks and standard tasks. This firstly prevents unauthorised access or manipulation of safety processes through the use of separate passwords. Secondly, operators still have the freedom to adapt non-critical standard functions as well as machine diagnostics to the application at hand.

## Safety circuit diagram

All typical safety functions are selected from a list containing a large number of safety function blocks, and the process defined by assigning them to the safety inputs and outputs.

## Simulation view

The ability to simulate the project on the PC ensures a considerable time saving during the design phase.

## Project view

Project view allows the graphical configuration of the project by drag and drop using easySafety variants in the machine. Either as a stand-alone solution or integrated in the easyNet network.

## Password protection

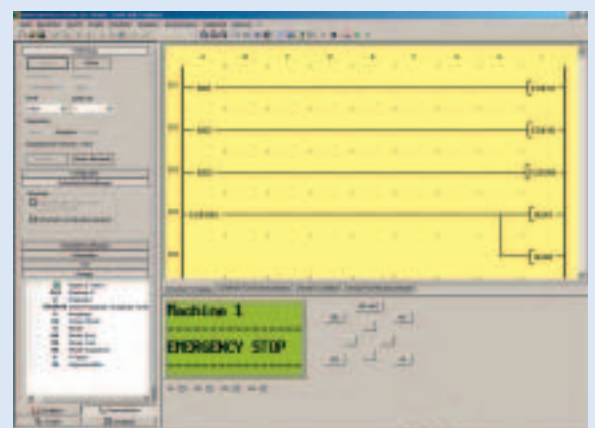
The multi-level password protection concept ensures optimum protection against unauthorised changes in the safety configuration, manipulation protection and know-how protection.

## Communication view

Communication view enables direct diagnostics of the connected device via the status display.



