Application Manual

The Safety System for Industry

INTEGRATED

4. Edition

SIEMENS

“The prevention of accidents should not be considered a question of legislation, but instead, our responsibility to fellow beings and economic sense.“

Werner von Siemens,
Berlin in the year of 1880

Siemens
Safety
Integrated

Content

Dear Readers,

Helmut Gierse
A&D Group Board

The founder of our company, Werner von Siemens, recognized back in 1880 that accident prevention should not just be considered a question of legislation, but it is also our responsibility to fellow beings and makes economic sense.

Today, this is also the philosophy of automation technology from Siemens. In addition to increasing availability and cost-effectiveness, our focus is always on human beings and the benefits we can provide. This philosophy is especially important where human beings work directly at machines which can represent potential hazards, or where human beings can be indirectly involved as a result of subsequent damage, e.g. due to environmental stressing.

The fourth Edition of the successful "Safety Integrated" Manual presents the ongoing development of the Siemens "Automation and Drives" Group (A&D) and the safety products and systems: SIGUARD, SIMATIC and SINUMERIK/SIMODRIVE. For years now, these have been setting the standard in safety technology in many applications.

Current examples include both the consequential expansion of the fail-safe SIMATIC PLCs by Distributed Safety with the S7-300F and ET 200S PROFIsafe components with the focus on the production and the new electronic 3TK28 safety combinations.

We as A&D are taking into account, with "Safety Integrated," the tremendous pace of development in the safety technology market - a market which is enjoying above average growth. The harmonization of the safety Standards within the EC and the fact that these EC Standards are being applied worldwide are the main drivers for this growth.

Using innovative, flexible solutions, "Safety Integrated" is increasing the safety and availability of automation tasks, whilst also increasing the productivity. With "Safety Integrated," users have access to a unified, integrated complete solution. This means standard, integrated control and field technology. A combined safety system platform will obtain new impetus as drive and process technology continue to merge.

Innovation and success have paved the way to today's standard of safety technology: As early as the 1960's, Siemens supplied the first pre-wired safety combinations. At the beginning of the 1980's, Siemens presented the compact SIGUARD 3TK combination using safety contactor technology.
At the same time, the programmable SIMATIC safety logic controller was introduced - the SIMATIC S5-110F for press controls. The SIMATIC S5-115F, launched back in 1988, represented a milestone in process technology.

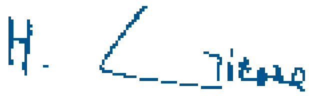
The modular SIMATIC S5-95F compact PLC, introduced in 1994, created a worldwide standard in production technology, for press controls, in process technology and in personnel transportation systems. In 1996, SINUMERIK/SIMODRIVE continued this tradition with the world's first safety-related control system for machine tools.

This means that our customers can simply and cost-effectively implement the requirements laid down in the EC Machinery Directive which came into force in 1995. The basis for a unified, "Safety Integrated" system is created as a result of the certification of the safety-related communications via the standard fieldbuses - PROFIBUS in 2000 and AS-Interface in 2001.
Using the high-availability safety-related SIMATIC S7-400F/HF, since 2000, safety concepts have been directly integrated, in a unified fashion, into the "Totally Integrated Automation" (TIA) concept.
In 2001, an optimized solution for the production industry was introduced in the form of the S7-300F and ET200S PROFIsafe components.
In parallel, the safety portfolio was expanded, in the sensor area, using the contactlessly operating SIGUARD light curtains and laser scanners.

For automation tasks which are less complex, in the area of evaluation, it is now possible to use innovative wiring and communication solutions. For instance, 3TK28 electronic safety combinations now optionally integrate the control and main circuits in a complete unit. The standard actuator sensor interface with the Safety Monitor as well as safe input modules and direct sensor connections can now be simply expanded by safety functions.

Safety Integrated allows user-friendly machines to be created using simple intelligent safety technology which does not obstruct standard working procedures.

Sincerely,



Helmut Gierse

Thomas Leiß
A&D Project Manager
"Safety Integrated"
Siemens AG, Erlangen

Whether for applications in the area of machine safety or process technology - state-of-the-art technology used in the automation process demands the highest degree of safety for man, machine and the environment.

The "Safety Integrated" Application Manual, which has now been updated several times, clearly shows how hazards, caused by functional faults, can be reduced or completely resolved using electrical and electronic equipment and devices.

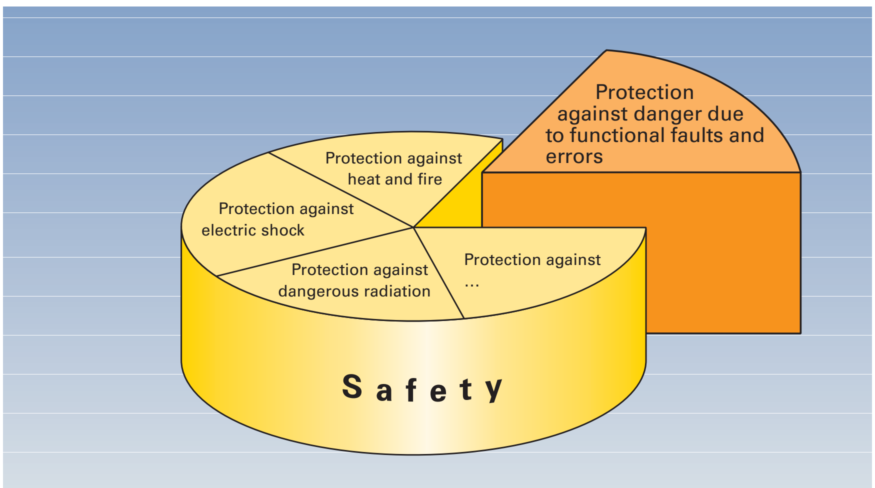
From sensor systems through evaluation units up to safe shutdown and in the future to the actuators, for example drives – "Safety Integrated" now provides maximum protection against functional faults using the SIGUARD, SIMATIC and SINUMERIK/SIMODRIVE product groups.

These product groups have already proven themselves for many years in standard automation solutions and that worldwide. These components can now also be combined in an overall system since safety-related communications via PROFIBUS and via the Actuator-Sensor interface were certified in 2000 and 2001 respectively.

In addition to conventional hard-wiring between the individual components, as an alternative, it is also possible to use standard fieldbus systems for the safety technology. This permits a unified, integrated system and in turn, cost-effective engineering, reduces the hardware costs by using common components and simultaneously increases the plant and system availability thanks to improved diagnostics.

Open and integrated

An automation system mainly comprises standard components such as PLCs, drives etc. The level of safety technology of a complete plant or system can differ depending on the particular application.



However, irrespective of the particular application, the safety level always comprises a series of sensors, safety evaluation units and actuators for safe shutdown.
Today, the two levels of a plant or system, standard and safety related technology, are strictly separated. Generally, different engineering techniques and tools are used for these two levels. This not only results in higher costs associated with personnel training, but also in many cases, these two levels can only be linked at considerable cost.

The requirement to achieve cost savings can be fulfilled by selecting the correct installation technology. In standard technology, the move to distributed concepts and the use of modern fieldbuses has already resulted in significant cost savings. Further cost savings in the future will be achieved by transferring additional safety-related signals along existing standard fieldbuses.
"Safety Integrated" is the practical implementation of this concept. Using this concept, both standard and safety components can be cost-effectively combined to form a completely unified and transparent system.
Costly wiring for diagnostics and feedback signals can be eliminated. Standard engineering tools and methods as well as visualization concepts guarantee cost saving in the planning phase and also during installation and service.

Sincerely,

Thomas Leiß

Thomas Leiß

Controlling and Sensing

Monitoring and Evaluation

Control and Stopping

Dr. rer. nat. M. Schaefer

Head of Division: Machinery Safety, Control Techniques in the Institute of Occupational Safety and Health, Germany

New technologies in the name of safety

If you compare the safety controls from the eighties employing conventional devices, with contacts and the sophisticated products of today, the advantages of intelligent safety technology using computer-based systems becomes quite clear:

- New sampling-type sensors allow a finely graduated safety technology optimally adapted to the particular application
- Computer channels, operating with high clock frequencies, result in extremely short response times
- Intelligent software allows aging processes to be identified before they can have a dangerous influence
- Safety fieldbus systems significantly reduce the amount of wiring and therefore potential problems, especially when troubleshooting.

However, new technologies can only have a positive influence on safety technology if the development takes into account measures, right from the very start, for fault tolerance and avoiding faults (refer to DIN V VDE 0801 and IEC 61508). Measures such as these not only have a significant impact on the complete development process, but generally enhance the availability above and beyond the pure safety technology. The experience gained from more than 150,000 customer systems in the field indicates that high technology, applied in this fashion, is also really safe.

Safety technology through dialog instead of checking

Since the middle of the eighties, the BIA and several other testing bodies have been developing testing methods for complex safety technology. The inspection no longer occurs at the end of product production, it now accompanies the development life cycle of a product from the initial concept through to final production. Only by using such simultaneous development and testing procedures is it possible to certify complex systems.
The measures applied are checked during the safety life cycle at specific milestones to an agreed standard, whilst error-avoiding techniques are applied by the testing body itself as part of the validation process. Using techniques and standards as defined above, the testing body ensures that the development process of a product is perfect. This is the reason why complex safety technology should be considered more as a process rather than as a product.

Increasing the acceptance of safety technology

New technology allows safety functionality to be directly integrated into a machine or plant as a result of the functional control. In newly developed CNC control systems with integrated safety technology, reduced velocity required during setting up and the safe stop are guaranteed using additional software without any external monitoring devices. This means, for the user, that safety is incorporated in the control and the likelihood of faults occurring is significantly reduced. In the same way, using safety-related data communication concepts, standard hardware can be used to safely network various control systems or even complete production systems. This completely eliminates additional manual operations, for example, parameterizing safety devices. Safety-related data can be centrally managed and reported.
This eliminates barriers for the use of safety technology and the level of acceptance is increased.

Safety technology from a cost perspective

Especially in the nineties, cost issues became increasingly important in safety technology. Although the development processes for complex safety technology are extremely cost-intensive, integrated safety, as a result of the software, can have an extremely positive impact on the overall product cost. Furthermore, downtimes are reduced as a result of a far more efficient diagnostics capability due to the use of safety computer systems.

From our perspective as the Berufsgenossenschaften [German Trade Association], we also see that in the future, it will be important that we support and promote the development process discussed above. And of course, this Manual demonstrates that this is a safe route to take - and which is extremely promising.

For the German Trade Association, innovation and prevention are important issues in working together. Our society requires ongoing innovation. This secures the competitiveness and facilitates a lifestyle and working methods to help humans generally.
The German Trade Associations therefore promote such innovation which plays a role in reducing all types of risks and hazards or which improves working techniques and procedures.

In order to present especially outstanding developments for enhanced health and safety at work to a larger trade public, for the first time, at the Hanover Fair 2003, the innovation prize of the German Trade Associations will be awarded.

(For more detailed information, refer to www.hvbg.de/d/pages/presse/aktuell/foerder.htm).

Heinz Gall

Head of the business sector Automation, Software and Information Technology
TÜV Anlagentechnik GmbH, Cologne Company Group TÜV Rheinland/Berlin-Brandenburg

Automation systems and components are responsible for safety-relevant tasks in many different application areas (machines and conveyor systems, the process industry, building technology etc.).This means that the health and safety of personnel as well as the protection of plant equipment and the environment are dependent on the correct functioning of these systems and components.

Today, the correct functioning of systems and components is handled under the term of "Functional Safety". This is documented in the IEC 61508 Standard "Functional safety of electrical, electronic and programmable electronic safety-related systems" which was passed in 2000.

This Standard is, in the meantime, also recognized as EN 61508 and will be included in the German Standards.
It is considered as a basis Standard, independent of the application and addresses developers of application-specific standards as well as the contents (description of measures for the safety concept, fault-avoidance and fault-controlling measures for hardware and software) essentially to the manufacturers of safety-related systems and components.

This has already been accepted by the application-oriented Standards groups. The first examples include the Drafts of IEC 61511 for the process industry, EN 50156 for the electrical equipment of furnace systems as well as IEC 62061 for safety-relevant control systems for machines. It goes without saying that in the area of machine safety, application-specific Standards, for example EN 954, must be applied.

In the future, it is hoped and also expected that other user groups will use the existing base standard for their work, to standardized the requirements placed on safety-related systems and components. This especially makes sense, because the principles involved with risk evaluation, risk reduction and the safety-related functions can be applied to the widest range of applications. From an application perspective, only a few aspects would have to be considered, e.g. the required response times or the safe condition for the process.

This means that manufacturers will be able to develop systems and components which will be able to be used for safety tasks, with comparable degrees of risk, in various applications. To realize this, the following generally applicable data must be available for each particular component:

- Maximum "Safety Integrity Level (SIL)" which can be achieved
- Hardware fault tolerance in conjunction with the component of safety failures (sum of the failures in the direction of a safe condition plus the sum of the failures which are recognized and controlled as a result of the internal diagnostics) referred to the sum of all of the failures
- Probability of failures where the system goes into a hazardous condition.

The above mentioned criteria will then permit safety-related functions to be viewed across the complete application, which generally comprises the sensor system, logic (e.g. PLC) and actuators as well as communications between these components.

Field devices, sensor systems and actuator systems are becoming increasingly intelligent. This means that communications between the components of a safety-related function will increasingly be realized via bus systems.

In the last two years, considerable progress has been made in the area of standardized safety-related bus systems.

This progress involves, on the one hand, the development of a basic philosophy to "Test and certify bus systems for the transfer of safety-related data" and, on the other hand, the successful completion of conceptual tests of such bus systems.

This means that in the foreseeable future it can be expected that devices from various manufacturers will be able to be operated on standardized safety bus systems.

In this case, manufacturers must accept the challenge to develop safety-related devices which can use the capability of safety-related communications via bus systems.

The TÜV Rheinland/Berlin-Brandenburg, in conjunction with the Automation, Software and Information Technology business field, is supporting manufacturers, project engineers and users worldwide (Europe, USA, Japan) in the implementation of the above mentioned safety-related tasks.

After a successful test, systems and components will be certified and will receive the FS test symbol "Functional Safety" of the TÜV Rheinland/Berlin-Brandenburg. This documents that they are in conformance with the requirements laid down in the relevant Standards.

Engineers and users will be supported in achieving the functional safety for both the application and the implemented safety functions.

Prof. Dr.-Ing. G. Reinhart

Head of the Institute for Machine Tools and Industrial Management (iwb), Technische Universitaet Muenchen

The features and performance of state-of-the-art production systems are essentially determined by how the mechanical system and control interact. Only a harmonized complete system will be able to fulfill the requirements placed on the functionality, productivity and quality of today's production systems. A distributed installation technology which offers diagnostics capability across the board provides the essential basis to increase the availability of complex production systems. Beyond this, the integration of safety-related functions in control technology represents an innovative way to adapt safety technology to the requirements of the machine operator - but still reduce costs.

Requirements placed on the safety technology of machine tools

The safety-related devices and equipment on machine tools are of special significance within the control and installation systems of machine tools. On one hand, the legal and standards requirements which define, using hazard analysis, the scope and quality of the safety technology to avoid or reduce potential hazards. On the other hand, the continually increasing performance parameters of today's production systems. These include, for example, maximum axis velocity, acceleration and availability which is reflected in the Overall Machine Effectiveness (OME). In order to guarantee the effectiveness of safety technology in today's protection systems, i.e. to fulfill the requirements for personnel protection in line with that required in practice, innovative concepts are required. In this case, innovative safety technology should be considered to be a technology which does not lag behind the control and installation technology applied in the area of non-safety-relevant automation technology. For instance, features such as flexibility, diagnostics capability and standardization.

Safety technology integrated in drives and control systems

It becomes even more necessary to have flexible safety circuits, on and in machine tools, which take into account everyday operator situations, if the creative capabilities of the machine operator are to be fully utilized in a production environment. From the perspective of personnel protection, the performance parameters of the machine required in automated production facilities must be reduced to a safe level when operators have to intervene.

When considering the performance of today's drives and production-related secondary conditions, safety drive functions and safely monitored drive statuses should be considered to be part of the basic functionality of modern variable-speed drives in production systems.

Furthermore, the ability to emulate all of the safety-relevant logic operations in the software allows, on the one hand, a significantly stronger differentiation to be made regarding operator control, and on the other hand, costs to be significantly reduced over conventional solutions using devices with contacts. The requirements placed on safety and the ability to be integrated into existing control structures are fulfilled by using existing control subsystems which can communicate with one another and redundant shutdown paths.

Distributed and standardized installation technology in the machine environment

Ongoing developments in the area of non-safety-relevant installation technology clearly show the way how to maximize cost-saving potential by using distributed concepts and standardized interfaces for installation in the machine environment. By using plug connections and pre-assembled cables in the field area and by reducing the number of versions of manufacturer-specific field-bus components, the machine OEM, the machine operator as well as the component manufacturers reap the benefits - from both a cost and functionality perspective. Simultaneously transferring safety-relevant and non-safety-relevant data along one bus system based on a standard fieldbus system significantly reduces the configuring/engineering, components, installation and commissioning costs

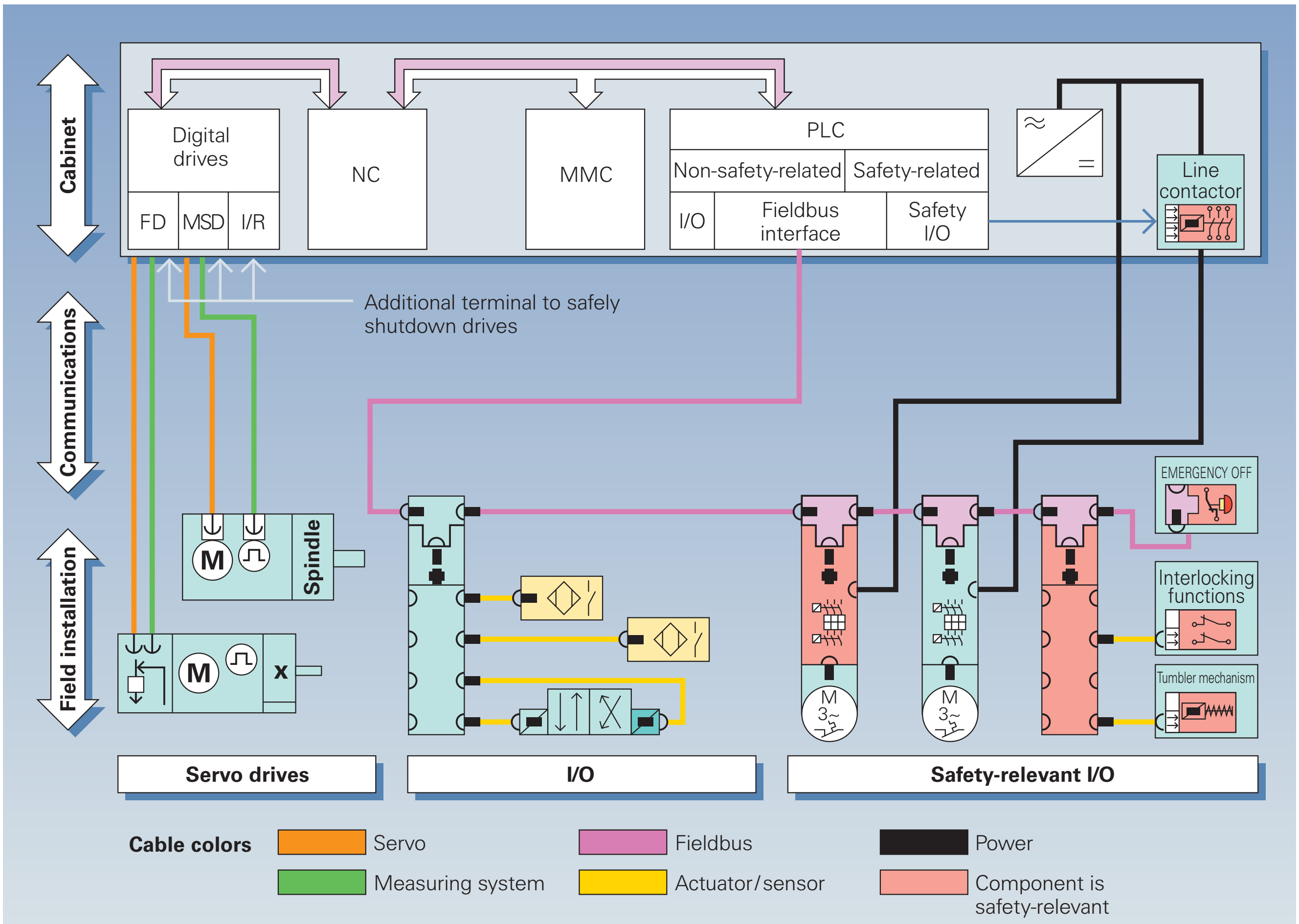


Fig. 1 Distributed and standardized installation technology in the machine environment

The increasing number of DESINA components (DESINA = Distributed Standardized Installation technology on machine tools) in the market and the significant interest on the part of the machine OEMs and users confirms the efforts made by the Vereins Deutscher Werkzeugmaschinenfabriken e.V (VDW) and the Institute for Machine Tools and Business Sciences (iwb) to incorporate safety components in the standardization process in compliance with DESINA. The structure of a unified safety concept for machine tools, which encompasses the above mentioned issues relating to the integration into the drive and control system, including DESINA, is illustrated in the diagram.

Summary

Current research work at iwb indicates that, as a result of understanding the safety-relevant behavior of moving machine parts and their specific interaction early on, in the near future, it will be taken for granted that innovative safety systems will establish themselves in machines tools. Examples include bus-based data transfer and data processing integrated in the control. The advantages of being able to take into account the detailed operator requirements of machine tools operators, the improved effectiveness of safety technology and ongoing cost reduction will only become reality when component manufacturers and development engineers are ready to accept new concepts and solutions openly and without any preconceptions.

D. Seibel

Head of Electrical Engineering Department, Berufsgenossenschaft der Feinmechanik und Elektrotechnik (The professional Association of Precision Mechanics and Electrical Industries, Cologne)

International discussions relating to fault control/fault analysis were initiated using the main regulations from Section 5.7 of EN 60204-1, "Electrical Equipment of Industrial Machines," status 1985. The safety considerations (protective goals), which are derived from the contents of the Standard, especially in the application field "Electrical controls," automatically lead inevitably and logically to different solutions. The goal of all of the basic solutions presented was, and still is, to create a unified, binding safety Standard within the European Community.

Hazard potential

A general control design (Graphic 2) must be the global starting point for practical safety philosophy. Depending on the potential hazard and the machine-specific operating conditions, it is necessary to have a graded level of safety for the switching logic (general control circuits). The risk evaluation is a mandatory prerequisite. Protective measures must be implemented, adapted to the hazard potential and orientated to the particular process.

Personnel protection

Protective devices must be provided everywhere, where plant and machinery can represent potential hazards. Moving protective devices, which mechanically isolate machine parts, i.e. protective doors, are some of the preferred ways of protecting personnel in the operating area of machines in industrial production plants, from hazardous motion or other dangers.
In order to guarantee the specified personnel-protective function, moving protective devices must be implemented and electrically interlocked, so that personnel cannot enter the hazardous area before the dangerous conditions have been removed (e.g. rotational movement of a machine tool).

Redundancy

Conventional safety circuits, in conjunction with the interlocking systems, almost completely fulfill the required personnel-protective functions. The types of failures which can be expected along with the associated safety risks are generally known and the technical solution used to overcome these problems are available and accepted (e.g. redundancy).

The position switch is the core of every latching or interlocking function. This must at least include one positively opening contact (positively opening/positively isolating). If the protective device is opened, the NC contact in the position switch must safety interrupt the safety circuit.

Application examples

In order to make it easier to select and mount the different latching systems and to ensure the required circuit interlocking of the safety-relevant signal sensors with the downstream actuators (power contactors, relays), the German Trade Association [Berufsgenossenschaften] has drawn up and presented numerous application examples.

The individual solutions are shown as example in the following documents from the German Trade Association

BGI 575 "Pamphlet to select and mount electro-mechanical latching-interlocking devices for safety functions"

and

BGI 670 "Pamphlet to select and mount proximity switches in latching/interlocking devices for safety functions"

A positively driven relay must be used if it is necessary to identify a fault (e.g. if a relay does not drop out).

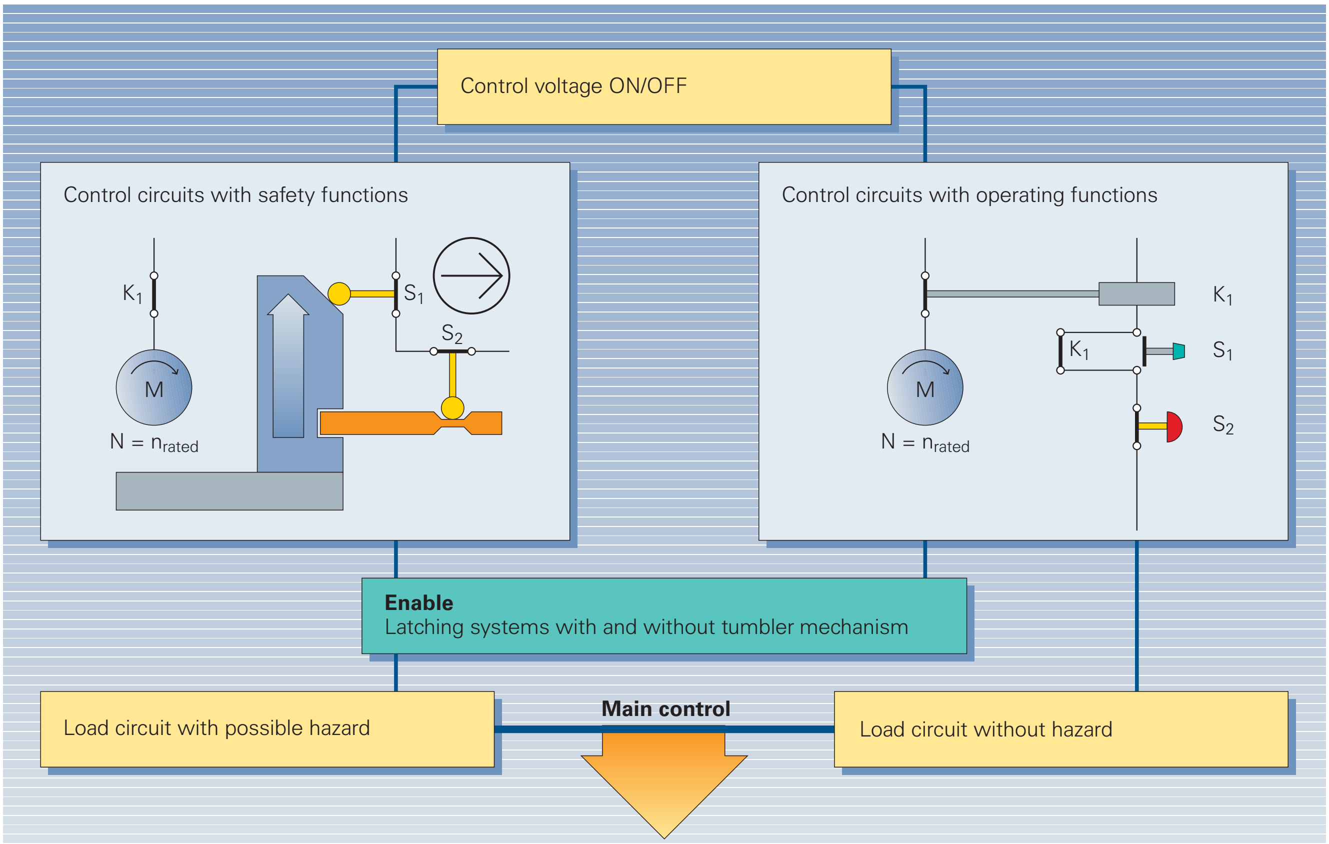


Fig. 2 General configuration of a machine control system (DIN VDE 0113/11.98)

Standards

The circuit versions which are presented and the associated necessary safety aspects (e.g. fault exclusion lists) have started to be included in European Standards. In this case, it is necessary to describe the two group Standards (type B Standards))

EN 1088 Safety of Machinery "Latching systems in conjunction with isolating-protective devices"
Guidelines for layout and selection

and

EN 954-1 Safety of Machinery "Safety-related parts of controls"
Part 1: General layout guidelines

which specify a uniform evaluation Standard, independent of the application, based on the rules and regulations of the German Trade Association.

This means that these evaluation Standards can also be transferred to the downstream safety and monitoring circuits. This takes into account the now available European Standard EN 60204-1 (Status 11.1998).

Typical applications include so-called "relay safety combinations," which are used to transfer signals from safety trips (e.g. protective door monitoring functions, switching strips, two-hand control devices, actions under emergency situations, light barriers etc.), maintaining the required control category in compliance with EN 954-1.

Standards and Regulations

kapitel 1

1.1 General information

Objectives

The goal of safety technology is to keep the potential hazards for man and the environment as low as possible by applying and utilizing the appropriate technology. However, this should be achieved without imposing unnecessary restrictions on industrial production, the use of machines and the production of chemicals. By applying internationally harmonized regulations, man and the environment should be protected to the same degree in every country. At the same time, differences in competitive environments, due to different safety requirements, should be eliminated.

In the various regions and countries around the globe, there are different concepts and requirements when it comes to guaranteeing safety. The legal concepts and the requirements regarding what has to be proven and how, as to whether there is sufficient safety, are just as different as the assignment of the levels of responsibility.
For example, in the EC, there are requirements, placed both on the manufacturer of a plant or system as well as the operating company which are regulated using the appropriate European Directives, Laws and Standards.
On the other hand, in the US, requirements differ both at a regional and even at a local level. However, throughout the US, there is a basic principle that an employer must guarantee a safe place of work. In the case of damage, as a result of the product liability, the manufacturer can be made liable due to the association with his product. On the other hand, in other countries and regions, other principles apply.

What is important for the manufacturers of machines and plant construction companies is that the legislation and rules of the location always apply in which the machine or plant is being operated. For instance, the control system of a machine, which is operated and used in the US, must fulfill US requirements, even if the machine manufacturer (i.e. OEM) is based in Europe. Even though the technical concepts with which safety is to be achieved, are subject to clear technical principles, it is still important to observe as to whether legislation or specific restrictions apply.

Functional safety

From the perspective of the object to be protected, safety cannot be segregated. The causes of hazards and the technical measures applied to avoid them can differ widely. This means that a differentiation is now made between various types of safety, e.g. by specifying the cause of the potential hazard. For instance, the term "electrical safety" is used if protection has to be provided against electrical hazards, or the term "functional safety" is used if the safety is dependent on the correct function.

This differentiation is now reflected in the most recent Standards, in so much that there are special Standards which are involved with functional safety. The area of machinery safety EN 954 deals specifically with safety-relevant parts of control systems and therefore concentrates on the functional safety. The IEC handles functional safety of electrical, electronic and programmable electronic systems, independent of any specific application in the pilot Standard IEC 61508 .

In IEC 61508, functional safety is defined as "part of the overall safety relating to the EUC* and the EUC control system which depends on the correct functioning of the E/E/PE** safety-related systems, other technology safety-related systems and external risk reduction facilities." In order to achieve functional safety of a machine or a plant, the safety-relevant parts of the protective and control devices must function correctly, and, when a fault or failure occurs, the plant or system must remain in a safe condition or be brought into a safe condition.

To realize this, proven technology is required, which fulfills the demands specified by the relevant Standards. The requirements to achieve functional safety are based on the following basic goals:

- Avoid systematic faults,
- Control systematic faults,
- Control random faults or failures.

The measure for the level of achieved functional safety is the probability of the occurrence of dangerous failures, the fault tolerance and the quality which should be guaranteed by avoiding systematic faults. In the Standards, this is expressed using various terms. In IEC 61508: "Safety Integrity Level" (SIL), in EN 954: "Categories" and in DIN V 19250 and DIN V VDE.
0801: "Requirement classes" (AK).

Standardization goals

The demand to make plant, machines and other equipment as safe as possible using state-of-the-art technology comes from the responsibility of the manufacturers and users of equipment for their safety. All safety-significant aspects of using state-of-the-art technology are described in the Standards. By maintaining and fulfilling these standards, it can be ensured that state-of-the-art technology is applied therefore ensuring that the company erecting a plant or the manufacturer producing a machine or a device has fulfilled his responsibility for ensuring safety.

Note: The Standards, Directives and Laws, listed in this Manual are just a selection to communicate the essential goals and principles. We do not claim that this list is complete.

* EUC: Equipment under control
** E/E/PE: Electrical, electronic, programmable electronic

1.2 Regulations and Standards in the European Union (EU)

1

1.2.1 Basic principles of European legislation*

Legislation states that we must focus our efforts "... on preserving and protecting the quality of the environment, and protecting human health through preventive actions" (Council Directive 96/82/EC "Seveso II").

It also demands "Health and safety at the workplace" (Machinery Directive, workplace, health and safety legislation, ...).Legislation demands that this and similar goals are achieved for various areas ("Areas which are legislated") in the EC Directives. In order to achieve these goals, legislation places demands on the operators and users of plant, and the manufacturers of equipment and machines. It also assigns the responsibility for possible injury or damage.

The EC Directives

- Specify demands placed on plant and systems and their operators/users to protect the health and safety of personnel and environmental quality;
- Contain regulations about health and safety at the workplace (minimum requirements);
- Define product features and characteristics to protect the health and safety of users;
- Make a differentiation between requirements placed on the realization and implementation of products to guarantee free trade and the requirements regarding the use of products.

The EC Directives, which are associated with implementing new products, are based on a new global concept ("new approach," "global approach"):

- EC Directives only contain general safety goals and define fundamental safety requirements.
- Standards Committees, which have received an appropriate mandate from the EC Commission (CEN, CENELEC), can define technical details in the Standards. These Standards are harmonized under a specific Directive and are listed in the Official Journal of the EC. When the harmonized standards are fulfilled, then it is assumed that the associated safety requirements of the directives are also fulfilled (for more detailed information, refer to Section 1.2.3 "Safety of Machinery")
- Legislation no longer specifies that specific standards have to be met. However, it can be "reasonably assumed" that when specific standards are observed, the associated safety goals of the EC Directives are fulfilled.
- EC Directives specify that Member States recognize each other's national regulations and laws.

The EC Directives have the same degree of importance, i.e. if several Directives apply for a specify piece of equipment or device, then the requirements of all of the relevant Directives have to be met (e.g. for a machine with electrical equipment, the Machinery Directive, and Low-Voltage Directive apply).

Other regulations apply to equipment where the EC Directives are not applicable. They include regulations and criteria for voluntary tests and certifications.

The list of EC Directives with the associated lists of harmonized standards is provided in the Internet under:

http://www.NewApproach.org/directiveList.asp

Low-Voltage Directive

The Low-Voltage Directive (73/23/EC) applies to electrical equipment with rated voltages in the range between 50 and 1000 V AC or between 75 and 1500 V DC (for the revision presently being carried-out, it is possible that the lower voltage limits may be omitted). This is a New Approach Directive. EN 60204-1 is listed under the Low-Voltage Directive for "Electrical equipment of machines." This means, that if EN 60204-1 is fulfilled, then it can be reasonably assumed that the Directive is fulfilled.

(Note: The requirements to fulfill the Low-Voltage Directive are not discussed in any more detail in this Manual.)

1.2.2 Health and safety at the workplace in the EC

The requirements placed on health and safety at the workplace are based on Article 137 (previously 118a) of the EC Contract. The Master Directive "Health and Safety of Personnel at the Workplace" (89/391/EC) specifies minimum requirements for safety at the workplace. The actual requirements are subject to domestic legislation and can exceed the requirements of these Master Directives. The requirements involve the operation of products (e.g. machines), and not with their implementation.

* Note: The EFTA countries have decided to adopt the EC concept.

1.2.3 Safety of Machinery in Europe

Machinery Directive (98/37/EC)*

With the introduction of a common European market, a decision was made to harmonize the national standards and regulations of all of the EC Member States. This meant that the Machinery Directive, as an internal Directive, had to be implemented in the domestic legislation of the individual Member States. In Germany, the contents of the Machinery Directive were implemented as the 9th Decree of the Equipment Safety law. For the Machinery Directive, this was realized with the goal of having unified protective goals and to reduce trading barriers. The area of application of the Machinery Directive corresponds to its definition "Machinery means an assembly of linked parts or components, at least one of which moves..." which encompasses a wide scope. With the Change Directives, the area of application has been subsequently extended to "safety components" and "interchangeable equipment." The Machinery Directive involves the implementation of machines.

"Machinery" is also defined as an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole"..

The application area of the Machinery Directive thus ranges from a basic machine up to a complete plant.

The Machinery Directive has 14 Articles and 7 Annexes.

The basic health and safety requirements in Annex I of the Directive are mandatory for the safety of machinery.

Machinery Directive

Application area, selling, marketing, freedom of movement, health and safety requirements	Certification procedure	CE marking, protection against arbitrary fulfillment	Coming into force, transitional regulations, cancellation of the regulations
Art. 1 – Art. 7	**Art. 8 – Art. 9**	**Art. 10 – Art. 12**	**Art. 13 – Art. 14**

Annex		Article
	Essential health and safety requirements relating to the design and construction of machinery, and • interchangeable equipment • safety components	3 5 10
II	Contents of 1. EC Declaration of Conformity for machinery, and • interchangeable equipment • safety components 2. Manufacturer's declaration for – specific components of the machinery – non-functioning machines	4 5 8 4
III	CE marking	10
IV	Types of machinery and safety components, where the procedure acc. to Article 8 must be applied.	
V	EC Declaration of conformity for machinery, and • interchangeable equipment • safety components	8
VI	EC type examination for machinery and • interchangeable equipment • safety components	8
VII	Minimum criteria for testing bodies	9

Fig. 1/1
Overview of the Machinery Directive

In selecting the most appropriate methods, the manufacturer must apply the following principles, in the order given (Annex I Paragraph 1.1.2):

a) "The machine design must guarantee that operation, equipping and maintenance, when the machine is correctly used, does not represent any potential danger to personnel."

"The measures must exclude any risk of accident..."

b) "When selecting the appropriate solutions, the manufacturer must apply the following basic philosophy, and more specifically in the specified sequence:

- Eliminate or reduce the risks as far as possible (integrating the safety concept into the development and the construction of the machine);
- Take the necessary protective measures against risks that cannot be eliminated;

* replaces 89/392/EC, 91/368/EC, 93/44/EC, 93/68/EC.

Types of machinery and safety components, for which the procedure referred to in Article 8, Paragraph 2, Letters b) and c) must be applied.

A. Machinery

1. Circular saws (single or multi-blade) for working with wood and analogous materials or for working with meat and analogous materials

1.1. Swing machines with fixed tool during operation, having a fixed bed with manual feed of the workpiece or with a demountable power feed.

1.2. Sawing machines with fixed tool during operation, having a manually operated reciprocating saw-bench carriage

1.3. Sawing machines with fixed tool during operation, having a built-in mechanical feed device for the workpieces, with manual loading and/or unloading

1.4. Sawing machines with movable tool during operation, with a mechanical feed device and manual loading and/or unloading

2. Hand-fed surface planing machines for woodworking
3. Thicknesses for one-side dressing with manual loading and/or unloading for woodworking
4. Band-saws with fixed or mobile bed and band-saws with a mobile carriage, with manual loading and/or unloading, for working with wood and analogous materials or for working with meat and analogous materials
5. Combined machines of the types referred to in 1 to 4 and 7 for working with wood and analogous materials
6. Hand-fed tenoning machine with several tool holders for woodworking
7. Hand-fed vertical spindle molding machines for working with wood and analogous materials
8. Portable chain saws for woodworking
9. Presses, including press-brakes, for the cold working of metals, with manual loading and/or unloading, whose movable working parts may have a travel exceeding 6 mm and a speed exceeding 30 mm/s
10. Injection or compression plastic-molding machines with manual loading or unloading
11. Injection or compression rubber-molding machines with manual loading or unloading
12. Machinery for underground working or the following types:
    – machinery or rails: Locomotives and brake-vans
    – hydraulic-powered roof supports
    – internal combustion engines to be fitted to machinery for underground working
13. Manually-loaded trucks for the collection of household refuse incorporating a compression mechanism
14. Guards and detachable transmission shafts with universal joints as described in Section 3.4.7.
15. Vehicle-servicing lifts
16. Devices for the lifting of persons involving a risk of falling from a vertical height of more than 3 meters
17. Machines for the manufacture of pyrotechnics

B. Safety components

1. Sensor-controlled devices to detect persons e.g. light barriers, sensor mats, electromagnetic detectors
2. Logic units which ensure the safety functions of bimanual controls
3. Automatic movable screens to protect the presses referred to in 9, 10 and 11 (Letter A)
4. Rollover protection structures (ROPS)
5. Falling-object protective structures (FOPS)

Fig. 1/2
Annex IV of the Machinery Directive

- Inform users of the residual risks due to any shortcomings of the protection measures adopted.

The protection goals must be responsibly implemented in order to fulfill the demand for conformance with the Directive.

The manufacturer of a machine must prove that the basic requirements have been fulfilled. This proof is made easier by applying harmonized standards.

A certification technique is required for machines listed in Annex IV of the Machinery Directive, which represent a more significant hazard potential. (Recommendation: Machinery, which is not listed in Annex IV, can also represent a high potential hazard and should be appropriately handled.) The precise "technique to define whether compliance exists" with the goals, is defined in Chapter II of the Directive.

Standards

To sell, market or operate/use products, these products must fulfill the basic safety requirements of the EC Directives. Standards can be extremely helpful when it involves fulfilling these safety requirements. In this case, a differentiation must be made between harmonized European Standards and other Standards, which although are ratified, they have still not been harmonized under a specific Directive, as well as other technical rules and regulations which are also known as "National Standards" in the Directives.

Ratified Standards describe recognized state-of the-art technology. This means, that by proving that he has applied them, a manufacturer can prove that he has fulfilled what is a recognized state-of-the-art technology.

Generally, all Standards, which have been ratified as European standards, must be included, unchanged in the domestic (national) Standards of the

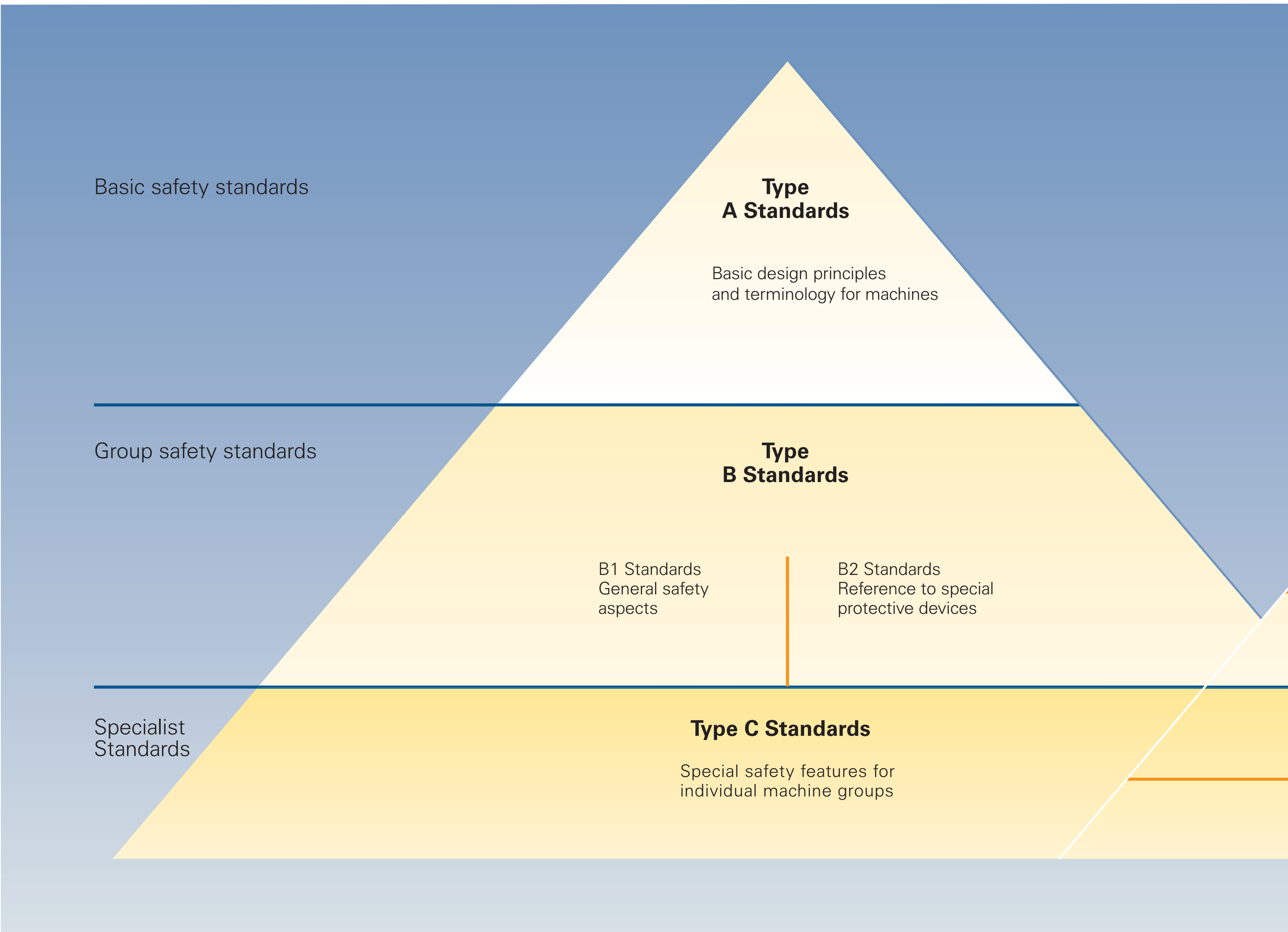


Fig. 1/3
European Standards for Safety of Machinery

Member States. This is independent of whether they are harmonized under a particular Directive or not. Existing National Standards, handling the same subject, must then be withdrawn. Thus, within a period of time in Europe, a unified set of regulations will be created (without any contradictions).

Note: IEC 61508 is an important Standard which has not been harmonized under a particular EC Directive - "Functional safety of electrical/electronic/programmable electronic safety-related systems," as there is no appropriate harmonized standard. It is ratified as EN 61508. The German Draft Standards DIN V VDE 0801 and DIN V 19250 and 19251 will therefore be withdrawn by August 2004.

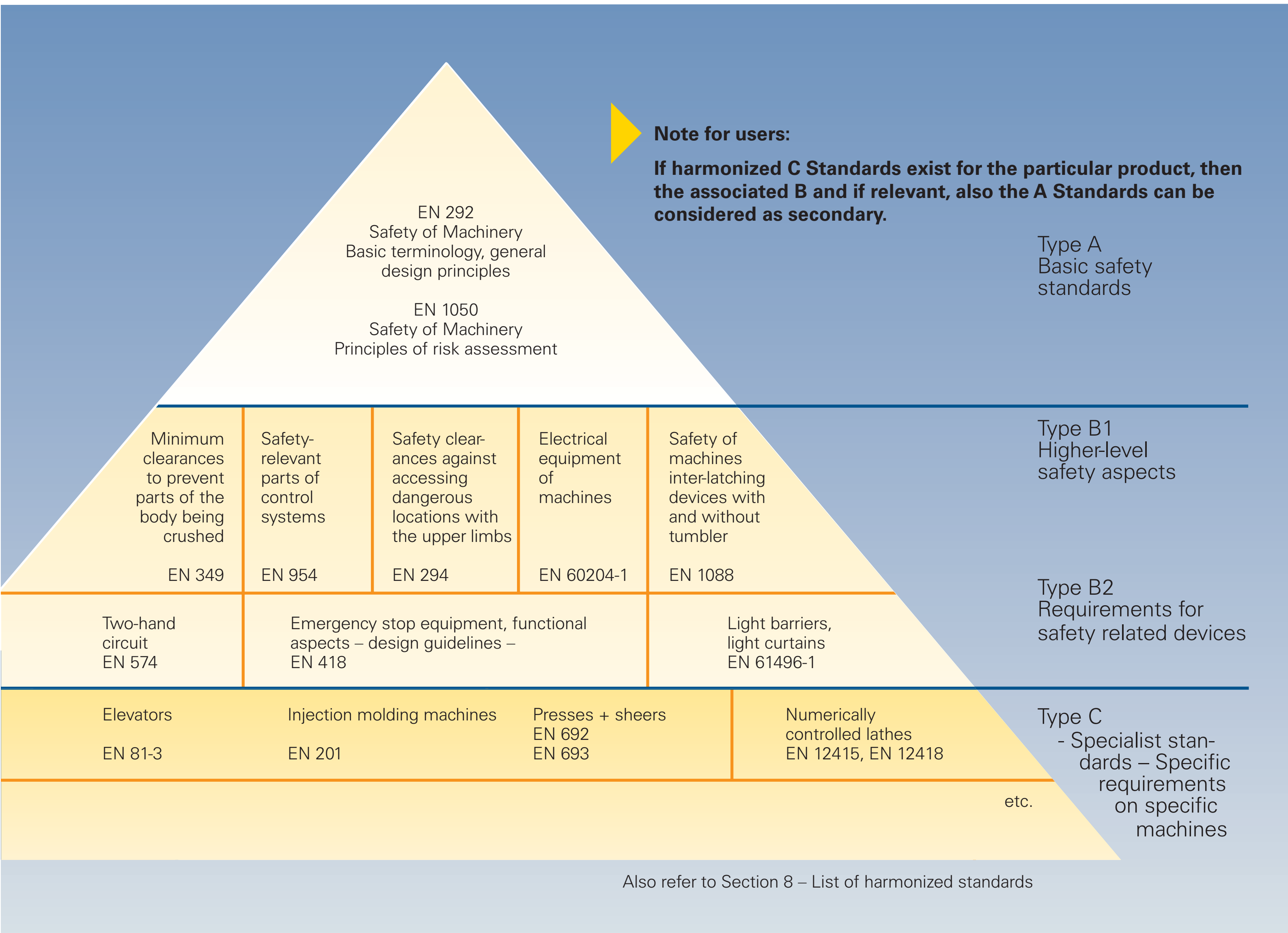
Harmonized European Standards

These are drawn up by the two standards organizations CEN (Comité Européen de Normalisation) and CENELEC (Comité Européen de Normalisation Électrotechnique) as mandate from the EC Commission in order to fulfill the requirements of the EU Directives for a specific product, which must be published in the official Council Journal of the European communities. These Standards (EN Standards) are then transferred into the national standards unchanged.

They are used to fulfill the basic health and safety requirements and the protective goals specified in Annex I of the Machinery Directive.

DIN and DKE are the contact partners for CEN / CENELEC .

By fulfilling such harmonized standards, there is an "automatic presumption of conformity," i.e. the manufacturer can be trusted to have fulfilled all of the safety aspects of the Directive as long as they are covered in the par-



ticular Standard. However, not every European Standard is harmonized in this sense. The listing in the European documentation is definitive The latest versions can be found in the Internet (address: http:// www.NewApproach.org/ directiveList.asp).

The European Standards for the safety of machinery are hierarchically structured as follows

- A Standards,
  also known as Basic Standards.
- B Standards,
  also known as Group Standards.
- C Standards,
  also known as Product Standards.

The diagram above shows the structure.

Type A Standards/Basic Standards

Type A Standards contain basic terminology and definitions for all machines. This includes EN 292 “Safety of machinery - Basic concepts, general principles for design.”

Type A Standards primarily address those parties setting B and C Standards. The techniques for minimizing risks, specified there, can, however, also be helpful for manufacturers if there are no relevant C Standards.

Type B Standards/Group Standards

These include all Standards with safety-related statements, which can involve several types of machines.

Type B Standards also primarily address those parties setting C Standards. However, they can also be helpful for manufacturers when designing and constructing machinery if there are no relevant C Standards.

For B Standards an additional subdivision was made:

Type B1 Standards for higher-level safety aspects, e.g. ergonomic design principles, safety distances from potential sources of danger, minimum clearances to prevent crushing of body parts.

Type B2 Standards for safety equipment are specified for various machine types, e.g. EMERGENCY STOP equipment, two-hand controls, interlocking/latching, non-contact protective devices, safety-related parts of controls.

Type C Standards/Product Standards

These involve the machinery-specific Standards, e.g. for machine tools, woodworking machines, elevators, packaging machines, printing machines etc.

The European Standards are structured so that general statements which are already included in type A or type B standards are not repeated. References to these are made in type C Standards

Product Standards include machinery-specific requirements. These requirements, under certain circumstances, deviate from the Basic and Group Standards. For machinery OEMs, type C Standard/Product standards have the highest priority. They (the machinery OEMs) can then assume that they fulfill the basic requirements of Annex I of the Machinery Directive (automatic presumption of conformity).
If there is no Product Standard for a particular machine, then Type B Standards can be applied for orientation purposes when constructing machinery.

In order to provide a method to harmonize the basic requirements of the Directive, with the mandate of the EC commission, harmonized standards were drawn-up in the technical committees of the CEN and CENELEC for machinery or machinery groups for almost all areas. Drawing-up the standards essentially involves representatives of the manufacturer of the particular machinery, the regulatory bodies, such as Trade Associations as well as users. An overview of the most important type A, B and C standards is provided in Section 8. A complete list of all of the listed Standards as well as the activities associated with Standards - with mandate - are provided in the Internet under:

http://www.NewApproach.org/directiveList.asp

Recommendation: Technology is progressing at a tremendous pace which is also reflected in changes made to machine concepts. For this reason, especially when using Type C Standards, they should be checked to ensure that they are up-to-date. It should also be noted that it is not mandatory to apply the standard but instead, the safety objective must be achieved.

National Standards

If harmonized European Standards are not available, or they cannot be applied for certain reasons, then the manufacturer can utilize "National Standards."All of the other technical rules fall under this term, e.g. also the accident prevention regulations and standards, which are not listed in the European Council Journal (also IEC or ISO Standards which were ratified as EN). By applying ratified standards, the manufacturer can prove that recognized state-of-the-art technology was fulfilled. However, when such standards are applied, the above mentioned "automatic presumption of conformity" does not apply.

Risk evaluation/assessment

As a result of their general design and functionality, machines and plants represent potential risks. Therefore, the Machinery Directive requires a risk assessment for every machine and, if relevant, risk reduction, so that the remaining risk is less than the tolerable risk. The following Standards should be applied for the technique to assess these risks:

- EN 292 "Safety of machinery – Basic concepts, general principles for design" and
- EN 1050 "Safety of machinery – Principles for risk assessment"

EN 292 mainly handles the risks to be evaluated and design principles to reduce risks. EN 1050 basically handles the iterative process with risk assessment and risk reduction to achieve safety.

Risk assessment

Risk assessment is a sequence of steps, which allows hazards, which are caused by machines, to be systematically investigated. Where necessary, the risk assessment phase is followed by risk reduction. The interactive process (refer to Graphic 1/5) is obtained by repeating this procedure. This allows potential hazards to be removed as far as possible, and allows the appropriate protective measures to be taken

The risk assessment includes:

- Risk analysis
  a) Determining the limits of the machine (EN 292, EN 1050 Paragraph 5)
  b) Identification of hazards (EN 292, EN 1050 Paragraph 6)
  c) Techniques to estimate risks (EN 1050 Paragraph 7)
- Risk evaluation (EN 1050 Paragraph 8)

After risks have been estimated, a risk evaluation is made as part of an iterative process to achieve safety. In this case, a decision has to be made

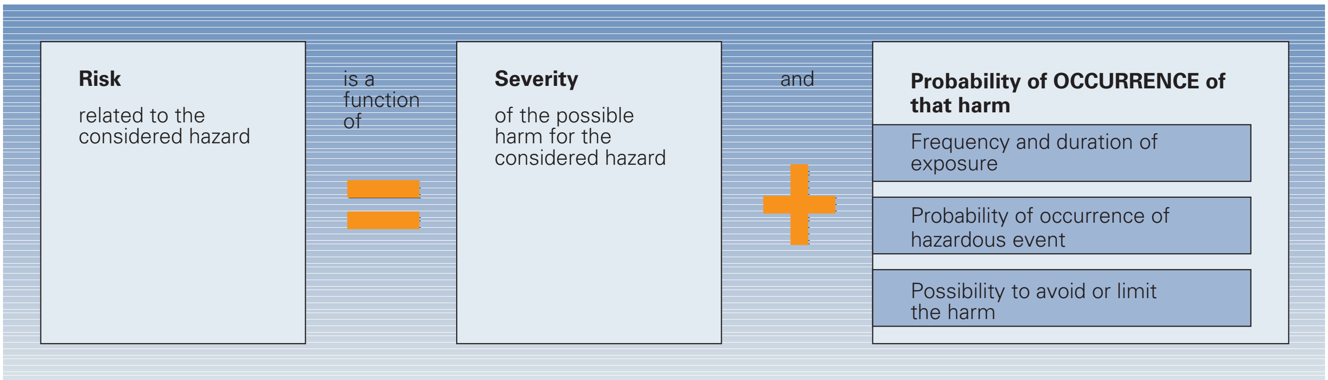


Fig. 1/4
Risk elements

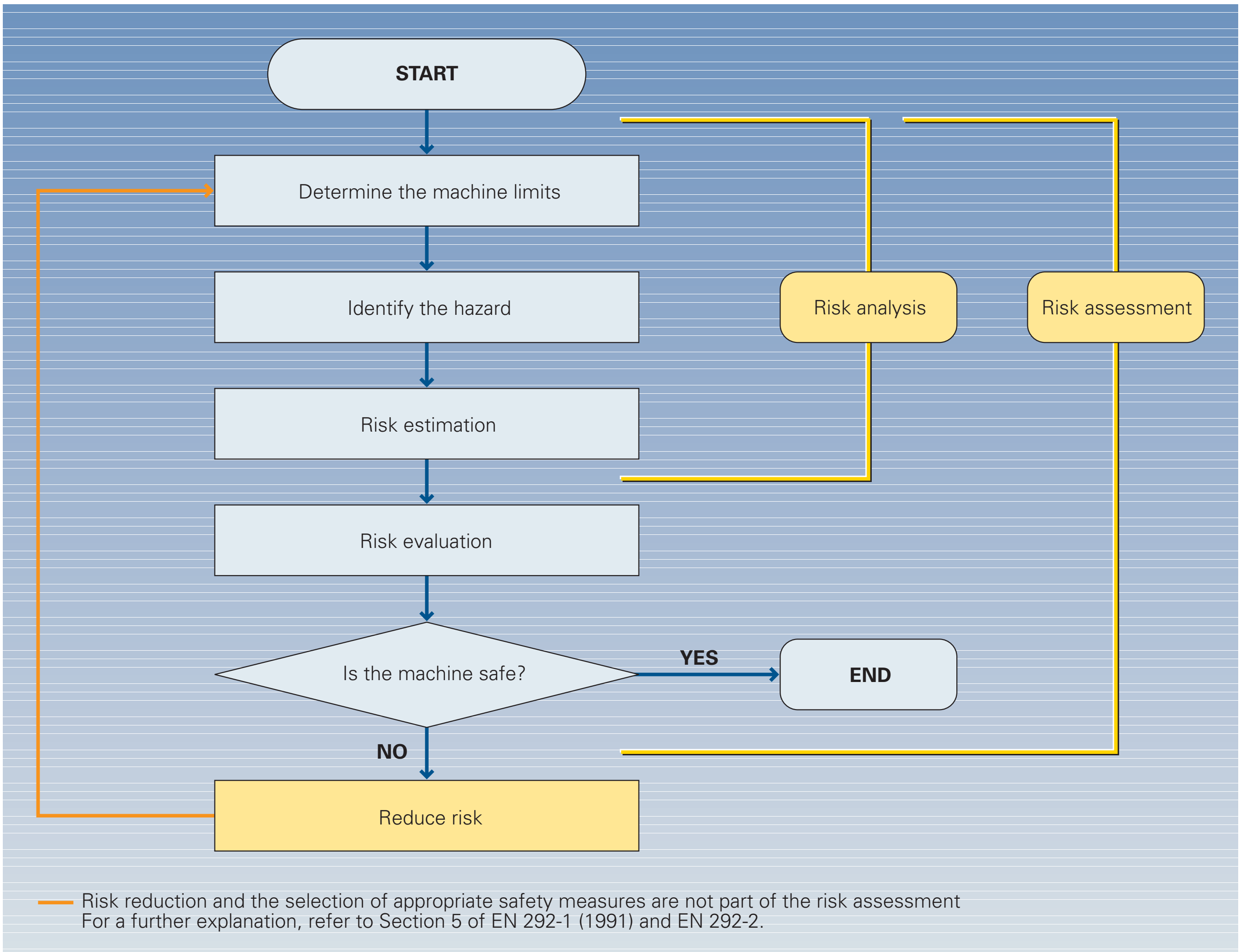


Fig. 1/5
Iterative process to achieve safety in accordance with EN 1050

whether it is necessary to reduce a risk. If the risk is to be further reduced, suitable protective measures must be selected and applied. The risk evaluation must then be repeated.

If the required degree of safety has still not been reached, measures are required to further reduce the risk. The risk must be reduced by suitably designing and implementing the machine. For instance, using suitable control or protective measures for the safety functions (also refer to the Section "Requirements of the Machinery Directive"). If the protective measures involve interlocking or control functions, then these must be configured in accordance with EN 954. When using electronic controls and bus systems to implement these protective measures, then, in addition, IEC / EN 61508 must also be fulfilled.

Standard EN 1050 calls this operation an iterative process to achieve safety (refer to Fig. 1/5).
Risk elements are defined as a support tool to evaluate risks. Graphic 1/4 shows the inter-relationship between these risks elements.

Residual risk (EN 1050)

Safety is a relative term in our technical environment. Unfortunately, it is not possible to implement the so-called "zero risk guarantee" where nothing can happen under any circumstances. The residual risk is defined as: Risk, which remains after the protective measures have been implemented.
In this case, protective measures represent all of the measures to reduce risks.

Reducing risks

In addition to applying structural measures, risk reduction for a machine can also be realized using safety-relevant control functions. For these control functions, special requirements must be observed, which are classified according to the level of risks. These are described in EN 954-1 and, for complex control systems with programmable electronics, in IEC 61508.

The requirements placed on safety-relevant parts of control systems are classified in categories according to the level of risk. Techniques to select a suitable Category as reference point for configuring the various safety-related parts of a control system are recommended in Annex B of EN 954-1 (refer to Fig. 1/6). A detailed concept to evaluate the risk and to determine the necessary requirements placed on the control system are presently drawn-up in the form of Draft IEC 62061. It is important that all of the parts and components of the controls, which are involved in implementing the safety-relevant function fulfill these requirements.

After the control has been implemented, it is necessary to check whether the requirements of the selected Category have been fulfilled. The control must be validated. The details of how this validation process is actually carried-out and what has to be taken into account is described in Section 2 of EN 954. Presently, this section is available as Draft prEN954-2.

The adjacent table shows a brief summary of the requirements for the various categories. The complete text of the requirements is contained in EN 954-1 "Safety-related parts of control systems," Section 6 "Categories." Basic requirements for configuring control systems are defined in the various categories. These are intended to make the systems tolerant to hardware failures.

Additional aspects must be taken into consideration for more complex control systems, especially programmable electronic systems, so that

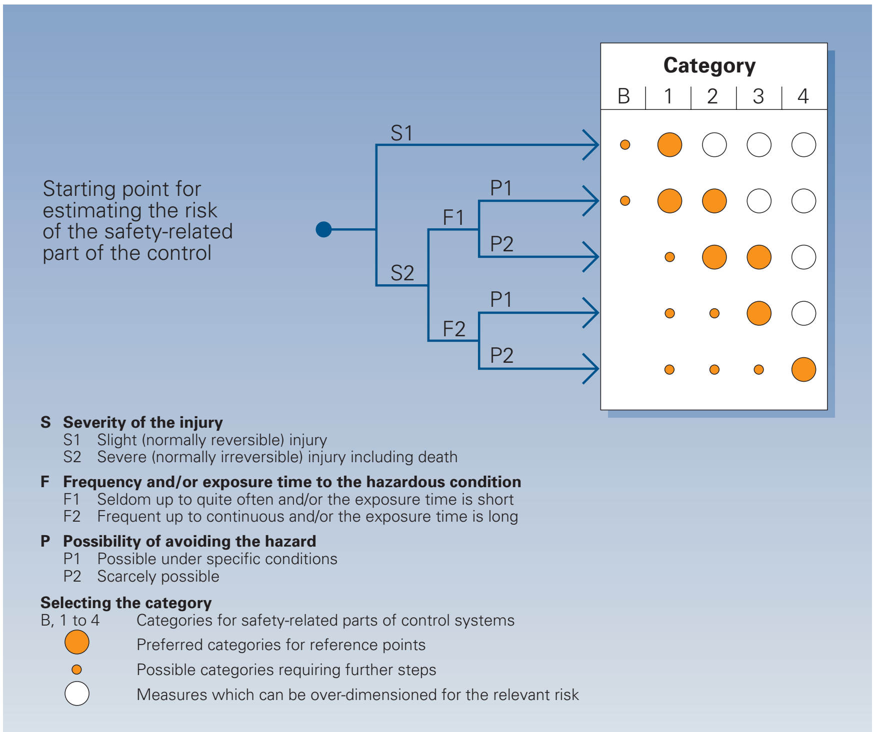


Fig. 1/6
Possible selection of the Categories in accordance with EN 954-1

• random hardware failures can be controlled,

• systematic errors/faults in the hardware and software are avoided

• systematic errors/faults in the hardware and software can be controlled,

and sufficient functional safety is achieved for safety-critical tasks. The necessary requirements are described in the International IEC 61508 Standard (the previous DIN V VDE 0801 will be withdrawn in August 2004 as part of the European harmonization of EN 61508) and for contactless protective devices such as light arrays or laser scanners IEC / EN 61496-1. The scope of the required measures is also graded corresponding to the risk reduction required.

In order to support the implementation and application of these systems, presently, other standards are being developed with IEC 62061 "Safety of Machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems " and IEC 61800-5-2 "Adjustable speed electrical power drive systems - functional safety requirements."

Validation

The subject of "validation" is handled in the Draft Standard prEN954-2 "Safety of Machinery – Safety-related parts of control systems." In this case, validation means that the safety functionality to be achieved is checked and evaluated. This Standard corresponds to the status of a B1 safety group Standard (general safety aspects). The purpose of the validation is to confirm the definitions and level of conformity of the safety-related parts of the controls within the overall definition of safety requirements on the machinery.

Category[1]	**Summary of requirements**	**System behavior**[2]	**Principles to achieve safety**
B	Safety-related parts of control systems and/or their protective-equipment, as well as their components, shall be designed, constructed selected, assembled and combined in accordance with relevant standards so that they can withstand the expected influence.	The occurrence of a fault can lead to the loss of the safety function	Mainly characterized by selection of components
1	Requirements of B shall apply. Well-tried components and well-tried safety principles shall be used.	The occurrence of a fault can lead to the loss of the safety function but the probability of occurrence is lower than for Category B.	
2	Requirements of B and the use of well-tried safety principles shall apply. The safety function shall be checked at suitable intervals by the machine control system.	– The occurrence of a fault can lead to the loss of the safety function between the checks. – The loss of the safety function is detected by the check.	Mainly characterized by structure
3	Requirements of B and the use of well-tried safety principles shall apply. Safety-related parts shall be designed, so that: – a single fault in any of these parts does not lead to the loss of the safety function, and – whenever reasonably practicable, the single fault is detected.	– When the single fault occurs, the safety function is always performed. – Some but not all faults will be detected. – Accumulation of undetected faults can lead to the loss of the safety function	
4	Requirements of B and the use of well-tried safety principles shall apply. Safety-related parts shall be designed so that: – a single fault in any of these parts does not lead to a loss of the safety function and – the single fault is detected at or before the next demand upon the safety function. If this is not possible, then an accumulation of faults shall not lead to a loss of the safety function	– When the faults occur, the safety function is always performed. – The faults will be detected in time to prevent the loss of the safety function.	

[1] The categories are not intended to be used in any given order or in any given hierarchy in respect of safety requirements.

[2] The risk assessment will indicate whether the total or partial loss of the safety function(s) arising from faults is acceptable.

Fig. 1/7
Description of the requirements for the Categories in accordance with EN 954-1

The validation must show that every safety-related part or component fulfills the requirements laid down in EN 954-1. The following aspects are described:

- Validation using analysis
- Validation using testing
- Fault lists
- Validation of safety functions
- Validation of categories
- Validation of the environment requirements
- Validation of the service/maintenance requirements

An overview of the validation technique in compliance with EN 954-2 is shown in Fig. 1/8.

The validation plan must identify and describe the requirements to carry-out the validation technique for the defined safety functions and their categories. Where appropriate, it must also document these. Fig. 1/9 illustrates the requirements placed on the documentation corresponding to the various Categories.

The requirements, described in EN 954-1, are not adequate for systems utilizing programmable electronic systems. This is the reason that EN 954-2 specifies that additional standards, e.g. the IEC 61508 or contactless protective devices, IEC 61496 are used for validation.

These extensive requirements refer to the development and implementation of controls, not to the application and parameterization of certified systems, Simatic S7-300F, Sinumerik Safety Integrated, Siguard Laser Scanner and Light Curtains, PROFIsafe or AS-i *Safety at Work*.

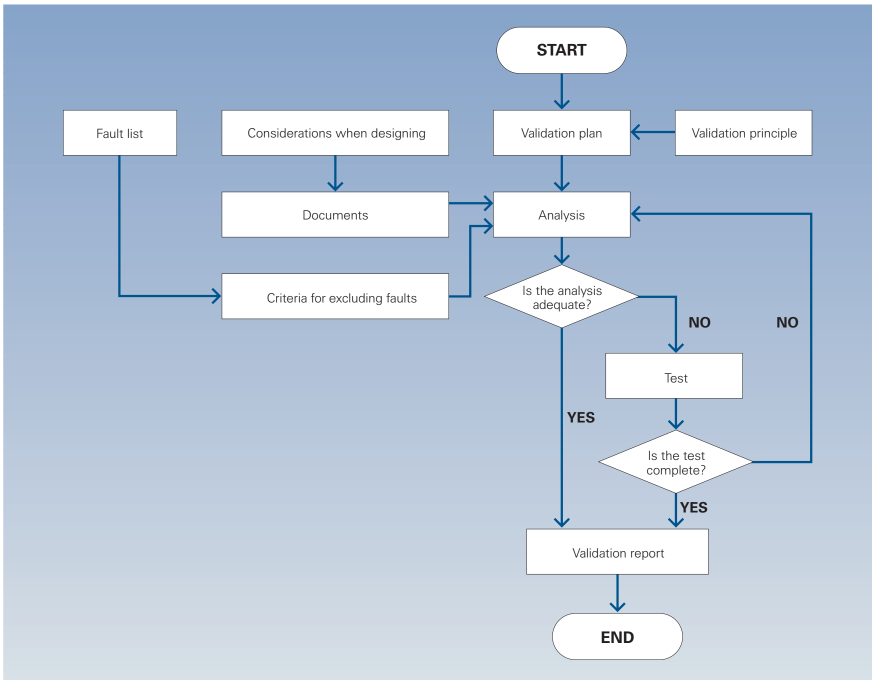


Fig. 1/8
Overview of the validation process (from prEN 954-2)

Documentation requirements	Category for which documentation is required				
	B	**1**	**2**	**3**	**4**
Basic safety principles	X	X	X	X	X
Stressing expected in operation	X	X	X	X	X
Influence of the material being processed	X	X	X	X	X
Performance during other relevant external influences	X	X	X	X	X
Proven components	–	X	–	–	–
Proven safety principles	–	X	X	X	X
The test technique for safety function(s)	–	–	X	–	–
Defined test internals	–	–	X	–	–
Individual faults which can be predicted and have been taken into account in the design and the detection technique applied	–	–	X	X	X
All identified faults with a common cause and how they can be prevented	–	–	–	X	X
How the safety function is maintained for each fault/error	–	–	–	X	X
Faults which are to be detected	–	–	X	X	X
Various fault groups which must be taken into account in the design	–	–	–	X	X
How the safety function should be maintained for all combinations of faults	–	–	–	–	X

Fig. 1/9
Documentation requirements (from prEN 954-2)

1

Safety Integrated

The measures which are required to make a complex control adequately and functionally safe for safety tasks are extremely extensive and involve the complete development and manufacturing process. Therefore, controls have to be specifically designed to fulfill safety functions. SIMATIC S7-300F / S7 400F/FH and SINUMERIK "Safety Integrated" are examples of such control systems. This also applies to the communication systems PROFIsafe and AS-i *Safety at Work*, PROFIBUS and AS-i which are used to transfer safety-related data.

Safety-related functions

The safety-related functions include, in addition to conventional functions

- Stop
- Actions in an emergency situation
- Preventing accidental starting

and, in the meantime, even complex functions, such as

- State-dependent interlocking
- Speed limiting
- Position limiting
- Speed deviation, to name just a few

The classic functions are defined in EN 60204-1 and were, up until now, generally implemented using mechanical components. Electronic programmable systems can also be used to implement more complex functions, if they fulfill the relevant Standards (IEC 61508, EN 954). Complex functions, e.g. which involve the behavior of variable-speed drives, are described in draft IEC 61800-5-2.

Stop

Stop categories of EN 60204-1

Three stop categories are defined in EN 60204-1 (VDE 0113 Part 1) which define the control sequence for stopping, independent of an emergency situation:

Stop category 0

Uncontrolled stop by immediately removing the power to the machine drive elements.

Stop Category 1

Controlled stop; the power is only removed after the machine has come to a standstill.

Stop Category 2

Controlled stop, where power is still fed to the machine at standstill.

Emergency operations and actions

EN 60204-1/11.98 has, harmonized with HD 384 (IEC 60364; VDE 0100) defined the following possible actions for emergency situations (EN 60204-1 Annex D):

Action in an emergency situation includes

individually, or a combination of:

- Stopping in an emergency situation (EMERGENCY STOP);
- Starting in an emergency situation (EMERGENCY START);
- Power-off in an emergency situation (EMERGENCY SWITCHING-OFF);
- Power-on in an emergency situation (EMERGENCY SWITCHING-ON).

According to EN 60204-1 and EN 418, these functions are exclusively initiated by a conscious manual intervention.
In the following text, only "Power-off in an emergency situation" and "stopping in an emergency situation" will be discussed. The latter fully corresponds to the same terminology in the EC Machinery Directive. For reasons of simplicity, EMERGENCY SWITCHING-OFF and EMERGENCY STOP will be used in the following.

EMERGENCY SWITCHING-OFF

This is an intervention (action) in an emergency situation, which disconnects power to a complete system or installation or part of it, if there is a risk of electric shock or another risk caused by electricity (from EN 60204-1 Annex D).

Functional aspects to disconnect the power in an emergency situation are defined in IEC 60364-4-46 (this is identical to HD 384-4-46 and VDE 0100 Part 460).

Power must be disconnected in an emergency situation, where

- Protection against direct contact (e.g. with contact cables, slip ring assemblies, switchgear in electrical rooms) is only achieved by maintaining a clearance or barrier;
- Other hazards or damage could occur as a result of electric power.

Further, the following is specified in 9.2.5.4.3 of EN 60204-1:

In an emergency situation, the power supply is disconnected from the machine, which results in a Category 0 Stop.

If a Category 0 Stop is not permissible for a machine, then it may be necessary to provide other protection, e.g. against direct contact, so that power does not have to be disconnected in an emergency situation.

This means that EMERGENCY SWITCHING-OFF should be used where the risk analysis indicates a hazard due to electric voltage/power and therefore requires that the voltage is immediately disconnected from the complete machine.

In the EC, EMERGENCY SWITCHING-OFF devices fall under the Low-Voltage Directive 73/23/EC if they are not used in conjunction with machines. If they are used in conjunction with machines, then they come under the Machinery Directive 98/37/EC as is true for all of the other electrical equipment associated with a machine.

EMERGENCY STOP

This is an action, in an emergency situation, which is defined to stop a process or movement which would otherwise have potentially hazardous consequences (from EN 60204-1 Annex D).

Further, the following is defined in 9.2.5.4.2 of EN 60204-1:

Stop

In addition to the requirements for Stop (refer to 9.2.5.3), the following requirements apply for an emergency stop:

– it must have priority over all other functions and actions in all operating modes;

– the power to the machine actuators, which could cause a hazardous condition or conditions must be disconnected as quickly as possible without creating other hazards (e. g. using mechanical stopping/braking devices, which do not require an external supply, by using counter-current braking for Stop Category 1);

– resetting may not initiate a restart.

Stopping in an emergency situation must either be effective as a Stop, Category 0 or Category 1 (refer to 9.2.2). The Stop Category in an emergency situation must be defined as the result of the risk evaluation for the particular machine.

To technically implement EMERGENCY STOP corresponding to the recommended application in the Foreword of EN 60204-1, either the requirements specified in EN 60204-1 or in EN 954 and IEC 61508 can be applied. EN 60204-1 primarily requires that this is implemented using electromechanical components, as "basic" (programmable) electronic systems are not safe enough. By correctly applying EN 954 and, if required, IEC 61508, electronic and programmable electronic components become functionally safe enough that they can also be used to implement EMERGENCY STOP for all categories (German National Foreword: "... this therefore clearly states that electronic equipment can also be used for EMERGENCY STOP devices independent of the Stop Category ...").

Devices for EMERGENCY SWITCHING-OFF and EMERGENCY STOP

Devices which are used to stop equipment and machinery in an emergency situation must be provided at every operator control location and also at other locations where it may be necessary to initiate a stop in an emergency situation (exception: operator control stations which are not connected through cables). In order to fulfill the protective goals, specified in EN 60204-1 as well as EN 418, the following requirements apply for both functions (also refer to 10.7 in EN 60204-1):

- When contacts switch even with just a brief actuation, the control device must *positively latch*.
- It is not permissible that the machine can be restarted from a remote main operator control station without the hazard or danger first having been removed. The emergency off device must be *consciously released again "locally"*.

Operator control stations which are connected without using cables must have a dedicated and clearly identified possibility of initiating the Stop function of the machine. The operator section, which initiates this stop function, may not be marked or labeled as a device to shut down the machine in an emergency situation.

Implementing safety-related functions

When implementing safety-related control functions using programmable electronic systems, the requirements of EN 954 and IEC 61508 must be fulfilled. When the requirements of these standards are taken into account, it is possible, to even implement complex functions by using electronics and programmable electronic systems, for example, a fail-safe SIMATIC or SINUMERIK. These functions can then be implemented in a safety-related fashion.

Man – Machine

In order to simplify the interaction between man and machine, reference is made to Standards EN 60073 and DIN EN 60204.

Switches, pushbuttons and signaling lamps are predominantly used as machine components as the interface between man and the machine. These operator control elements are clearly and uniformly identified using color coding, which has a very specific significance. This guarantees that the safety of operating personnel is increased and it is easier to handle and maintain the operating resources/plants and systems.

The colors of pushbuttons, the significance of these colors, explanations and application examples are shown in Fig. 1/10.

According to DIN EN 60204-1 (VDE 0113 Part 1) the following information has to be observed:

The preferred colors for START/ON operator devices should be WHITE, GREY or BLACK - preferably WHITE. GREEN may be used, RED may not be used.

RED must be used for EMERGENCY STOP devices. The colors for STOP/OFF operator control devices should be BLACK, GREY or WHITE - preferably BLACK. RED is also permitted. It is not permissible to use GREEN.

WHITE, GREY and BLACK are the preferred colors for pushbuttons, which can be used alternating as START/ON and STOP/OFF pushbuttons. It is not permissible to use RED, YELLOW or GREEN.

WHITE, GREY and BLACK are the preferred colors for pushbutton control elements which initiate an operation while they are being pressed and end that operation when they are released (e. g. jogging). It is not permissible to use RED, YELLOW or GREEN.

Color	Meaning	Explanation	Examples of application
RED	Emergency	Actuate in the event of a hazardous condition or emergency	EMERGENCY STOP, Initiation of EMERGENCY STOP functions, conditional for STOP/OFF
YELLOW	Abnormal	Actuate in the event of an abnormal condition	Intervention to suppress an abnormal condition, Intervention to restart an interrupted automatic cycle
GREEN	Normal	Actuate to initiate normal conditions or normal status	START/ON, however WHITE should be preferably used
BLUE	Mandatory	Actuate for a condition requiring mandatory action	Reset function
WHITE	No specific meaning assigned	For general initiation of functions except for EMERGENCY STOP (see note)	START/ON (preferred), STOP/OFF
GREY			START/ON, STOP/OFF
BLACK			START/ON, STOP/OFF (preferred)

Note: Where a supplemental means of coding (e. g. shape, position, texture) is used for the identification of pushbutton actuators, then the same color WHITE, GREY or BLACK may be used for various functions , e. g. WHITE for START/ON and for STOP/OFF actuators.

Fig. 1/10
Colors for pushbuttons and their significance in accordance with EN 60204-1 (VDE 0113 Part 1): 06.93

Color	Meaning	Explanation	Action by operator	Examples of application
RED	Emergency	Hazardous condition	Immediate action to deal with a hazardous condition (e.g. by operating emergency stop)	Pressure/temperature outside safe limits, voltage drop, voltage interruption, passing through a stop position
YELLOW	Abnormal	Abnormal condition Impending critical condition	Monitoring and/or intervention (e.g. by re-establishing the intended function)	Pressure/ temperature outside normal operating ranges Tripping a protective device
GREEN	Normal	Normal condition	Optional	Pressure/temperature within the normal operating ranges, permissive signal to continue
BLUE	Mandatory	Indication of a condition that requires action by the operator	Mandatory action	Prompt to enter specified values
WHITE	Neutral	Other conditions; may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring	General information

Fig.1/11
Colors for indicator lamps and their significance in accordance with EN 60204-1 (VDE 0113 Part 1): 06.93

GREEN is reserved for functions which display a safe or normal operating condition.

YELLOW is reserved for functions which display an alarm or a non-standard (abnormal) condition.

BLUE is reserved for functions which require a specific action.

Reset pushbuttons must be BLUE, WHITE, GREY or BLACK. If they also act as STOP/OFF pushbuttons, WHITE, GREY or BLACK are permissible - but preferably BLACK. It is not permissible to use GREEN.

The colors of the indicating lamps, their significance with reference to the status of the machine as well as their handling and application examples are listed in Fig. 1/11.

For illuminated pushbuttons, the information in Figs. 1/10 and 1/11 applies. If problems are encountered when assigning suitable colors, WHITE must be used. For EMERGENCY STOP devices, the color RED may not be dependent on the illumination state of the device.

Coding cables

The color coding of switches, pushbuttons and indicator lamps has been discussed in the previous Section. EN 60204 offers a higher degree of flexibility when coding cables. It specifies that, "... cables at every connection must be able to be identified in conformance with the technical documentation..." .

It is sufficient if terminals are numbered, corresponding to the information in the circuit diagram if the cable can be visually traced. For complex controls, we recommend that the internal cables used for wiring as well as the outgoing cables are coded so that after the cable has been disconnected from the terminal, it can be easily re-connected to the same terminal. This is also recommended for terminal locations which have to be disconnected when the equipment is transported.

Using the formulation in IEC 60204-1 1997, Paragraph 14.2.1 conductor core coding/identification, the Standards Committee wanted to make the following statement:

1. Each individual cable must be able to be identified, however, only in conjunction with the documentation. It is not necessary that every cable can be identified without using the documentation.
2. The type of coding and also the identification technique should be agreed between the manufacturer and the owner/operating company.

It is not the intention of the Standard to specify a specific coding type worldwide. For instance, for safety reasons, factory-internal specifications may have a higher priority in order to avoid confusion in specific areas which are handled by the same personnel. These definitions cannot be generalized due to the wide application range of the particular Standard - from small individual machines (high unit volume standard products) up to large, complex plants (with unique equipment and systems).

Primarily, appropriate testing should be used to avoid installation/assembly faults.

Instead of many different colors, a single color can be used for the internal wiring. It should be color-coded as follows:

- *Black for*
  Main AC and DC circuits
- *Red for*
  AC control circuits
- *Blue for*
  DC control circuits
- *Orange for*
  Interlocking circuits which are supplied from an external power source.

The above color assignment is recommended if a decision is made to just use color coding. The only mandatory specification is the color coding of the protective conductor and the neutral conductor. For all other cabling and wiring, one of the methods listed in 14.2.4 can be selected (color, numbers or letters; or a combination of colors and numbers or colors and letters).

Protective conductor marking

The protective conductor must be able to be uniquely identified as a result of its shape, location, coding or color. If it is only identified as a result of its color, then a two color-combination of *green/yellow* must be used along the whole length of the cable. The green/yellow color may only be used for protective conductors.

Neutral conductor marking

If a circuit has a color-coded neutral conductor, then *light blue* must be used. Light blue may not be used to code other cables if there is a danger of accidentally interchanging them.

If a neutral conductor is not used, a light-blue conductor may be used for other purposes, but not as protective conductor.

1.2.4 Process technology in Europe

Legislative requirements in Europe

For process technology, essentially the following EC Directives must be applied:

- Council Directive 96/82/EC from the 9th of December 1996 on the control of major accident hazards involving dangerous substances ("Seveso Directive" II).
- Low-Voltage Directive
- Machinery Directive (98/37/EC)
- Pressure Equipment Directive (97/23/EC). The latter is only relevant in so much that the devices used must fulfill this directive. "The Directive on the other hand does not apply for assembling devices at the user's plant, for example, in industrial systems under his responsibility."

At the same time, the Health and Safety at Work and Accident Prevention Regulations must always be carefully observed and adhered to.

"Seveso Directive"

This EC Directive specifies, corresponding to the principles explained in the introduction, the safety goal,

⇒"... preserving and protecting the quality of the environment, and protecting human health through preventive action."

In order to achieve this goal, the following basic requirements have been drawn-up, which the Member States must ensure are fulfilled.

⇒ Concept to prevent severe accidents

The owner/operating company is responsible for "... drawing-up a document setting-out his major accident prevention policy and appropriate steps to ensure that it is properly implemented. The major accident prevention policy established by the owner/operating company shall be designed to guarantee a high level of protection for man and the environment by applying appropriate means, structures and management systems" (Article 7 Paragraph 1).

The document must also take into account . the following basic principles:

- The concept to prevent severe accidents must be in written form.
- A safety management system in which, among others, the following issues are regulated:
  - determining an evaluating the risks – defining and applying techniques to systematically determine hazards.
  - operation monitoring – defining and applying techniques for safe operation, including the maintenance and service of the plants and systems.
  - quality assurance – defining and applying techniques to continuously ensure that the goals are achieved.

⇒ Safety report

The owner/operating company is responsible in generating a safety report, in which the following is defined,

- that a concept.... has been implemented,
- that the hazards have been identified and all of the required measures to prevent these types of accidents and limit the impact for man and the environment have been put in place, and
- the implementation, building/construction, installation and operation of all plant and systems, ... is adequately safe and reliable.

⇒ Inspection

The regulatory bodies must set up a system of inspections to systematically check the operational, organizational and management-specific systems of the operation which will allow these regulatory bodes to confirm that the user/operating company can prove

- that he has undertake measures to prevent severe accidents,
- he has provided adequate measures to limit the results of any accidents.

This EC Directive must be nationally implemented.
In Germany, this is realized using the fault case regulations.

Note: The "Seveso Directive" is not a Directive of the "New Approach." This means that it cannot be automatically assumed that the goals of the Directive are fulfilled if the harmonized Standards are applied. The exact requirements are regulated at a national level.

Technical measures to fulfill legislative goals

The first priority is to design the process so that it is inherently safe. Where this is not possible, as a result of the process, then additional measures are required in order to reduce the remaining risk to a tolerable level. This can be realized using electronic controllers if these are suitable for the particular task. Electronic controllers are suitable for securing the safety of the plant, if they have been specifically designed for this purpose. The requirements are described in the Standards.

Relevant Standards for safety measures using process control technology

For safety measures using process control technology, for example in Germany, the following national standards have been applied, so far.

- DIN V 19250 "Basic safety issues for control and instrumentation protective devices"
- DIN V 19251 "Instrumentation and control protective devices - requirements and measures for safety-related functioning"
- DIN V VDE 0801 "Basic rules for computers in systems with safety-related tasks".

These standards will lose their validity in 08.2004 due to the ratification of EN 61508. EN 61508 should then be applied. The specific standard for the process industry is IEC 61511 "Functional safety: Safety instrumented systems for the process industry sector" which was finally decided by vote in 2002. IEC 61511 defines the requirements of EN/IEC 61508, specifically for the process industry.

Beyond this, additional Standards apply for the devices and equipment used. These Standards involve the specific safety requirements. Also refer to Chapter Safety of Machinery (refer to Chapter 1.2).