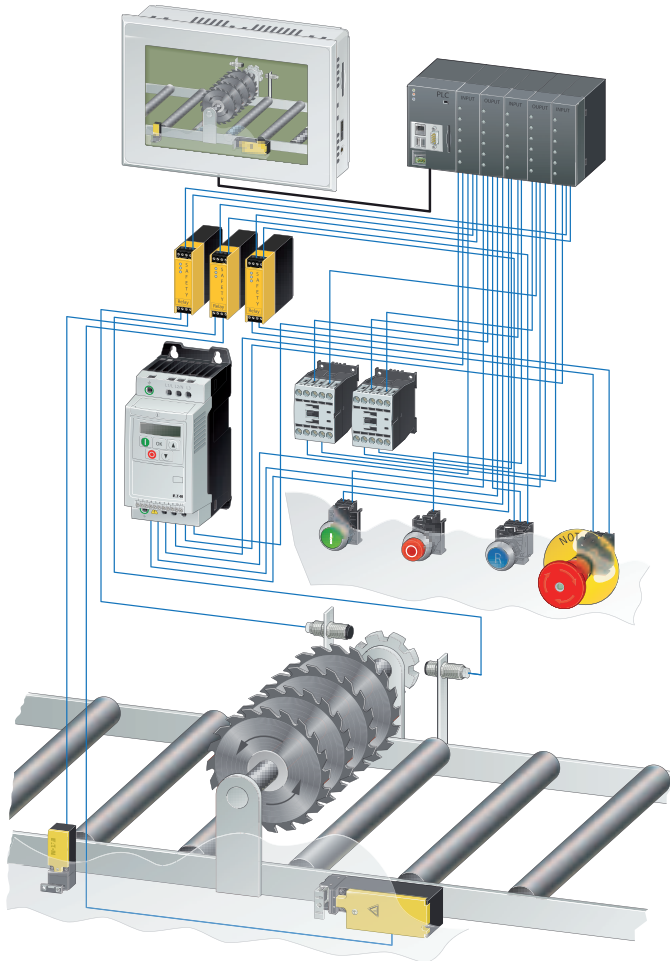
Project view



Safety circuit diagram

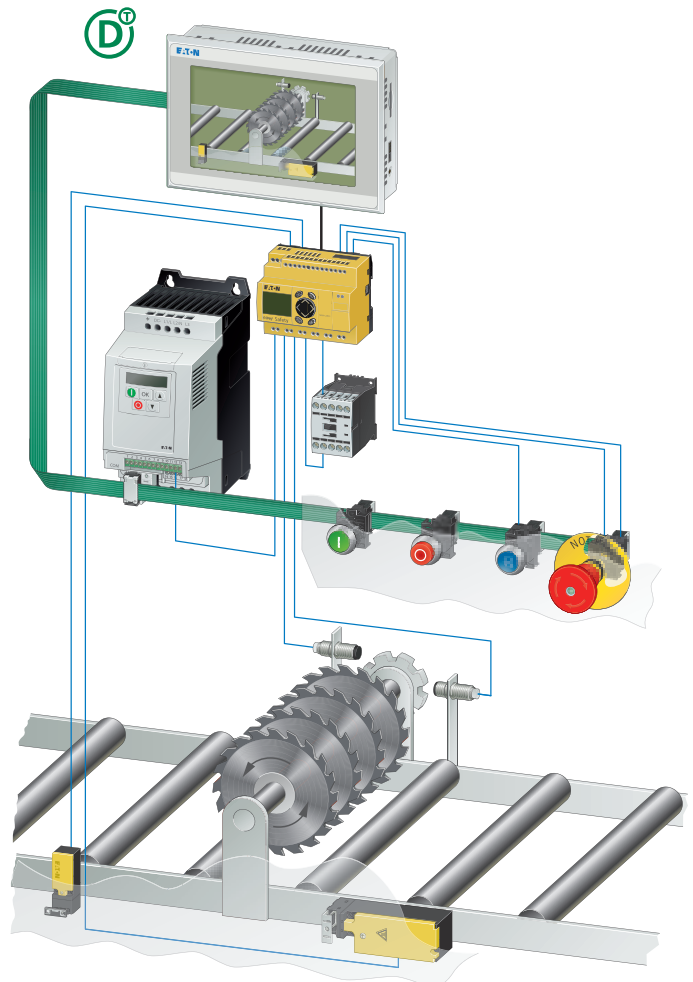
# Functional safety with integrated diagnostics

## Conventional device setup



In conventional designs, the safety function is independent from the machine's control system and is implemented using sensors, an emergency-stop button, safety relays, and contactors. The control and operating level is then connected to these safety relays through inputs/outputs. This connection is necessary, as starting a drive requires not only the operator's corresponding command, but also an enable signal from the safety devices. In addition, diagnostics concerning the safety circuit's state are forwarded to the operator via the PLC. All in all, this requires a significant amount of wiring.

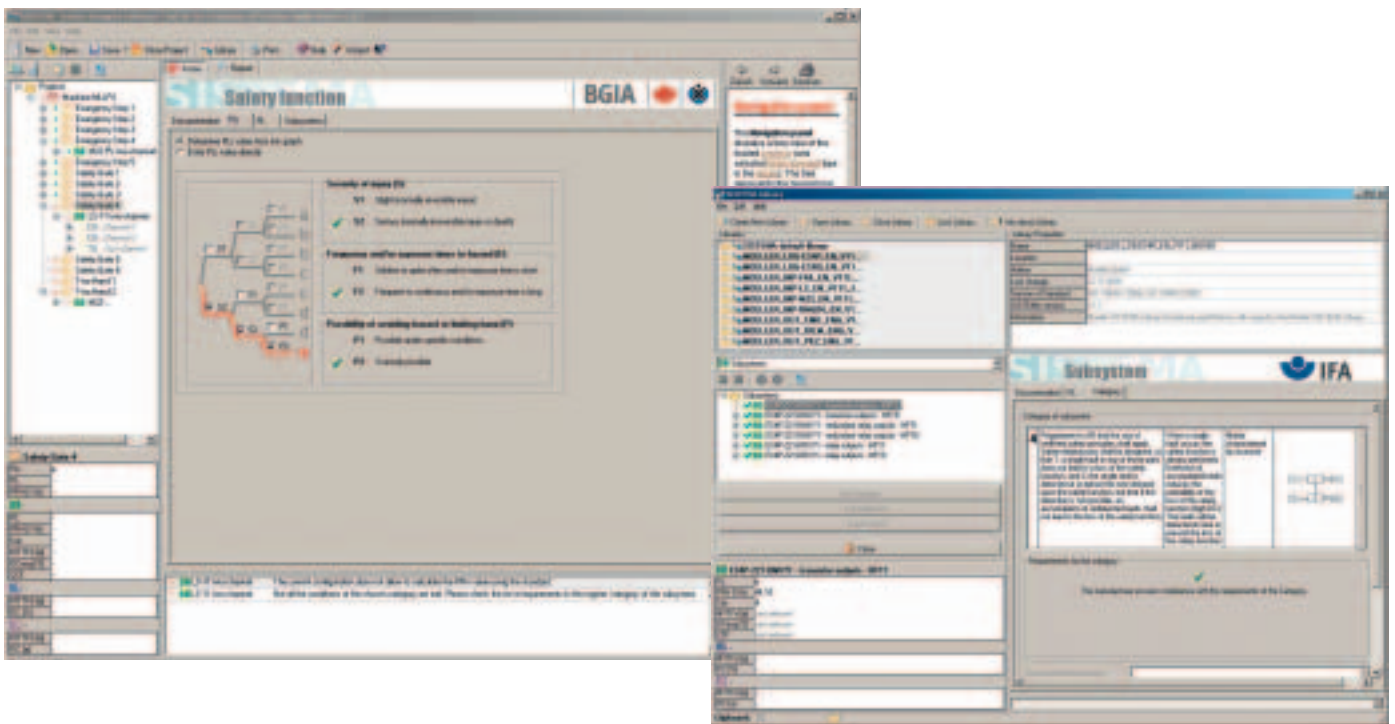
## Network-based safety logic simplifies setup