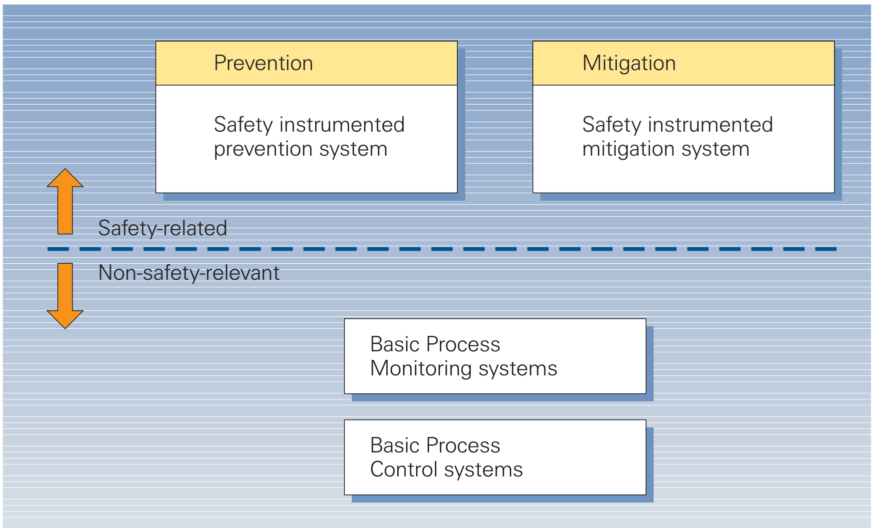


Fig. 1/12
Arrangement of process control systems in safety-related/non-safety-related configurations

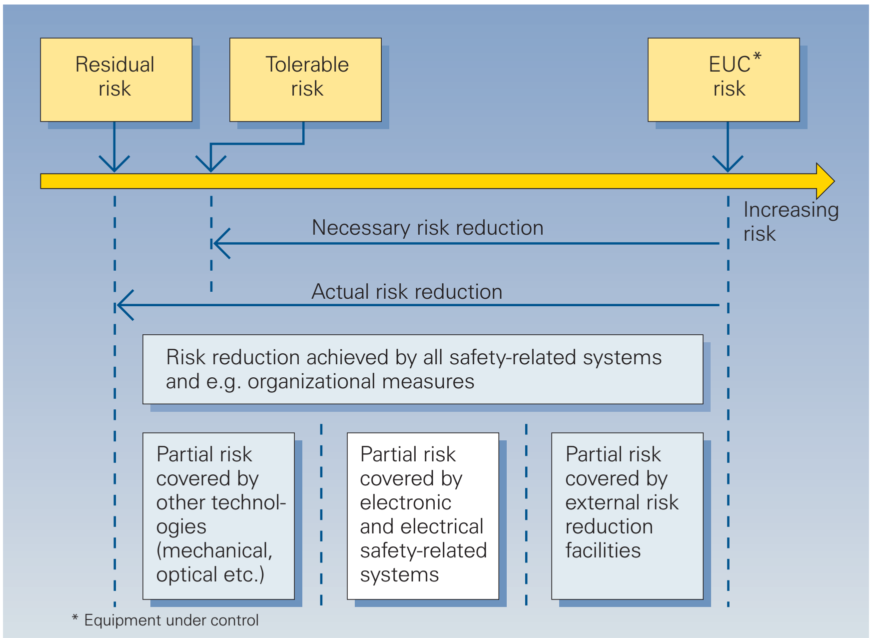


Fig. 1/13
Principle of risk reduction (acc. to IEC 61508)

Reducing risks when using process control technology

Measures are required to reduce risks, if faults or disturbances in the basic process control system and monitoring devices can lead to a dangerous event or can cause the plant or system to go into a hazardous condition and if the resulting risk is unacceptably high.
In this case, suitable protective measures must be taken, either to sufficiently reduce the probability of a hazardous event occurring, or to reduce the extent of the damage. This can be achieved using process control protective equipment and systems if these fulfill the safety requirements.

Risk reduction

As it is not possible to completely exclude certain risks - both from a technical and cost-effective standpoint - it is necessary not only to determine the existing risk, but also to define and specify a risk which can be tolerated. The measure for the safety integrity of the risk-reducing functions is then derived from the difference between these two factors. EN 61508 defines "Safety Integrity Level" (SIL) as a target measure for the probability of failure when executing risk-reducing functions.

Safety Integrity Level	**High demand or continuous mode of operation** (probability of a dangerous failure per hour)	**Low demand mode of operation** (average probability of failure to perform its design function on demand)
4	$\geq 10^{-9}$ to $< 10^{-8}$	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-8}$ to $< 10^{-7}$	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-7}$ to $< 10^{-6}$	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-6}$ to $< 10^{-5}$	$\geq 10^{-2}$ to $< 10^{-1}$

Fig.1/14
Safety Integrity levels according to IEC 61508: Target failure measure for a safety function, allocated to a safety-related system

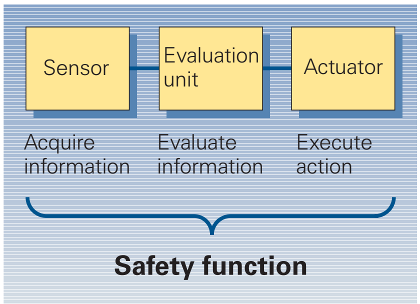


Fig. 1/15
Evaluation unit, e.g. safety PLC

Selecting the equipment and basics of the required features

Safety function

Risk reduction using electronic controllers is realized by defining functions for each possible hazardous event or each possible dangerous condition of the plant or system, which prevents the dangerous event occurring. These so-called "safety functions" are to maintain the plant or system in a safe state or to re-establish this safe state if a dangerous event could occur due to a failure or a disturbance in the plant or system. This means that the safety function can also be used to reduce the extent of the damage due to a hazardous event.

The definition of a safety function always includes the specification of the function itself (e. g. inhibiting the feed to a container, if the level has reached the upper limit), and the "Safety Integrity (SIL)," derived from the risk analysis.

Implementing the safety functions

Every safety function always includes the complete chain, from information acquisition, through information evaluation up to executing the required action.

The equipment involved, for example, fail-safe PLCs, sensors and actuators etc. must fulfill, as a total, the determined SIL.
If a device is used at the same time for various safety functions, it must fulfill the highest SIL of the individual functions.

Device characteristics and features

If PLCs are used for information processing, these must fulfill as "safety PLC," the requirements of the relevant Standards (i.e. IEC 61508), and fulfill the specified SIL. They must also be certified by an independent tester. The essential characteristics and features of a fail-safe PLC which are specified by the standards are:

- When developing, manufacturing and servicing, specific measures and techniques must be applied so that systematic faults can be avoided.
- The PLC must be able to control systematic failures which occur during operation.
- The PLC must detect random hardware failures during operation and be able to control them.
- To be able to control a failure means that when the system detects a fault or failure, the safety function, defined for this particular case (e. g. shut down the plant) is reliably executed.

Similar requirements also apply for complex field devices. Details on this are described in IEC 61511.

Application

When using a fail-safe PLC, only the conditions defined in the associated Safety Manual, and, if relevant, additional conditions of the certificate, must be maintained.

In addition, for the peripheral devices which are to be connected (e.g. sensors and actuators), the requirements in the Standards (IEC 61508 or IEC 61511) must also be taken into account regarding the following aspects:

- Systematic faults must be avoided, e. g. configuring, installation and handling faults.
- Random faults or failures must be detected and controlled.
- Necessary fault tolerance. This depends on the proportion of faults which go towards a safe condition.
- Required service/maintenance (repeated tests).

"Safe" failure fraction	Hardware fault tolerance (refer to Note 2)		
	0 (refer to Note 3)	**1**	**2**
< 60%	not permissible	SIL 1	SIL 2
90%	SIL 1	SIL 2	SIL 3
99%	SIL 2	SIL 3	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

Note 2: Hardware fault tolerance is the maximum number of faults, as a result of random hardware failures, which can occur without resulting in a hazardous failure.

Note 3: A hardware fault tolerance of zero means that a single fault can result in a hazardous failure.

Fig. 1/16
Maximum permissible SIL for complex subsystems, dependent on their fault tolerance and the "safe failure fraction" (acc. to IEC 61508-2)

IEC 61508 defines the maximum permissible SIL as a function of its fault tolerance and the safe failure fraction (also refer to Fig. 1/17). ("Safe failure" means all those failures where the system remains in a safe condition). This can be achieved using fault detection and a defined response to the fault. A required response must be performed within a suitably short time. These times are specified in IEC 61508-2.

In order to detect faults or failures in peripheral devices, test and monitor functions can be integrated into the safety PLC.

When using complex peripheral devices (e.g. transmitters with microprocessor), it must be ensured that these devices themselves fulfill the relevant Standards (EN 61508 or IEC 61511).

The complete safety-instrumented system must be configured so that it fulfills the relevant standards for all of the safety-relevant functions. EN 61508 or IEC 61511 are relevant regarding functional safety.

1.2.5 Furnace systems in Europe

EC Directives

Furnaces and burners are subject to the relevant Directives as a result of their application and the devices and equipment which are used (e.g. Machinery Directive, Pressured Equipment Directive (...), Directive for gas burners (90/396/EEC)). There are no specific EC Directives for furnace systems. Furnaces are subject, where relevant, to application-specific Directives. Industrial thermo-processing equipment is, for example, classified as machinery under the Machinery Directive.

Standards

Industrial thermo-processing equipment and systems

There is a European draft standard for these systems, which was drawn-up under a mandate of the Machinery Directive, and more precisely EN 746 "Industrial thermo-processing equipment" with

Part 1: General safety requirements of industrial thermo-processing equipment

Part 2: Safety requirements for combustion and fuel handling systems.

EN 746 can be applied to industrial thermal-processing equipment, for example

- Metal producing and processing plants,
- Glassworks,
- Ceramic plants,
- Cement, lime and gypsum plants,
- Chemical plants,
- Incinerators etc.

This refers to EN 60204-1 and EN 954-1 and for safety-relevant electronic systems, also to IEC 61508.

Furnaces

For furnaces which do not belong to industrial thermal-processing equipment and are not used to heat process liquids and gases in the chemical industry, there are the following general Standards for electrical equipment - the European Draft Standard.

- EN 50156 "Electrical equipment for furnaces Part 1: Requirements for application design and installation"

And the German Standard

- DIN VDE 0116 "Electrical equipment for furnaces."

The following standards are presently in force for burners

- EN 676 gas burners;
- EN 230 oil vapor burner in a monoblock design;
- EN 267 oil burner;
- EN 298 automation equipment for furnaces for gas burners and bas units with and without blower.

1.3 Legal Requirements and Standards Regarding Safety at Work in the US

Note: The following information is only intended to provide an overview of the general principles and basic requirements. It may not be considered as a complete description of the situation. The reader of this document must, in addition, inform himself about the precise requirements as well as the domestic and local regulations for his particular application.

A significant difference between the legal requirements for Safety at Work between the US and Europe is that in the US there is no unified legislation, across the US, which is applicable for the safety of machines, and which fully covers the responsibility of the manufacturer/supplier. In fact, there is a general requirement that the employer provides a safe place of work. This is regulated with the Occupational Safety and Health Act (OSHA) of 1970. The core requirements of OSHA are listed in Section 5 "Duties":

(a) Each employer --

(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;

(2) shall comply with occupational safety and health standards promulgated under this Act.

The requirements from the OSH Act are administered and managed by the Occupational Safety and Health Administration (also called OSHA). OSHA uses regional inspectors which check whether the workplace (places of employment) fulfill the applicable regulations.

The regulations, relevant for safety at work of the OSHA are defined and described in OSHA 29 CFR 1910.xxx ("OSHA Regulations (29 CFR) PART 1910 Occupational Safety and Health"). (CFR: Code of Federal Regulations).

Also refer to www.osha.gov.

The following is stated at the beginning of the regulations for the Safety and Health Program (29 CFR 1900.1):

"(b)(1) What are the employer's basic obligations under the rule? Each employer must set up a safety and health program to manage workplace safety and health to reduce injuries, illnesses and fatalities by systematically achieving compliance with OSHA standards and the General Duty Clause."

And later

"(e) Hazard prevention and control.

(e)(1) What is the employer's basic obligation? The employer's basic obligation is to systematically comply with the hazard prevention and control requirements of the General Duty Clause and OSHA standards.

(e)(2) If it is not possible for the employer to comply immediately, what must the employer do? The employer must develop a plan for coming into compliance as promptly as possible, which includes setting priorities and deadlines and tracking progress in controlling hazards.

Note: Any hazard identified by the employer's hazard identification and assessment process that is covered by an OSHA standard or the General Duty Clause must be controlled as required by that standard or that clause, as appropriate."

The application and use of various Standards is regulated in 29 CFR 1910.5 "Applicability of standards." The concept is similar to that in Europe. Product-specific standards have priority over general standards as long as the associated aspects are actually handled there. When the standards are fulfilled, the employer can assume that he has fulfilled the core requirements of the OSH Act regarding the aspects actually handled in the standard.

1910.5 (f) "An employer who is in compliance with any standard in this part shall be deemed to be in compliance with the requirement of section 5(a)(1) of the Act, but only to the extent of the condition, practice, means, method, operation, or process covered by the standard."

1.3.1 Machine safety

Minimum requirements of the OSHA

The OSHA Regulations under 29 CFR 1910 include general requirements for machines and machinery (1910.121) and a series of specific requirements for certain types of machines. The requirements specified are extremely specific but have little technical detail.

Excerpt from 29 CFR 1910.212 "General requirements for all machines":

"(a)(1)

Types of guarding. One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are barrier guards, two-hand tripping devices, electronic safety devices, etc."

An example for the requirements placed on the control of presses is the following excerpt from 29 CFR 1910.217 "Mechanical Power Presses":

"(b)(13)

Control reliability. When required by paragraph (c)(5) of this section, the control system shall be constructed so that a failure within the system does not prevent the normal stopping action from being applied to the press when required, but does prevent initiation of a successive stroke until the failure is corrected. The failure shall be detectable by a simple test, or indicated by the control system. This requirement does not apply to those elements of the control system which have no effect on the protection against point of operation injuries."

"(h)(6)(xvii)

Controls with internally stored programs (e.g., mechanical, electro-mechanical, or electronic) shall meet the requirements of paragraph (b)(13) of this section, and shall default to a predetermined safe condition in the event of any single failure within the system. Programmable controllers which meet the requirements for controls with internally stored programs stated above shall be permitted only if all logic elements affecting the safety system and point of operation safety are internally stored and protected in such a manner that they cannot be altered or manipulated by the user to an unsafe condition."

The OSHA regulations define minimum requirements to guarantee safe places of employment. However, they should not prevent employers from applying innovative methods and techniques, e.g. "state of the art" protective systems in order to maximize the safety for employees.

(Refer to, for example: www.osha.gov/ ...Standard Interpretations ... 06/05/2001 - Use of Electro Sensitive Protection Equipment ...)

For specific applications, OSHA specifies that all of the electrical devices and equipment, which are used to protect the employee, are authorized for the application by a nationally recognized testing laboratory (NRTL) which has been authorized by OSHA

(For example, refer to: www.osha.gov/ ...Standard Interpretations ... 08/11/1994 - Presence sensing devices (PSDs) for power presses.: "..OSHA requires that all electrical products used by employees must be treated and approved for their intended use by an OSHA Approved Nationally Recognized Testing Laboratory (NRTL)....").

Application and use of additional standards

In addition to OSHA Regulations, it is just as important to carefully observe the current standards of organizations such as NFPA and ANSI as well as the extensive product liability legislation which is in force in the US. As a result of the product liability, it is in the interests of the manufacturers and operating companies to carefully observe and maintain the regulations and are more or less forced to fulfill the state-of-the-art technology requirement".

Third-party insurance contracts generally demand that the parties fulfill the applicable standards of the standardization organizations. Companies who are self-insured initially do not have this requirement. However, in the case of an accident, they must prove that they had applied generally recognized safety principles.

NPFA 70 (known as the National Electric Code (NEC)) and NFPA 79 (Electrical Standard for Industrial Machinery) are two especially important standards regarding safety in industry. Both of these describe the basic requirements placed on the features and the implementation of electrical equipment. The National Electric Code (NFPA 70) predominantly applies to buildings, but also for the electrical connections from machines and parts of machines. NFPA 79 applies to machines. This results in a grey area (somewhat undefined) in the demarcation between both standards for large machines and machinery which comprise partial machines. For instance, large conveyor systems can be considered to be part of the building so that NFPA 70 and/or NFPA 79 should be applied.

NFPA 79

This standard is valid for the electrical equipment of industrial machines with rated voltages less than 600V. (A group of machines, which operate together in a coordinated fashion, is considered as a machine.)

The new Edition of NFPA 79 - 2002 includes some basic requirements for programmable electronics and buses if these are used to execute safety-relevant functions. If these requirements are fulfilled, electronic controls and buses can also be utilized for Emergency Stop functions of Stop Categories 0 and 1 (refer to NFPA 79 - 2002 9.2.5.4.1.4). Contrary to EN 60204-1, NFPA 79 specifies that, for Emergency Stop functions, the electrical power must be disconnected using electromechanical devices.

The core requirements placed on programmable electronics and buses include:

System requirements
(refer to NFPA 79 - 2002 9.4.3)

- Control systems, which must contain software-based controllers,
  (1) if a single fault/error occurs,
  - the system must be shutdown and brought into a safe state
  - restart must be prevented until the fault has been removed
  - Unexpected starting must be prevented

  (2) must offer a comparable degree of protection to hard-wired control systems

  (3) must be implemented in accordance with a recognized Standard which defines the requirements for such systems.

  In a Note, it is stated that IEC 61508 is a suitable standard.

Requirements placed on programmable equipment and devices (refer to NFPA 79 - 2002 11.3.4)

- Software and firmware-based controllers, which are used for safety-relevant functions, must be listed for such an application (this means, certified by an NRTL).
  In a Note, a statement is made that IEC 61508 specifies the requirements to design such controllers.

ANSI B11

There is a series of additional standards on safety in industry, specified under ANSI B11, which offer additional instructions to achieve the required degree of safety.

1.3.2 Process industry

The basic safety requirements of the OSHA for the process industry are defined in OSHA's Process Safety Management of Highly Hazardous Chemicals, Explosives and Blasting Agents Standard (PSM),
29 CFR 1910.119.
(Refer to www.osha.gov).

Excerpt from 29 CFR 1910.119:

Purpose. This section contains requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. These releases may result in toxic, fire or explosion hazards.

Section (d) with its sub-sections contains the basic requirements placed on process instrumentation.

1910.119(d)

Process safety information. ... the employer shall complete a compilation of written process safety information ... This process safety information shall include information pertaining to the hazards of the highly hazardous chemicals used or produced by the process, information pertaining to the technology of the process, and information pertaining to the equipment in the process.

1910.119(d)(3)

Information pertaining to the equipment in the process.

1910.119(d)(3)(i)(F)

Design codes and standards employed;

1910.119(d)(3)(ii)

The employer shall document that equipment complies with recognized and generally accepted good engineering practices.

OSHA provides guidelines on this with: CPL 2-2.45A "Process Safety Management of Highly Hazardous Chemicals-- Compliance Guidelines and Enforcement Procedures.

OSHA demands that the process instrumentation is implemented in accordance with generally accepted "good engineering practice." With a letter, dated March 2000, OSHA clarified an inquiry from ISA, that ANSI/ISA 84.01 is a standard which is applicable nationwide and which OSHA recognizes as generally accepted "good engineering practice." However, in the same letter, OSHA clearly stated that ISA 84.01 is not the only standard which is considered when fulfilling the requirements of 1910.119 (PSM).

CFR 1910.119 doesn't clearly state whether the requirements refer to the complete instrumentation. Two types of instrumentation are generally used in the process industry. "Safety Instrumented Systems" (SIS) and "Basic Process Control System" (BPCS). ANSI/ISA 91.01 defines that only the SIS is to be handled under the OSHA regulations.

IEC 61511 "Functional safety: Safety Instrumented Systems for the process industry sector" is the IEC standard with the same scope as ISA 84.01. It was developed with significant ISA participation and contains the same principles as ISA 84.01.

A large proportion of processes falls within the scope of ISA 84.01, but does not formally fall under 29 CFR 1910.119 (PSM). Also in this case, the Standard should be applied in order not to violate the basic requirements of the "Duties" section of the Occupational Safety and Health Act (OSHA).

1.4 Safety Requirements for Machines in Japan

1

For applications in Japan

The situation in Japan is different than in Europe and the US. Comparable legal requirements regarding functional safety, which exist in Europe, do not apply here. The product liability does not play such a role as in the US.

There is no legal requirement to apply standards, however, an administrative recommendation to apply JIS (Japanese Industrial Standards):

Japan bases its standards on the European concept and has included basic standards as national standards (refer to the Table))

For machinery OEMs and users operating worldwide

Machinery OEMs who do a lot of export business are extremely interested in fulfilling European and American requirements, so that their products fulfill the requirements and specifications of the various target markets. Companies with globally distributed production facilities also align themselves to the European and American requirements in order to have, as far as possible, standard safety concepts in all of their plants.

ISO/IEC number	JIS number	Note
ISO12100-1 (EN292-1)	TR B 0008	JIS number will be given after ISO12100-1 is approved as IS
ISO12100-2 (EN292-2)	TR B 0009	JIS number will be given after ISO12100-2 is approved as IS
ISO14121 (EN1050)	JIS B 9702	
ISO13849-1 (EN954-1)	JIS B 9705-1	
IEC60204-1	JIS B 9960-1	
IEC1508-1 to 7	JIS C 0508	

Fail-Safe Communications via Standard Fieldbuses

kapitel 2

Fail-Safe Communications using Standard Fieldbuses

Fail-safe communications using standard fieldbuses with PROFIsafe and AS-Interface *Safety at Work*

Selecting the correct installation technology is an important step in reducing costs. In standard technology, the move to distributed concepts and the use of modern fieldbuses have already resulted in significant cost savings.
In the future, further cost savings will be achieved by transferring additional safety-related signals along existing standard fieldbuses.

Overall system with integrated safety

With the "Safety Integrated" concept, for the first time, safety-related signals can be combined with the standard automation data of a system. The PROFIBUS and AS-Interface fieldbus systems are used to form a transparent harmonized overall system.

By placing safety-related communications on these proven standard fieldbuses, plant and system engineers can work more cost-effectively in the standard automation environment as well as in safety technology as they can use the same engineering tools and methods. Contrary to concepts which use special buses to transfer safety-related data, in this case, there is data transparency between the standard and safety-related part of an overall plant or system without requiring any additional interfaces.

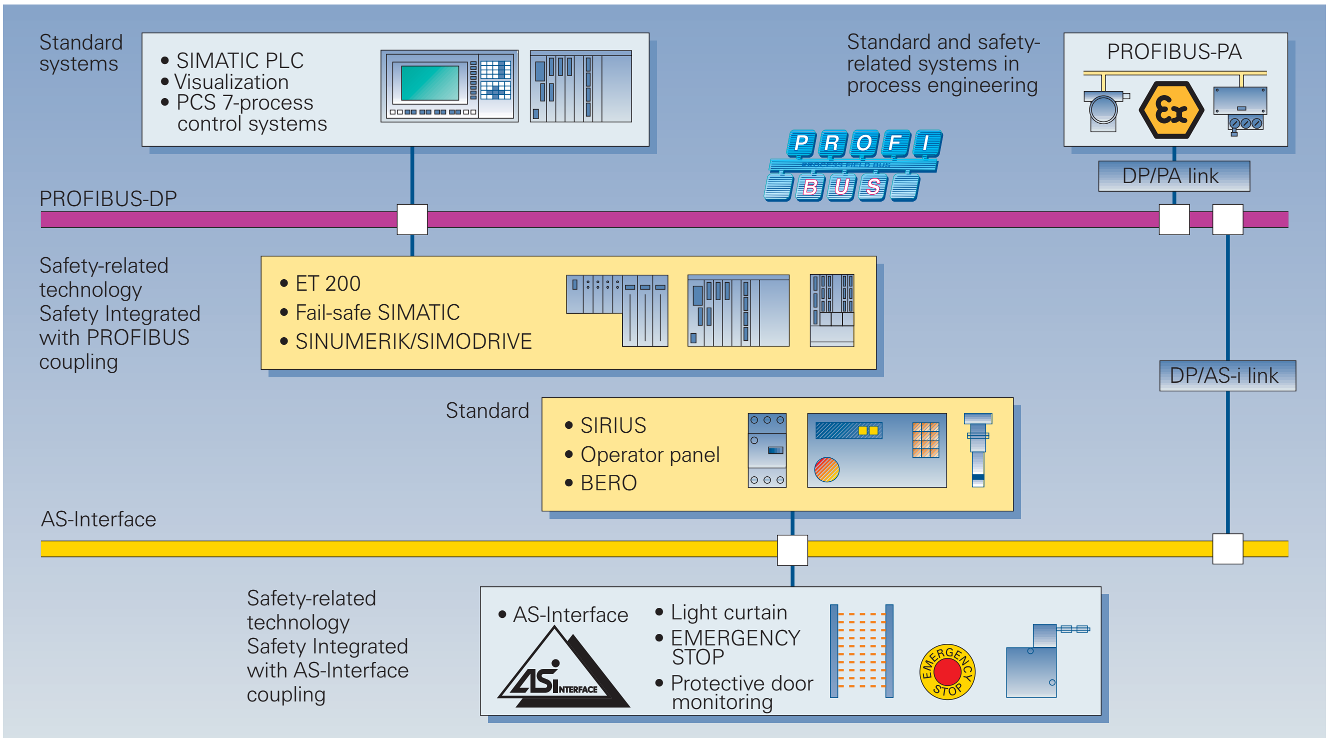


Fig. 2/1
The basic principle of "Safety Integrated":
A unified automation system with integrated safety functions

2.1 PROFIsafe

Safety-related communications via PROFIBUS-DP using PROFIsafe

The PROFIBUS User Organization (PNO) published, in the Spring of 1999, Directives for safety-related communications on Standard PROFIBUS under the PROFIsafe trademark. This was the result of a working group and has also been acknowledged by the BIA [German Trade Association] and the TÜV [German Inspectorate] in the form of positive reports.

From the very start, the goal of the working group was to involve as many possible partners in defining and generating a solution and to make the result available in an open form. In addition to manufacturers of safety systems, more than 25 well-known domestic and international manufacturers of safety-related sensors and actuators, machine tool companies, end users and universities are represented. Intermediate and final results are continually harmonized with the TÜV [German Inspectorate] and the BIA. The Verein Deutscher Werkzeugmaschinenfirmen (VDW) [Association of German Machine Tool Manufacturers], who influenced the development of safety-related technology in the DESINA project, also played a major role. Standardized, complete specifications for distributed safety-related technology have been created by discussing various safety scenarios as a group. The standardized safety technology solutions created reflect the PROFIsafe concept.

PROFIsafe and PROFIBUS stations co-exist on the same cable

The main stipulation when defining the PROFIsafe profile was that safety-related and standard communications should co-exist on one and the same bus cable. The required safety should still be able to be implemented using a single-channel communications system, however, the optional strategy of increased availability by having redundant data channels was not to be excluded.

This is the reason that PROFIsafe is based on already established standard communication components such as cables, ASICs and software packages. The safety-related measures are encapsulated in the safety-related communication end stations. There are essentially no restrictions regarding the baud rate, number of stations or the data transfer technology as long as the required response times of the automation task permit this. The PROFIsafe Directive was already developed in accordance with the new IEC 61508 Standard. prEN 50159-1, which outlines similar solutions for railway

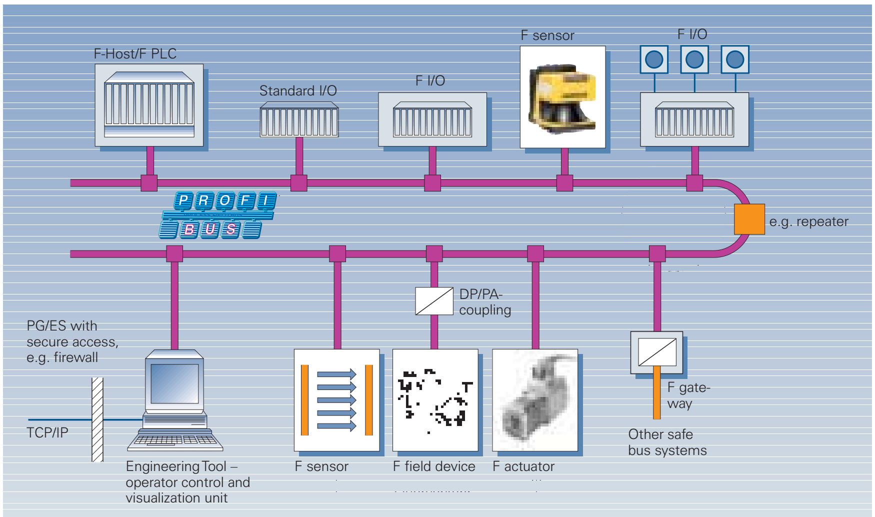


Fig. 2/2
PROFIsafe and PROFIBUS nodes co-exist on the same cable

applications, was used as basis. Additional relevant Standards and regulations were also taken into account. Safety Integrity Level 3 (IEC 61508), Category 4 (EN 954-1) and AK6 (DIN V 19250) have been achieved.

The safety measures incorporated in the PROFIsafe profile are realized using layer 7 of the ISO/OSI communications model. In this case, an additional layer was required which handles the safety-related provision and conditioning of the net data. In a safety-related field device, this function can, for example, be assumed by its technological firmware. As for standard automation, the process signals and process values are packaged in the form of data telegrams. For safety-related data, they are only supplemented by the safety-related information. A standard "Master-Slave mode" mechanism from PROFIBUS is used to send safety-related telegrams. A master, which is generally assigned a CPU, exchanges telegrams with all of the configured slaves.

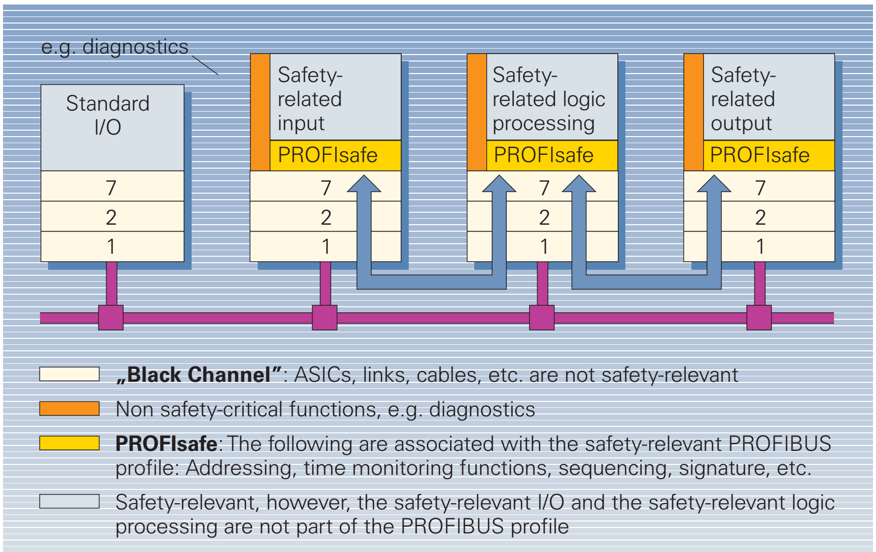


Fig. 2/3
PROFIsafe safety layer above the OSI model

A whole series of errors can occur when sending telegrams. Telegrams can get lost, be received repeatedly, be additionally inserted, arrive in the incorrect sequence or be delayed and corrupted. For safety-related applications, erroneous addressing is also an issue. This means that a standard telegram is erroneously received by a safety-related node (station) and presents itself as safety-related telegram (this is known as masquerading).

The possible error causes and the counter-measures selected for PROFIsafe have been entered into a matrix which is shown in Table 2/1. These include

– consecutive numbering of the safety-related telegrams,

– watchdog with acknowledgment,

– and ID which is transmitted between the sender and receiver ("solution word"), and

– additional data security mechanism (CRC – cyclic redundancy check).

Using the consecutive number, a receiver can recognize whether it received all of the telegrams in the correct sequence.

For safety-related technology, it isn't only important that a telegram transfers the correct process signals or values. These must also be received within a fault tolerance time so that the particular station can, when necessary, automatically and locally initiate the safety responses. To realize this, the stations have an adjustable timeout function, which is restarted after a safety-related telegram has been received.

The 1:1 relationship between a master and slave makes it easier to recognize incorrectly routed telegrams. Both of these have a unique ID in the network ("solution word"), which can be used to check the authenticity of a telegram. Data security using CRC plays a key role. In addition to the data integrity of the transported net data, CRC is also responsible for the integrity of the parameters in various terminal devices.

Measure: / Error:	Consecutive number (sign of life)	Expected time with acknowledgment	ID for sender and receiver	Data security
Repeat	x			
Loss	x	x		
Insertion	x	x	x	
Incorrect sequence	x			
Net data corruption				x
Delay		x		
Coupling safety-relevant and standard messages (masquerade) including erroneous and double addressing		x	x	x
FIFO error within the router		x		

Fig. 2/4
Possible communication errors and how they can be recognized with PROFIsafe functionality

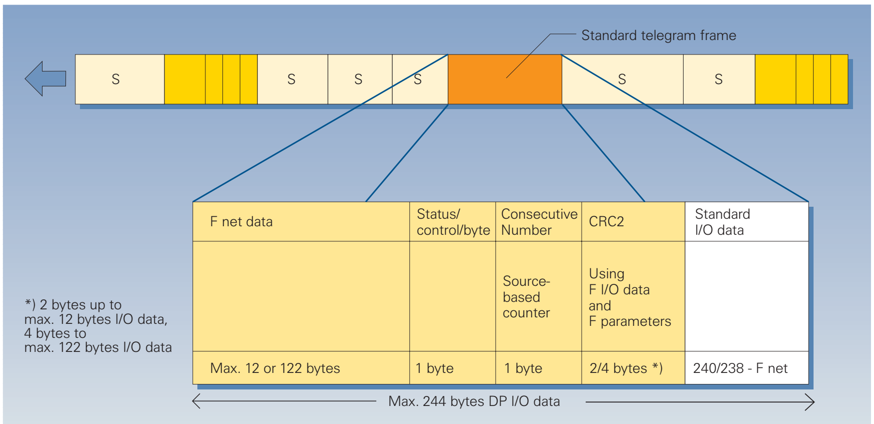


Fig. 2/5
PROFIsafe telegrams simply packaged in standard telegrams

It was more complex to prove the degree of safety for PROFIsafe, as the date integrity measures and the reliability of the standard PROFIBUS were not used for the proof of safety. However, this has the advantage that the users don't have to take any special measures regarding bus cables, shielded, bus couplers etc. for PROFIsafe.

A Markov model is specified in prEN 50159-1. In a slightly expanded form, this can be used to calculate the residual error probability of safety circuits. It assumes three essential causes of corrupted messages which can all be recognized by the two data integrity devices: Failures in ASICs and drivers, electromagnetic disturbances and a special case where only the safety devices in the bus ASIC have failed. Without specific measures, special proof would have to have been provided for every bus configuration.

This would represent a significant restriction for an open standard fieldbus such as PROFIBUS. Thus, a mechanism was created which guarantees that all of the SIL stages are maintained over the lifetime of a distributed safety-related automation solution, independent of the components and configuration used: A patented SIL Monitor, which is implemented in the software.
This Monitor takes into account all conceivable effects arising from errors/faults, and initiates a response if the number of faults or disturbances exceeds a specific level per unit time. The number of permissible faults/errors per unit time depends on the selected SIL stage.

Using PROFIsafe, safety-related plants and systems can be implemented with a high degree of flexibility. On one hand, a single-cable solution with combined standard and safety automation is possible in one CPU. On the other hand, two CPUs and two separate bus cables can also be used. The "homogeneous solution" with a single bus system naturally offers many advantages - especially when it comes to engineering.

Connecting complex terminal devices to PROFIsafe

As a result of the various discussions, the working group members quickly saw that a pure profile description would not be adequate for fast implementation in many "PROFIsafe products." Especially optical safety-related technologies, e.g. utilizing laser scanners and light curtains require a high number of parameters which demand special handling in the teach-in phase. The working group described solutions in the Guidelines, which could be applied for these and additional complex devices.

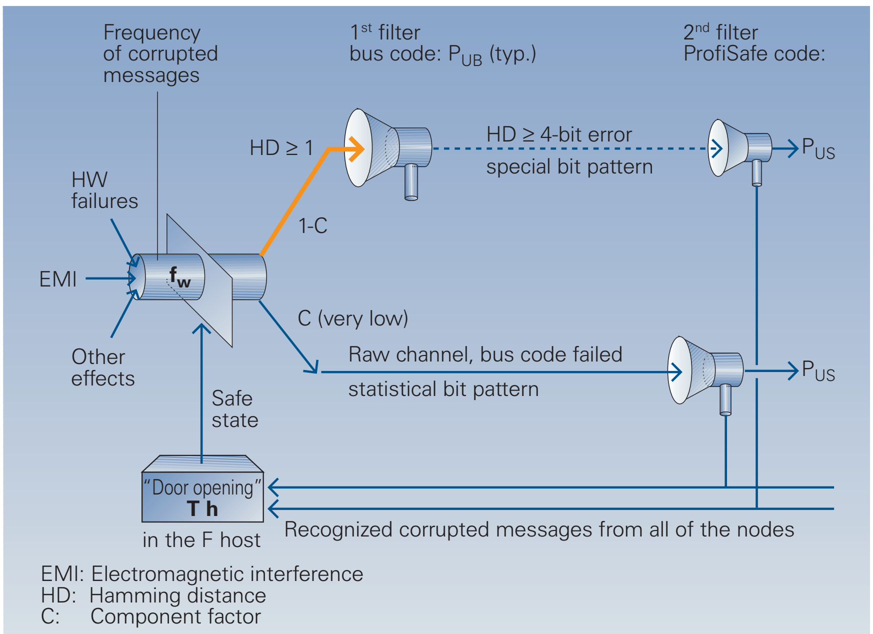


Fig. 2/6
Patented SIL monitor continually monitors the functional safety of PROFIsafe

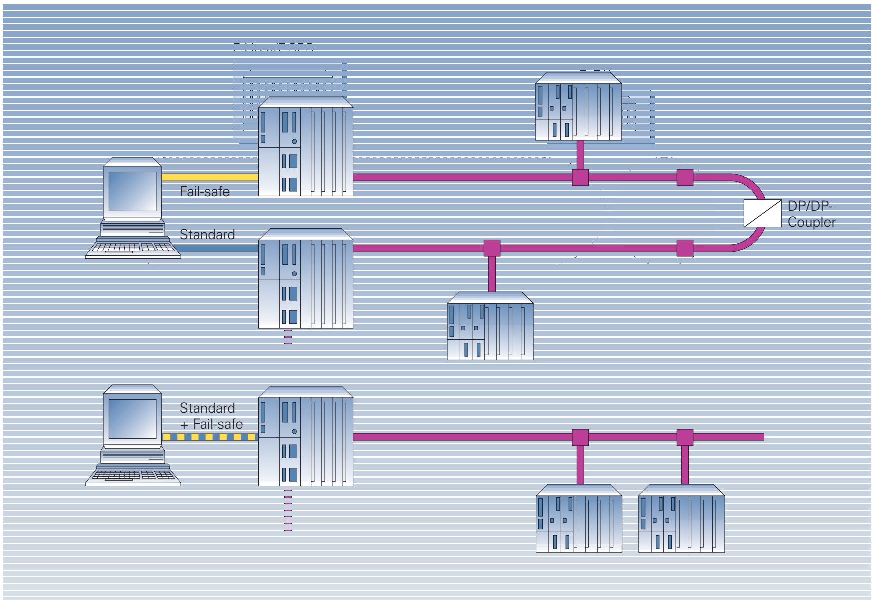


Fig. 2/7
Versions for safety-related systems (below: One bus system for standard and safety automation, top: Separate standard and fail-safe bus system)

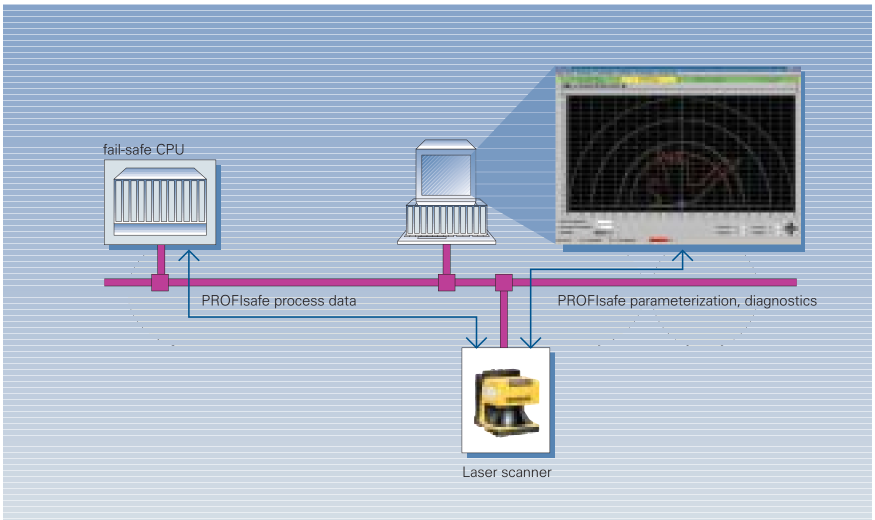


Fig. 2/8
Parameterization and diagnostics of PROFIsafe components

PROFIsafe components can be parameterized and diagnosed using a PC directly connected to PROFIBUS – as is usual for PROFIBUS.

In order to make it simpler to engineer safety-related circuits, the engineering tools have access to all of the necessary parameters. When calculating the overall response times of the safety process, manufacturers must specify the processing times of sensors and actuators in the GSD (master device data) data sheets.

The SIMATIC S7-400F/FH (refer to Section 4) with distributed, fail-safe I/O was introduced as the first PROFIsafe product. Further, SIMATIC S7-300F (refer to Section 4) is a fail-safe PLC with the focus on production technology. This is complemented by complex sensors and actuators and contactless protective devices from the SIGUARD Safety Integrated range. These can be directly connected to PROFIBUS/ PROFIsafe. The fail-safe SINUMERIK 840D can be coupled in the same way.

This means that PROFIsafe provides a high degree of integration and standardization for safety technology, similar to the standard automation solutions on PROFIBUS. This fits in with "Totally Integrated Automation" and creates a high degree of flexibility to implement even more complex tasks.

2.2 AS-Interface *Safety at Work*

"*Safety at Work* - AS-Interface is a standard bus and a safety bus at the same time"

Standard and safety-related data along one bus system – AS-Interface *Safety at Work* makes it possible. Safety-relevant components such as EMERGENCY STOP, position switches, light curtains etc. up to Category 4 according to EN 954-1 can also be connected to AS-Interface. The complete concept is designed so that safety-related and standard data can be transferred together along the same bus without having to have a safety-related CPU or special master. In spite of this new functionality, AS-Interface remains the simple networking system for low level field devices such as actuators and sensors - just the same as it was in previous years - and which is held in high esteem by everybody who uses it.

The success of AS-Interface in the market should come as no surprise. It is the simplest networking system for the actuator-sensor level and has indisputable advantages, both with respect to conventional parallel wiring and to the fieldbuses located one level above in the fieldbus hierarchy. These fieldbuses include, for example, Interbus, PROFIBUS, CAN etc. However, AS-Interface is the ideal partner when combined with the higher level bus systems mentioned above, and it is being increasingly used for applications in this area. Gateways permit straightforward data transfer between the two fieldbus levels.

With the *Safety at Work* system expansion, AS-Interface is again setting new standards. More than just a safety-related bus is created, as safety-related and standard data are transferred together along a yellow AS-Interface cable. A response time of max. 40 ms (worse case) sets new standards when it comes to safety-related fieldbuses.

The components for *Safety at Work* are, in compliance with EN 50295 and IEC 62026-2, fully compatible with all of the other AS-Interface components. This means that existing applications can be expanded to include safety-related functions.

But what makes AS-Interface safe?

A conventional AS-Interface network comprises a control system/master, power supply unit, the yellow AS-Interface cables as well as various slaves. Just two additional components are required for safety-related applications: A Safety Monitor and safety slaves.

The code value "0000" is reserved for specific stopping. For instance, when an Emergency Stop button is pressed, then "0000" is sent to the Safety Monitor, and this safely stops the system using the appropriate enable circuit.

The Safety Monitor receives the safety-relevant code tables by cyclically interrogating the master which is typical for the AS Interface. This information is only communicated to the Master and PLC, without them having an active role. For example, the information can be additionally evaluated for diagnostic purposes using the plant or system control.

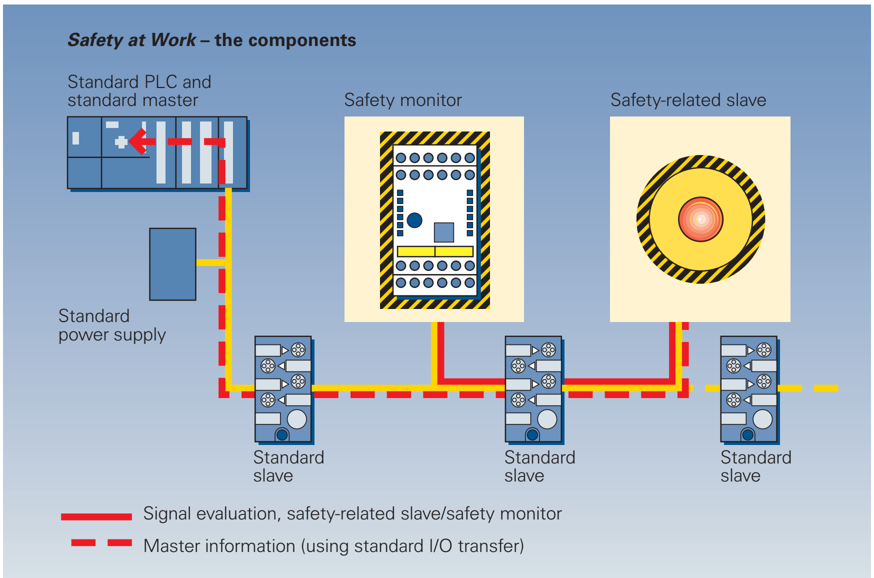


Fig. 2/9
Core components of AS-Interface Safety at Work

A dynamic safety data transfer protocol forms the basis for secure data transfer.

A unique code table is saved in each slave, which allows the master to identify them. Every safe slave must be parameterized in the Safety Monitor and its associated code table must be saved in the comparator of the Safety Monitor. Each time that the master calls a slave, the comparator checks the sent code values against those that it has stored to ensure that they correspond. If deviations occur or monitoring times are violated (watchdog), safe shutdown is initiated at the Safety Monitor through dual-channel enable circuits.

2

Configuring *Safety at Work* is extremely simple

For monitors with two dual-channel enable circuits, the following operating modes can be parameterized - door tumbler mechanism and Stop Categories 0 and 1. In this case, each of the monitors can be configured using a PC. This PC is connected to the Safety Monitor using an appropriate cable. Here, the operating modes as well as additional functions such as contactor control, restart inhibit, local acknowledgment and safety switch can be parameterized using a simple drag & drop operation. The Safety Monitor configuration can be saved to document the system and it can also be printed-out or downloaded into additional monitors.

Certified safety with *Safety at Work*

AS-Interface *Safety at Work* is certified up to Category 4 in compliance with EN 954-1 by the TÜV [German Inspectorate]. The responsible parties were involved from the conceptual phase onwards and this close contact was maintained throughout development. This approach ensures that users can fully depend on AS-Interface Safety at Work for all of their safety requirements.

The Safety Monitor is the core of *Safety at Work*. Depending on the particular requirements, it is available with one or two dual-channel enable circuits.

The standard modules, which all AS-Interface users know, are also available in special safety versions. Using these, for example, safety position switches or EMERGENCY STOP pushbuttons up to Category 4 according to EN 954-1 can be connected through the safety module.

It goes without saying that there are also integrated slaves for *Safety at Work*. For example, EMERGENCY STOP pushbuttons, position switches, light curtains and light grids from the SIGUARD range with integrated AS-I interface These components can be directly connected to the yellow AS-Interface cable.

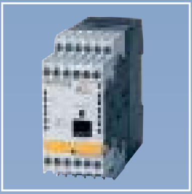
***Safety at Work* – Headlines**

- All safety-related components can be integrated on AS-Interface, for example:
  – EMERGENCY STOP
  – Protective door switch
  – Safety-related light barriers/grids
  – Contactor monitoring etc.
- Standard and safety-relevant components can be operated together via the yellow AS interface cable
- Neither fail-safe PLC nor special master are required when using the Safety Monitor
- Groups of safety-related signals are possible within a network
- Diagnostics using standard master/PLC

System features

- Can be used and certified up to Category 4 in accordance with EN 954-1
- Response time max. 40 ms
- Fully compatible to all AS-Interface components in accordance with EN 50 295 and IEC 62026-2
- The Standard AS-Interface protocol is used
- The system can be expanded to include up to 31 safety-related slaves
- Stop Category 0 or 1 can be parameterized

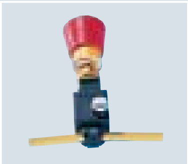
2.2.1 *Safety at Work* Products

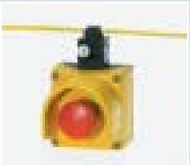


Safety Monitor

The Safety Monitor is the core of *Safety at Work*. A safety-related application can be configured using a PC. In this case, various user-specific operating modes can be selected. These include, e.g. EMERGENCY STOP function, door interlock function, two-hand control as well as selecting Stop Category 0 or 1. In order to be able to fully utilize the AS-Interface diagnostic capabilities, the monitor can be operated with an AS-Interface address. There are two monitor versions:

- Safety Monitor with one dual-channel enable circuit 3RK1105-1AE04-0CA0
- Safety Monitor with two dual-channel enable circuits 3RK1105-1BE04-0CA0



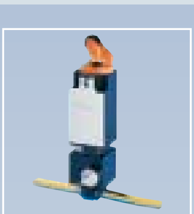


SIGNUM EMERGENCY STOP

Now, even EMERGENCY STOP devices can be directly connected via the standard AS-Interface using safety-related communications. This is valid for EMERGENCY STOP devices from the SIGNUM 3SB3 series for mounting on front panels and in enclosures. An EMERGENCY STOP pushbutton, mounted on a front panel, can be directly coupled to AS-Interface via a safety module.

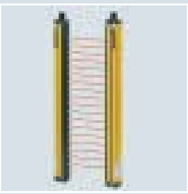
EMERGENCY STOP in enclosures

AS-Interface-capable enclosure with 3SB3 control devices can be designed with safe connection of the EMERGENCY STOP.



SIGUARD position switches

SIGUARD position switches can also be directly connected via Standard AS-Interface with safety-related communications. A special interface module is used, which can be mounted at the base of a position switch. This means that the safety functions no longer have to be conventionally wired.



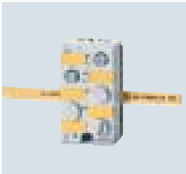
SIGUARD light curtains and light grids

The light curtains and light grids of Category 4 in compliance with EN 954-1 provide active optical protection for personnel working at machines. They can be connected directly and in accordance with safety regulations to AS-Interface.

SIGUARD LS4 laser scanner

The laser scanner is an optical distance sensor to secure hazardous areas up to a radius of 4 m.
The AS-Interface version allows the scanner to be directly connected and therefore safe shutdown via the AS-Interface.

2



K45F safety module

The compact K45F safety module has 2 “safety-related” inputs for electromechanical transmitters. In operation, up to Safety Category 2, both of these inputs can be separately assigned. However, if Category 4 is required, a two-channel input is available on the module. 3RK1205-0AQ00-0AA3

K60F safety-related module

The compact K60F module is equipped with 2 “safety-related” inputs for electromechanical transmitters. In operation, up to Safety Category 2, both inputs can be separately assigned. However, if Category 4 is required, a 2-channel input is available at the module.In addition, the module has two non-safety-related standard outputs. K60F is available in two versions:

- Power supply for the outputs via yellow cable 3RK1405-0BQ00-0AA3
- Auxiliary power supply for the outputs via black cable (V_{aux}) 3RK1405-1BQ00-0AA3

Accessories for *Safety at Work*

Configuration software for the Safety Monitor

This software is used to configure Safety Monitors with standard PCs under Windows 95/98/NT.

System-tested function blocks for SIMATIC S7-200 and SIMATIC S7-300 are included in the software package. These permit extensive and additional diagnostics. 3RK1802-2FB06-0GA0

Cable set

A cable to configure a Safety Monitor with a PC and an additional cable to directly transfer a configuration from one monitor to a second monitor are included in the cable set - 3RK1901-5AA00

Jumper connector M12 for K45F and K60F

If a K45F or K60F module is operated in safety Category 2, but only one safety-related input is required, then input 1 must be assigned. Input 2 remains free and must be shorted (jumpered). PINs 1 and 2 can be safety and simply shorted using the jumper connector. Input 2 is simultaneously sealed with degree of protection IP 67 - 3RK1901-1AA00

2.2.2 Connecting Examples

Category 2 according to EN 954-1 with safety-related modules

Circuit example, Safety Monitor with one/two enable circuits

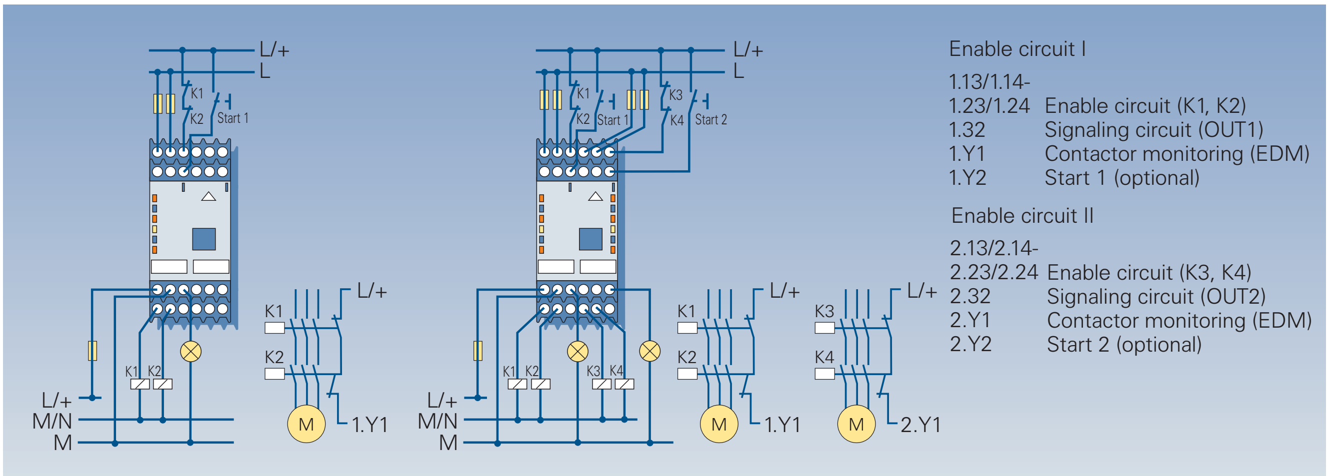


Fig. 2/10
Circuit example, Safety Monitor with enable circuits

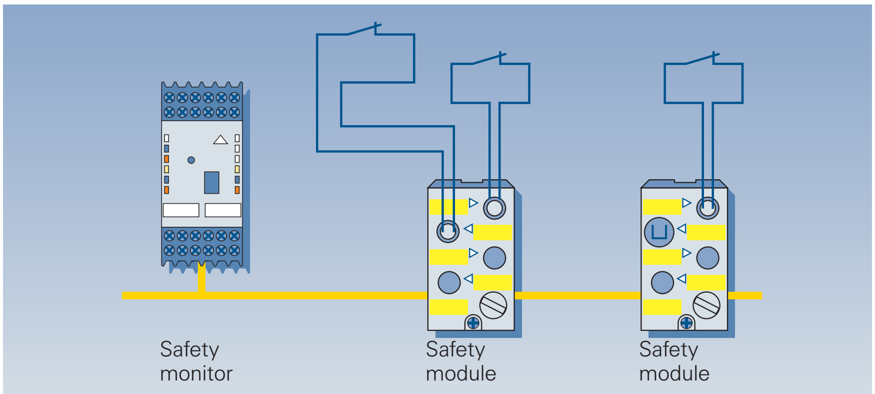


Fig. 2/11
Category 2 with safety-related modules

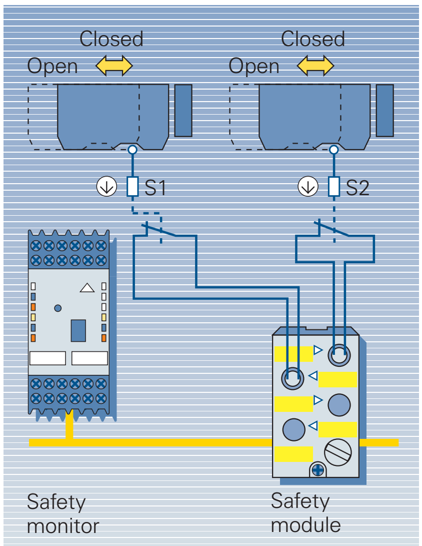


Fig. 2/12
Protective door monitoring, Category 2 with position switch and safety-related module

- For applications in compliance with Category 2, both inputs at the safety module can be used.
- This means that two electromechanical sensors, in compliance with Category 2, can be operated at an AS-Interface address.
- Inputs 1 and 2 can each be equipped with a 1-channel standard sensor.
- PINs 1 and 2 are each assigned at both inputs.
- If only input 1 is assigned in compliance with Category 2 and input 2 is not assigned, then pins 1 and 2 must be shorted (connected together) at input 2 (jumper connector IP 67 as accessory).

Category 3/4 according to EN 954-1 with safety modules

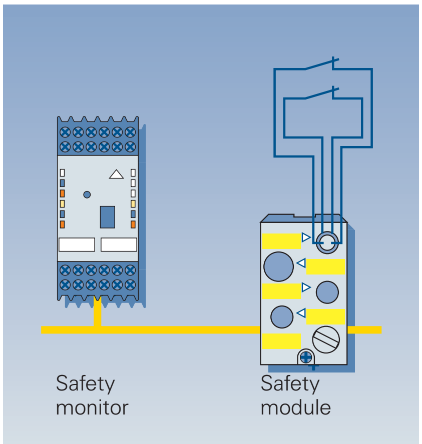


Fig. 2/13
Category 3/4 with safety modules

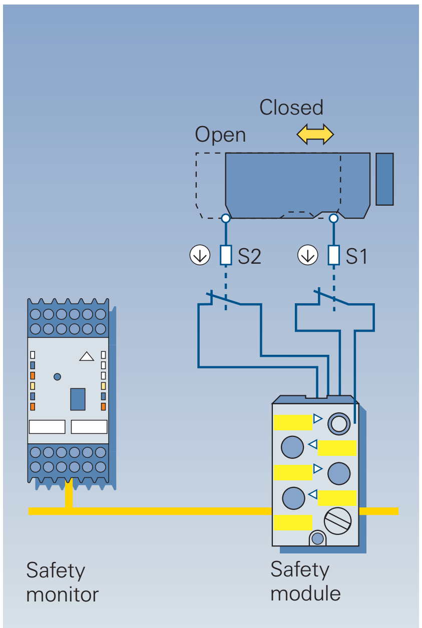


Fig. 2/14
Protective door monitoring, Category 3/4 with position switch and safety module

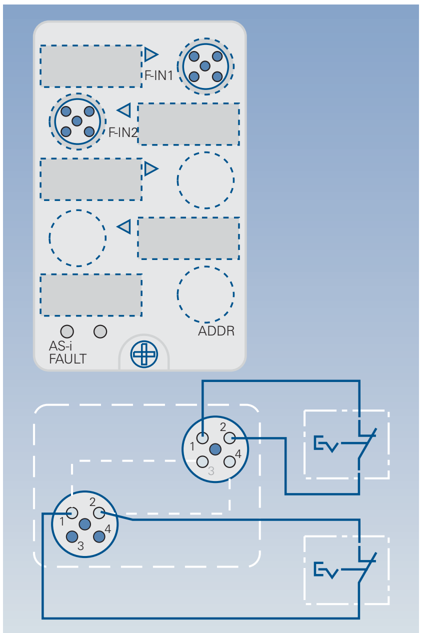


Fig. 2/15
Category 4: 1 protective door with 2 safety switches (1 NC contact)

- For applications in compliance with Category 3/4, a 2-channel input is used at the safety module.
- This means that an electromechanical sensor, in compliance with Category 4, can be used at an AS-Interface address.
- Input 1 is assigned a 2-channel sensor.
- PINs 1–4 are assigned at input 1.
- Input 2 is sealed using an M12 cap, in order to guarantee degree of protection IP 67.

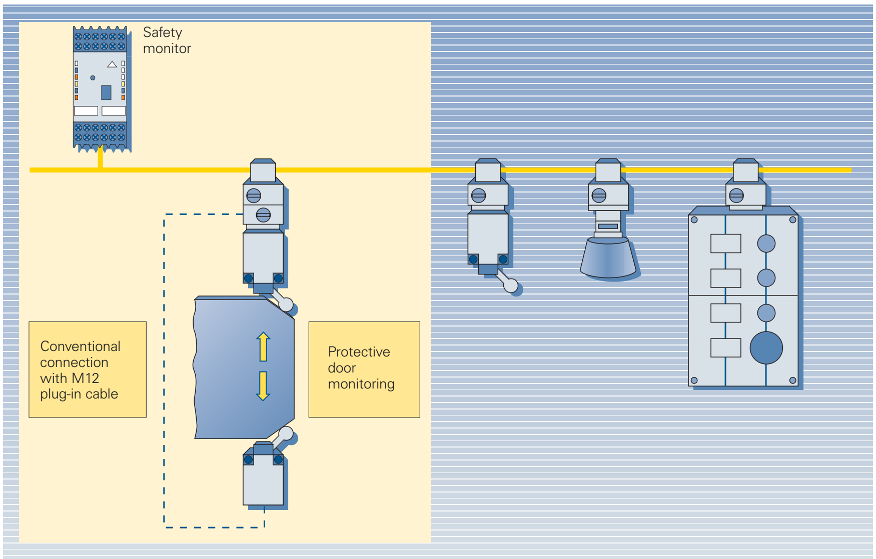


Fig. 2/16
Protective door monitoring, Category 3/4 with safety AS-Interface adapter and additional spur

Exchanging safety-related signals between two AS-Interface networks

Safety-related data can be exchanged between two AS-Interface networks using *Safety at Work* components. To realize this, an enable circuit of a Safety Monitor from network 1 is connected to a safety input at a module from network 2.

For this application, for the transferred safety signal, a response time of max. 80 ms is obtained (2 x 40 ms)

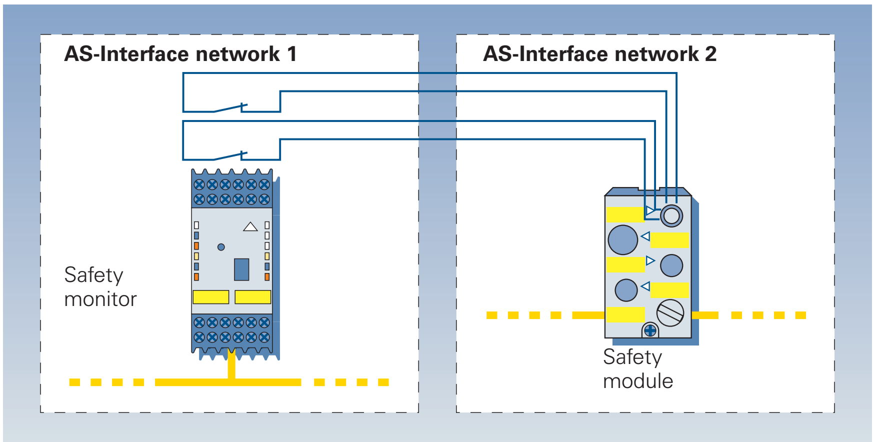


Fig. 2/17
Exchanging safety-related signals between two AS-Interface networks (Category 4)

Forming groups of safety-related signals using *Safety at Work*

Groups of safety-related signals can be formed using AS-Interface *Safety at Work*.

The diagram shows a network which includes, in addition to standard components, two Safety Monitors, each with a 2-channel enable circuit and four safety-relevant slaves. For instance, each monitor is assigned a section of the plant or system which can then be powered-down via an appropriate enable circuit.

A PC is used to assign the safety-related slaves to the Safety Monitors.

This example has been configured so that the safety module and EMERGENCY STOP 1 acts on Safety Monitor 1. For example, if EMERGENCY STOP 1 is pressed, the plant section, assigned to the monitor, is shut down via the appropriate enable circuit.

EMERGENCY STOP 2 acts on both Safety Monitors, i.e. if EMERGENCY STOP 2 is pressed, both plant sections are shut down.

EMERGENCY STOP 3 only acts on Safety Monitor 2 and shuts down the plant section assigned to it.

As shown in this example, several Safety Monitors can be connected to an AS-Interface network. This means that not only can safety-related signals be grouped, but it is also possible to combine various operating modes in a single network.

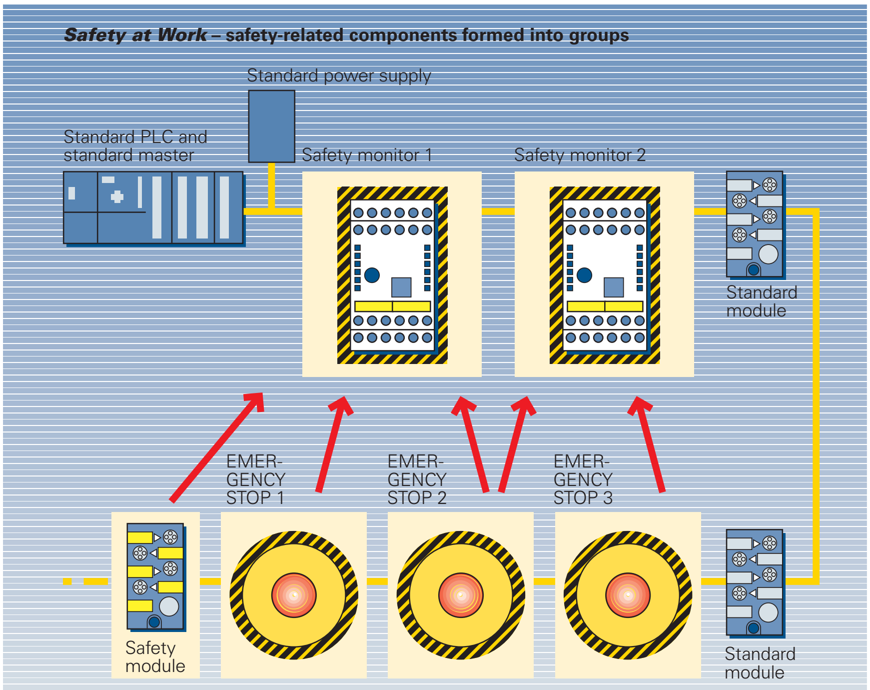


Fig. 2/18
Forming groups of safety-related signals allows individual plant sections to be shut down

2.2.3 Connection Assignments

Safety at Work also operates together with ET 200S SIGUARD

An AS-Interface network with *Safety at Work* components can also be subordinate to an ET 200S SIGUARD station.

To realize this, an enable circuit of a Safety Monitor is incorporated in the safety circuit of the ET 200S SIGUARD. The response time of the ET 200S SIGUARD of about 20 ms is added to the response time of *Safety at Work* (max. 40 ms).

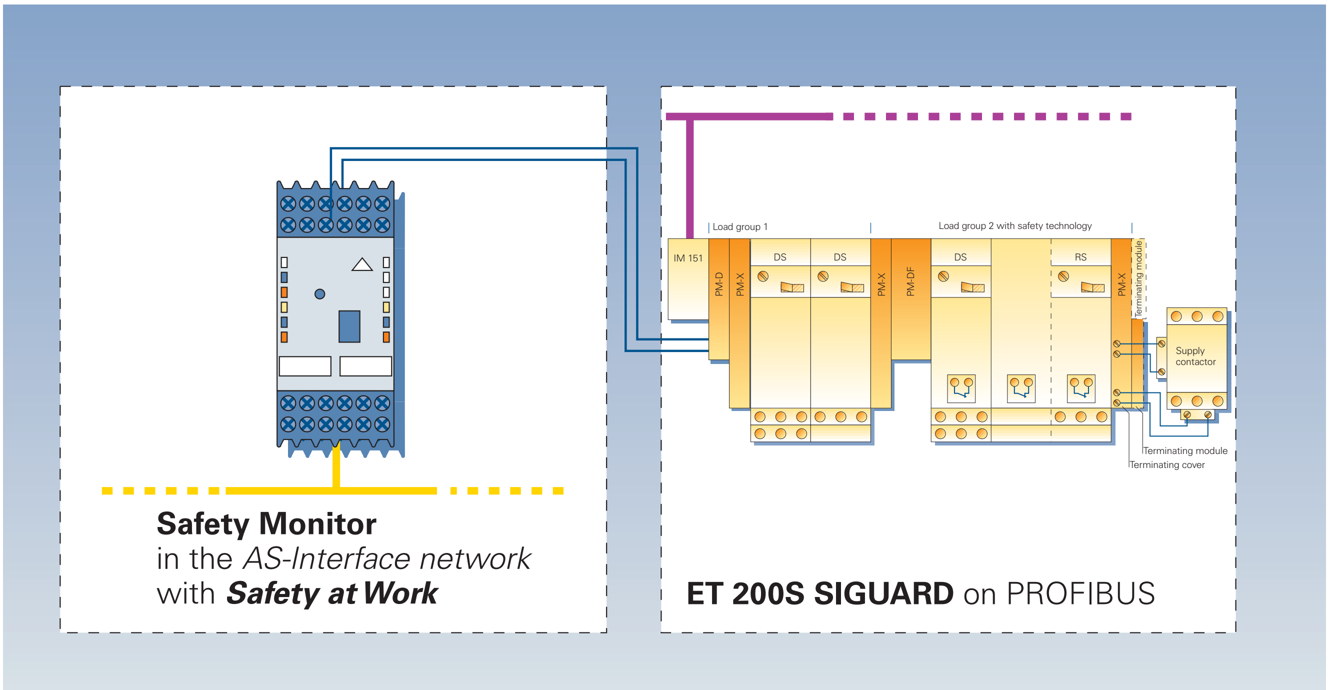


Fig. 2/19
Safety at Work also operates closely with ET 200S SIGUARD

2.2.4 Technical Data

2

The Safety Monitor monitors the safety-relevant data transfer for "AS-Interface *Safety at Work*."

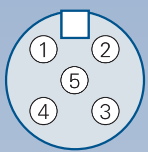
There are 2 versions (1 safety-related 2-channel enable circuit or 2 safety-related enable circuits). A PC program is used to assign the safety-related slaves to the safety-related enable circuits. It is possible to have several Safety Monitors in one network. Category 4 in compliance with EN 954-1 can be achieved using the appropriate safety-related AS-Interface slaves and the appropriate circuitry.

Each safety-related enable circuit has the following rated operating currents (relay output):

	Safety Monitor
	
Rated operating current	I_e/AC-12 to 250 V, 2A I_e/AC-15 115 V, 2 A 230 V, 2 A I_e/DC-12 to 24 V, 2 A I_e/DC-13 24 V, 1 A 115 V, 0.1 A 230 V, 0.05 A

	EMERGENCY STOP / position switch	Light grid / light curtains	Laser scanner
			
Version	2 safe inputs	Standard assignment	Standard assignment
Code	2 F-IN	Light curtain/light array	Laser scanner LS4
Order No.	3SB3.. / 3SE3..	3SF 7842-..	3SF 7834-..
AS-Interface chip	SAP 4.0	SAP 4.0	SAP 4.0
Operating voltage V	26.5 to 31.5 V	26.5 to 31.5	29.5 to 31.5
Total current drain mA	< 45 mA	≤ 200 mA (sender + receiver)	350 mA
Inputs			
– Sensor supply via AS-Interface	–	–	–
– Sensors	Mech. switching contact	–	–
– Voltage range V	–	–	–
– Current load capability	–	–	–
– Switching level, high V	V_{peak} > 20 V (contact closed)	–	–
– Input current, low/high mA	$–/I_{peak}$ ≥ 5 mA	–	–
– Socket assignments, inputs	–	PIN Assignment 1 ASI + 3 ASI – M12	PIN Assignment 1 ASI + 3 ASI – M12

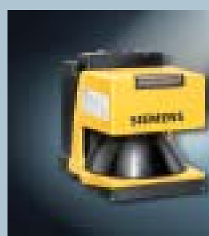
2

<table>
<tr><th></th><th>EMERGENCY STOP / position switch</th><th>Light grid / light curtains</th><th>Laser scanner</th></tr>
<tr><td></td><td></td><td></td><td>
</td></tr>
<tr><td>Outputs</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>I/O configuration</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>ID/ID2 code</td><td>B/–</td><td>B/–</td><td>B/–</td></tr>
<tr><td>– short-circuit protection</td><td>integrated</td><td>integrated</td><td>integrated</td></tr>
<tr><td>– induction protection</td><td>integrated</td><td>integrated</td><td>integrated</td></tr>
<tr><td>– external 24 V DC power supply</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>– watchdog</td><td>integrated</td><td>integrated</td><td>integrated</td></tr>
<tr><td>Assignment of the data bits

</td><td>
<table>
<tr><th>Conductor pair</th><th>Function</th></tr>
<tr><td>red</td><td>influences bits D0 and D1 = channel 1</td></tr>
<tr><td>black</td><td>influences bits D2 and D3 = channel 2</td></tr>
</table>
</td><td>–</td><td>–</td></tr>
<tr><td>AS-Interface certificate</td><td>available</td><td>available</td><td>being prepared</td></tr>
<tr><td>Approvals</td><td>UL, CSA</td><td>UL, CSA, marine</td><td>being prepared</td></tr>
<tr><td>Degree of protection</td><td>IP 67, IP 20 for EMERGENCY STOP in the front panel</td><td>IP 65</td><td>IP 65</td></tr>
<tr><td>Ground connection</td><td>–</td><td></td><td></td></tr>
<tr><td>Ambient temperature</td><td>–25 °C to 60 °C</td><td>0 °C to +55 °C</td><td>0 °C to +50 °C</td></tr>
<tr><td>Storage temperature</td><td>–25 °C to 85 °C</td><td>-25 °C to +75 °C</td><td>-20 °C to +60 °C</td></tr>
<tr><td>No. of I/O sockets</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Status display</td><td></td><td></td><td></td></tr>
<tr><td>– I/O display</td><td>LED yellow</td><td>–</td><td>–</td></tr>
<tr><td>– V_{aux}</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>– AS-Interface/ diagnostics display</td><td>LED green/red</td><td>–</td><td>–</td></tr>
<tr><td>Connection</td><td>Via the mounting clip directly on the AS-Interface cable</td><td>M12 connector</td><td>M12 connector</td></tr>
<tr><td>Address assignment</td><td>The module keeps the last address after the 15th address assignment.</td><td>–</td><td>–</td></tr>
</table>

Safety-Related Low-Voltage

Switching Devices and Sensors (SIGUARD)

kapitel3



3.1 SIGUARD Control and Signaling Devices

Controlling

3SB EMERGENCY STOP control devices
- Latching in accordance with EN 418
- With CES, BKS, OMR and RONIS safety locks
- BIA approval (Germany Statutory Industrial Accident Insurance Association)

SIGUARD two-hand operation console acc. to DIN 24980 (EN 574)
- Safety for presses and stamping machines
- Both of the operator's hands must be used
- Simultaneous actuation < 0.5 s

3SB safety locks
- CES, BKS, OMR, IKON, RONIS with various tumbler mechanisms
- Changeover for continuous operation of presses
- For 3SB1, with key monitoring

3SB encapsulated EMERGENCY STOP switch
- Latching in accordance with EN 418
- Protection against accidental actuation

SIGUARD 3SE7 cable-operated switches
- Monitors especially long endangered system sections
- Protective device can be actuated at each point along the cable
- Latching in accordance with EN 418

Sensing

SIGUARD 3SE position switches
- Mechanically monitor protective doors
- Enclosure according to EN 50041 and EN 50047
- Positive opening according to EN 947-5-1
- Separate actuator to protect against simple tampering

SIGUARD 3SE3 8/3SE3 7 position switch with tumbler
- Positive opening according to EN 947-5-1
- Latched using either spring or magnetic force
- Takes into account overtravel times of machines
- Integrated auxiliary release
- Metal and molded-plastic enclosed

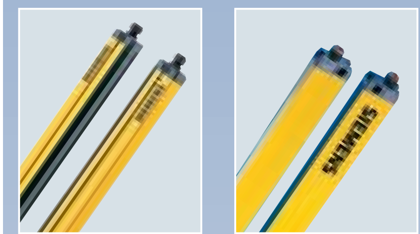
SIGUARD 3SE hinge switch
- Shutdown command using spring-loaded contacts after a rotary motion of just 5°
- Mounted directly at the hinged pivot
- Positive opening according to EN 947-5-1
- Can be used in control circuits up to Category 4 acc. to EN 947-5-1

SIGUARD 3RG78 3 laser scanner

- Securing hazardous zones - can be freely parameterized
- 4 m detecting distance
- 4 protective and 4 warning fields
- Certified for Category 3 (EN 954-1)

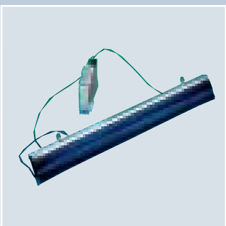
SIGUARD 3RG78 2 light barriers

- 2 systems for Cat. 2 and Cat. 4 acc. to EN 954-1
- Several light sensors can be connected to an evaluation unit



SIGUARD 3RG78 4 light curtains and light grids

- Contactless protective devices for securing protective areas
- Various resolutions and lengths
- Certified for Cat. 2 and Cat 4 (EN 954-1)
- Evaluation units with muting and cycle control function
- Integrated restart inhibit
- Fixed and floating blanking



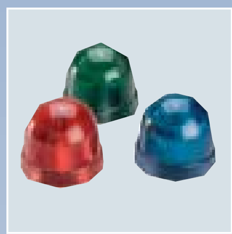
SIGUARD 3RG78 5 switching columns

- Provide edge protection
- Customer-specific assembly
- The rubber profile is optically monitored
- Certified with evaluation unit up to Cat. 4 (EN 954-1)

Signaling

8WD4 signaling columns

- Acoustic and visual signaling devices
- 70-mm and 50-mm versions
- Filament lamps and LED elements
- Can be combined in a modular fashion



8WD53 built-in signal lamps

- Impact-resistant and tough
- High degree of protection

3SB indicator lights

3.1.1 EMERGENCY STOP control devices

Relevant standards

- EN 60947-5-1 (Low-voltage Switching Devices, Positive Opening)
- EN 999 (Approach speed)
- EN 292-1 (Safety of Machinery – General Design Guidelines)
- EN 954-1 (Safety of Machinery – Safety-related parts of control systems)
- EN 60204-1 (Safety of Machinery – Electrical equipment on machines)

Product overview

SIGUARD Safety Integrated control and signaling devices offer a complete program with three product series for EMERGENCY STOP:

- 3SB1 - proven and in use worldwide
- 3SB2 - small dimensions with a high performance
- SIGNUM® 3SB3 - state-of-the-art with fast mounting.

Refer to Catalog NSK, Section 9, Control and Signaling Devices, for more detailed information and selection and ordering data.

- Siemens EMERGENCY STOP control devices comply with all of the requirements for use in safety circuits in conformance with EN 418
- BIA approval
- Single-pole and two-pole contacts
- Red mushroom pushbutton with yellow backing plate
- Positive opening NC contacts
- Increased security using a key-operated release
- Standard high IP 65 degree of protection

Fig. 3/1

EMERGENCY STOP mushroom pushbutton switches, latching according to EN 418

- 3SB1 with a nominal 22 mm or 30 mm diameter
- 3SB2 with a nominal 16 mm diameter
- SIGNUM 3SB3 with a nominal 22 mm diameter or 26 x 26 mm mounting cut-out
- released by rotating or pulling

Fig. 3/2

EMERGENCY STOP mushroom pushbutton switches, latching according to EN 418

- 3SB1 with a nominal 22 mm or 30 mm diameter
- SIGNUM 3SB3 with a nominal 22 mm diameter or 26 x 26 mm mounting cut-out
- Lock types: CES, RONIS, BKS, OMR; released by rotating

Fig. 3/3

Safety locks with CES, BKS, IKON, OMR or RONIS lock mechanisms

- 3SB1 with a nominal 22 mm or 30 mm diameter
- 3SB2 with a nominal 16 mm diameter (only CES)
- SIGNUM 3SB3 with a nominal 22 mm diameter and mounting cut-out 26 x 26 mm
- 2 and 3 switch positions, maintained contact type, momentary contact type

Fig. 3/4

Encapsulated EMERGENCY STOP mushroom pushbutton switches, latching according to EN 418

- 3SB1 with a nominal 22 mm diameter (molded-plastic-enclosed and cast-metal clad)
- SIGNUM 3SB3 with nominal 22 mm diameter (molded-plastic enclosed)
- Yellow upper enclosure section with or without protective collar

Use in various categories

EMERGENCY STOP control devices in conjunction with 3TK28 SIGUARD safety combinations or fail-safe SIMATIC control systems

EMERGENCY STOP control devices, when actuated, must interrupt the safety circuit in a fail-safe fashion and stop the drive. This must be exclusively realized using NC contacts.

Siemens 3SB product series offers several contact blocks. With two single-pole contact blocks (2 x 1NC or 2 x 1NO + 1NC) EMERGENCY STOP circuits with the highest Category 4 according to EN 954-1 can be achieved. This is shown in the adjacent examples. Two-pole contact blocks should not be used for safety reasons. For two-channel systems, two separate single-pole contact blocks must be used, because a failure of one contact block only affects one channel.

Fail-safety for a specific category can naturally only be achieved if the evaluation units also fulfill the same requirements (refer to the circuit examples).

Positive contact opening (EN 60947-5-1)

The prerequisite is that the off command must always interrupt the safety circuit by de-energizing it. This is the reason why only NC contacts are used. Positive opening NC contacts must always be used for EMERGENCY STOP control devices (also refer to the SIGUARD position switches, Section 3.1.4).

EMERGENCY STOP control devices according to EN 418

If the plant or system is shut down as a result of an EMERGENCY STOP command, then automatic restart is not permissible. This means that the EMERGENCY STOP control device must have a positive latching. This requirement is specified in the B Standard EN 418 and is required for every EMERGENCY STOP device. 3SB EMERGENCY STOP mushroom pushbutton units fulfill these requirements. These are mechanically actuated using a force-storage element, whereby the contacts are positively opened when the device latches.

Category 2: according EN 954-1

Using a contact element

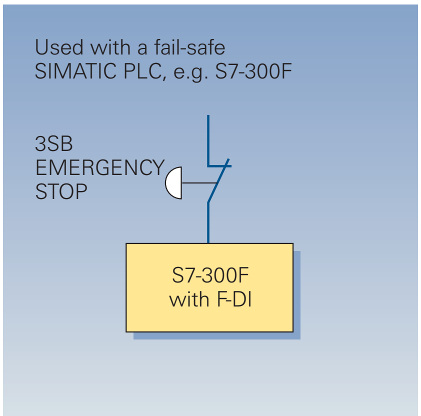


Fig. 3/5

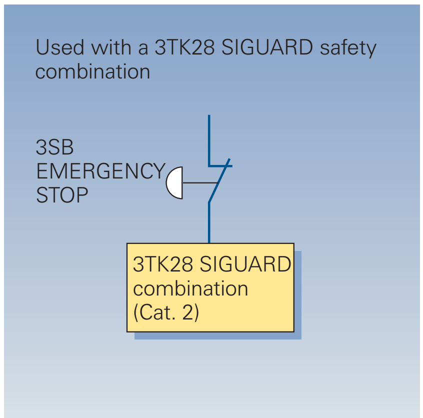


Fig. 3/6

Category 3, 4: acc. to EN 954-1

Using two contact blocks. In conjunction with fail-safe evaluation and diagnostic devices (3TK28, S5-95F), two-channel control is mandatory for these categories.

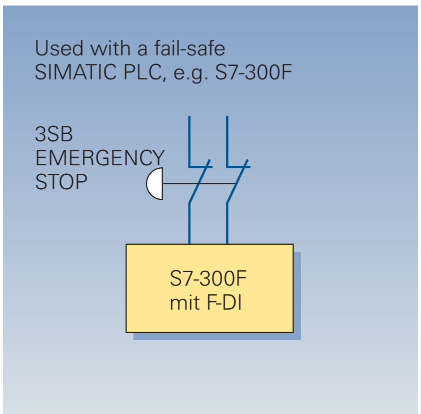


Fig. 3/7

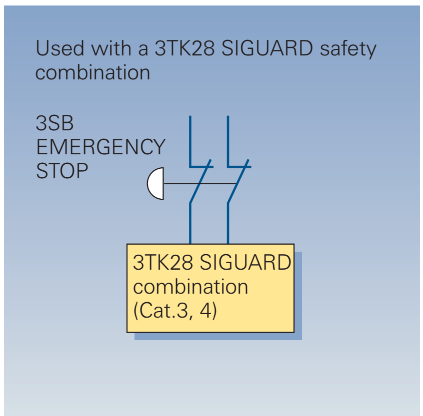


Fig. 3/8

3.1.2 SIGUARD cable-operated switches

Relevant Standards

- EN 418
  (Safety of Machinery - EMERGENCY STOP devices)
- EN 292-1
  (Safety of Machinery – General Design Guidelines)
- EN 954-1
  (Safety of Machinery – Safety-related parts of control systems)
- EN 60 204-1
  (Safety of Machinery – Electrical equipment of machines)
- EN 60 947-5-1
  (Low-voltage control devices - positively opening operation)

SIGUARD cable-operated switch as EMERGENCY STOP device acc. to EN 418

SIGUARD cable-operated switches are also permitted as EMERGENCY STOP devices in accordance with the current standards. Thus, as far as their mechanical mode of operation is concerned, Standard EN 418 applies. This standard also makes special mention of cable-operated switches with latching as a type of EMERGENCY STOP device.

The advantage is that longer distances can be monitored, and the plant or system can be stopped from any position along the cable. The cable itself is in accordance with the specifications and is manufactured from rugged steel with a red sheath. The NC contact of the cable-operated switch is positively opened and is actuated, both when the cable is pulled and when the cable breaks. Two positively opening NC contacts must be used for safety circuits up to Category in accordance with EN 954-1.

Product spectrum (refer to the Catalog for an additional selection)

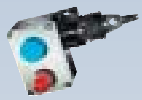
Cable length				
≤ 25 m 	**Metal-enclosure** with dust protection and adjustment window 2 x (M20 x 1.5)	without latching	1NO + 1NC	⊖ **3SE7 150-2DD00**
		with latching and push to release	1NO + 1NC	⊖ **3SE7 150-1BD00**
			2NC	⊖ **3SE7 150-1BF00**
		and key release	1NO + 1NC	⊖ **3SE7 150-1CD00**
≤ 50 m 	**Metal-enclosed** with dust protection 1 x (M16 x 1.5)	with latching and push to release	1NO + 1NC	⊖ **3SE7 140-1BD00**
			2NC	⊖ **3SE7 140-1BF00**
		and key-release	1NO + 1NC	⊖ **3SE7 140-1CD00**
≤ 2 x 50 m with 2-sided actuation	**Metal-enclosed** 2 x (M25 x 1.5)	with latching and push to release	2 x (1NO+1NC)	⊖ **3SE7 160-1AE00**
≤ 25 m 	**Metal-enclosed** (molded-plastic cover and adjustment window) 2 x (M20 x 1.5)	without latching	1NO + 1NC	⊖ **3SE7 150-2DD04**
		with latching	1NO + 1NC	⊖ **3SE7 150-1BD04**
		with latching	2NC	⊖ **3SE7 150-1BF00-0BA1** with AS-I *Safety at Work*
≤ 50 m 	**Metal-enclosed** 1 x (M16 x 1.5)	with latching	1NO + 1NC	⊖ **3SE7 140-1BD04**
≤ 50 m 	**Metal-enclosed** 2 x (M25 x 1.5)	with latching	2 x (1NO+1NC)	⊖ **3SE7 160-1AE04**

Fig. 3/9

3

SIGUARD 3SE7 cable-operated switches with LED – safety along the cable

- A high-intensity LED is used to display the operation
- Cable-operated switch with latching acc. to EN 418, full EMERGENCY STOP function using positively opening contacts
- Control functions and EMERGENCY STOP are always immediately within range
- Increased safety along long stretches to 2x50 m
- Complete system for every requirement and cable routing
- Simple release
- Range of standard mounting accessories

The SIGUARD 3SE7 cable-operated switch with LED is the optimum solution to secure large distances in hazardous areas. The operating display is clearly visible from a distance using an LED with exceptional light intensity. The plant or system can be safely shut down at any point along the cable. This allows distances of up to 2x50 m to be effectively secured. The high intensity LED of the new version with metal enclosure allows the status of the switch to be visible everywhere. The lifetime of the LED using innovative chip-on-board technology is 50,000 hours – almost 6 years for 24 hour operation throughout the year.

Selecting and mounting 3SE7 SIGUARD cable-operated switches

SIGUARD cable-operated switches must be selected in-line with the particular application. The following questions have to be clarified:

- Will the switch be used as an EMERGENCY STOP device?

  ⇒ Latching is required according to EN 418

- What is the length to be monitored?

  ⇒ Required cable length

- Which temperature fluctuations can be expected?

  ⇒ The maximum cable length may have to be reduced

Siemens offers cable-operated switches with latching for various cable lengths:

3SE7 110 and 3SE7 2	up to 6 m (enclosure acc. to EN 50041 and EN 50047)
3SE7 150	up to 25 m
3SE7 140	up to 50 m
3SE7 160	up to 100 m (2 x 50 m)

Reliable switching when the cable is pulled or breaks

Cable-operated switches are operational when actuated at one end as a result of the tension of the turnbuckle. For cable-operated switches 3SE7 110/210/230, the switching contacts (1NO + 1NC) are then in the overlap range, so that both contacts are closed. One contact opens when the cable breaks and the other when the cable is pulled. For cable-operated switches 3SE7 140/150, both switching contacts are available for the cable break-cable tension signal.

3SE7 cable-operated switches can be adjusted to an accuracy of millimeters using the turnbuckle. If the cable is pulled or if the cable breaks, then the appropriate contact opens and the circuit is interrupted.

SIGUARD cable operated switches without latching are often used as signaling switches. After the cable has been released again, the switch is reset into its initial position.

The devices should be used in environments with a constant ambient temperature in order to prevent the cable length increasing and decreasing. The devices can actuate themselves if higher temperature fluctuations occur. They then have to be re-adjusted. The application ranges of 3SE7140 and 3SE7150 SIGUARD cable-operated switches are shown in the following diagrams.

Example for 3/11:

For a required cable length of 20 m and when using a 3SE7 150, in order to avoid erroneous functions, the temperature fluctuations should not be more than 10 °C (shown: 20°C +/– 5).