easySafety is designed to efficiently handle communications with the control and operating level via an easyNet standard network. Standard switching commands and diagnostics are transmitted using bus communications, and the system's safety is fully retained thanks to the fact that communications with safety-relevant components remain hardwired. As a result, easySafety raises the bar in terms of transparency, flexibility, and simplicity.

And to simplify things even further, SmartWire-DT takes care of direct communications between control devices and switchgear and the HMI PLC, which in turn takes over all visualization and control tasks.

# Safety of controls on machines – simple calculation with Eaton libraries for SISTEMA



The manufacturer-independent calculation tool SISTEMA from the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) provides assistance in the evaluation of safety-related control components in the context of EN ISO 13849-1 and simplifies risk assessment analysis.

Selection of the design structure of the protective devices and the assignment to an architecture compliant to the EN ISO 13849-1 is implemented in a Windows user interface. On this basis, the software calculates the reliability values as well as the attained Performance Level (PL). A direct comparison with the required Performance Level (PLr) is thus possible.

The software records the relevant parameters for evaluation such as MTTFd, B10d, DCavg and CCF. It directly indicates the influence of variable parameters on the overall result.

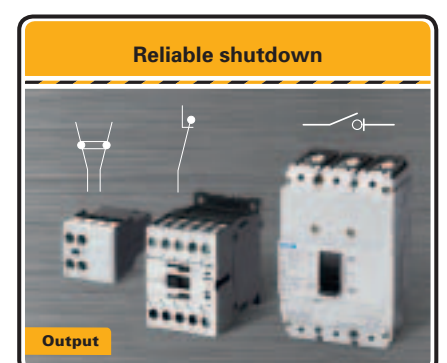
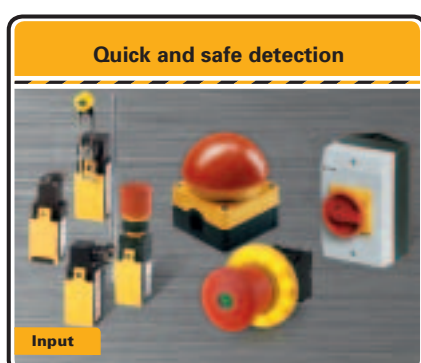
The calculation tool can be downloaded directly from the IFA website.

The software assistant SISTEMA provides the opportunity to load the technical safety-related parameters of components into the program from an existing library. Design engineers have the manufacturer's data directly available in the software. Manual data entry is not necessary.

Eaton provides the libraries for integration into the SISTEMA software free-of-charge under: Input, Logic or Output. The individual libraries can be downloaded at [www.eaton.com/moellerproducts](http://www.eaton.com/moellerproducts). Please note that the libraries are updated on an ongoing basis and new products are continuously added.

## Universal database for additional analysis tools

There are various tools that can be used to calculate the probability of a dangerous control system failure. This is why the VDMA German Engineering Association has defined a universal database for safety characteristic values for components so that data can be easily imported into any well-established analysis tool. The result? Users are no longer tied to a specific manufacturer or vendor when selecting safety components or analysis tools.



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