The 3SE7 140 should be used if higher temperature fluctuations are expected. For a 20 m cable, the permissible temperature fluctuation is 50 °C (shown: 20°C +/– 25).

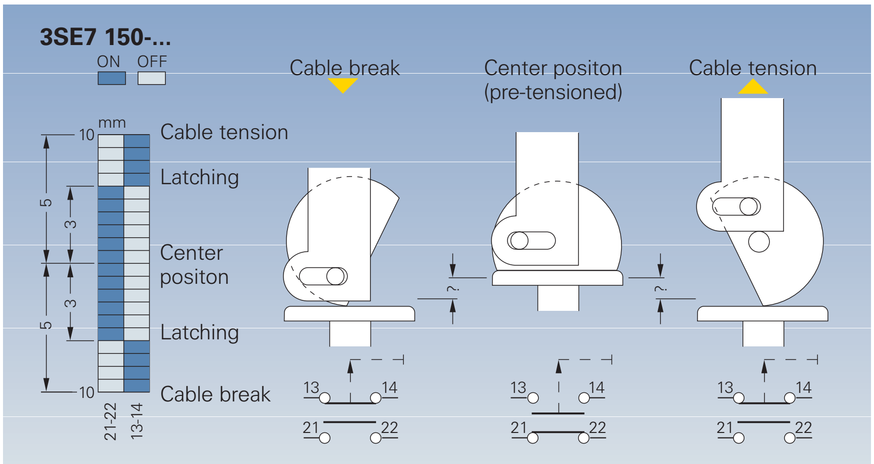


Fig. 3/10
Switching statuses of 3SE7 SIGUARD cable-operated switches

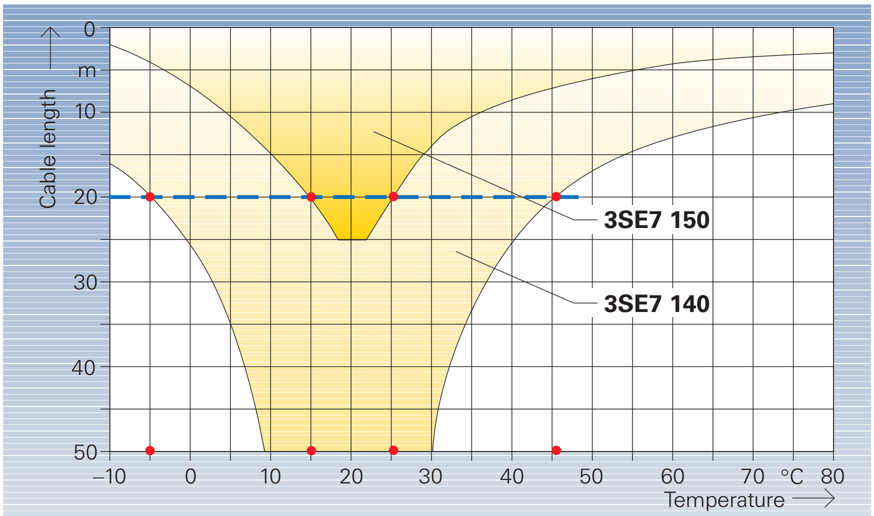


Fig. 3/11
Recommended cable lengths for safety cable-operated switches as a function of the ambient temperature range

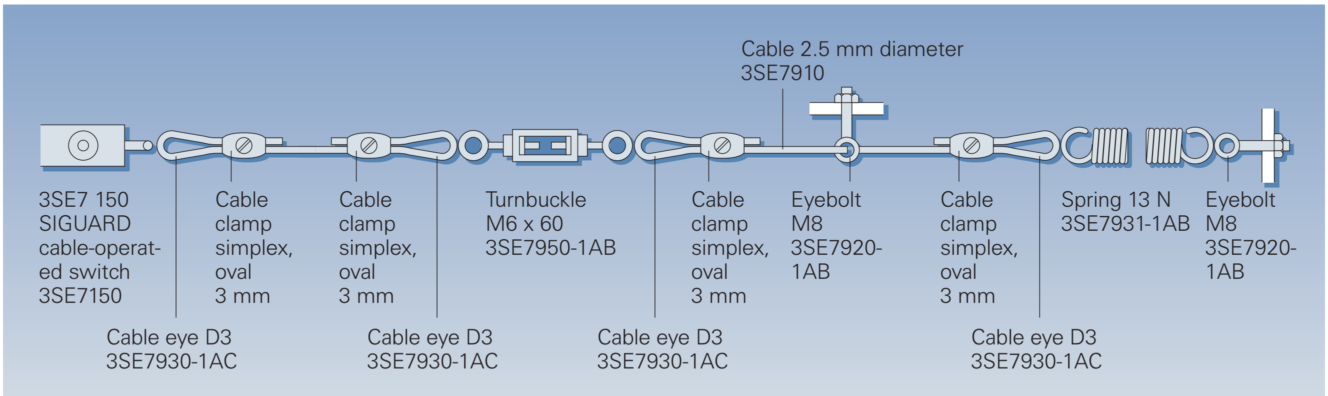


Fig. 3/12
Mounting example for 3SE7 150 SIGUARD cable-operated switches

Various accessories are available to mount the devices. These include cable clamps, turnbuckles, springs etc. If the cable length exceeds 10 m, cable supports are necessary every 3 m for 3SE7 150 and every 5 m for 3SE7 140 (refer to the mounting example).

3.1.3 SIGUARD Two-hand operation consoles and foot switches

Relevant Standards

- DIN 24980 (EN 574) (Safety of Machinery – Two-hand circuit)
- EN 418 (Safety of Machinery – EMERGENCY STOP device)
- pr EN 999 (Approach speed)
- EN 292-1 (Safety of Machinery – General Design Guidelines)
- EN 954-1 (Safety of Machinery – Safety-related parts of control systems)
- EN 60204-1 (Safety of Machinery – Electrical equipment of machines)
- EN 60947-5-1 (Low-voltage switchgear - positively opening)

Two-hand circuits – in conformance with EN 574

A safety circuit for a two-hand circuit according to DIN 24 980 (EN 574) must fulfill the following conditions:

- The operation console must be designed so that both hands are simultaneously required for actuation.
- The control device connected to the operation console must safely monitor and evaluate the two input signals.

Complete solutions

3SB38 6 SIGUARD two-hand operation consoles correspond to the requirements for Category 4 acc. to EN 954-1. All of the operation consoles are equipped, as standard, with two operator control pushbuttons and an EMERGENCY STOP mushroom pushbutton. In order that it is correctly integrated into safety circuits, Siemens 3TK2834 SIGUARD two-hand control devices can be used in conjunction with two-hand operation consoles, or they can be used directly with the fail-safe SIMATIC S5-95F PLC. In this case, the EMERGENCY STOP mushroom pushbutton must be included in the EMERGENCY STOP circuit of the machine.

Mounting

The two-hand operation console can be

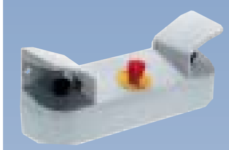
- Mounted directly at the machine, or
- Mounted on a 3SB3901-OAQ stand. In this case, it can be equipped in various ways.

When used in conjunction with 3TK2834 two-hand control devices and 3TK2835 overtravel testers, applications include (refer to Section 3.2):

- Presses
- Stamping machines, and
- Printing and woodworking machines.

Product spectrum

Two-hand operation consoles + control devices



3SB38 63-3BB
3SB38 63-1BB

Two-hand control device
and
overtravel tester

3TK28 34-1BB40
3TK28 35-1BB40

Safety foot-operated switch

3SE39 24-3AA20

Fig. 3/13

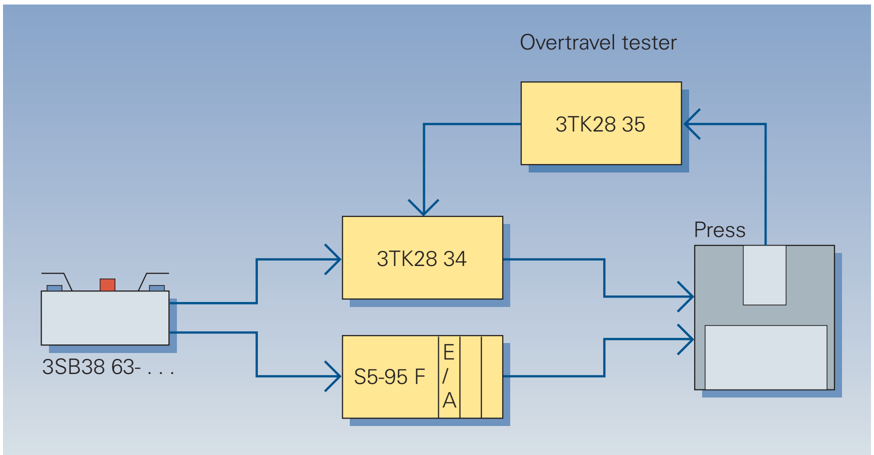


Fig. 3/14
Safety circuit of a two-hand control for presses

List of two-hand operation consoles and minimum safety requirements					
Requirements			**Types**		
	I	II			III
			A	B	C
Both hands are used for actuation (simultaneous))	X	X	X	X	X
Relationship between input and output signals	X	X	X	X	X
End of output signal	X	X	X	X	X
Avoiding accidental actuation	X	X	X	X	X
Avoiding bypassing	X	X	X	X	X
Renewed generation of the output signal		X	X	X	X
Synchronous actuation			X	X	X
Applications, Category 1 (EN 954-1)	X		X		
Applications, Category 3 (EN 954-1)		X		X	
Applications, Category 4 (EN 954-1)					X

Fig. 3/15
List of two-hand operation consoles and the minimum safety requirements according to DIN EN 574

Assignment to the individual Categories (acc. to EN 574)							
Two-hand operation console	**Category**					**Examples of operating procedures**	**Application**
	B	**1**	**2**	**3**	**4**		
Type I		X				Operating procedures without feeding any materials to the tool. Little reason to stay in the hazardous zone.	Clippers, tool clamping
Type II				X		Working extremely close to the - hazardous zone, but generally not having to enter it.	Setting-up
Type III A Type III B Type III C		X 		 X 	 X	Repeated feeding (equipping and/or removing materials) manually in the hazardous zone.	Mechanical press

Fig. 3/16

3.1.4 SIGUARD position switches

Relevant Standards

- EN 1088
  (Latching devices in conjunction with isolating protective devices)
- EN 60947-5-1
  (Low-voltage switchgear with positive opening contacts)
- pr EN 999
  (Approach speed)
- EN 292-1
  (Safety of Machinery – General Design Guidelines)
- EN 954-1
  (Safety of Machinery – Safety-related parts of control systems)
- EN 60204-1
  (Safety of Machinery – Electrical equipment of machines)

Product spectrum

SIGUARD position switches can be used for:

- Monitoring protective equipment with hinges, such as hinged doors, flaps, covers, etc.
- Monitoring protective equipment that can be moved sideways, for example, sliding doors, protective screens, etc.
- Detecting hazardous movements of machine parts.

Every category can be achieved by using SIGUARD position switches in safety circuits. However, it is important to select the right device and use it correctly in conjunction with fail-safe evaluation units 3TK28 or SIMATIC S5-95F, S7 300F, S7 400F/FH and SINUMERIK/SIMODRIVE.

Siemens SIGUARD position switches are designed for the highest degree of safety and offer the following advantages:

- Positive opening of the NC contacts
- Version with/without separate actuator
- Increased safety using additional latching (tumbler) mechanism
- High degree of protection IP 65/67
- Standard enclosure, also in accordance with DIN EN 50047 and 50041
- Different actuators
- Electrically insulated contacts with moving double contacts.
- Also available with metric connection threads.

SIGUARD position switches are supplied with separate actuators or without actuator.
The actuator elements are shown for the particular switch types in Fig. 3/20.

Positively opening operation of the contacts (EN 60947-5-1)

Positively opening operation is specified in accordance with *DIN VDE 0660 Part 200*, and is the same as *IEC 947-5-1-3* and *EN 60947-5-1*.

For the electrical equipment of machines, the positive opening of NC contacts is mandatory in all safety circuits. It is designated according to *IEC 947-5-1-3* by the following character ➔ (personnel protective function).

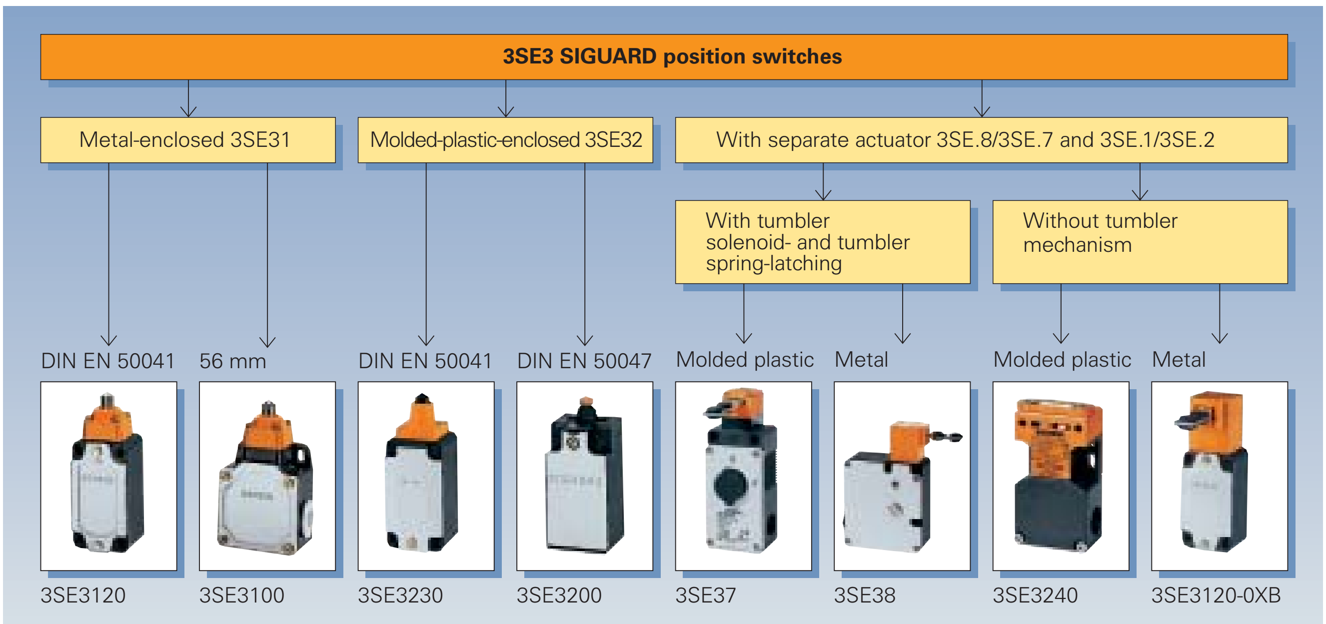


Fig. 3/17
Product overview

Monitoring and latching of mechanical protective devices using 3SE3 SIGUARD position switches

Protective doors can be monitored and latched, with protection against tampering without any special safety measures, in several ways:

- Position monitoring using *one* positive opening position switch with integrated actuator element (Category 1)
- Position monitoring using *one* positive opening position switch with separate actuator (Category 1)
- Position monitoring using two positive opening mechanical position switches (Category 4)
- Position monitoring with tumbler (Category 1)
- Position monitoring with tumbler and additional position switch (Category 4).

The degree of safety can be increased by:

- Using additional measures against tampering such as the mounting position, actuator located in a guide channel etc.
- Shielding and mechanically protecting the cables
- Radius actuators can be used, especially for SIGUARD position switches with separate actuators
- SIGUARD position switches with auxiliary release with separate actuator and tumbler allow fast intervention even when the power fails
- Fail-safe circuit for the tumbler solenoid for latching.

When monitoring protective doors, it must be detected when they are opened and the machine must be brought to a standstill in the hazardous zone, for example, for lathes, production lines, punches etc.

SIGUARD position switches Standard switch, switch with separate actuator, switch with tumbler	Category acc. to EN 954-1	Additionally required measures
	1	Single-channel connection, positively opening contacts, positively driven-position switch
 	3, 4	Two-channel, redundant version, cross-circuit proof for Category 4
	1	Single-channel connection, positively opening-contacts
 	3, 4	Two-channel connection, redundant version of the switch (two switches) with positively opening contacts, cross-circuit proof for Cat. 4
 	3, 4	Positively opening contacts, by additionally monitoring the protective device with an additional position-switch and two-channel, cross-circuit-proof connection

Fig. 3/18

SIGUARD position switches are available in different versions

- Position switch and actuator element form a single unit (Switch Category 1)
- Switch and actuator element are separate (Switch Category 2)
- Actuator elements can include the following: Actuator with roller crank, overtravel plunger, roller plunger etc.
- Various sizes, e. g. acc. to DIN EN 50041 or DIN EN 50047
- With positive opening acc. to EN 60947-5-1 (IEC 947-5-1).

Position switches with separate actuator are preferred to monitor protective doors acc. to EN 1088.

In addition to the fact that they can be simply mounted, the position switches have the additional advantage that they cannot be bypassed/tampered using simple measures, e.g. using wire, screwdrivers, etc. Another advantage is the fact that they can be actuated without having to use any other devices such as switching cams etc. Not only this, they are even actuated when the doors are just slightly opened.

Protective door latching using position switches with integrated tumbler mechanism

If protective doors with integrated tumbler mechanism according to Category 4 (EN 954-1) are to be monitored in a fail-safe fashion, fault identification requirements have to be fulfilled in accordance with EN 954-1. In this case, the complete safety circuit up to the mechanical section of the position switch has to be included in the fault identification.

Faults, for example, if the actuator breaks off, or if a mechanical component fails, must be prevented using additional measures or by using a second position switch to monitor the protective doors (Category 3 or 4).

Position switches with tumbler mechanism must fulfill the following requirements:

- The contacts must be positively driven NC contacts
- The solenoid circuit and the switching circuit must be electrically isolated
- None of the NC contacts may be closed when the protective door is in the open position (incorrect closure protection)
- 2 NC contacts must be used in the safety circuit.

A second protective door position switch must fulfill the following requirements:

- It must have positively driven NC contacts as above
- An electromagnetic tumbler mechanism is not required
- 2 NC contacts must be used in the same circuit.

SIGUARD 3TK28 safety combinations must be connected in accordance with EN 954-1. In this case, the evaluation unit must detect short circuits in the feeder cables, for example, if cables or wires are crushed.

Type of safety contacts for position switches with separate actuator and tumbler mechanism

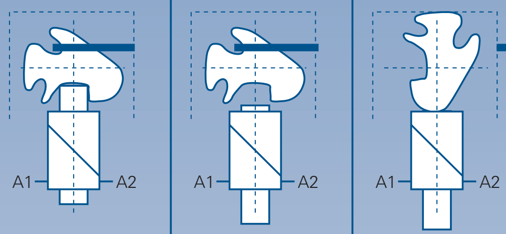
SIGUARD position switches with integrated tumbler mechanism are available with 2 or 4 contacts. All of the NC contacts must be positively driven according to EN 60 947-5-1. If the protective door is open, it must not be possible to close a safety contact (incorrect closure protection).

The contacts are actuated in one of the following ways:

- Contacts which monitor the operation of the solenoids open when the solenoids are released. This means that the safety circuit is interrupted even when the protective doors are closed.
- Contacts which monitor the position of the protective doors open when the protective door is actuated.

The main function of the solenoid monitoring contacts is to ensure the safety of the system. NC contacts which are used to monitor the position of protective doors can also be integrated in the safety circuit. They provide the user with another possibility of monitoring the status of the protective doors.

The switching statuses of the individual contacts for 3SE3 7, 3SE3 85, 3SE3 86 SIGUARD position switches with tumbler



Actuator		Inserted	Inserted	Withdrawn
Contact position		Latched	Unlatched	Opened
Order code for the contacts				
3SE3...-2...	M M	21–22 13–14	21–22 13–14	21–22 13–14
3SE3...-8...	M M	11–12 21–22	11–12 21–22	11–12 21–22
3SE3...-7...	M B	11–12 21–22	11–12 21–22	11–12 21–22
3SE3...-3...	M M B M	11–12 21–22 31–32 43–44	11–12 21–22 31–32 43–44	11–12 21–22 31–32 43–44
3SE3...-6...	M M B B	11–12 21–22 31–32 41–42	11–12 21–22 31–32 41–42	11–12 21–22 31–32 41–42

M = switched by solenoid B = switched by actuator

Fig. 3/19

Actuation elements for SIGUARD position switches:

SIGUARD position switches with separate actuator are shipped without actuator element.

Various actuators significantly expand the applications of the position switches.

This additionally simplifies mounting and installation.

Small approach radii for position switches mounted close to door hinges can be implemented using a radius actuator.

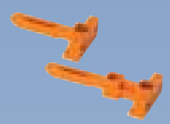
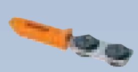
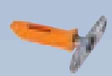
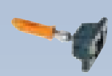
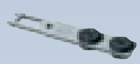
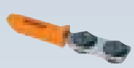
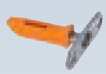
Switch/actuator	Standard actuator for longitudinal mounting	Standard actuator for lateral mounting	Radius actuator	Actuator for approach direction from the left
 3SE. 200-.XX03 3SE. 200-.XX04	–	 3SX3 196 (50 mm) 3SX3 195 (70 mm)	–	–
 3SE. 200-.XX13	 3SX3 220	 3SX3 221	 3SX3 222	–
 3SE. 24.-.XX.. 3SE. 25.-.XX..	–	 3SX3 218	 3SX3 228	–
 3SE. 120-.XX	 3SX3 197	 3SX3 206	 3SX3 203	–
 3SE. 7.-.XX.. 3SE. 85.-.XX.. 3SE. 86.-.XX..	 3SX3 226	 3SX3 227	 3SE3 222	–
  3SE. 83.-.XX				

Fig. 3/20

SIGUARD position switches used to monitor protective doors

Monitoring a protective door using a SIGUARD position switch ➲ (1-channel)

Category: 1/2 acc. to EN 954-1

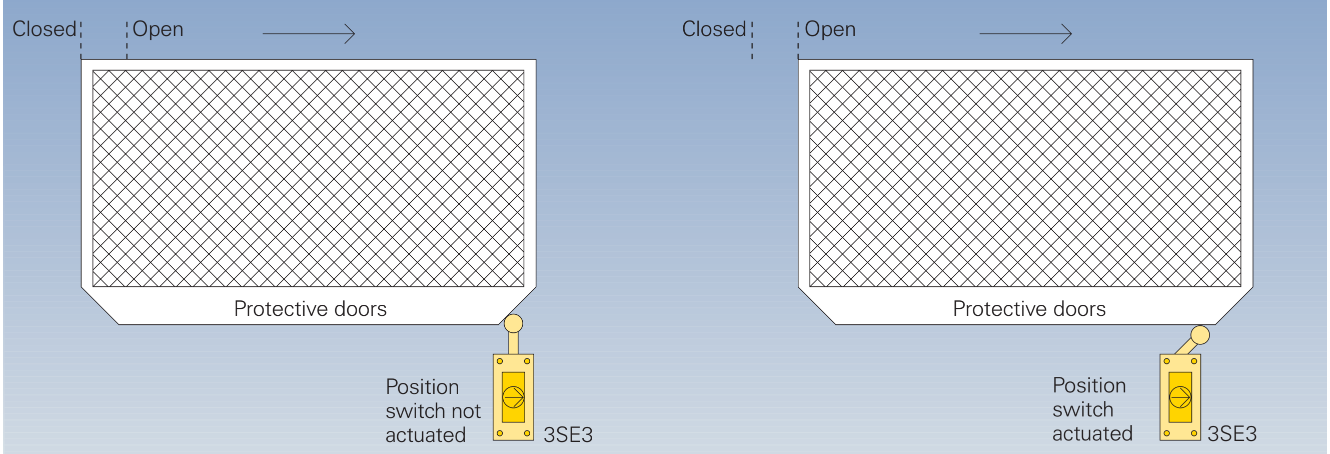


Fig. 3/21
Using well-proven safety-related components and principles

Positive actuation

The position switches must be positively operated when the protective door is opened. Thus, it is especially important to ensure that the position switch is *correctly mounted* (Figs. 3/22 and 3/24).

Sensing the control commands

Position switches must fulfill the following requirements:

- Positive opening contacts ➲
- 1NC contact for Category 1/2 (acc. to EN 954-1)
- Positive operation (mechanical actuation) when the doors are opened
- Switching cams must be mounted at the pivotal points of doors and covers
- For sliding doors, the switch is actuated through a rod.

Evaluation

For Category 2 (1-channel) with 3TK28 SIGUARD safety combinations or SIMATIC fail-safe control.

Direct *shutdown via* the motor contactor or circuit-breaker.

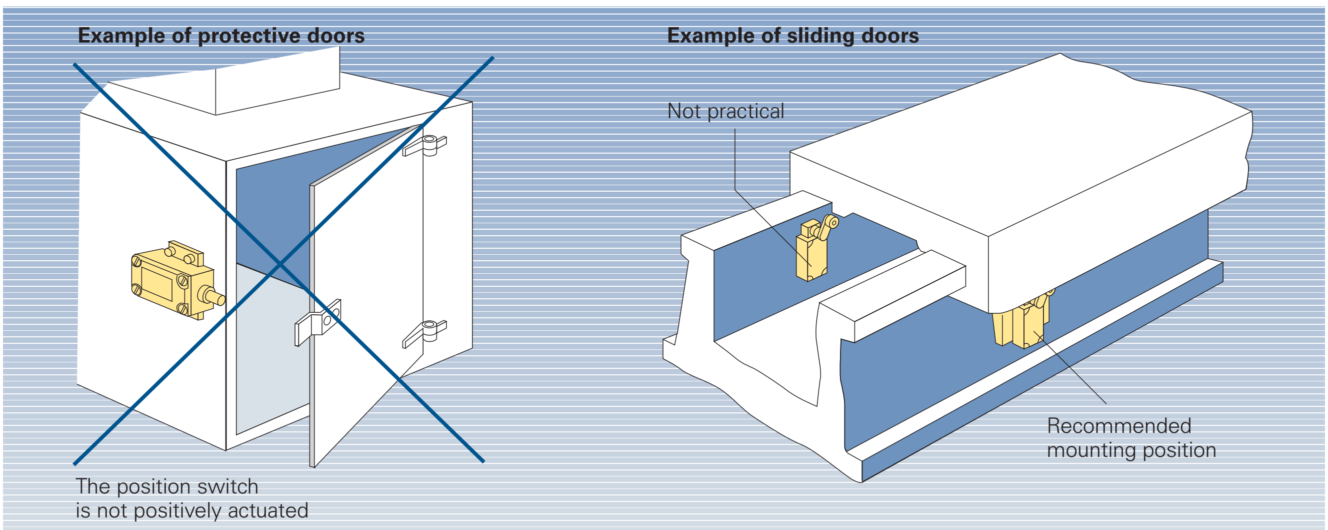


Fig. 3/22
Mounting position switches to ensure the correct function

Monitoring using two SIGUARD position switches ⊖ (2-channel)

Categories: 3, 4 (acc. to EN 954-1) in conjunction with 3TK28 or S7-300F

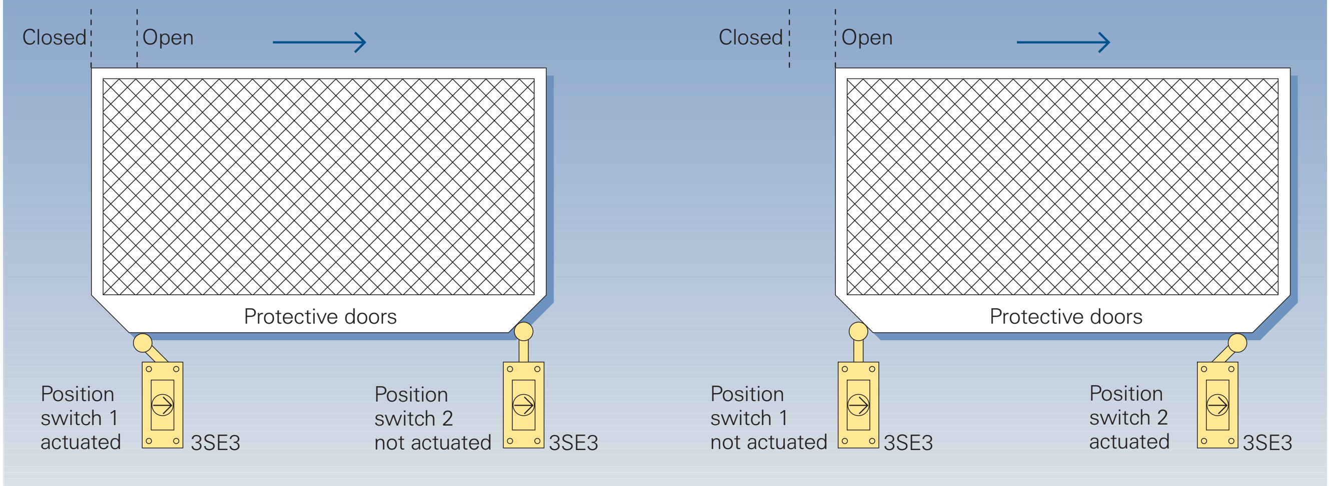


Fig. 3/24

The following is necessary for the highest category

- Cross-circuit protection
- Self-monitoring of the contacts
- Two SIGUARD position switches must be used.

Sensing the control command

The position switch must fulfill the following requirements:

- Positively-opening contacts ⊖
- 2-channel connection
- Positive mechanical actuation
- Switching cams are mounted at the pivotal point of doors and covers
- For sliding doors, the switch is actuated via a rod.

Evaluation

A fail-safe, redundant evaluation is mandatory for Category 3 and Category 4.

⇒ Use 3TK28 SIGUARD safety combination or a direct connection to a fail-safe S7-300F PLC.

Direct *shutdown* via the motor contactor or circuit-breaker.

The higher Category 4 can be achieved by appropriately connecting up the evaluation unit (cross-circuit proof, 2-channel).

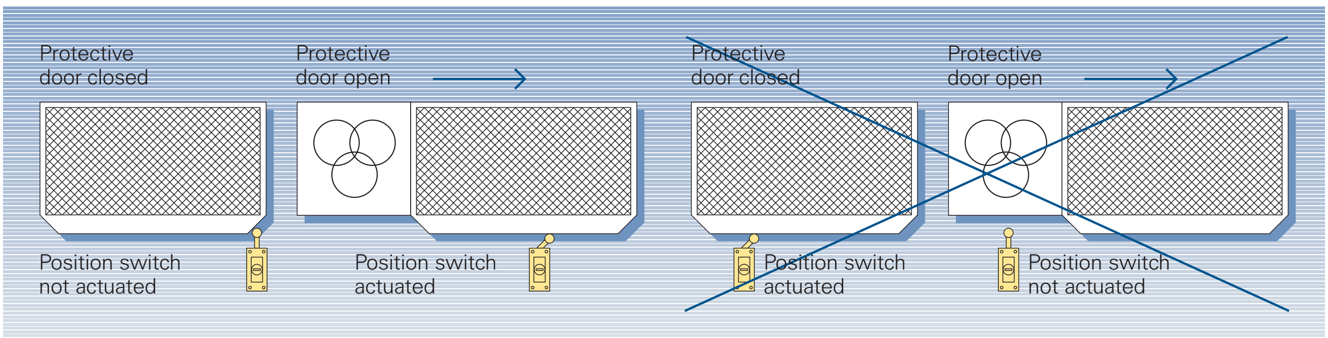


Fig. 3/25
Mounting position switches to ensure a correct function (positive actuation)

Monitoring using two SIGUARD position switches ⊖ with separate actuator (2-channel)

Category: 4 (acc. to EN 954-1) in conjunction with 3TK28 or S7-300F

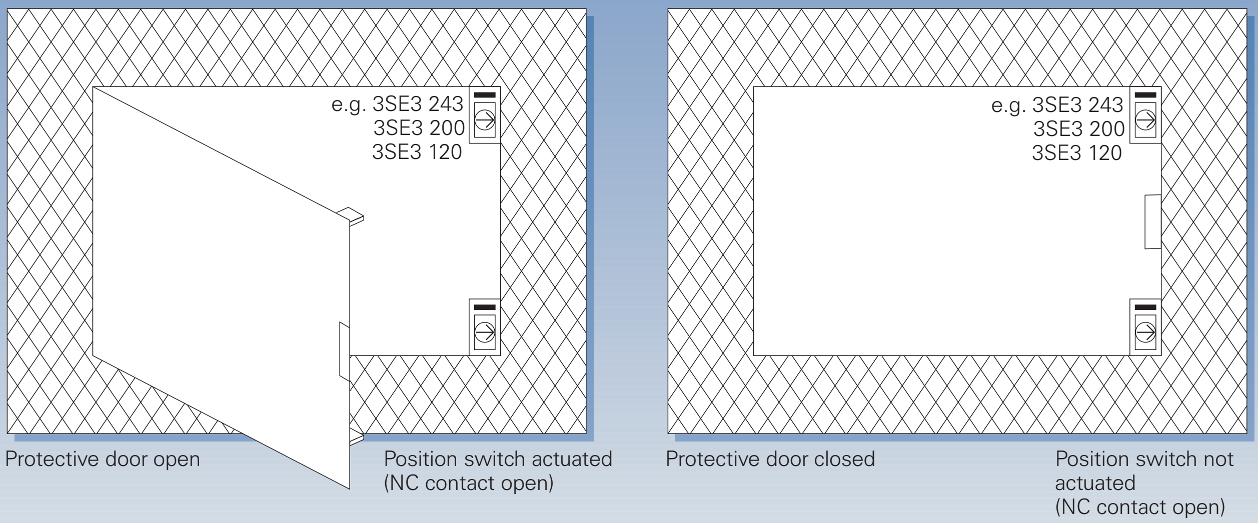


Fig. 3/26

Position switch version with separate actuator

- Switch and actuator element do not form a single mechanical entity (Switch Category 2)
- No additional switching cams or rods
- Variable approach radius using radius actuators expands the range of applications
- Tamper-proof functionality can be simply achieved.

The safety contacts are opened when the actuator is withdrawn when opening the door.

The following is necessary for Category 4

- Cross-circuit protection
- Actuator should not be able to be broken off
- 2 SIGUARD position switches with separate actuator must also be used to guarantee redundancy, also for the mechanical parts.

Sensing the control command

The position switch must fulfill the following requirements:

- Positively-opening contacts ⊖
- Positive mechanical actuation
- Mounted onto the closing edge of doors, covers or sliding screens
- The switch enclosure is mounted to the stationary part while the actuator is mounted flush on the moving protective device
- 2-channel connection

Evaluation

A fail-safe redundant evaluation is mandatory for Category 3 and Category 4.

⇒ 3TK28 SIGUARD safety combination is used or direct connection to a fail-safe SIMATIC PLC.

Shutdown via motor contactor or circuit-breaker.

Monitoring using one SIGUARD position switch ⊖ with separate actuator <u>and</u> tumbler and a switch with positively-opening contacts <u>without</u> tumbler

Category: 4 (acc. EN 954-1) in conjunction with 3TK28 S7 400F/FH or S7-300F

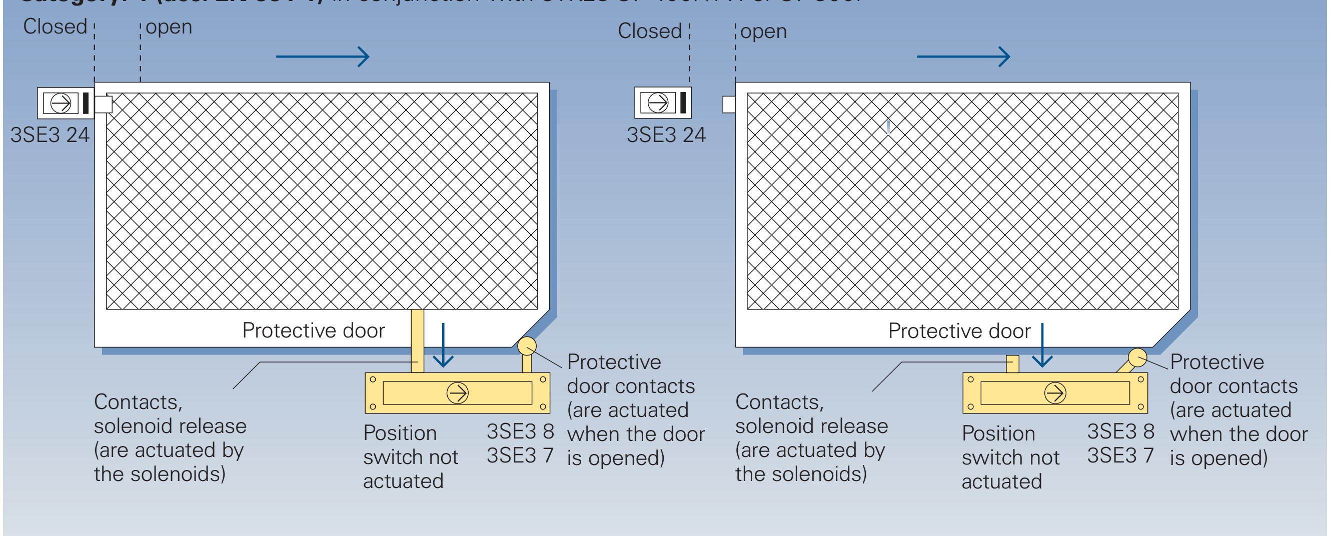


Fig. 3/27

For machines with longer stopping times, there is an increased danger until the machine comes to a final stop.

Overtravel time of the drive
> access time

Protective doors are locked using the tumbler mechanism

It is only possible to open the doors in the safe condition when the drive is at a standstill

SIGUARD position switches with tumbler mechanism have an integrated solenoid, which locks the actuator element when it is energized.

Position switch with separate actuator and tumbler

- Switch and actuating element do not form a single mechanical entity (switch Category 2)
- Spring-locked in the no-voltage condition
- No additional switching cams or rods
- Erroneous closure protection: If the protective door is open, it is not possible to close the safety contacts.

For Category 4 a second 3SE3 SIGUARD position switch is required in order to monitor the protective device. A tumbler mechanism is not required for this switch. The switch is incorporated in the safety-related circuit using 1 or 2 NC contacts.

Sensing the command

Position switches with tumbler must fulfill the following requirements:

- Positively-opening contacts ⊖
- Solenoid and switching circuit are electrically isolated
- 1 NC or 2 NC contacts to monitor the position switch
- Positive mechanical actuation of the contacts.

Evaluation

A fail-safe evaluation is required.

⇒ 3TK28 SIGUARD safety combinations is used or a direct connection to a fail-safe SIMATIC PLC

Shutdown via motor contactor or circuit-breaker.

Example: Cover

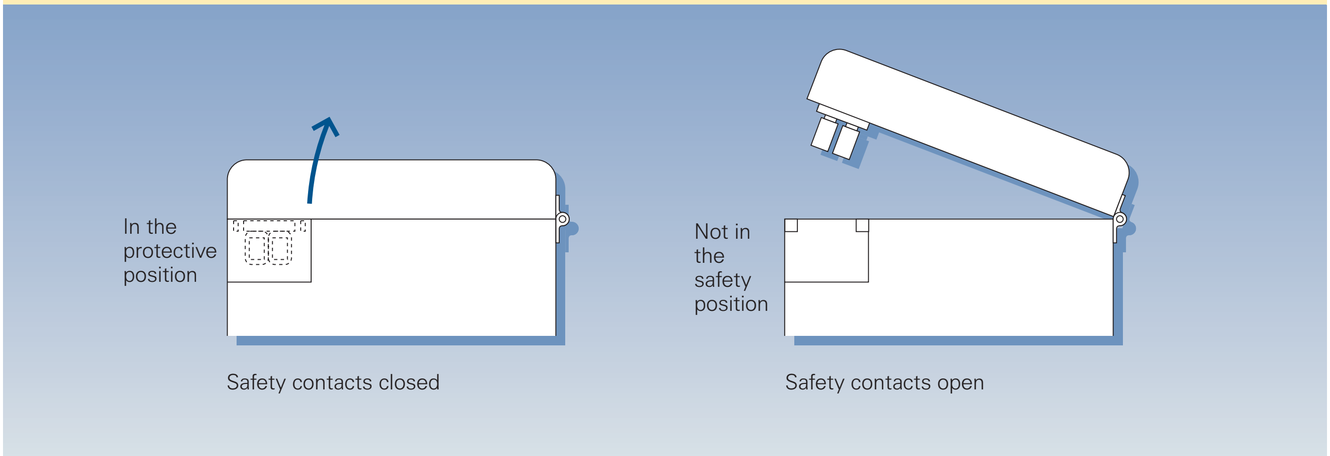


Fig. 3/28
Using position switches with separate actuators

"Sliding door" application

When the door is opened, the actuator is withdrawn from the switch.

Measures can be taken to prevent tampering by mounting the switch so that it cannot be manipulated and by installing the actuator in a guide, e.g. using a guide rail or by mounting the actuator at a "secure" position.

Further, it must be ensured that the actuator cannot be broken off, e.g. through misalignment.

Special actuator elements (radius actuators) have higher tolerances which can be prevent damage as a result of misalignment. A hazardous condition can occur if the actuator element remains in the switch after it has broken off.

"Cover" application

The switch has to be flush-mounted, which means that it is not possible to rule out tampering, e.g. by deliberately breaking off the actuator or using a second actuator.

⇒ Category 1 (acc. to EN 954-1) (when using a switch with a separate actuator)

⇒ or Category 4 (acc. to EN 954-1) (when using 2 switches with separate actuators).

"Hinged door" application

SIGUARD switches to monitor hinged doors or flaps are directly mounted at the hinge. Even at an angle of only 4°, the NC contacts open and initiate a stop command. These switch types enhance the level of protection against manipulation and tampering by directly integrating the protective device.

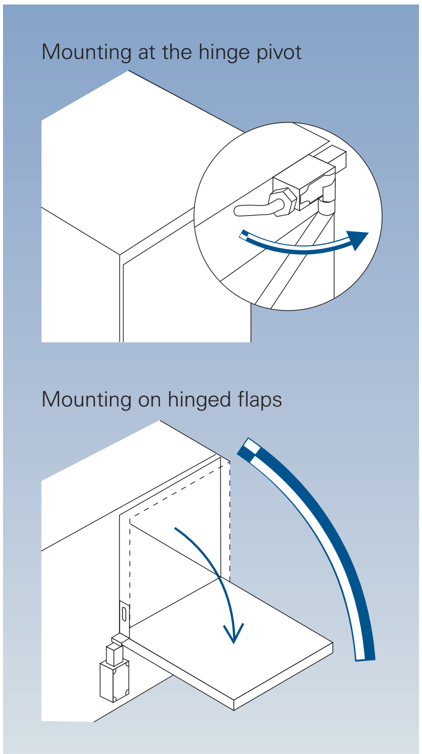


Fig. 3/29

Selection and Ordering Data for SIGUARD 3SE Hinge-Mounted Switches

Selection and ordering data for 3SE SIGUARD hinge-mounted switches

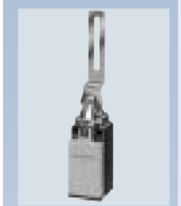
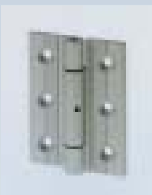
	Version Contact	Molded-element	Plastic enclosed EN 50 047 Order No.	Metal-enclosed EN 50 041 Order No.
	**For mounting on hinge pivots 1 x M20 x 1.5**	Switching point	Spring-contact	
	• Solid shaft d = 10 mm	15°	**1 NO/1 NC**	→ **3SE2 200-1GA11**
	• Hollow shaft d = 8 mm	15°	**1 NO/1 NC**	→ **3SE2 200-1GA10**
	• Solid shaft d = 10 mm	5°	**1 NO/1 NC**	→ **3SE2 200-1GA31**
	• Hollow shaft d = 8 mm	5°	**1 NO/1 NC**	→ **3SE2 200-1GA30**
		Slow-acting-contact		
	For mounting on* hinge pivots 1 x Pg 13.5	**1 NO/1 NC**	→ **3SE3 200-0GA10**	→ **3SE3 120-0GA10**
		2 NC	→ **3SE3 200-6GA10**	→ **3SE3 120-6GA10**
	**For mounting on* hinge pivots 1 x Pg 13.5**			
	Initial setting:			
	• vertical	**1 NO/1 NC**	→ **3SE3 200-0GA40**	→ **3SE3 120-0GA10**
	• right		→ **3SE3 200-6GA41**	→ **3SE3 120-6GA10**
	• left		→ **3SE3 200-0GA42**	→ **3SE3 120-0GA10**
	• vertical	**2 NC**	→ **3SE3 200-6GA40**	→ **3SE3 120-6GA10**
	• right		→ **3SE3 200-6GA41**	→ **3SE3 120-6GA10**
	• left		→ **3SE3 200-0GA42**	→ **3SE3 120-0GA10**
	**Hinge-mounted switch**			
		1 NO/1 NC		→ **3SE2 283-0GA43**
		3 NC		→ **3SE2 283-6GA43**
	**Additional hinge**			→ **3SX3 225**

Fig. 3/30

→ Safety function acc. to IEC 60 947-5-1-3 and DIN VDE 0660 Part 200

* for metric connections, the Pg 13.5 to M20 x 1.5 insert should be ordered (metal: 3SX9915; molded plastic: 3SX9916)

Application examples:

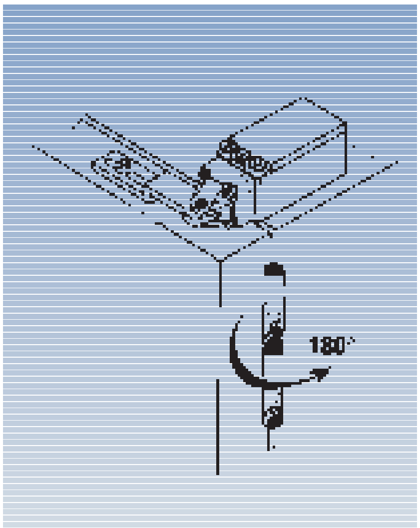


Fig. 3/31a

SIGUARD hinge-mounted switches on hinged flaps and doors

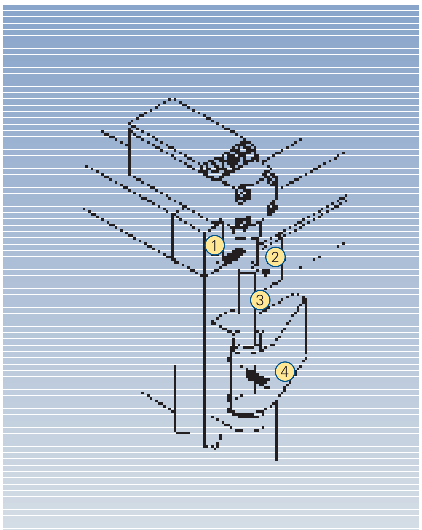


Fig. 3/31

SIGUARD hinge-mounted switches for mounting on hinged axes

1 *Pin to establish a connection between the switch shaft and the hinge extension*

2 *Clamping screw*

3 *Hinge axis extension*

4 *Pin to establish a connection between the hinge extension and door hinge*

3.1.5 SIGUARD magnetically-operated position switches

Relevant Standards

- EN 60 204-1
  (Safety of Machinery –
  Electrical equipment of
  machines)
- EN 1088
  (Latching devices in conjunction
  with isolating protective devices)
- EN 292-2
  (Safety of Machinery –
  General Design Guidelines)

Used to monitor protective doors

SIGUARD magnetically-operated-position switches are ideally suited to monitor protective doors. They operate contactlessly. The reed contacts in the switching element are actuated via a coded switching magnet and are therefore especially tamper-proof.

Contrary to monitoring protective doors using SIGUARD position switches, as a result of the fail-safe operation and tamper-proof design of the SIGUARD magnetically-operated switches, for Category 3 acc. to EN 954-1, only one switch is required. However, cables must be routed separately and an appropriate evaluation unit must be used.

Product overview
Switching elements and switching magnets

Round sensor unit

3SE6 704-1BA

3SE6 605-1BA

Switching magnet (coded)	M 30			**3SE6 704-1BA**
Switching element	M 30	5–15 mm	1NO + 1NC	**3SE6 605-1BA**

Rectangular sensor unit

3SE6 704-2BA

3SE6 60.-2BA

Switching magnet (coded)	25 x 88 mm			**3SE6 704-2BA**
Switching element	25 x 88 mm	5–15 mm	1NO + 1NC	**3SE6 605-2BA**
				3SE6 604-2BA
Switching magnet (coded)	25 x 33 mm			**3SE6 704-3BA**
Switching element	25 x 33 mm	4–14 mm	1NO + 1NC	**3SE6 605-3BA**

Evaluation unit (Category 3 acc. to EN 954-1)

3SE6 801-1CC

3SE6 808-6DB

24	22.5 mm	2 NO	1	**3SE6 801-1CC**
24	120 mm per sensor	2 NO, 1 x SC	8	**3SE6 808-6DB**

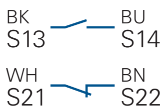
Fig. 3/32

Technical data of SIGUARD magnetically-operated position switches	
Sensor units	
Regulations	DIN VDE 0660; EN 1088 (in conjunction with a monitoring unit)
Enclosure	Fiber-glass-reinforced thermoplastic
Mode of operation	Magnetic
Voltage	100 V AC / DC (24 V DC for 3SE6...–3BA.)
Current	400 mA (100 mA for 3SE6...–3BA.)
Power	10 VA / W (1 W for 3SE6...–3BA.)
Storage, transport and operating temperature	–25 °C to +70 °C
Shock strength	10 g/11 ms
Vibration strength	10 to 55 Hz, amplitude 1 mm
Max. switching frequency	5 Hz
Degree of protection	IP 67 acc. to IEC 60 529/EN 60 529/DIN VDE 0470-1
Connection	LIYY 4 x 0.25 mm cable^2
Cable length	max. 1000 m (when connecting to a monitoring unit and cable LIYY 4 x 0.25 mm^2) (100 m for 3SE6...–3BA.)

Fig. 3/33
Technical data of the evaluation units, refer to Section 7/27 or Catalog NSK.

Mounting and connecting-up SIGUARD magnetically-operated position switches

We recommend that the switching magnets are always adjusted using the specified diagram. The correct function should always be checked with the evaluation unit connected. Please note: The marking on the magnet must line-up with the marking on the switching element. The label on the switching magnets and evaluation units always refer to the no-voltage condition with the protective doors closed (magnetically-operated position switch actuated, evaluation unit voltage-free).



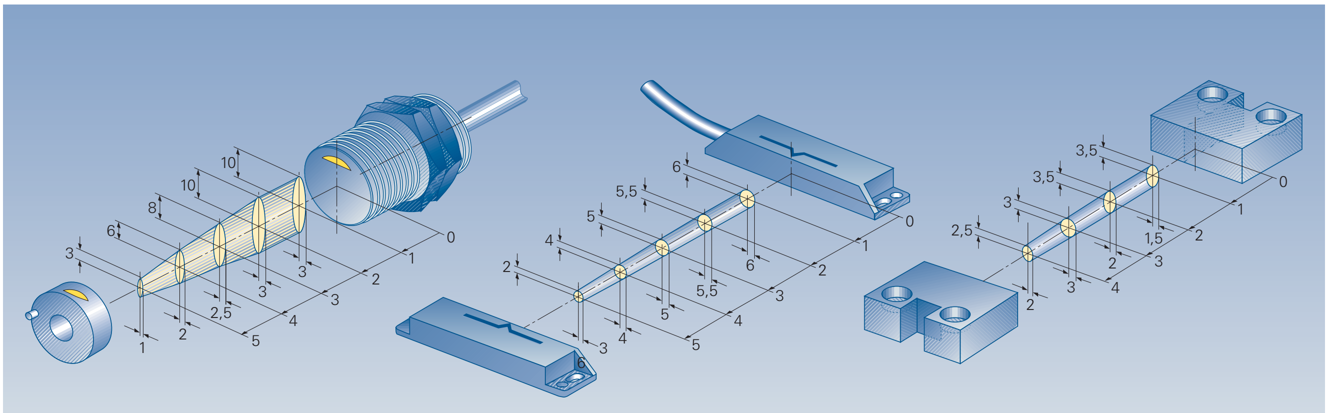


Fig. 3/34
Enabling ranges of the SIGUARD magnetically-operated position switches 3SE6 605-.BA

3.1.6 SIGUARD safety switch strips

Product overview and mode of operation

3RG78 5 SIGUARD safety switch strips for machinery construction prevent dangerous edges crushing parts of the human body. The safety switch strips consist of an aluminum mounting rail and a rubber profile, which is used to realize the shutdown function, a transmitter and a receiver unit, which optically monitors the safety switch strip. It is extremely easy to handle these safety switch strips and they are extremely flexible.

Transmitter and receiver units are inserted into the hollow space in the rubber profile at each end. The rubber profile can be cut to the required length on-site and is resistant to, for example, ozone, oils, solvents, acids and fuels.

The German Trade Association [BG] has certified 3RG78 5 SIGUARD safety switch strips for Category 4 acc. to EN 954-1. The fail-safe functionality is achieved using the associated evaluation unit.

	Version	Length in m	Order No.
Optical safety switch strips			
3RG78 55-1R . 	**Transmitter/receiver sensors**	0.5 to 10 m	**3RG78 55-1RG**
	Sensor strip (rubber profile)	1 2.5 5 10	**3RG78 55-2BB** **3RG78 55-2BD** **3RG78 55-2BF** **3RG78 55-2BG**
3RG78 55-.BB 	**Mounting strip** (Aluminum profile)	1 2.5	**3RG78 55-3BB** **3RG78 55-3BD**

	Version	Control	Version release circuit/ signaling circuit	Achieved Category acc. to EN 954-1	Order No.
24 V DC evaluation unit					
3RG78 57-1BD 	Monitoring safety switch strips	Dynamic signal	2 NO/1 NC (SC)	4	**3RG78 57-1BD**

Fig.3/35

Technical Data

Technical data			
Evaluation			
Operating voltage	24V DC (+20%/–10%)	Function displays	Green LED : Power
Own consumption	< 4W		Green LED: Channel
Output contacts	2 NO (safety-related)/ 1 NC (semiconductor)	Power supply fusing	1 A (slow-acting)
Response time	approx. 32 ms	Overvoltage category	3 (4 kV) acc. to DIN VDE 0110
Ambient temperature	+ 5 °C to + 55 °C	Enclosure mounting	Snapped onto 35-mm mounting
Continuous current	4 A		rails acc. to EN 50 022
Switching current	max. 4 A	Operating position	Any
Switching voltage	max. 250 V AC 50/60 Hz	Degree of protection	Terminal housing, IP 20 acc. to
Mechanical lifetime	30 million switching cycles		DIN VDE 0440
AC switching power	max. 1250 VA	Certification	Category 4 acc. to EN 954-1
Switching strip (rubber profile)			
Material	EPDM, 60 Shore		
Dimensions	B = 25 mm H = 30 mm		
Temperature resistance	–40 °C to + 150 °C (briefly)		
	–30 °C to + 120 °C (long term)		
Resistant to	Ozone, conditionally against oils,		
	solvents, acids, fuels		

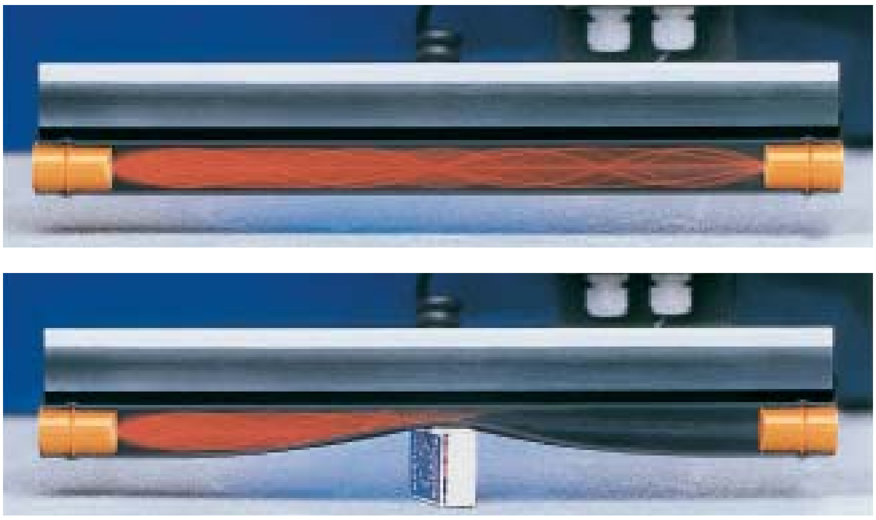


Fig. 3/36 Mode of operation of SIGUARD switching strips

3.1.7 SIGUARD light curtains and light grids

Relevant Standards

- EN 61 496-1, -2, IEC 61 496-1, -2 (requirements placed on contactless protective systems)
- EN 999 (including calculating safety clearances)
- EN 954-1 (Safety of Machinery - Safety-related parts of control systems)

Fig. 3/37
SIGUARD light curtains, light grids and evaluation units

SIGUARD light curtains and light grids

- Are active opto-electronic protective devices (AOPD)
- Type 2 (3RG78 41)
- Type 4 (3RG78 42/44)
- Are EC-prototype tested
- Protect operating personnel at or close to dangerous machines
- Operate contactlessly
- Are wear-free in comparison to mechanical systems (e.g. safety mats)

The prerequisites are:

- They are correctly installed
- They are corrected integrated into the machine control

Information is provided in this section and is in the Instruction Manuals provided with the particular devices.

Light curtains/grids 3RG78 44

Integrated functions:

- Restart inhibit
- Contactor monitoring
- Emergency Stop switch
- Fixed blanking
- Floating blanking
- Reduced resolution

Configuration

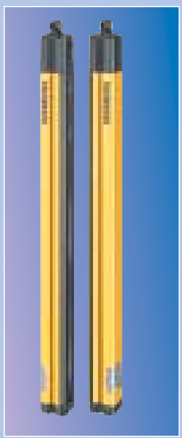
- Using teach-in key via the opto-magnetic key
- The Configuring data is transferred using a plug-in configuration card

Customer advantages:

- Double-Scan function
- 2 data transfer channels
- Sensor expansion module to connect additional safety sensors
- Integrated laser adjustment tool
- Host and guest devices can be cascaded
- Extended display (2x7 segment display)

Selection and ordering data

Light curtains, standard function and blanking function with Hirschmann connection

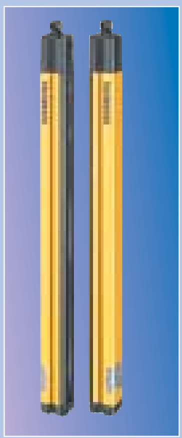


Light curtain height mm	Version	Standard function 14 mm resolution Order No.	Blanking function 14 mm resolution Order No.	Standard function 30 mm resolution Order No.
150	Receiver	3RG78 44-2SB02- □ SS1	3RG78 44-2BB02- □ SS1	3RG78 44-2SD02- □ SS1
	Transmitter	3RG78 44-2SB02- □ SS0	3RG78 44-2SB02- □ SS0	3RG78 44-2SD02- □ SS0
225	Receiver	3RG78 44-2SB03- □ SS1	3RG78 44-2BB03- □ SS1	3RG78 44-2SD03- □ SS1
	Transmitter	3RG78 44-2SB03- □ SS0	3RG78 44-2SB03- □ SS0	3RG78 44-2SD03- □ SS0
300	Receiver	3RG78 44-2SB04- □ SS1	3RG78 44-2BB04- □ SS1	3RG78 44-2SD04- □ SS1
	Transmitter	3RG78 44-2SB04- □ SS0	3RG78 44-2SB04- □ SS0	3RG78 44-2SD04- □ SS0
450	Receiver	3RG78 44-2SB06- □ SS1	3RG78 44-2BB06- □ SS1	3RG78 44-2SD06- □ SS1
	Transmitter	3RG78 44-2SB06- □ SS0	3RG78 44-2SB06- □ SS0	3RG78 44-2SD06- □ SS0
600	Receiver	3RG78 44-2SB08- □ SS1	3RG78 44-2BB08- □ SS1	3RG78 44-2SD08- □ SS1
	Transmitter	3RG78 44-2SB08- □ SS0	3RG78 44-2SB08- □ SS0	3RG78 44-2SD08- □ SS0
750	Receiver	3RG78 44-2SB11- □ SS1	3RG78 44-2BB11- □ SS1	3RG78 44-2SD11- □ SS1
	Transmitter	3RG78 44-2SB11- □ SS0	3RG78 44-2SB11- □ SS0	3RG78 44-2SD11- □ SS0
900	Receiver	3RG78 44-2SB13- □ SS1	3RG78 44-2BB13- □ SS1	3RG78 44-2SD13- □ SS1
	Transmitter	3RG78 44-2SB13- □ SS0	3RG78 44-2SB13- □ SS0	3RG78 44-2SD13- □ SS0
1050	Receiver	3RG78 44-2SB15- □ SS1	3RG78 44-2BB15- □ SS1	3RG78 44-2SD15- □ SS1
	Transmitter	3RG78 44-2SB15- □ SS0	3RG78 44-2SB15- □ SS0	3RG78 44-2SD15- □ SS0
1200	Receiver	3RG78 44-2SB17- □ SS1	3RG78 44-2BB17- □ SS1	3RG78 44-2SD17- □ SS1
	Transmitter	3RG78 44-2SB17- □ SS0	3RG78 44-2SB17- □ SS0	3RG78 44-2SD17- □ SS0
1350	Receiver	3RG78 44-2SB20- □ SS1	3RG78 44-2BB20- □ SS1	3RG78 44-2SD20- □ SS1
	Transmitter	3RG78 44-2SB20- □ SS0	3RG78 44-2SB20- □ SS0	3RG78 44-2SD20- □ SS0
1500	Receiver	3RG78 44-2SB22- □ SS1	3RG78 44-2BB22- □ SS1	3RG78 44-2SD22- □ SS1
	Transmitter	3RG78 44-2SB22- □ SS0	3RG78 44-2SB22- □ SS0	3RG78 44-2SD22- □ SS0
1650	Receiver	3RG78 44-2SB24- □ SS1	3RG78 44-2BB24- □ SS1	3RG78 44-2SD24- □ SS1
	Transmitter	3RG78 44-2SB24- □ SS0	3RG78 44-2SB24- □ SS0	3RG78 44-2SD24- □ SS0
1800	Receiver	3RG78 44-2SB26- □ SS1	3RG78 44-2BB26- □ SS1	3RG78 44-2SD26- □ SS1
	Transmitter	3RG78 44-2SB26- □ SS0	3RG78 44-2SB26- □ SS0	3RG78 44-2SD26- □ SS0
2100	Receiver	– –		
	Transmitter	– –		
2400	Receiver	– –		
	Transmitter	– –		
2700	Receiver	– –		
	Transmitter	– –		
3000	Receiver	– –		
	Transmitter	– –		
Order No. supplement				
• Standard device		0	0	0
• Master for slave expansion		1	1	1

Blanking function **30 mm** resolution Order No.	Standard function **50 mm** resolution Order No.	Blanking function **50 mm** resolution Order No.
3RG78 44-2BD02-□ SS1	–	–
3RG78 44-2SD02-□ SS0	–	–
3RG78 44-2BD03-□ SS1	–	–
3RG78 44-2SD03-□ SS0	–	–
3RG78 44-2BD04-□ SS1	–	–
3RG78 44-2SD04-□ SS0	–	–
3RG78 44-2BD06-□ SS1	3RG78 44-2SE06-□ SS1	3RG78 44-2BE06-□ SS1
3RG78 44-2SD06-□ SS0	3RG78 44-2SE06-□ SS0	3RG78 44-2SE06-□ SS0
3RG78 44-2BD08-□ SS1	3RG78 44-2SE08-□ SS1	3RG78 44-2BE08-□ SS1
3RG78 44-2SD08-□ SS0	3RG78 44-2SE08-□ SS0	3RG78 44-2SE08-□ SS0
3RG78 44-2BD11-□ SS1	3RG78 44-2SE11-□ SS1	3RG78 44-2BE11-□ SS1
3RG78 44-2SD11-□ SS0	3RG78 44-2SE11-□ SS0	3RG78 44-2SE11-□ SS0
3RG78 44-2BD13-□ SS1	3RG78 44-2SE13-□ SS1	3RG78 44-2BE13-□ SS1
3RG78 44-2SD13-□ SS0	3RG78 44-2SE13-□ SS0	3RG78 44-2SE13-□ SS0
3RG78 44-2BD15-□ SS1	3RG78 44-2SE15-□ SS1	3RG78 44-2BE15-□ SS1
3RG78 44-2SD15-□ SS0	3RG78 44-2SE15-□ SS0	3RG78 44-2SE15-□ SS0
3RG78 44-2BD17-□ SS1	3RG78 44-2SE17-□ SS1	3RG78 44-2BE17-□ SS1
3RG78 44-2SD17-□ SS0	3RG78 44-2SE17-□ SS0	3RG78 44-2SE17-□ SS0
3RG78 44-2BD20-□ SS1	3RG78 44-2SE20-□ SS1	3RG78 44-2BE20-□ SS1
3RG78 44-2SD20-□ SS0	3RG78 44-2SE20-□ SS0	3RG78 44-2SE20-□ SS0
3RG78 44-2BD22-□ SS1	3RG78 44-2SE22-□ SS1	3RG78 44-2BE22-□ SS1
3RG78 44-2SD22-□ SS0	3RG78 44-2SE22-□ SS0	3RG78 44-2SE22-□ SS0
3RG78 44-2BD24-□ SS1	3RG78 44-2SE24-□ SS1	3RG78 44-2BE24-□ SS1
3RG78 44-2SD24-□ SS0	3RG78 44-2SE24-□ SS0	3RG78 44-2SE24-□ SS0
3RG78 44-2BD26-□ SS1	3RG78 44-2SE26-□ SS1	3RG78 44-2BE26-□ SS1
3RG78 44-2SD26-□ SS0	3RG78 44-2SE26-□ SS0	3RG78 44-2SE26-□ SS0
	3RG78 44-2SE28-□ SS1	3RG78 44-2BE28-□ SS1
	3RG78 44-2SE28-□ SS0	3RG78 44-2SE28-□ SS0
	3RG78 44-2SE31-□ SS1	3RG78 44-2BE31-□ SS1
	3RG78 44-2SE31-□ SS0	3RG78 44-2SE31-□ SS0
	3RG78 44-2SE33-□ SS1	3RG78 44-2BE33-□ SS1
	3RG78 44-2SE33-□ SS0	3RG78 44-2SE33-□ SS0
	3RG78 44-2SE35-□ SS1	3RG78 44-2BE35-□ SS1
	3RG78 44-2SE35-□ SS0	3RG78 44-2SE35-□ SS0
0 1	0 1	0 1

Selection and ordering data

Light curtains, standard function and blanking function with cable gland



Light curtain height mm	Version	Standard function **14 mm** resolution Order No.	Blanking function **14 mm** resolution Order No.	Standard function **30 mm** resolution Order No.
150	Receiver	**3RG78 44-6SB02- □ SS1**	**3RG78 44-6BB02- □ SS1**	**3RG78 44-6SD02- □ SS1**
	Transmitter	**3RG78 44-6SB02- □ SS0**	**3RG78 44-6SB02- □ SS0**	**3RG78 44-6SD02- □ SS0**
225	Receiver	**3RG78 44-6SB03- □ SS1**	**3RG78 44-6BB03- □ SS1**	**3RG78 44-6SD03- □ SS1**
	Transmitter	**3RG78 44-6SB03- □ SS0**	**3RG78 44-6SB03- □ SS0**	**3RG78 44-6SD03- □ SS0**
300	Receiver	**3RG78 44-6SB04- □ SS1**	**3RG78 44-6BB04- □ SS1**	**3RG78 44-6SD04- □ SS1**
	Transmitter	**3RG78 44-6SB04- □ SS0**	**3RG78 44-6SB04- □ SS0**	**3RG78 44-6SD04- □ SS0**
450	Receiver	**3RG78 44-6SB06- □ SS1**	**3RG78 44-6BB06- □ SS1**	**3RG78 44-6SD06- □ SS1**
	Transmitter	**3RG78 44-6SB06- □ SS0**	**3RG78 44-6SB06- □ SS0**	**3RG78 44-6SD06- □ SS0**
600	Receiver	**3RG78 44-6SB08- □ SS1**	**3RG78 44-6BB08- □ SS1**	**3RG78 44-6SD08- □ SS1**
	Transmitter	**3RG78 44-6SB08- □ SS0**	**3RG78 44-6SB08- □ SS0**	**3RG78 44-6SD08- □ SS0**
750	Receiver	**3RG78 44-6SB11- □ SS1**	**3RG78 44-6BB11- □ SS1**	**3RG78 44-6SD11- □ SS1**
	Transmitter	**3RG78 44-6SB11- □ SS0**	**3RG78 44-6SB11- □ SS0**	**3RG78 44-6SD11- □ SS0**
900	Receiver	**3RG78 44-6SB13- □ SS1**	**3RG78 44-6BB13- □ SS1**	**3RG78 44-6SD13- □ SS1**
	Transmitter	**3RG78 44-6SB13- □ SS0**	**3RG78 44-6SB13- □ SS0**	**3RG78 44-6SD13- □ SS0**
1050	Receiver	**3RG78 44-6SB15- □ SS1**	**3RG78 44-6BB15- □ SS1**	**3RG78 44-6SD15- □ SS1**
	Transmitter	**3RG78 44-6SB15- □ SS0**	**3RG78 44-6SB15- □ SS0**	**3RG78 44-6SD15- □ SS0**
1200	Receiver	**3RG78 44-6SB17- □ SS1**	**3RG78 44-6BB17- □ SS1**	**3RG78 44-6SD17- □ SS1**
	Transmitter	**3RG78 44-6SB17- □ SS0**	**3RG78 44-6SB17- □ SS0**	**3RG78 44-6SD17- □ SS0**
1350	Receiver	**3RG78 44-6SB20- □ SS1**	**3RG78 44-6BB20- □ SS1**	**3RG78 44-6SD20- □ SS1**
	Transmitter	**3RG78 44-6SB20- □ SS0**	**3RG78 44-6SB20- □ SS0**	**3RG78 44-6SD20- □ SS0**
1500	Receiver	**3RG78 44-6SB22- □ SS1**	**3RG78 44-6BB22- □ SS1**	**3RG78 44-6SD22- □ SS1**
	Transmitter	**3RG78 44-6SB22- □ SS0**	**3RG78 44-6SB22- □ SS0**	**3RG78 44-6SD22- □ SS0**
1650	Receiver	**3RG78 44-6SB24- □ SS1**	**3RG78 44-6BB24- □ SS1**	**3RG78 44-6SD24- □ SS1**
	Transmitter	**3RG78 44-6SB24- □ SS0**	**3RG78 44-6SB24- □ SS0**	**3RG78 44-6SD24- □ SS0**
1800	Receiver	**3RG78 44-6SB26- □ SS1**	**3RG78 44-6BB26- □ SS1**	**3RG78 44-6SD26- □ SS1**
	Transmitter	**3RG78 44-6SB26- □ SS0**	**3RG78 44-6SB26- □ SS0**	**3RG78 44-6SD26- □ SS0**
2100	Receiver	– –		
	Transmitter	– –		
2400	Receiver	– –		
	Transmitter	– –		
2700	Receiver	– –		
	Transmitter	– –		
3000	Receiver	– –		
	Transmitter	– –		
Order No. supplement				
• Standard device		**0**	**0**	**0**
• Master for slave expansion		**1**	**1**	**1**

Blanking function **30 mm** resolution Order No.	**Standard function** **50 mm** resolution Order No.	**Blanking function** **50 mm** resolution Order No.
3RG78 44-6BD02- □ SS1	–	–
3RG78 44-6SD02- □ SS0	–	–
3RG78 44-6BD03- □ SS1	–	–
3RG78 44-6SD03- □ SS0	–	–
3RG78 44-6BD04- □ SS1	–	–
3RG78 44-6SD04- □ SS0	–	–
3RG78 44-6BD06- □ SS1	3RG78 44-6SE06- □ SS1	3RG78 44-6BE06- □ SS1
3RG78 44-6SD06- □ SS0	3RG78 44-6SE06- □ SS0	3RG78 44-6SE06- □ SS0
3RG78 44-6BD08- □ SS1	3RG78 44-6SE08- □ SS1	3RG78 44-6BE08- □ SS1
3RG78 44-6SD08- □ SS0	3RG78 44-6SE08- □ SS0	3RG78 44-6SE08- □ SS0
3RG78 44-6BD11- □ SS1	3RG78 44-6SE11- □ SS1	3RG78 44-6BE11- □ SS1
3RG78 44-6SD11- □ SS0	3RG78 44-6SE11- □ SS0	3RG78 44-6SE11- □ SS0
3RG78 44-6BD13- □ SS1	3RG78 44-6SE13- □ SS1	3RG78 44-6BE13- □ SS1
3RG78 44-6SD13- □ SS0	3RG78 44-6SE13- □ SS0	3RG78 44-6SE13- □ SS0
3RG78 44-6BD15- □ SS1	3RG78 44-6SE15- □ SS1	3RG78 44-6BE15- □ SS1
3RG78 44-6SD15- □ SS0	3RG78 44-6SE15- □ SS0	3RG78 44-6SE15- □ SS0
3RG78 44-6BD17- □ SS1	3RG78 44-6SE17- □ SS1	3RG78 44-6BE17- □ SS1
3RG78 44-6SD17- □ SS0	3RG78 44-6SE17- □ SS0	3RG78 44-6SE17- □ SS0
3RG78 44-6BD20- □ SS1	3RG78 44-6SE20- □ SS1	3RG78 44-6BE20- □ SS1
3RG78 44-6SD20- □ SS0	3RG78 44-6SE20- □ SS0	3RG78 44-6SE20- □ SS0
3RG78 44-6BD22- □ SS1	3RG78 44-6SE22- □ SS1	3RG78 44-6BE22- □ SS1
3RG78 44-6SD22- □ SS0	3RG78 44-6SE22- □ SS0	3RG78 44-6SE22- □ SS0
3RG78 44-6BD24- □ SS1	3RG78 44-6SE24- □ SS1	3RG78 44-6BE24- □ SS1
3RG78 44-6SD24- □ SS0	3RG78 44-6SE24- □ SS0	3RG78 44-6SE24- □ SS0
3RG78 44-6BD26- □ SS1	3RG78 44-6SE26- □ SS1	3RG78 44-6BE26- □ SS1
3RG78 44-6SD26- □ SS0	3RG78 44-6SE26- □ SS0	3RG78 44-6SE26- □ SS0
	3RG78 44-6SE28- □ SS1	3RG78 44-6BE28- □ SS1
	3RG78 44-6SE28- □ SS0	3RG78 44-6SE28- □ SS0
	3RG78 44-6SE31- □ SS1	3RG78 44-6BE31- □ SS1
	3RG78 44-6SE31- □ SS0	3RG78 44-6SE31- □ SS0
	3RG78 44-6SE33- □ SS1	3RG78 44-6BE33- □ SS1
	3RG78 44-6SE33- □ SS0	3RG78 44-6SE33- □ SS0
	3RG78 44-6SE35- □ SS1	3RG78 44-6BE35- □ SS1
	3RG78 44-6SE35- □ SS0	3RG78 44-6SE35- □ SS0
0 **1**	**0** **1**	**0** **1**

3RG78 44 light grids

Light grids with Hirschmann connection

Resolution mm	Version	Light beams	**18 m** range Order No.	**60 m** range Order No.
500	Receiver	2	**3RG78 44-2SS50- □ SS1**	**3RG78 44-2SS51- □ SS1**
	Transmitter	2	**3RG78 44-2SS50- □ SS0**	**3RG78 44-2SS51- □ SS0**
400	Receiver	3	**3RG78 44-2SP50- □ SS1**	**3RG78 44-2SP51- □ SS1**
	Transmitter	3	**3RG78 44-2SP50- □ SS0**	**3RG78 44-2SP51- □ SS0**
300	Receiver	4	**3RG78 44-2SM50-□ SS1**	**3RG78 44-2SM51-□ SS1**
	Transmitter	4	**3RG78 44-2SM50-□ SS1**	**3RG78 44-2SM51-□ SS0**

Order No. supplement		
• Standard device	**0**	**0**
• Master for slave expansion	**1**	**1**

3RG78 44 light grids

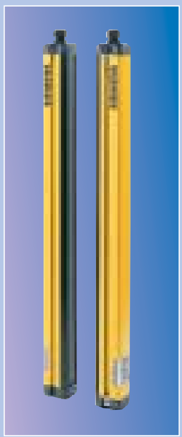
Light grid with cable gland

Resolution mm	Version	Light beams	18 m range Order No.	60 m range Order No.
500	Receiver	2	**3RG78 44-6SS50- □ SS1**	**3RG78 44-6SS51- □ SS1**
	Transmitter	2	**3RG78 44-6SS50- □ SS0**	**3RG78 44-6SS51- □ SS0**
400	Receiver	3	**3RG78 44-6SP50- □ SS1**	**3RG78 44-6SP51- □ SS1**
	Transmitter	3	**3RG78 44-6SP50- □ SS0**	**3RG78 44-6SP51- □ SS0**
300	Receiver	4	**3RG78 44-6SM50- □ SS1**	**3RG78 44-6SM51- □ SS1**
	Transmitter	4	**3RG78 44-6SM50- □ SS1**	**3RG78 44-6SM51- □ SS0**
Order No. supplement				
• Standard device			**0**	**0**
• Master for slave expansion			**1**	**1**

Product Overview

Light curtains for Category 4 in accordance with EN 954-1

Light curtains, Type 4 acc. to IEC 61496-1, -2, standard, master with slave connection and slave terminal device



Protective field height mm	**Type**	**14 mm** resolution Order No.	**30 mm** resolution Order No.	**50 mm** resolution Order No.
150[1]	Transmitter	**3RG78 42-6BB □ 0**	**3RG78 42-6DB □ 0**	–
	Receiver	**3RG78 42-6BB □ 1**	**3RG78 42-6DB □ 1**	–
225	Transmitter	**3RG78 42-6BC □ 0**	**3RG78 42-6DC □ 0**	–
	Receiver	**3RG78 42-6BC □ 1**	**3RG78 42-6DC □ 1**	–
300	Transmitter	**3RG78 42-6BD □ 0**	**3RG78 42-6DD □ 0**	–
	Receiver	**3RG78 42-6BD □ 1**	**3RG78 42-6DD □ 1**	–
450	Transmitter	**3RG78 42-6BE □ 0**	**3RG78 42-6DE □ 0**	**3RG78 42-6EE □ 0**
	Receiver	**3RG78 42-6BE □ 1**	**3RG78 42-6DE □ 1**	**3RG78 42-6EE □ 1**
600	Transmitter	**3RG78 42-6BF □ 0**	**3RG78 42-6DF □ 0**	**3RG78 42-6EF □ 0**
	Receiver	**3RG78 42-6BF □ 1**	**3RG78 42-6DF □ 1**	**3RG78 42-6EF □ 1**
750	Transmitter	**3RG78 42-6BG □ 0**	**3RG78 42-6DG □ 0**	**3RG78 42-6EG □ 0**
	Receiver	**3RG78 42-6BG □ 1**	**3RG78 42-6DG □ 1**	**3RG78 42-6EG □ 1**
900	Transmitter	**3RG78 42-6BH □ 0**	**3RG78 42-6DH □ 0**	**3RG78 42-6EH □ 0**
	Receiver	**3RG78 42-6BH □ 1**	**3RG78 42-6DH □ 1**	**3RG78 42-6EH □ 1**
1050	Transmitter	**3RG78 42-6BJ □ 0**	**3RG78 42-6DJ □ 0**	**3RG78 42-6EJ □ 0**
	Receiver	**3RG78 42-6BJ □ 1**	**3RG78 42-6DJ □ 1**	**3RG78 42-6EJ □ 1**
1200	Transmitter	**3RG78 42-6BK □ 0**	**3RG78 42-6DK □ 0**	**3RG78 42-6EK □ 0**
	Receiver	**3RG78 42-6BK □ 1**	**3RG78 42-6DK □ 1**	**3RG78 42-6EK □ 1**
1350	Transmitter	**3RG78 42-6BL □ 0**	**3RG78 42-6DL □ 0**	**3RG78 42-6EL □ 0**
	Receiver	**3RG78 42-6BL □ 1**	**3RG78 42-6DL □ 1**	**3RG78 42-6EL □ 1**
1500	Transmitter	**3RG78 42-6BM □ 0**	**3RG78 42-6DM □ 0**	**3RG78 42-6EM □ 0**
	Receiver	**3RG78 42-6BM □ 1**	**3RG78 42-6DM □ 1**	**3RG78 42-6EM □ 1**
1650	Transmitter	**3RG78 42-6BN □ 0**	**3RG78 42-6DN □ 0**	**3RG78 42-6EN □ 0**
	Receiver	**3RG78 42-6BN □ 1**	**3RG78 42-6DN □ 1**	**3RG78 42-6EN □ 1**
1800	Transmitter	**3RG78 42-6BP □ 0**	**3RG78 42-6DP □ 0**	**3RG78 42-6EP □ 0**
	Receiver	**3RG78 42-6BP □ 1**	**3RG78 42-6DP □ 1**	**3RG78 42-6EP □ 1**
2100	Transmitter	–	–	**3RG78 42-6ER □ 0**
	Receiver	–	–	**3RG78 42-6ER □ 1**
2400	Transmitter	–	–	**3RG78 42-6ES □ 0**
	Receiver	–	–	**3RG78 42-6ES □ 1**
2700	Transmitter	–	–	**3RG78 42-6ET □ 0**
	Receiver	–	–	**3RG78 42-6ET □ 1**
3000	Transmitter	–	–	**3RG78 42-6EU □ 0**
	Receiver	–	–	**3RG78 42-6EU □ 1**

Order No. supplement

	14 mm	30 mm	50 mm
• Standard light curtains	**0**	**0**	**0**
• Master with slave connection	**1**[1]	**1**[1]	**1**
• Slave terminal device	**–**	**2**	**2**

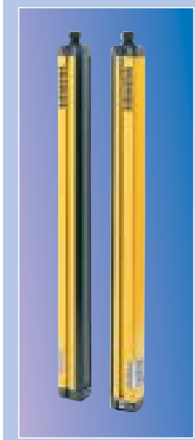
1) Master with slave connection is not available with a 150 mm protective field height

90 mm resolution Order No.
–
–
–
–
–
–
–
–
–
–
3RG78 42-6JG □ 0
3RG78 42-6JG □ 1
3RG78 42-6JH □ 0
3RG78 42-6JH □ 1
3RG78 42-6JJ □ 0
3RG78 42-6JJ □ 1
3RG78 42-6JK □ 0
3RG78 42-6JK □ 1
3RG78 42-6JL □ 0
3RG78 42-6JL □ 1
3RG78 42-6JM □ 0
3RG78 42-6JM □ 1
3RG78 42-6JN □ 0
3RG78 42-6JN □ 1
3RG78 42-6JP □ 0
3RG78 42-6JP □ 1
3RG78 42-6JR □ 0
3RG78 42-6JR □ 1
3RG78 42-6JS □ 0
3RG78 42-6JS □ 1
3RG78 42-6JT □ 0
3RG78 42-6JT □ 1
3RG78 42-6JU □ 0
3RG78 42-6JU □ 1

↑
0
1
2

Light grids for Category 4 in accordance with EN 954-1

Light grids, Type 4 in accordance with IEC 61496-1, -2



Type	**Clearance between beams**		Range **18 m**
2-beam	500 mm	Transmitter	**3RG78 42-6SE00**
		Receiver	**3RG78 42-6SE01**
3-beam	400 mm	Transmitter	**3RG78 42-6PG00**
		Receiver	**3RG78 42-6PG01**
4-beam	300 mm	Transmitter	**3RG78 42-6MH00**
		Receiver	**3RG78 42-6MH01**

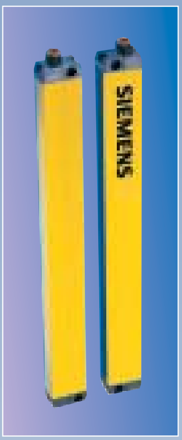
Type	**Clearance between beams**		Range **60 m**
2-beam	500 mm	Transmitter	**3RG78 42-6SE50**
		Receiver	**3RG78 42-6SE51**
3-beam	400 mm	Transmitter	**3RG78 42-6PG50**
		Receiver	**3RG78 42-6PG51**
4-beam	300 mm	Transmitter	**3RG78 42-6MH50**
		Receiver	**3RG78 42-6MH51**

The 3RG78 42 light curtains and light grids are also available with connection to the AS-Interface *Safety at Work* (refer to Section 2).

Product Overview

Light curtains for Category 2 in accordance with EN 954-1

Light curtains, Type 2 in accordance with IEC 61496-1, -2, standard, master with slave connection and slave terminal device



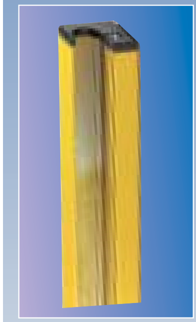
Protective-field height mm	**Type**	**30 mm** resolution Order No.	**55 mm** resolution Order No.	**80 mm** resolution Order No.
150	Transmitter	**3RG78 41-3DB □ 0**	–	–
	Receiver	**3RG78 41-3DB □ 1**	–	–
225	Transmitter	**3RG78 41-3DC □ 0**	–	–
	Receiver	**3RG78 41-3DC □ 1**	–	–
300	Transmitter	**3RG78 41-3DD □ 0**	**3RG78 41-3FD □ 0**	–
	Receiver	**3RG78 41-3DD □ 1**	**3RG78 41-3FD □ 1**	–
450	Transmitter	**3RG78 41-3DE □ 0**	**3RG78 41-3FE □ 0**	**3RG78 41-3HE □ 0**
	Receiver	**3RG78 41-3DE □ 1**	**3RG78 41-3FE □ 1**	**3RG78 41-3HE □ 1**
600	Transmitter	**3RG78 41-3DF □ 0**	**3RG78 41-3FF □ 0**	**3RG78 41-3HF □ 0**
	Receiver	**3RG78 41-3DF □ 1**	**3RG78 41-3FF □ 1**	**3RG78 41-3HF □ 1**
750	Transmitter	**3RG78 41-3DG □ 0**	**3RG78 41-3FG □ 0**	
	Receiver	**3RG78 41-3DG □ 1**	**3RG78 41-3FG □ 1**	
900	Transmitter	**3RG78 41-3DH □ 0**	**3RG78 41-3FH □ 0**	**3RG78 41-3HH □ 0**
	Receiver	**3RG78 41-3DH □ 1**	**3RG78 41-3FH □ 1**	**3RG78 41-3HH □ 1**
1050	Transmitter	**3RG78 41-3DJ □ 0**	**3RG78 41-3FJ □ 0**	
	Receiver	**3RG78 41-3DJ □ 1**	**3RG78 41-3FJ □ 1**	
1200	Transmitter	**3RG78 41-3DK □ 0**	**3RG78 41-3FK □ 0**	**3RG78 41-3HK □ 0**
	Receiver	**3RG78 41-3DK □ 1**	**3RG78 41-3FK □ 1**	**3RG78 41-3HK □ 1**
1350	Transmitter	**3RG78 41-3DL □ 0**	**3RG78 41-3FL □ 0**	
	Receiver	**3RG78 41-3DL □ 1**	**3RG78 41-3FL □ 1**	
1500	Transmitter	**3RG78 41-3DM □ 0**	**3RG78 41-3FM □ 0**	**3RG78 41-3HM □ 0**
	Receiver	**3RG78 41-3DM □ 1**	**3RG78 41-3FM □ 1**	**3RG78 41-3HM □ 1**
1650	Transmitter	**3RG78 41-3DN □ 0**	**3RG78 41-3FN □ 0**	
	Receiver	**3RG78 41-3DN □ 1**	**3RG78 41-3FN □ 1**	
1800	Transmitter	**3RG78 41-3DP □ 0**	**3RG78 41-3FP □ 0**	**3RG78 41-3HP □ 0**
	Receiver	**3RG78 41-3DP □ 1**	**3RG78 41-3FP □ 1**	**3RG78 41-3HP □ 1**

Order No. supplement	30 mm	55 mm	80 mm
• Standard light curtains	**0**	**0**	**0**
• Master with slave connection	**1**[1]	**1**[2]	**1**
• Slave terminal device	**2**	**2**	**2**

1) Master with slave connection, 30 mm resolution, not available with protective field heights 150 mm and 225 mm
2) Master with slave connection, 55 mm resolution, not available with protective field height 300 mm

3

Protection and mounting profile for light curtains, Category 2



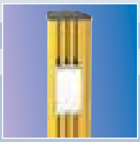
(these are required to mount light curtains Category 2 with holding brackets and in the retaining columns)

Length	Order No.
150 mm	**3RG78 48-0GB**
225 mm	**3RG78 48-0GC**
300 mm	**3RG78 48-0GD**
450 mm	**3RG78 48-0GE**
600 mm	**3RG78 48-0GF**
750 mm	**3RG78 48-0GG**
900 mm	**3RG78 48-0GH**
1050 mm	**3RG78 48-0GJ**
1200 mm	**3RG78 48-0GK**
1350 mm	**3RG78 48-0GL**
1500 mm	**3RG78 48-0GM**
1650 mm	**3RG78 48-0GN**
1800 mm	**3RG78 48-0GP**

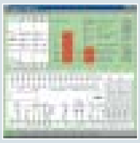
Connecting cable

Connecting cable with M12 connector, 5 m long, straight	**3RG78 48-1BA**
Connecting cable with M12 connector, 5 m long, angled	**3RG78 48-1BC**
Connecting cable with M12 connector, 15 m long, straight	**3RG78 48-1BD**
Connecting cable with M12 connector, 15 m long, angled	**3RG78 48-1BE**

Product Overview

Accessory	Length	Order No.
Retaining columns		
	1060 mm	**3RG78 48-0CL**
	1360 mm	**3RG78 48-0CP**
	1660 mm	**3RG78 48-0CR**
	1960 mm	**3RG78 48-0CU**
Deflection mirror columns		
	1060 mm	**3RG78 48-0DL**
	1360 mm	**3RG78 48-0DP**
	1660 mm	**3RG78 48-0DR**
	1960 mm	**3RG78 48-0DU**
Deflection mirror columns for light grids (adjustable single mirror)		
	1060 mm, 2-beam	**3RG78 48-0FL**
	1360 mm, 3-beam	**3RG78 48-0FP**
	1360 mm, 4-beam	**3RG78 48-0FR**
Deflection mirror		
	410 mm	**3RG78 48-0ED**
	510 mm	**3RG78 48-0EE**
	625 mm	**3RG78 48-0EF**
	740 mm	**3RG78 48-0EG**
	830 mm	**3RG78 48-0EH**
	930 mm	**3RG78 48-0EJ**
	1030 mm	**3RG78 48-0EK**
	1125 mm	**3RG78 48-0EL**
	1220 mm	**3RG78 48-0EM**
	1365 mm	**3RG78 48-0EN**
	1510 mm	**3RG78 48-0EP**
	1650 mm	**3RG78 48-0EQ**
	1830 mm	**3RG78 48-0ER**

Accessory	Length	Order No.
Retaining brackets		
	Retaining bracket, can be swiveled, vibration-damping (incl. 2 screws and 2 captive nuts)	**3RG78 48-0BB**
	Standard retaining bracket set (2 elements incl. screws)	**3RG78 48-0AB**
Laser alignment aids		
	Standard version	**3RG78 48-1AB**
	Version for mounting with retaining columns	**3RG78 48-1AG**
Software and programming accessories		
	Diagnostics software for light curtains and grids	**3RG78 48-1AC**
	RS485/232 converter for diagnostics interface	**3RG78 48-1AD**
	RS232 connecting cable	**3RG78 48-1AE**
	Diagnostics cable set Light curtains, Category 4	**3RG78 48-1AF**
	Diagnostics cable set Light curtains, Category 2, straight connector	**3RG78 48-1AL**
	Diagnostics cable set Light curtains, Category 2, angled connector	**3RG78 48-1AM**

	Type	Relay output Order No.	Semiconductor output Order No.
Evaluation units (Category 4 in accordance with EN 954-1)			
	Standard, restart inhibit, contactor monitoring (no diagnostics and test function, only suitable for light curtains and grids, Category 4)	**3RG78 47-4BB**	
	Standard, restart inhibit, contactor monitoring	**3RG78 47-4BD**	**3RG78 47-4DD**
	Standard, restart inhibit, contactor monitoring, expanded version*	**3RG78 47-4BE**	**3RG78 47-4DE**
	Muting function, restart inhibit, contactor monitoring	**3RG78 47-4BF**	**3RG78 47-4DF**
	Muting function, restart inhibit, contactor monitoring, expanded version *	**3RG78 47-4BG**	**3RG78 47-4DG**
	Cycle control, restart inhibit, contactor monitoring	**3RG78 47-4BH**	**3RG78 47-4DH**
	Cycle control, restart inhibit, contactor monitoring, expanded version *	**3RG78 47-4BJ**	**3RG78 47-4DJ**
	Muting function and cycle control, restart inhibit, contactor monitoring	**3RG78 47-4BK**	**3RG78 47-4DK**
	Muting function and cycle control, restart inhibit, contactor monitoring, expanded version *	**3RG78 47-4BL**	**3RG78 47-4DL**
	* up to 2 light curtains, Type 4 and additional safety switches (e.g. EMERGENCY STOP) can be connected to the expanded version		
Diagnostics software for evaluation units			
	Diagnostics software for evaluation units including PC cable	**3RG78 48-4AC**	

Description

A SIGUARD light curtain or light grid comprises a transmitter and a receiver, which are mounted opposite to one another. Depending on the resolution and length, a specific number of transmitting and receiving diodes are located one above the other. The infrared LEDs of the transmitter send short light pulses, which are received by the associated receiver diodes.

The transmitter and receiver are synchronized with one another optically without requiring a direct electrical connection.

Depending on the application, light curtains are required with various resolutions. The resolution (detection capability) of a safety light curtain is the size of an object which can be reliably and safety detected at any position in the protective field and which results in a shutdown command.

The distance between the individual light beams is always less than the particular resolution.

If all of the light beams (light axes) are free, then the semiconductor outputs of the receiver switch to 24V. If only one of the light beams is interrupted, then the semiconductor outputs safely shut down. This occurs, e.g. when an object enters the hazardous location.

For 3RG78 42/4 light curtains (Category 4), the semiconductor outputs are redundant and are self-monitoring. This means that they detect a possible erroneous function as well as a possible fault occurring in the external circuit (e.g. cross-circuit or short-circuit).

For 3RG78 41 light curtains (Category 2), this is achieved using a cyclic test function, which is automatically executed at periodic internals by the SIGUARD evaluation unit (or from a safety control system).

When the light curtain outputs are shut down, this causes the potentially hazardous motion of the machine to be safely stopped. The downstream circuit can, in this case, be a 3RG78 47 SIGUARD evaluation unit or a safety control (e.g. S7-400F/FH, S7-315F, SINUMERIK).

SIGUARD light curtains and light grids are available for applications, Safety Category 2 and for the highest safety requirements for Safety Category 4 acc. to EN 954-1.

SIGUARD light curtains 3RG78 42/44 for Category 4:

- Resolutions 14, 30, 50 and 90 mm
- Lengths 150 mm to 3 m
- Master and slave units can be cascaded for higher protective field heights or lengths and for angled arrangements

SIGUARD light grids 3RG78 42/44 for Category 4:

- 2, 3 or 4-beam for access security

SIGUARD light curtains 3RG78 41 for Category 2

- Resolutions 30, 55 and 80 mm
- Protective field heights from 150 to 1800 mm

Master/slave combinations

A master and slave light curtain can be cascaded with one another or arranged at an angle to one another. Devices with different resolutions and lengths can be combined for up to a total of 240 light axes.

D scan (for 3RG78 42/44 for Category 4):

For extremely noisy environments, for example, close to welding robots, the D scan multiple scanning mode can be set. This can significantly increase the availability of the machine.

Channel changeover:

Two different transfer channels can be set in order to avoid devices mutually influencing one another. In this case, it is possible to operate several units which are close to another.

Integrated diagnostic functions:

The diagnostics software, which is available as an option, permits straightforward, easy commissioning/alignment (especially for long master-slave combinations) as well as in-depth diagnostics by being able to visualize and record/trace data.

Application

The following factors must be fulfilled/observed when using optical protection systems:

- It must not be possible to pass around, pass below or go behind the protective field - if this cannot be guaranteed, then additional protective devices must be used.
- The machine control must be able to be electrically influenced and it must be possible to immediately terminate or exit the hazardous state in each operating phase.
- Danger of injury due to heat, radiation or materials or components being flung out of the machine must be completely excluded by applying other safety measures.
- The ambient conditions may not have a negative impact on the effectiveness of the contactless protective equipment.

Safety clearance

Machine movement or motion which can be potentially hazardous, must be safely stopped before personnel are injured. In this case, the safety clearance between the light curtain and hazardous location must be maintained.

If a C Standard with other requirements is not applicable, then the minimum clearance to the hazardous area is calculated using the following formula according to EN 999:

S = (K * T) + C

Where:

S is the minimum clearance in millimeters, measured from the hazardous area to the protective field (or the detection point, to the detection line or to the detection plane);

K is a parameter in millimeters per millisecond, derived from the data associated with the approach velocity of the body or parts of the body;

T is the run-on time of the complete system in milliseconds;

C is an additional clearance in millimeters, which is used as basis when penetrating the hazardous area and before the protective device or equipment is triggered.

The values for K and C depend on the protective function (e.g. hand or finger protection, access security), resolution and the approach direction.

Vertically arranged light curtain (max. 40 mm resolution)

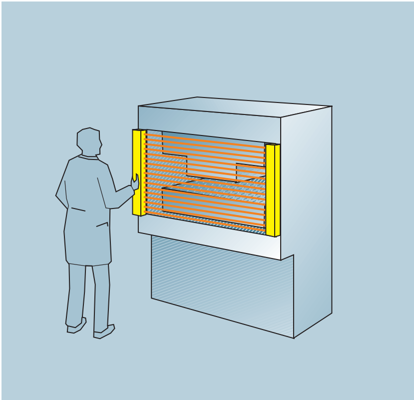


Fig. 3/38

It must not be possible to reach around, reach over or reach under the protective field. This can be realized by using additional mechanical meshes/gates or by cascading master and slave light curtains.

The minimum safety clearance S is calculated as follows

S = (K * T)) + C

With

K = 2.0 mm/ms

C = 8 (d – 14 mm), however, not less than 0

Whereby:

d = resolution of the light curtain in mm

If the calculation results in a value less than 100 mm, then, under all circumstances, a minimum clearance of 100 mm must be maintained.

If the calculation results in a value greater than 500 mm, then this can be repeated with K=1.6 mm/ms. In this particular case, the safety clearance may not be less than 500 mm.

If the clearance between the light curtain and the machine is greater than 75 mm, then protection must be provided against reaching around (e.g. using a horizontally arranged light curtain).

Vertically arranged light curtain (resolution 40 mm ≤ 70 mm)

The minimum safety clearance is calculated as follows:

S = (K * T) + C

With

K = 1.6 mm/ms

C = 850 mm

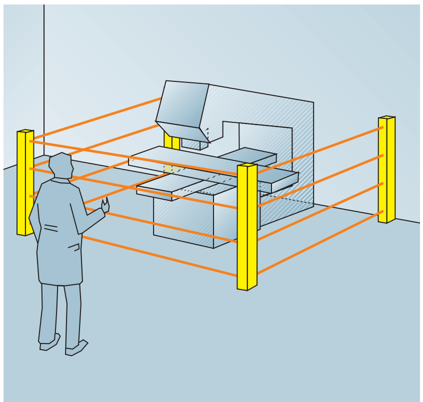


Fig. 3/39

Multi-beam light grid, vertically arranged for access security

It must not be possible to reach around, reach over or reach under the protective field. This can be realized by using additional mechanical meshes/gates or by cascading master and slave light curtains.

The number and distance between the light beams depends on the risk evaluation and on the machine-specific regulations.

The minimum safety clearance is calculated as follows according to EN 999:

S = (K * T) + C

With

K = 1.6 mm/ms

C = 850 mm

No. of beams	Height above the reference plane (e.g. floor) in mm
4	300, 600, 900, 1200
3	300, 700, 1100
2	400, 900

Horizontally arranged light curtains for securing hazardous areas

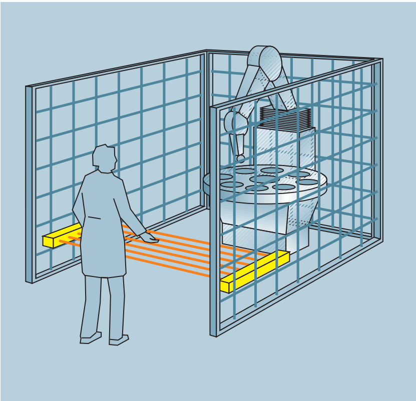


Fig. 3/40

When securing hazardous areas using horizontally mounted light curtains, the height H of the protective field may be a maximum of 1000 mm. If H is greater than 300 mm (200 mm if children are present), then it is possible to crawl below the protective field. This must be taken into account when evaluating the risk.

The lowest permissible mounting height depends on the resolution of the light curtain in order to guarantee that a human leg or foot joint can be reliably detected.

S = (K * T) + C

K = 1.6 mm/ms

C = (1200 mm – 0.4 x H)

Where:

H = Height of the protective field above the reference plane

H_{max} = 1000 mm

H_{min} = 15 (d – 50 mm)

d = Light curtain resolution

If the calculation for C results in a lower value than 850 mm, then a minimum value of C = 850 mm should be assumed.

SIGUARD 3RG78 47 evaluation units

SIGUARD 3RG78 47 evaluation units are used to integrate safety signals from the light curtains into the machine control.

They form a flexible product family of interface modules. This modular series of devices can be used up to Category 4 in accordance with EN 954-1.

They extend the functional scope of light curtains and grids as follows:

- Start/restart inhibit
- Contactor monitoring
- Cycle control
- Muting

Furthermore, the following supplementary functions are possible:

- An early failure alarm for the relay contacts
- Diagnostic functions using a PC
- Numerous signal outputs to a higher-level control

Start/restart inhibit and contactor monitoring

All of the SIGUARD evaluation units have the basic start/restart inhibit and contactor monitoring functions already integrated (or general monitoring of external devices EDM).

The start/restart inhibit prevents machines automatically starting

- after the power supply voltage has been switched-in
- after the light curtain has responded
- after changing the actuation or operating mode of the machine

The contactor monitoring monitors the state of external devices, for example, the contactor downsteam from the evaluation unit or the main control element of the drive.

Testing and monitoring type 2 light curtains

The SIGUARD 3RG78 47 evaluation units (with the exception of 3RG78 47-4BB) execute an automatic test without interrupting the process. A failure (e.g. loss of detection capability), which could have a negative impact on correct operation is then detected at the next test cycle.

The device can be used for the 3RG78 41 type 2 light curtain in order to identify a potentially hazardous failure, e.g. the loss of detection capability. A single fault/error, which could have a negative impact on correct operation, is therefore detected at the latest during the next test cycle.

Initiating machine motion using the light curtain (cycle control)

The optional cycle control function must be selected if it is necessary to intervene once or twice in the protective field of the light curtain (e.g. to insert or withdrawn workpieces, in order to initiate a specific operating sequence of the machine). The appropriate SIGUARD evaluation units have this functionality and therefore permit faster and more productive machine operation.

Muting operation

Muting is a function to suppress the protective function. This is necessary, for example, when material is being transported or conveyed into the hazardous area.

There must be at least two independently connected signal sources to be able to use the muting function. Using two or four muting sensors and the correct integration into the production operation, it must be guaranteed that nobody can enter the hazardous area while the light curtain is bypassed.

Muting sensors can be pushbuttons, proximity switches, light barriers, and limit switches etc., which do not have to be fail-safe. The redundant fault monitoring is realized using the muting evaluation unit in compliance with the requirements for Category 4 according to EN 954-1. If the muting sensors are actuated in the correct sequence (in time), the muting evaluation unit switches into the muting mode and bypasses the fail-safe outputs of the light curtain.

The muting status must be displayed using a monitored light signal. The adjacent figures show the two principle muting techniques with four (serial muting) or two (parallel muting) muting sensors.

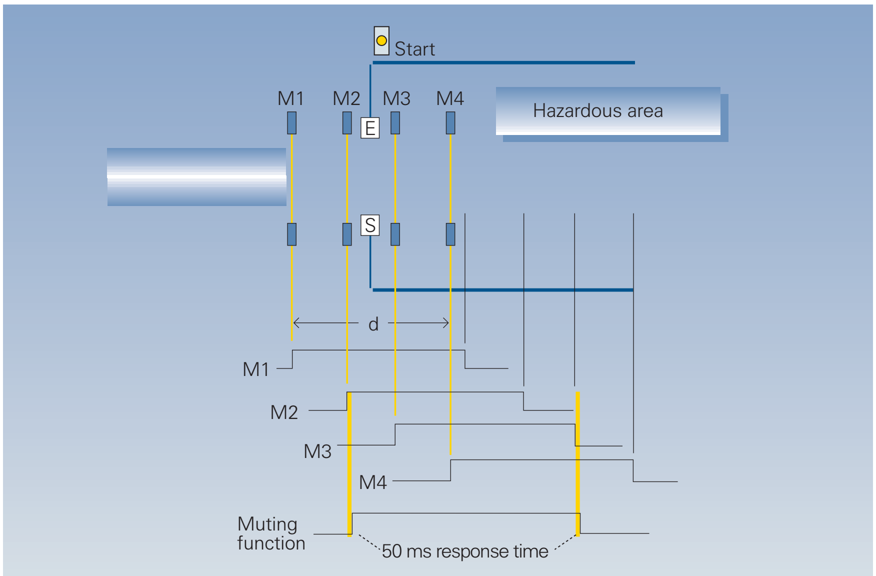


Fig. 3/41 Serial muting

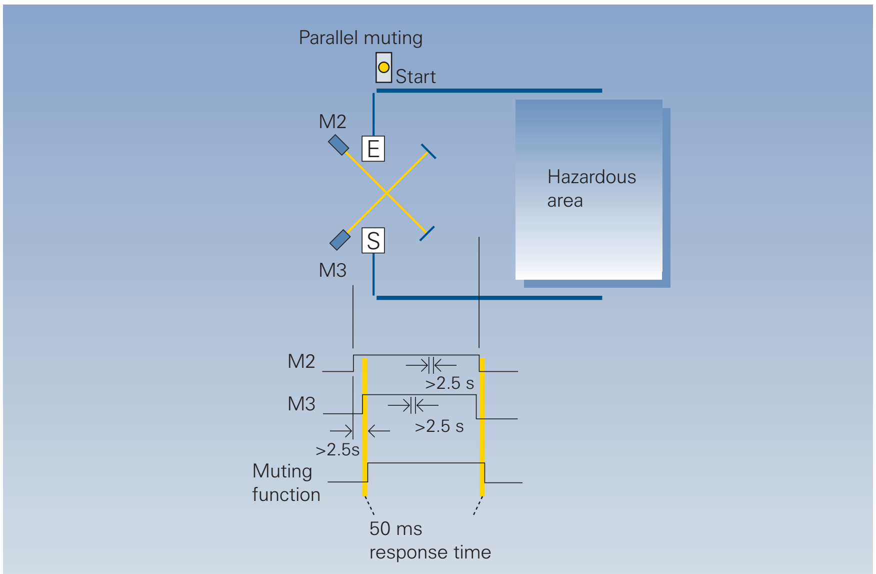


Fig. 3/42 Parallel muting

Blanking functions

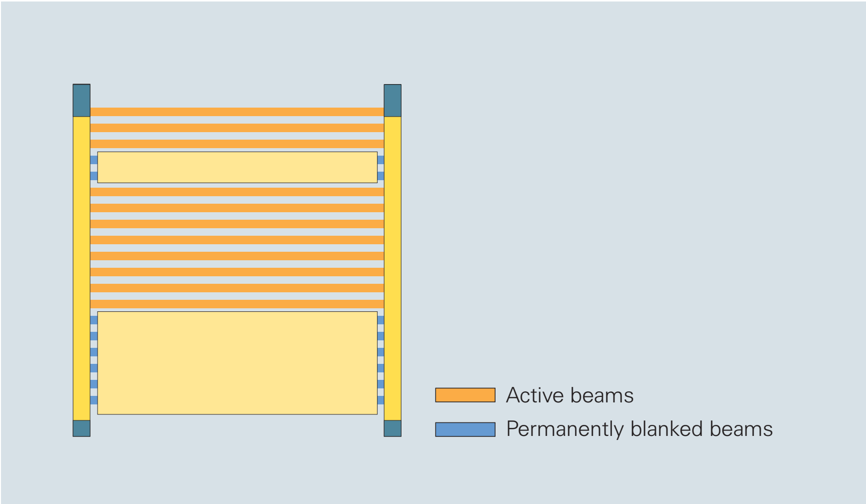
Fixed blanking

if an object is permanently in the light beam area, then the appropriate area can be blanked. This is realized by blanking as many of the beams as required. If the blanked objects are withdrawn from this area, the light curtain shuts down the system.

The blanked objects must be permanently located in the protective area, as otherwise safety can no longer be guaranteed. The light curtain shuts down the system.

For applications where the beams at the edge could be disturbed due to vibration, tolerance levels can be entered.

The system is configured using a teach-in function with safety keys.

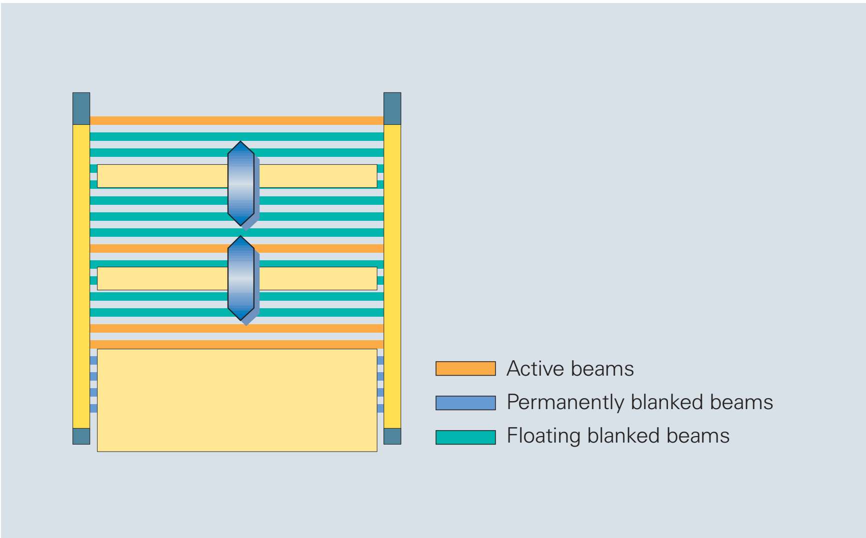


Floating blanking

If moving objects are in the area of the light beams, as many light beams can be blanked as required. The objects can move within the blanked light beams without the light curtain shutting down the system.

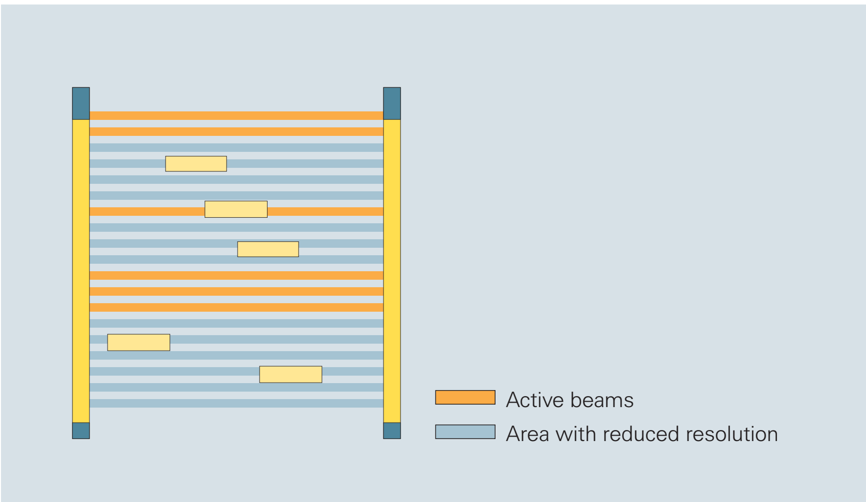
If the moving objects are withdrawn from this protected area, the light curtain interrupts the potentially hazardous motion as otherwise safety would no longer be guaranteed.

A DIP switch is used to blank 1 or 2 beams.



Reduced resolution

If an object is in the area of the light beams, two or three beams can be blanked. The difference between this and the fixed blanking mode is the fact that no beam must be interrupted, but several beams can be interrupted.



Software

Both SIGUARD light curtains, Types 2 and 4 as well as evaluation units can be connected to a PC or laptop via the serial interface, for visualization and diagnostics.

The diagnostics software for light curtains visualizes the statuses of the individual light beams, which means that devices can be simply aligned. Furthermore, the software allows this data to be acquired during operation so that, for example, sporadic faults and errors can be pinpointed.

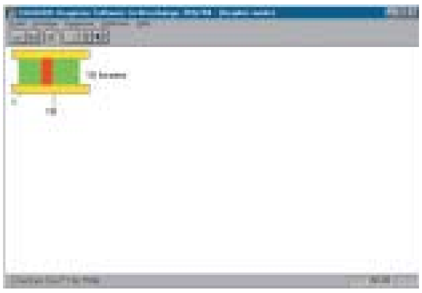


Fig. 3/43 Screenshot, diagnostics software for light curtains

The software for the evaluation units offers the above-mentioned possibility of visualizing and tracing signals for the SIGUARD evaluation units. The diagnostics cable is simply connected at the socket of the unit. This software automatically recognizes the device version and visualizes the statuses of all of the inputs and outputs.

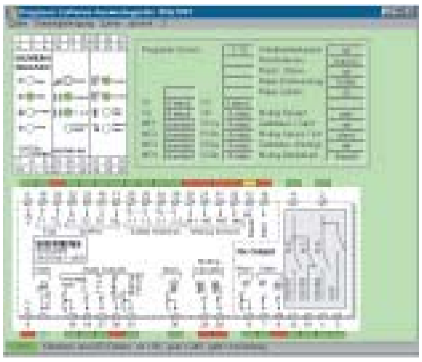


Fig. 3/44 Screenshot, diagnostics software for evaluation units

Accessories

There is a range of accessories, optimized for use in the field, that simplify mounting, alignment/adjustment, commissioning and troubleshooting. These include retaining columns, deflection mirror columns, deflection mirrors, retaining brackets and laser alignment devices. The light curtains and light grids can be simply mounted onto the floor using the retaining columns and deflection mirror columns. After the columns have been bolted to the floor, a special mechanical design allows the light beams to be precisely aligned.

It is absolutely necessary that the light curtains and light beams are correctly aligned, especially when using the maximum detection distance and the arrangements with the deflection mirrors.

This operation can be easily carried-out using the laser alignment devices.

Technical Data

Technical data: 3RG78 44 light curtains				
Type		**Type 3RG7844-..B**	**3RG7844-..D**	**3RG7844-..E**
Resolution	mm	14	30	50
Range	m	0.3 to 6	0.8 to 18	
Power supply voltage		A 24 V, 20% external power supply unit is required with protective line supply separation and a buffer function for 20 ms voltage dip		
Residual ripple	%	5		
Current drain • Transmitter • Receiver (without load)	 mA mA	 75 180		
Fuse, external feeder cable	A	4		
Transmitter, wavelength	nm	880		
Synchronization		Optical, between the transmitter and receiver		
Protective class acc. to VDE 106		III		
Degree of protection		IP 65		
Ambient temperature in operation	°C	0 to 50		
Ambient temperature in storage	°C	-25 to + 70		
Relative air humidity	%	15 to 95		
OSSDs safety switching outputs		2 safety-related pnp semiconductor outputs, cross-circuit fault monitored,, short-circuit proof		
Switching voltage • High active (UB-1V) - minimum - typical - maximum • Low - minimum - typical - maximum	 V V V V V V	 18.2 23 27.8 - 0 2.5		
Switching current • Minimum • Typical • Maximum	 mA mA mA	 - 500 650		
Leakage current • Minimum • Typical • Maximum	 mA mA mA	 - - 0.1		
Load capacitance • Minimum • Typical • Maximum	 nF nF nF	 - - 200		
Permissible cable resistance between the receiver and load • Minimum • Typical • Maximum	 Ohm Ohm Ohm	 - - 20		

3

Technical data: 3RG78 44 light curtains				
Type		Type 3RG7844-..B	3RG7844-..D	3RG7844-..E
Permissible cable length between the receiver and load (for 1 mm^2)				
• Minimum	m	-		
• Typical	m	-		
• Maximum	m	100		
OSSDs				
• Response time ($t_{AOPD\ rms}$)				
- 14 mm resolution	ms	6.8 ... 38.6		
- 30 mm resolution	ms	10.2 ... 19.4		
- 50 mm resolution	ms	10.0 ... 9.8		
• Restart time after a beam has been interrupted (without restart inhibit), can be parameterized				
- minimum	ms	80		
- typical	ms	100		
- maximum	s	5		
Signal inputs, machine interface				
• Restart inhibit, release		1 pushbutton with 1 NO contact, floating		
- min. switching time	ms	300		
- max. switching time	s	4		
• Contactor monitoring (EDM)		2 feedback contacts, floating		
- max. switching time	ms	300		
Signal outputs, machine interface				
• Restart inhibit				
- restart inhibit active		+24 V, max. 60mA		
- restart inhibit inactive		0 V		
• Fault display				
- fault-free		+24 V, max. 60 mA		
- fault		0 V		
Voltage output, local socket (optional)				
• only for control devices or safety sensor systems		24 V DC ± 20%, max. 0.5A		
Signal inputs, local socket (optional)				
• Restart inhibit, release		1 pushbutton with 1 NO contact, floating		
- min. switching time	ms	300		
- max. switching time	s	4		
• Teach-in with 2-pole key-actuated switch		1 key actuated switch with 2-pole changeover contact, floating		
- Coincidence factor	ms	< 500		

Technical Data

Technical data: 3RG78 42 light curtains, Type 4	
Category	Type 4 acc. to EN 61 496-1, -2 or IEC 61 496-1, -2 (self-monitoring)
Protective field height	150 to 1800 mm for a 14 mm resolution 150 to 1800 mm for a 30 mm resolution 450 to 3000 mm for a 50 mm resolution 750 to 3000 mm for a 90 mm resolution
Protective field width, range	0.3 to 6 m for a 14 mm resolution 0.8 to 18 m for 30 mm, 50 mm and 90 mm resolutions and light grids (18 m version), 6.0 to 60 m for light grids (60 m version)
Detection capability (resolution)	14 mm, 30 mm, 50 mm, 90 mm or a complete person with 2, 3 or 4 beams
Response time (from the protective field being interrupted up to the safety outputs being shutdown)	The response time increases with the increasing number of beams 14 mm: 7 to 39 ms (d-scan 10 to 78 ms) 30 mm: 7 to 20 ms (d-scan 10 to 39 ms) 50 mm: 17 ms (d-scan 33 ms) 90 mm: 13 ms (d-scan 20 ms) 2, 3, 4-beam: 5 ms (d-scan 8 ms)
Restart time (after the protective field has been enabled up to the safety outputs switching-in)	0.5 ms for all series. When the protective field is only very briefly interrupted, the safety outputs remain shut down for 100 ms.
Degree of protection	IP 65
Ambient operating temperature	0 to +55 °C
Power supply voltage	24 V DC ±20 % External power supply section with protective line supply separation and 20 ms line supply failure buffering
Current drain	Transmitter: 75 mA Receiver: 180 mA (without load)
Safety outputs	2 fail-safe pnp outputs with cross-circuit monitoring $V_{output\ min} = V_{vers}$ –2.7 V, $I_{output\ max}$ = 0.3 A
Pollution and fault signal output	pnp output, short-circuit proof max. 70 mA
Safety and diagnostics interface	RS 485
Test input, transmitter	Closed-circuit current principle, minimum opening time 50 ms
Electrical connection	Via PG 13.5 screw terminal and plug-in connection space
Connecting cable	Transmitter: 7-core, 0.5 mm² (max. 1.0 mm²) Receiver: 7-core, 0.5 mm² (max. 1.0 mm²; when required, shielded)
Cable length	max. 100 m at 1.0 mm²
Mode	Protective mode without restart inhibit
Transmitter/receiver synchronization	optical synchronization 2 data transfer channels can be selected
Infrared light suppression	2 techniques can be selected Standard: high degree of suppression d-scan: extremely high degree of suppression (response time increases)
Air humidity	15 to 95 %
Storage temperature	–25 to +70 °C

Technical data: 3RG78 41 light curtains, Type 2	
Category	Type 2 (can be tested) acc. to EN-, IEC 61496-1, -2 in conjunction with an external type 2 evaluation unit (SIGUARD 3RG78 47 evaluation units)
Protective height	150 to 1800 mm for a 30 mm resolution 300 to 1800 mm for a 55 mm resolution 450 to 1800 mm for a 80 mm resolution
Protective field width, range	0.3 to 6 m
Detection capability (resolution)	30 mm, 55 mm or 80 mm
Response time (from the protective-field being interrupted up to the OSSD output being shut down, without response time of the test monitoring unit)	The reaction time depends on the protective height: 30 mm resolution: 8 to 29 ms 55 mm resolution: 8 to 19 ms 80 mm resolution: 8 to 15 ms Precise response times, refer to the Operating Instructions
Restart time (after the protective field is enabled up to the OSSD output switching-in)	0.5 ms for all series. If the protective field is only extremely briefly interrupted, the OSSD output is shut down for a minimum of 100 ms.
Test execution time	10 ms
Test input, transmitter	+24 V = no test, 0 V or high-ohmic = test via the floating NC contact or pnp output (signal for the test resolution, min. 20 ms)
Degree of protection	IP 65
Ambient operating temperature	0 to 55 °C
Protective class	I
Power supply voltage	24 V DC ± 20 % (via an external power supply with protective line separation and 20 ms line failure buffering)
Current drain	Transmitter: 75 mA Receiver: 75 mA (without load)
OSSD output	pnp output, short-circuit proof, 100 mA max.
Pollution and fault signal output	pnp output, short-circuit proof, 70 mA max.
Diagnostics interface, receiver	RS 485
Electrical connection	8-pin M12 round connector
Connecting cable	7-core, 0.25 mm², shielded with molded connector, 5 m or 15 m long (refer to Accessories)
Operating mode	Protective operation without start/restart inhibit
Transmitter/receiver synchronization	Optical synchronization, 2 selectable data transfer channels
Dimensions	Cross-section 17 mm x 33 mm, Length (with connector and connection space) = protective height + 96 mm
Air humidity	15 to 95 % (no moisture condensation)
Storage temperature	–25 to +75 °C

Technical Data

Technical data: 3RG78 47-4BB evaluation unit	
Category	4 acc. to EN 954-1
Stop Category	Stop 0 acc. to IEC 60204-1
Operating voltage V_B	24 V AC/DC, –15% to +10%
Residual ripple (for DC)/ frequency (for AC)	2.4 V_{PP} / 50–60 Hz
Power drain	2.1 W (for AC) / 1.7 W (for DC)
External fuses for the supply circuit	1 A slow-acting
Output contacts	2 NO contacts, 1 NC contact AgSnO2 gold-flashed
Switching capability according to EN 60947-5-1	AC-15 : 230 V / 6 A *) DC-13 : 24 V / 6 A **) DC-13 : 24 V / 3 A *) *) 3600 switching cycles/h, **) 360 switching cycles/h
Max. continuous current per current path	6 A
Contact fusing per current path	6.3 A fast-acting 4 A slow-acting
Max. summed current for all current paths	12 A
Max. operating frequency	3600 switching cycles/h
Mechanical endurance	10 x 10^6 switching cycles
Pull-in delay (man. start)	70 ms
Pull-in delay (automatic start)	230 ms
Drop-out delay, response time	20 ms
Minimum switch-in duration S34, S35	80 ms
Time window for the sensor outputs to switch-in	20 ms
Electronic fuse (protection) response/readiness time	2 s / 2 s
Control voltage/current at S11, S22, S31	24 V DC / 20 mA
Permissible incoming cable resistance	< 70 Ω
Operating temperature	–25 °C to +55 °C
Air and creepage distances	DIN VDE 0110-1:04.97:4 kV
Noise emission	EN 50081-1, -2
Noise immunity	EN 50082-2
Degree of protection	Enclosure IP 40, terminals IP 20
Connection cross-sections	2 x 0.14 to 0.75 mm finely-stranded or 2 x 0.25 to 0.5 mm finely-stranded with end sleeves 2 x 1.5 mm finely-stranded with twin connector sleeves 1 x 0.14 to 2.5 mm solid or 2 x 0.25 to 2.5 mm finely-stranded with end sleeves
Dimensions (height x width x depth)	99 x 22.5 x 111.5 mm
Weight	200 g

Technical data: Evaluation units 3RG78 47-4.D, E, F, G, H, J, K, L	
Relevant Standards, Category	Type 4 acc. to EN IEC 61496 T1 EN 954-1 (12/96). Category 4, IEC, DIN EN 60204-1 (11/98), Stop 0
Safety sensors which can be connected, extended versions:	1 light curtain, Type 4 or up to 2 light curtains, Type 2 (all to EN IEC 61496), up to 2 light curtains, Type 4 or up to 4 light curtains, Type 2 (all to EN IEC 61496)
Safety switches and control devices which can be connected	Safety switch according to EN 1088 area EMERGENCY STOP button acc. to EN 418
Test outputs T1 and T2, test interval	200 ms
Available functions All versions:	Start/restart inhibit Contactor monitoring, diagnostics
Versions with cycle control:	Protective, single-cycle and two-cycle operation
Versions with muting function:	Sequential muting, parallel muting, parallel double muting (only 3RG78 47-4.G)
Control input, start/restart inhibit (reset)	Floating NO contact (pushbutton or key-actuated switch)
Control input contactor monitoring (EDM)	Feedback of positively-driven contacts from subsequent) contactors (refer to the connection examples)
Connection, muting sensors which cannot be tested	Signal level when energized: Active high, +24 V
Connection, muting sensors which can be tested	Active high, +24 V, plus test pulses from T1 and T2
Outputs, muting displays for lamps 24 V/ 5 W max.	pnp switching outputs muting function on, active high, +24 V, 200 mA max.
Signaling outputs (depending on the version)	including light curtain free/interrupted, switching status, relay/transistor output restart inhibit, latched/unlatched, muting function status, muting error warning, muting lamp defective, internal fault
Power supply voltage	24 V DC, ± 20 %, external power supply with protective line separation and equalization required for 20 ms voltage dip
Current drain	approx. 200 mA without external load
External fusing (power supply)	2.5 A mT
Enclosure Degree of protection	IP 20, mounted in a cabinet or enclosure with min. IP 54 degree of protection required Mounting on 35-mm mounting rail
Ambient temperature, operation	0 ... +55 °C
Connection system	Plug-in, coded screw terminals up to 2.5 mm^2
Dimensions	111 x 99 x 35 mm or 111 x 99 x 52.5 mm

Outputs	Relay outputs	Semiconductor outputs
OSSD safety outputs Switching voltage/switching current Only expanded versions:	2 safety-related NO contacts 60 V DC, 250 V AC, 6 A max. 1 safety-related NC contact, 60 V DC, 250 V AC, 6 A max. min. switching current, 20 mA	2 safety-related pnp semiconductor outputs with cross-circuit detection 24 V DC, 300 mA max.
OSSD external fusing	6 A T	–
OSSD response time SIGUARD evaluation unit (without light curtain)	for light curtain, Type 4 with semiconductor output: 18 ms for light curtain, Type 2: 54 ms for safety switches: 54 ms	for light curtain, Type 4 with semiconductor output: 8 ms for light curtain, Type 2: 44 ms for safety switches: 44 ms
OSSD restart time	100 ms	100 ms
Arc quenching suitable for OSSD over the coils of the following relay	required	–

3.1.8 SIGUARD light barriers

SIGUARD light barriers are contactless protective devices for Category 2 or 4 acc. to EN 954-1. They are designed to protect hazardous areas and dangerous locations on machines which represent a potential risk of injury. When correctly used, they cause the machines to go into a non-hazardous condition, before personnel can be injured.

The complete safety system comprises an evaluation unit and the associated light barriers. A maximum of 2 (system for Category 2) or max. 4 (system for Category 4) certified safety one-way sensors can be connected.

System design

The evaluation units are designed, in conjunction with the associated safety light barriers as self-monitoring component, in accordance with EN 954-1, Category 2 or 4. They form the transition element between the light barriers and the machine control, and provide the required interfaces, including the power supply to operate the light barriers.

The safe functioning of the complete system is tested after powering-up (start test after “power-on”) and after a test request (when depressing a START button). Further, the system is cyclically tested during operation to test the internal hardware.

The contacts (contactors) of the machine/system control are switched via a safe output (positively-driven relay). The safety output can be directly integrated into the EMERGENCY STOP circuit of the machine. For interruption and error-free operation, the contacts of the safety relay are closed. The safety relay opens (drops-out) when

Fig. 3/48

the light barriers are interrupted or an internal error/fault occurs.

Further, there is a signaling output that tracks the safety output.

Features

- Up to four safety one-way light barrier pairs can be connected
- Extremely compact (it is one of the smallest accident light barriers for the particular safety category in the world)
- Manually initiated test and cyclic testing
- Various operating modes can be set
- Operation with or without start/restart inhibit
- Operation with or without contactor monitoring
- Integrated monitoring system to check the accumulation of dirt/pollution
- Status and fault displays
- Display LEDs (light barrier) visible from 2 sides
- Light barrier with 3 through holes can be easily and flexibly mounted and adjusted
- Safety monitoring module can be snapped onto a standard mounting rail
- Category 2 or 4 acc. to EN 954-1

Operating modes

The system can be used in one of two possible operating modes
- with or without start/restart inhibit, and
- with or without contactor monitoring

The required modes are simply selected using DIP switches which are located under the housing cover of the safety monitoring module.

Operation with start/restart inhibit

In the start/restart inhibit mode, the safety output is not automatically switched-in after the power supply voltage is switched-on or during operation after an intervention in the protective field or if the light beam is interrupted. This inhibited condition remains until the restart inhibit is manually released by pressing a control device. The outputs are only switched-in with the light barrier uninterrupted (negative edge evaluation) after the START button has been pressed and released again. The “Wait for release of the restart inhibit” display also goes dark.

The control device to release the start/restart inhibit must be mounted so that,

- the hazardous zone is clearly visible from the control device, and
- the control device cannot be actuated from within the hazardous zone.

The START button is connected according to the diagram in Section 7.1.3, Fig. 7/78 .

Selection and ordering data

	Version	Range	Size	Connection	Order No.
Safety light barrier (Cat. 2 acc. to EN 954-1) 	Transmitter		50 x 31 x 16 mm	M8, Type A	**3RG78 21-7BG00**
	Receiver	0...4 m	50 x 31 x 16 mm	M8, Type B	**3RG78 21-7CD00**
Safety light barrier (Cat. 4 acc. to EN 954-1) 	Transmitter		50 x 50 x 17 mm	M12, Type F	**3RG78 22-7BG00**
	Receiver	0...15 m	50 x 50 x 17 mm	M12, Type F	**3RG78 22-7CD00**

	Category acc. to EN 954-1	Size	Max. No. of light barriers which can be connected	Order No.
Monitoring unit for 3RG78 21	2	45 x 84 x 118 mm	2	**3RG78 26-1CB1**
Monitoring unit for 3RG78 22	4	75 x 100 x 110 mm	4	**3RG78 27-1DE2**

Fig. 3/49

Operation without start/restart inhibit

In the mode without start/restart inhibit, the safety output of the evaluation unit is automatically re-closed after the light beam is no longer interrupted.

Operation with contactor monitoring

The contactor monitoring function is used to check the safe function of the externally connected contactors including the connecting cables between the protective system and the machine control. In order to monitor the status of the contactors when they are not energized, an NC contact of the external contactors is fed back to the safety-monitoring module where it is interrogated. If the contacts are welded, or if there is a broken cable, this is detected before the safety outputs switch-in again. The safety outputs of the safety-monitoring module remain open and the machine cannot be started.

Operation without contactor monitoring

If the machine control monitors the contactors (fail-safe control), the function can be disabled using the DIP switch which is located under the housing cover of the safety monitoring module.

Application conditions

The protective function of the protective equipment is provided if the following prerequisites are fulfilled:

- The control of the machine or the plant must be able to be electrically influenced.
- A switching command, which is issued from the evaluation unit, must cause the machine or system to shut down immediately.
- The connected light barriers must be arranged so that when the hazardous zone is accessed, at least one light beam must be completely interrupted.

- When using and configuring safety equipment, the relevant legislation and regulations of the various Safety Committees and/or the EC Directives for safety-related requirements on machines and plants apply.
- The light barriers must be mounted so that, when at least one light beam is interrupted, the hazardous location is only reached when the movements of the driven machine no longer represent a hazard. In this case, safety clearances must be maintained in accordance with EN 999.
- All of the information in the Technical Description and Operating Instructions, especially the Sections "Safety information" and "Commissioning" must be carefully observed.
- Only qualified, trained personnel may install, commission and maintain/service the devices.
- Electrical work may only be carried-out by professionally trained, electrical technicians.
- Settings and changes to the safety equipment (e.g. positioning the light beams, safety clearance etc.) may only be carried-out by personnel who have been certified to do such safety-related work.
- Repairs, especially opening the housing of the units, may only be carried-out by the manufacturer or by a person who is authorized by the manufacturer.
- If the light barriers alone do not offer adequate protection, e.g. due to their mounting location, then additional mechanical protective devices and equipment must be used.
- The hazardous location must only be able to be accessed via the protective field (it must not be possible to bypass this).
- It is not permissible that the plant or system starts-up (starts to run) as long as someone is in the hazardous zone.
- It must not be possible to press the START button from the hazardous zone.

Installation instructions

The evaluation unit is mounted on a mounting rail in the cabinet and connected-up according to the connection schematic.

The light barriers can be operated in any mounting position. They must be mounted so that the hazardous zone can only be reached by interrupting at least one beam (also refer to EN 999).

The number of beams and the distance between these beams is defined by the requirements of the particular driven machine and the relevant legislation. Protection is possible using between one and four light barriers.

When installing the system, it must be ensured that the protective field cannot be bypassed by:

- Climbing over
- Crawling under, or
- Going around

This is the reason that one light beam can no longer be used to secure a potentially hazardous zone in (also refer to Fig. 3/50).

Protection/protective field heights

The protective heights and the number of light beams are defined by the requirements of the particular driven machine and the applicable accident prevention regulations, EN 999 or as a result of a risk analysis in accordance with EN 954-1. For protection, between one and four light barriers can be used. The usual protective heights applied are in accordance with EN 999 as shown in the Table.

Safety clearance

There is a delay between the light barrier being interrupted and the machine coming to a standstill. Thus, the light barriers must be mounted so that when the hazardous area is entered, the hazardous location is not reached before the hazardous motion has been stopped.

Number of light beams and their height above the reference plane acc. to EN 999

No. of light beams	Height of the light beams above the reference plane in mm	Beam clearance S in mm
4	300, 600, 900, 1200	300
3	300, 700, 1100	400
2	400, 900	500
1	750	

Fig. 3/50
Height and safety clearances of the beams (EN 999 must be observed for all applications)

According to EN 999, the safety clearance S between the protective device (light barrier) and the hazardous zone is defined according to the following formula:

$$S = K \times T + C$$

S Minimum safety clearance between the light barrier and the hazardous zone in mm

K Gripping or approach velocity in mm/s (constant)

T Delay time between the light beam being interrupted and the machine coming to a standstill in s, consisting of: t_1: Response time of the protective equipment in s
t_2 : Overtravel time of the machine in s

C Safety constant (additional clearance in mm)

Caution:
The following standards are decisive EN 294 (Section 1, Fig. 1/3) and EN 999.

Clearance to reflective surfaces

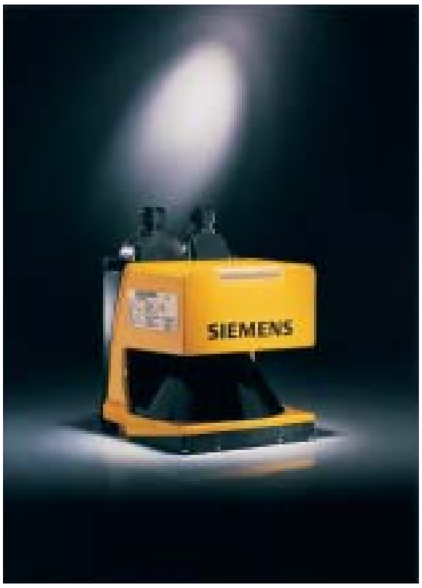
Reflective surfaces, which are located within the transmitting and receiving cone of the light barriers, can cause reflections, which means that an obstruction may not be identified. Thus, there must be a minimum clearance between reflective objects and the optical axis. This clearance is dependent on the angular aperture of the light sensor and the distance between the transmitter and receiver.

Technical data: Light barriers 3RG782

		Category 2 acc. to EN 954-1	Category 4 acc. to EN 954-1
Light barriers acc. to EN 954-1	Operating voltage	24 V DC	24 V DC
	Operating range	0 – 4 m	0 – 15 m
	Light type	Infrared (880 nm)	Infrared (880 nm)
	Aperture	≤ 4°	≤ 2°
	Obstruction size	≤ 9 mm diameter	≤ 13 mm diameter
	Connection	10 cm cable with connector M8, Type A	Connector M12, Type F
	Operating temperature	–10 to +55 °C	–20 to +60 °C
	Degree of protection	IP 67	IP 67
Monitoring units acc. to EN 954-1	Operating voltage	24 V DC	24 V DC
	Response time	≤ 25 ms	≤ 30 ms
	Current drain	180 mA	≤ 300 mA
	Safety outputs	2 relays (positively driven)	2 relays (positively driven)
	Switching voltage	max. 250 V AC	max. 250 V AC
	Switching current	max. 5 A (ohmic load)	max. 4 A (ohmic load)
	Switching power	max. 2000 VA	max. 1000 VA
	Signaling outputs	1	4
	Operating temperature	0 to + 50 °C	0 to + 50 °C
	Degree of protection	IP 67	IP 67

Fig. 3/51

3.1.9 SIGUARD laser scanners



SIGUARD laser scanners are optical distance sensors. These devices transmit periodic light pulses in a 190° working field. If these pulses strike an obstruction or a person, the light is reflected, is received by the laser scanner and evaluated. The scanner calculates the precise coordinates of the "detected" object from the light propagation time. A stop function is executed if the object or the person is located within a defined area. In this case, the semiconductor switching outputs are switched-off within the system response time. When the protective field is free, the stop function, depending on the mode, is automatically or, after acknowledgment, reset.

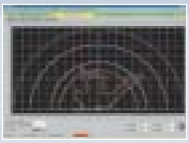
SIGUARD laser scanners can detect people up to a distance of 4.0 m, even if they are wearing dark clothing. By using this so-called safety-relevant protective field, the SIGUARD laser scanner is designed for personnel protection. Non-safety-relevant objects can be detected up to 15 m away.

Four programmable protective field pairs allow the protective area to be optimally adapted to the application. A field pair is the combination of a pre-warning field (object protective field) and a protective field (personnel protective field).

The scanner can be used on vehicles (driverless transport systems, shunting vehicles) and can be permanently mounted (to secure hazardous areas of machines).

As a result of the long detection range and the contactless measuring principle, the SIGUARD scanner is a protective device that can be used universally.

Product Overview

SIGUARD laser scanners		Order No.
	SIGUARD laser scanner LS4	**3RG78 34-6DD00**
Accessories		
	Mounting system	**3RG78 38-1AA**
	Adapter plate	**3RG78 38-1AB**
	Replacement window	**3RG78 38-7AA**
	Connector, complete, 15-pin, X1	**3RG78 38-1BA**
	Connector, complete., 9-pin, X2	**3RG78 38-1CA**
Connecting cable		
	Connecting cable incl. connector, 15-pin, 5 m	**3RG78 38-1BD**
	Connecting cable incl. connector, 15-pin, 10 m	**3RG78 38-1BE**
	Connecting cable incl. connector, 15-pin, 20 m	**3RG78 38-1BF**
	Connecting cable incl. connector, 15-pin, 35 m	**3RG78 38-1BG**
	Connecting cable incl. connector, 15-pin, 50 m	**3RG78 38-1BH**
	Connecting cable incl. connector, 9-pin, 3 m	**3RG78 38-1CC**
	Connecting cable incl. connector, 9-pin, 5 m	**3RG78 38-1CD**
	Connecting cable incl. connector, 9-pin, 10 m	**3RG78 38-1CE**
Software		
	LS4Soft operator control software	**3RG78 38-4AD**

Mode of operation of the scanner

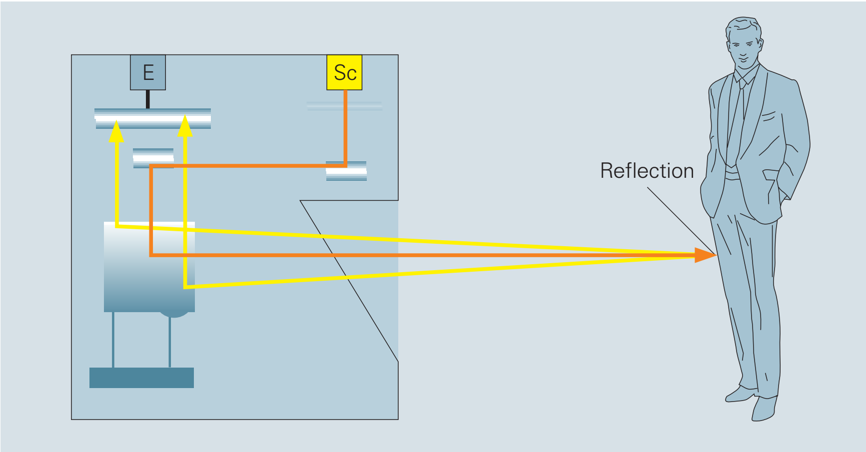


Fig. 3/52 *Mode of operation*

Short infrared laser pulses lasting three nanoseconds are generated by a laser diode. These laser pulses are transferred to a rotating mirror through various optical elements. This rotating mirror deflects these pulses so that during one mirror revolution, a circular surface is scanned within 40 milliseconds. The actual working area of the scanner - this means the window opening - is a 190° arc. The pulses in the remaining angular segment are reflected to internal reference objects and are used by the scanner for continually executed self tests.

If a laser pulse strikes a person or an object in the working area, then a pulse is diffusely reflected. The component of the light pulse, which returns to the scanner is deflected, by the rotating mirror, upwards to a collecting lens and the receiver unit located above this. A fast counter measures the time which the laser pulse requires to be transmitted from the scanner to the object and back. The scanner calculates the precise coordinates of the detected object from the light propagation time and the actual angle.

The working range of the scanner (190°) is subdivided into 0.36° angular segments.

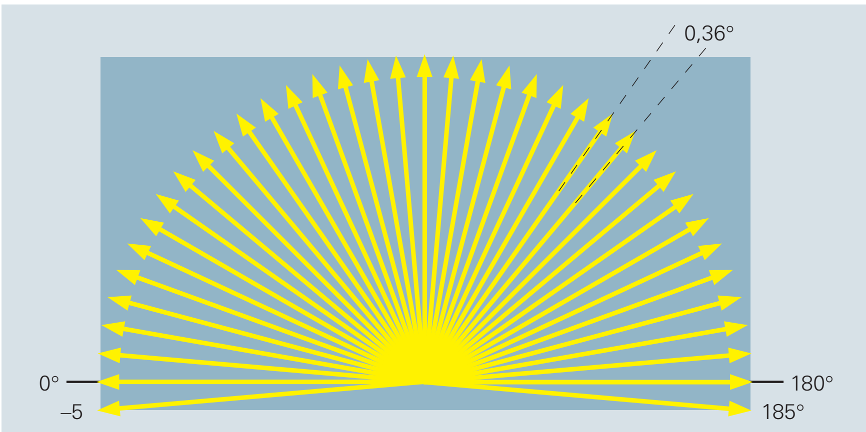


Fig. 3/53 *Working area and angular resolution*

Combination of hardware and software

The laser scanner can be programmed using the software provided. In addition to configuring the device, the protective field pairs can be adapted to the particular application and these can be saved in the scanner. The image of the environment created from the scanning process is compared with the specified protective field contours. If an object or a person violates one of the protective fields for at least two scans (80 ms) an appropriate user-specific response is initiated.

Flexible using four protective and warning fields which can be toggled between

One of the special features of the SIGUARD laser scanner LS4 is that up to four independent protective and warning field pairs can be programmed. During operation, it is possible to toggle between these to select the required pair.

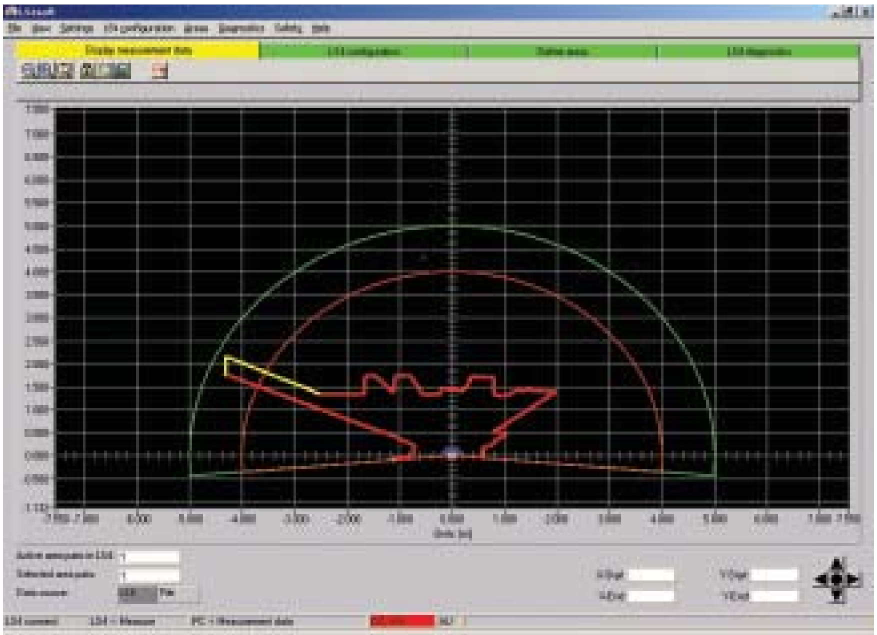


Fig. 3/54a *Parameterizing software LS4Soft*

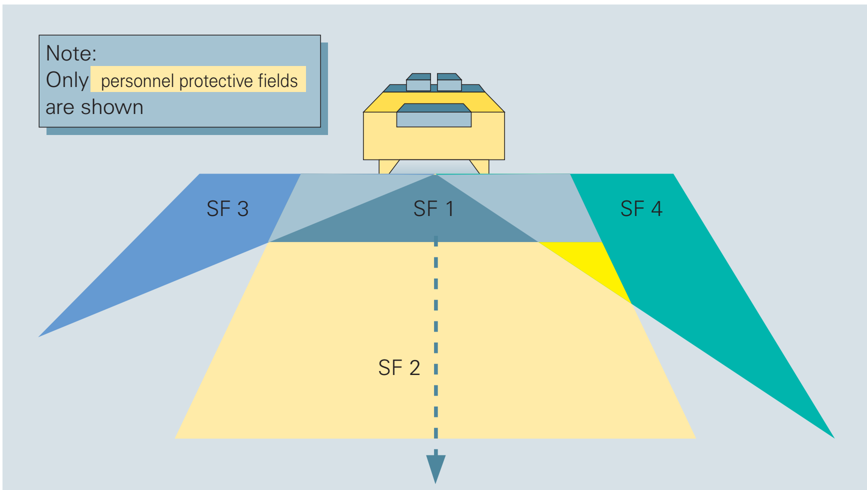


Fig. 3/54b *Protective fields*

Applications

The following examples are typical applications of the SIGUARD laser scanner.

When dimensioning the protective fields, DIN EN 999 as well as IEC 61496-3 and the calculation formulas included in them, should be carefully observed!

Calculating the minimum protective field depths (general)

The minimum protective field depth can be calculated as follows according to IEC 61496-3:

$S_T = (K * T) + C + Z$

S_T = Minimum protective field depth in mm

K = Approach velocity of a person or parts of the body in mm/s

T = Run-on time of the complete system $T = t_1 + t_2$ in s

t_1 = Laser scanner response time (minimum 0.080 s)

t_2 = Run-on time of the machine (in s)

C = 1200 mm – 0.4*H, however, not less than 850 mm

H = Scan height from the floor in mm

Z = Tolerances in mm

Distance	Max. measuring error
< 3.5 m	81 mm
3.5 m – 4 m	98 mm

Tolerances for the maximum measuring error:

For strongly reflecting backgrounds, e.g. retro-reflectors, under certain circumstances, an additional tolerance of 50 mm for measuring errors must be added.
Refer to the Technical Instructions of the SIGUARD laser scanner LS4 for additional tolerances dependent on the application

Securing hazardous areas

Frequently, in modern production systems, personnel must enter hazardous areas. While personnel are in such a hazardous area, it must be absolutely guaranteed that the machine or plant does not represent any danger to this personnel.

However, the safety measures required should not restrict production operations.

If a person approaches the hazardous area and enters a defined object protective field, the laser scanner signals approaching danger. If the personnel protective field is entered, the machine shuts down.

The scanner can fulfill almost any requirement on a machine or plant with its four selectable protective field pairs.

If there are machine components, which are continually moving in the area to be protected, then several protective zones are obtained which alternate with one another. Also here, the scanner can guarantee a high degree of personnel protection. With the distance sensors used up until now, it was not possible to absolutely secure the complete area. In this case, several distance sensors were required. Using its protective fields, which can be switched, the laser scanner can adapt itself to the alternating protective conditions. The laser scanner can be quickly adapted to a changing environment by simply using the configuration software provided.

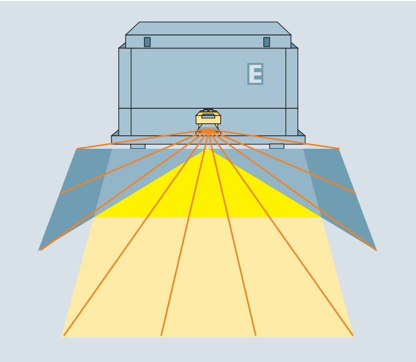


Fig. 3/55 Example - protecting hazardous areas using 4 protective fields which can be toggled between

After a protective field has been violated, to secure the area, the automatic restart must be inhibited. The actuation element to re-enable the unit must be located outside the protective fields. The user must be able to view the hazardous area of the protective field zones from this actuation element.

It must be ensured that the hazardous area cannot be laterally accessed (areas, which are not completely covered by the protective field).

When securing areas, a maximum approach velocity of 1600 mm/s and the penetration of body parts in accordance with DIN EN 999 must be taken into account (depending on the mounting height).

The protective field depth corresponds to the product of the approach velocity and the time that is required for the machine to stop any hazardous motion. The following application values were used as basis for the next example:

Access velocity = 1600 mm/s (constant)

Response time of the LS4 = 0.08 s

Run-on time of the machine = 0.6 s

From the formula

$S_T = (K * T) + C + Z$

S_T = Protective field depth

K = Access velocity

T = Response time of the LS4 + run-on-time of the machine

C = 1200 mm - 0.4*H

Height of the sensor scan plane H = 300 mm

Protective field tolerance, total = 150 mm

Results in a protective field depth which should be set:
S_T = 1600 mm/s * (0.08 s + 0.6 s) + 1200 mm - 0.4 * 300 mm + 150 mm
= 2318 mm

3

Application for driverless transport systems

For driverless transport systems, the SIGUARD laser scanner is used to monitor the vehicle route. Personnel and objects approaching the vehicle should be detected. Previous protective systems, such as bumpers, protective bars etc. only permit a low travel velocity. A significantly higher safety area is obtained using the laser scanner as "leading bumper." This allows these types of vehicles to travel faster. Furthermore, the scanner operates wear-free therefore reducing the service/maintenance costs.

As a result of the continuous sensing of the environment, the long detection range and the four protective fields, which can be toggled between, the laser scanner is ideally suited for vehicle navigation. Obstructions are detected in plenty of time and can be passed around if there is sufficient space or the vehicle can be brought to a standstill.

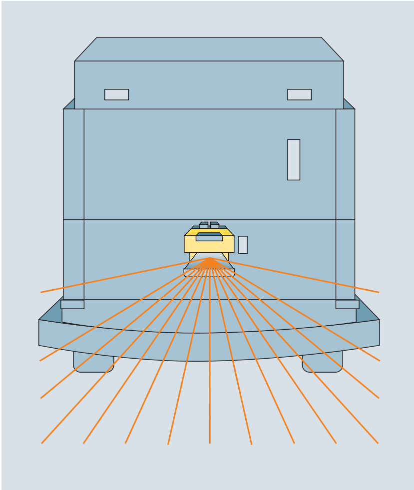


Fig. 3/56 Driverless vehicle application

The following typical application values have been used as example:

From the formula (refer to IEC 61496-3):

S_T = (V * T) + s + Z

S_T = Protective field depth

V = Vehicle velocity

T = LS4 response time + vehicle response time

s = Braking travel

Z = Tolerances for measuring errors, brake wear, space for feet, etc.

results in a protective field depth which should be set as follows:

Velocity = 1500 mm/s

LS4 response time = 0.08 s

Vehicle response time = 0.1 s

Braking travel = 1000 mm

Brake wear = 1.1 (10% lump sum tolerance to take into account possible brake wear)

Total protective field tolerance = 150 mm

Protective field depth = 1500 mm/s * (0.08 s + 0.1 s) + 1000 mm * 1.1 + 150 mm = 1520 mm

Other possible applications of the laser scanner

- Transport trolleys
- Measuring contours (e.g. in fully automatic parking houses)
- Personnel detection/counting
- Room security/facade monitoring
- Access control etc.

Technical Data

Technical data Protective field data	
Personnel protective field	
Detection range	0–4 m (no dead zones when correctly mounted)
Reflection capacity	min. 1.8% (matt-black)
Measuring error	max. 81 mm (for a protective field radius< 3.5 m) max. 98 mm (for a protective field radius ≥ 3.5 m)
Object size	≥ 70 mm (cylindrical test body)
Response time	80 ms (corresponds to 2 scans)
Number of protective fields	4 (can be changed-over using switching inputs)
Output	Two fail-safe PNP transistor outputs 24 V/250 mA
Category	Class 4 acc. to DIN V 19250, single-fault proof, Category 3 acc. to EN 954-1. Type 3 acc. to DIN EN IEC 61496-1, IEC 61496-3
Starting	The start test routine and the start inhibit can be separately parameterized.
Object protective field	
Detection range	0–15 m
Reflection capacity	Min. 20%
Object size	150 x 150 mm
Response time	80 ms (corresponds to 2 scans)
Number of protective fields	4 (can be switched-over using switching inputs)
Output	PNP transistor output, max. 100 mA
Contour measurement	
Detection range	0–50 m
Reflection level	Min. 20%
Object size	–
Output	Serial interface RS 232, RS 422
Resolution, radial	5 mm
Resolution, lateral	0.36°
General	
Supply	
Power supply	+ 24 V DC +20% / –30%
Overcurrent protection	Using a fuse 1.25 A medium slow-acting in the cabinet
Current drain	Approx. 300 mA (use a 2.5 A power supply)
Power drain	< 8 W at 24 V plus the output load
Overvoltage protection	Overvoltage protection with safe end cut-off
Voltage dips	Acc. to DIN EN IEC 61496-1

3

Inputs	
Restart/reset	Control device to select an operating mode with restart inhibit and/or unit reset, dynamically monitored 24 V DC de-coupled through opto-couplers
Protective field changeover	4 protective field pairs can be selected using 4 control cables with internal monitoring (protective field pair = 1 personnel protective field and 1 objective protective field), 24 V DC de-coupled through opto-couplers
Outputs	
Personnel protective field	2 x safe semiconductor outputs, PNP max. 250 mA short-circuit monitored, overcurrent-protected.
Object protective field/dirt accumulation	PNP transistor output, max. 100 mA
Parameterization	
Operator control software	Communications software under Windows 95/98/2000/NT with secure protocol for programming
Interfaces	
RS 232 RS 422	To parameterize the unit and define the protective field
Optical properties	
Angular area	190°
Angular resolution	0.36°
Scan rate	25 scans/s or 40 ms/scan
Laser protection class	Class 1 (safe to eyes), DIN EN 60825-1 Wavelength, 905 nm, Beam divergence= 2 mrad, Time base = 100 s
Ambient and material data	
Degree of protection	IP 65 acc. to IEC 60529
Shock protection	Totally insulated; Protective Class 2
Operating temperature	0...+ 50 °C
Storage temperature	– 20 °C...+ 60 °C
Humidity	DIN 40040 Table 10, code letter. E (essentially dry)
Dimensions	140 x 155 x 135 (W x H x D) in mm
Distance between the scan plane and the lower housing edge	48.75 mm
Connection	2 connectors (inserted from the top, solder connection)
Cable length	max. 50 m for a 0.5 mm^2 cable cross-section
Transmitter	Infrared laser diode (wavelength = 905 nm)
Housing	Die-cast aluminum, plastic
Weight	Approx. 2 kg

3.1.10 SIGUARD signaling devices

It is extremely important that hazards and dangers are visually and acoustically signaled and this can prevent accidents.

There is a comprehensive range of SIGUARD signaling devices available:

- 8WD4 signaling columns
- 8WD5 built-in indicator lights
- 3SB illuminated pushbuttons

8WD44 signaling columns, selection and ordering data (70 mm diameter, thermoplast enclosure, degree of protection IP 65)

	Version	Color	8WD44 signaling columns with rated voltage **24 V AC/DC**	8WD44 signaling columns with rated voltage **115 V AC/DC**	8WD44 signaling columns with rated voltage **230 V AC/DC**
			Order No.	Order No.	Order No.
Bulb: Lamp base BA 15d, 5 W, 24 V/115 V/230 V (not included in the scope of supply); LED: Lamp base BA 15d					
8WD44 00-1A 	• Steady-light element		Rated voltage 12 to 230 V AC/DC		
		red green yellow clear blue	**8WD44 00-1AB** **8WD44 00-1AC** **8WD44 00-1AD** **8WD44 00-1AE** **8WD44 00-1AF**		
	• Repeated-flash light element (only for bulbs)	red green yellow clear blue	**8WD44 20-1BB** **8WD44 20-1BC** **8WD44 20-1BD** **8WD44 20-1BE** **8WD44 20-1BF**	**8WD44 40-1BB** **8WD44 40-1BC** **8WD44 40-1BD** **8WD44 40-1BE** **8WD44 40-1BF**	**8WD44 50-1BB** **8WD44 50-1BC** **8WD44 50-1BD** **8WD44 50-1BE** **8WD44 50-1BF**
	• Single-flash light element with built-in flash electronics (no additional bulb or LED required)	red green yellow clear blue	**8WD44 20-0CB** **8WD44 20-0CC** **8WD44 20-0CD** **8WD44 20-0CE** **8WD44 20-0CF**	**8WD44 40-0CB** **8WD44 40-0CC** **8WD44 40-0CD** **8WD44 40-0CE** **8WD44 40-0CF**	**8WD44 50-0CB** **8WD44 50-0CC** **8WD44 50-0CD** **8WD44 50-0CE** **8WD44 50-0CF**
LED version (integrated version)					
8WD44 20-5AB 	• Steady-light LED element	red green yellow clear blue	**8WD44 20-5AB** **8WD44 20-5AC** **8WD44 20-5AD** **8WD44 20-5AE** **8WD44 20-5AF**	**8WD44 40-5AB** **8WD44 40-5AC** **8WD44 40-5AD** **8WD44 40-5AE** **8WD44 40-5AF**	**8WD44 50-5AB** **8WD44 40-5AC** **8WD44 40-5AD** **8WD44 40-5AE** **8WD44 40-5AF**
	• Repeated-flash light LED element	red green yellow	**8WD44 20-5BB** **8WD44 20-5BC** **8WD44 20-5BD**	–	–
	• Rotating beacon LED element	red green yellow	**8WD44 20-5DB** **8WD44 20-5DC** **8WD44 20-5DD**	–	–
Acoustic element					
8WD44 20-0FA 	• 85 dB buzzer element tone (can be set): pulsating or continuous		**8WD44 20-0FA**	**8WD44 40-0FA**	**8WD44 50-0FA**
	• Siren element 105 dB	IP 40	**8WD44 20-0EA**	–	–
	• Multi-tone siren 100 dB (8 tones and intensity can be set)		**8WD44 20-0EA2**	**8WD44 40-0EA2**	**8WD44 50-0EA2**

Fig. 3/56

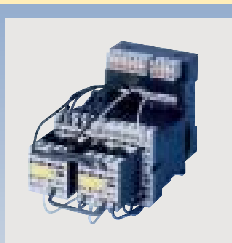
8WD44 signaling columns selection and ordering data (70 mm diameter, thermoplastic enclosure, degree of protection IP 65)

	Version	Color	8WD44 signaling columns with rated voltage **24 V** Order No.	8WD44 signaling columns with rated voltage **115 V** Order No.	8WD44 signaling columns with rated voltage **230 V** Order No.
Connecting element including cover, screw terminals					
8WD44 08-0AA 	• for pipe mounting		**8WD44 08-0AA**		
	• for mounting on brackets, bases or floors		**8WD44 08-0AB**		
Cage-clamp terminals, connection element including cover					
8WD44 08-0AD 	• for pipe mounting		**8WD44 08-0AD**		
	• for mounting on brackets, bases or floors		**8WD44 08-0AE**		
Accessories					
	LED Base BA 15d	Red Green Yellow Clear Blue	**8WD44 28-6XB** **8WD44 28-6XC** **8WD44 28-6XD** **8WD44 28-6XE** **8WD44 28-6XF**	**8WD44 48-6XB** **8WD44 48-6XC** **8WD44 48-6XD** **8WD44 48-6XE** **8WD44 48-6XF**	**8WD44 58-6XB** **8WD44 58-6XC** **8WD44 58-6XD** **8WD44 58-6XE** **8WD44 58-6XF**
	**Lamps** Socket BA 15d, 5 W		**8WD43 28-1XX**	**8WD43 48-1XX**	**8WD43 58-1XX**
8WD44 08-0DB 	**Foot, single**		Plastic		**8WD43 08-0DB**
	**Foot with pipe**		Plastic		**8WD43 08-0DA**
	Foot, single		Cast foot for pipe mounting > 400 mm		**8WD43 08-0DC**
 	**Socket for foot**		Cable version, lateral Cable, lateral with magnetic mounting		**8WD43 08-0DD** **8WD43 08-0DE**
	**Foot, single**		100 mm 150 mm 250 mm 400 mm 1000 mm		**8WD43 08-0EF** **8WD43 08-0EE** **8WD43 08-0EA** **8WD43 08-0EB** **8WD43 08-0ED**
8WD44 08-0CA  	**Bracket for wall mounting** for single-sided mounting for double-sided mounting			**24 V** **24 V**	**8WD43 08-0CA** **8WD43 08-0CB**
	**Bracket for foot mounting**				**8WD44 08-0CC**
	**Bracket for socket mounting**				**8WD44 08-0CD**
	**AS-Interface adapter element** without external auxiliary voltage with external auxiliary voltage		4 signal elements up to max. 200 mA, 24 V possible 4 signal elements up to max. 1.5 mA, 24 V possible		**8WD44 28-0BA** **8WD44 28-0BB**

Fig. 3/57

Detailed ordering data for the range of 8WD42 signaling columns with 50-mm diameter as well as built-in signal lamps are provided in the main Catalog NSK , Section 8 or in the brochure E20001-A0240-P305-7600: SIGUARD 8WD4 signaling devices: Modular and communications-capable.

3.2 SIGUARD 3TK28 Safety Combinations

Shutdown with safety relay	**Shutdown with safety electronics**	**Shutdown with safety electronics with integrated contactors**
		
• 3TK28 2 relay safety combination	• 3TK28 4 electronic safety combination	• 3TK28 52 electronic safety combination

The complete program of SIGUARD safety combinations has been especially designed for the requirements of state-of-the-art safety technology. SIGUARD safety combinations can be simply used to configure safety circuits, as the devices fulfill EN 60204-1 (VDE 0113 Part 1) EN292, EN 954-1, IEC 61508 and are certified by the German Trade Association (BG), the German Statutory Industrial Accident Insurance Association (BIA) and the Swiss Accident Insurance Institution (SUVA) and the Germany Inspectorate (TÜV).

Applications

SIGUARD safety combinations cover a wide range of applications. These include monitoring EMERGENCY STOP and protective door devices. It is also possible to monitor press control systems.

SIGUARD safety combinations tend to be used for somewhat less complex safety circuits as conventional switching technology with electromechanical contacts. Safety circuits using PLC technology (fail-safe SIMATIC, also refer to Section 4) can be used for more complex plants and systems with a high functional scope (e.g. with a diagnostics function when an EMERGENCY STOP is initiated).

3.2.1 Safety relays

Positively-driven contacts - a plus for safety

Relays are often used for safety circuits. The special feature of Siemens SIGUARD safety combinations is the fact that contactors or safety relays have positively-driven contacts.

Siemens offers the following versions

- Relay technology
- Safety electronics
- Safety electronics with integrated auxiliary contactors.

Relevant standards

- EN 60204-1 (VDE 0113 Part 1), electrical equipment of machines
- EN 292, Safety of Machinery
- EN 60947, Low-Voltage Switchgear
- EN 954-1, Safety of Machinery – Safety-related parts of control systems
- EN 574 Type III C, Safety of Machinery – Two-handed circuits
- DIN EN 50205 Electric Relays – Relays with positively-driven contacts (VDE 0435)

In recent years, the trend in low-voltage technology has been towards miniaturization of the switching devices. With newly developed smaller devices, it was possible to accommodate more functionality in a cabinet. It was therefore a logical step that when it came to safety technology, there would also be a higher demand for smaller, more compact safety combinations. Siemens fulfilled this enhanced safety demand by using space-saving safety relays with positively-driven contacts. These safety relays switch so that they are intrinsically fail-safe. In this case, 2 contacts, which are independent of one another, have to be switched in series; normally, NO contacts of monostable relays are used. If a contact was to weld, then the 2nd contact, connected in series, is used to disconnect the circuit. A positively-driven NC contact is used to signal the fault, in this case, the welded NO contact. This NC contact is actuated in synchronism with the NO contact. For example, if the NO contact is closed, then the NC contact, which is provided for monitoring, must be opened and vice versa. Using these paired, positively-driven contacts, it is ensured that the safety relay also drops-out if all of the contacts of the circuit to be protected are welded.

With this new type of contact arrangement, the safety relay has positively-driven contacts which are tested and recognized by SUVA and which fully conform to Standard ZH1/457.

SIGUARD 3TK28 relay safety combinations can be used in ambient temperatures of up to 60°C - up to 70°C with some restrictions when mounted in-line.

Many switching functions can be implemented using the SIGUARD 3TK28 safety combinations.

Fig. 3/58
3TK28 2 relay safety combinations

The SIGUARD 3TK28 safety combinations comprise:

- Basic devices
- Expansion devices, as well as
- Press control devices

Basic devices

Basic devices are used to safely monitor EMERGENCY STOP devices and equipment as well as protective doors. The SIGUARD basic devices have, in addition to instantaneous enable contacts, also enable contacts with a dropout delay Depending on the version of the particular device, delay times of between 0.05 and 30 s are available.

A cover, which can be sealed, protects the delay time from being changed by unauthorized personnel.

EMERGENCY STOP devices and equipment must have priority over all of the other functions. The power feed to the machine drives, which can cause hazardous conditions, must be shutdown as quickly as possible without creating other hazards. When the drives are reset, a restart may not be initiated. EMERGENCY STOP must act as Stop Category 0 or Category 1.

The basic SIGUARD combination units can be used for EMERGENCY STOP applications up to a maximum of Category 4 acc. to EN 954-1. Depending on the external circuitry and how the cables are routed to the sensors, Category 3 or Category 4 can be achieved.

Protective door monitoring according to EN 1088 makes a differentiation between latching, isolating protective devices and latching isolating protective devices with tumbler.

SIGUARD safety combinations are also used here. Control systems up to Category 4 according to EN 954-1 can be configured.

Expansion units

Expansion units may not be used separately in safety circuits. They must be configured with a basic SIGUARD 3TK28 safety combination unit. An enabling contact of the basic unit is required to connect an expansion unit. The category of a control system with expansion unit corresponds to the category of the basic unit.

Presses and punches

The two-hand control device is a device where both hands of the operator must be simultaneously used. This protects the operator from various hazards.

The overtravel tester is used for linear driven presses and punches in accordance with VBG7n5.2.

It only checks once at each test stroke

- that the operator control elements have been correctly connected
- for external cable interruptions and breaks
- if the components which are cyclically monitored have failed.

The overtravel tester can only be used in conjunction with a two-hand control device.

The press control devices and overtravel testers are suitable for installation in control systems for eccentric, hydraulic and spindle presses. They can be used up to Category 4 in accordance with EN 954-1. Type III C according to EN 574 can be especially used for presses.

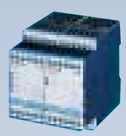
Please refer to Section 7 for circuit examples.

Selection and ordering data for SIGUARD 3TK28 safety combinations using relays

	Enable contacts[1]	Signaling contacts	Achievable category[2] acc. to EN 954-1	Rated control supply-voltage V_S	**With screw terminals** Order No.	**With cage-clamp terminals** Order No.
Basic devices for EMERGENCY STOP and protective doors						
3TK28 21 to 3TK28 24	**Auto start**					
Screw connection	3 NO	1 NC	B, 1, 2, 3, 4[3]	24 V AC/DC	**3TK28 21-1CB30**	**3TK28 21-2CB30**
	2 NO	–	B, 1, 2, 3, 4	24 V AC/DC	**3TK28 22-1CB30**	**3TK28 22-2CB30**
	**Monitored start**					
	2 NO	–	B, 1, 2, 3, 4	24 V AC/DC	**3TK28 23-1CB30**	**3TK28 23-2CB30**
	Auto start					
	2 NO	–	B, 1, 2, 3, 4[3]	24 V AC/DC	**3TK28 24-1CB30**	**3TK28 24-2CB30**
	2 NO	–	B, 1, 2, 3, 4[3]	24 V DC	**3TK28 24-1BB40**	**3TK28 24-2BB40**
	2 NO	–	B, 1, 2, 3, 4[3]	115 V AC	**3TK28 24-1AJ20**	**3TK28 24-2AJ20**
	2 NO	–	B, 1, 2, 3, 4[3]	230 V AC	**3TK28 24-1AL20**	**3TK28 24-2AL20**
3TK28 25	**Auto start/monitored start**					
Screw connection	3 NO	2 NC	B, 1, 2, 3, 4	24 V DC	**3TK28 25-1BB40**	**3TK28 25-2BB40**
	3 NO	2 NC	B, 1, 2, 3, 4	24 V AC	**3TK28 25-1AB20**	**3TK28 25-2AB20**
	3 NO	2 NC	B, 1, 2, 3, 4	115 V AC	**3TK28 25-1AJ20**	**3TK28 25-2AJ20**
	3 NO	2 NC	B, 1, 2, 3, 4	230 V AC	**3TK28 25-1AL20**	**3TK28 25-2AL20**
	Monitored start					
	2 NO + 2 NC	1 NC	B, 1, 2, 3, 4[4]	24 V DC	**3TK28 27-1BB40**	**3TK28 27-2BB40**
	2 NO + 2 NC	1 NC	B, 1, 2, 3, 4[4]	24 V AC	**3TK28 27-1AB20**	**3TK28 27-2AB20**
3TK28 27 and 3TK28 28	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	115 V AC	**3TK28 27-1AJ20**	**3TK28 27-2AJ20**
Screw connection	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	230 V AC	**3TK28 27-1AL20**	**3TK28 27-2AL20**
	Delayed dropout, t_v 0.5–30 s					
	**Monitored stop**					
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V DC	**3TK28 27-1BB41**	**3TK28 27-2BB41**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V AC	**3TK28 27-1AB21**	**3TK28 27-2AB21**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	115 V AC	**3TK28 27-1AJ21**	**3TK28 27-2AJ21**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	230 V AC	**3TK28 27-1AL21**	**3TK28 27-2AL21**
	Delayed dropout, t_v 0.05–3 s					
3TK28 21	**Auto start**					
Cage-clamp terminal	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V DC	**3TK28 28-1BB40**	**3TK28 28-2BB40**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V AC	**3TK28 28-1AB20**	**3TK28 28-2AB20**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	115 V AC	**3TK28 28-1AJ20**	**3TK28 28-2AJ20**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	230 V AC	**3TK28 28-1AL20**	**3TK28 28-2AL20**
	Delayed dropout, t_v 0.5–30 s					
	Auto start					
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V DC	**3TK28 28-1BB41**	**3TK28 28-2BB41**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	24 V AC	**3TK28 28-1AB21**	**3TK28 28-2AB21**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	115 V AC	**3TK28 28-1AJ21**	**3TK28 28-2AJ21**
	2 NO + 2 NO	1 NC	B, 1, 2, 3, 4[4]	230 V AC	**3TK28 28-1AL21**	**3TK28 28-2AL21**
	Delayed dropout, t_v 0.05–3 s					

1) Enable contacts are safety-relevant contacts, which can also be used as signaling contacts.
2) The maximum achievable Category according to EN 954-1 corresponds to the Category of the basic device. The Category depends on the external circuitry, the control devices selected and their local arrangement at or in the machine. The regulations in the Standards for safety at the machine must be carefully observed.
3) Possible with additional external measures. Data only apply if the cables and sensors are safely routed and mechanically protected. Also refer to the Instruction Manual and Application Manual.
4) Only applies for instantaneous enable contacts.

Selection and ordering data for SIGUARD 3TK28 safety combinations using relays

	Enable contacts[1]	Signaling contacts	Achievable category[2] acc. to EN 954-1	Rated control supply voltage V_S	**With screw terminals** Order No.	**With cage-clamp terminals** Order No.
Expansion device						
3TK28 30 	**To extend the contacts of the safety combinations** (1 enable contact of the basic devices required to connect to the expansion device)					
	4 NO	–	as for the basic device	24 V AC/DC	**3TK28 30-1CB30**	**3TK28 30-2CB30**
	4 NO	–	as for the basic device	115 V AC	**3TK28 30-1AJ20**	**3TK28 30-2AJ20**
	4 NO	–	as for the basic device	230 V AC	**3TK28 30-1AL20**	**3TK28 30-2AL20**
Press control units						
3TK28 34, 3TK28 35 Screw connection 	**For use with presses and stamping machines**					
	Two-hand control device 2-channel					
	2 NO	2 NC	4	24 V DC	**3TK28 34-1BB40**	**3TK28 34-2BB40**
	2 NO	2 NC	4	24 V AC	**3TK28 34-1AB20**	**3TK28 34-2AB40**
	2 NO	2 NC	4	115 V AC	**3TK28 34-1AJ20**	**3TK28 34-2AJ20**
	2 NO	2 NC	4	230 V AC	**3TK28 34-1AL20**	**3TK28 34-2AL20**
	Overtravel tester[5]					
	3 NO	1 NC	4	24 V DC	**3TK28 34-1BB40**	**3TK28 34-2BB40**
	3 NO	1 NC	4	24 V AC	**3TK28 34-1AB20**	**3TK28 34-2AB40**
	3 NO	1 NC	4	115 V AC	**3TK28 34-1AJ20**	**3TK28 34-2AJ20**
	3 NO	1 NC	4	230 V AC	**3TK28 34-1AL20**	**3TK28 34-2AL20**

[1] Enable contacts are safety-relevant contacts, which can also be used as signaling contacts.
[2] The maximum achievable category according to EN 954-1 corresponds to the category of the basic device. The category depends on the external circuitry, the control devices selected and their local arrangement at or in the machine. The regulations in the standards for safety at the machine must be carefully observed.
[3] Possible with additional external measures. Data only apply if the cables and sensors are safely routed and mechanically protected. Also refer to the Instruction Manual and Application Manual.
[4] Only applies for instantaneous enable contacts.
[5] The 3TK28 35 overtravel tester can only be used in conjunction with the 3TK28 34 two-hand control device

3.2.2 Safety electronics

Relevant Standards

- EN 60204-1 (VDE 0113 Part 1), Electronic Equipment of Machinery
- EN 292, Safety of Machinery
- EN 60947, Low-Voltage Switchgear
- EN 954-1, Safety of Machinery – Safety-related parts of control systems
- VDE 0660-500 Low-Voltage Switchgear Combinations
- DIN V 19250 Basic safety considerations for control and instrumentation protective devices
- IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems

Fig. 3/59
3TK28 4 electronic safety combination

Recently, in addition to miniaturization of the products, as an additional innovative step, electronics are being increasingly used for safety-related applications. The European Foreword of EN 60204-1, Edition 11/98, also permits, in addition to the previously generally used switching devices with contacts, also electronic solutions for safety tasks. The condition is that electronic solutions must fulfill the same safety level as the previously established devices with contacts.

For operating companies, it is irrelevant as to whether devices with contacts are used or electronic safety combinations. The new electronic safety combinations are also accommodated in the familiar SIRIUS housing. This distinguishes itself as a result of its low depth, low housing width, low weight as well as the proven termination systems using screw or cage-clamp terminal systems. The electronic combinations are also certified for Categories 3 or 4 according to EN 954-1, depending on how the sensors/actuators are controlled.

Additional advantages of an electronic solution include:

- High switching frequency
- High electrical lifetime
- No wear as it switches electronically
- No faulty contacts at low currents/voltages
- Min. cable lengths up to 1000 m possible
- Permanent cyclic self-test in the sensor/actuator circuit
- Short shutdown times

The electronic safety combinations can be controlled through 1 or 2 channels. They are suitable for monitored start as well as for auto start. They are also suitable for EMERGENCY STOP and protective door monitoring. The following safety pilot shows has the various units and devices can be used. The versions differ between the basic, standard, standard time delays (STOP category 1) and multi-function unit. The circuit has a redundant configuration with diversity. The switching elements monitor themselves dynamically. The outputs are also redundantly configured, have diversity and their function is regularly checked when they are switched-on. All of the input signals are subject to a dynamic test so that faults associated with sensors, cables (cross-circuit, interrupted conductor) can be detected at any time. Due to the fact that no electromagnetic switching elements are used, response times of less than 15 ms are obtained (between the actuation signal of the sensors up to the final shutdown).

3.2.3 Safety electronics with integrated contactors

An additional new feature is the combination of safety functionality in an electronic design and switching device with contacts as complete unit. This unit is already assembled, wired and certified.

This "safe electronics safety combination" with floating enable contacts 3TK285 is snapped, as a complete unit, onto a mounting rail. It distinguishes itself by the fact that it has the benefits of electronic safety combinations but it also has the advantage that auxiliary contactors can be used.

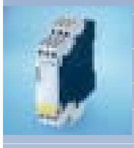
Fig. 3/60
3TK28 5 electronic safety combination with auxiliary contactors

The advantages are as follows:

- No additional wiring is required (errors are minimized as the unit is wired in the factory, lower cost)
- No wear in the contactor control as the redundantly configured contactors are electronically controlled which results in a high lifetime
- DC-13 10 A at 24 V, AC-15 6 A with a 230 V switching capacity,
- Floating enable contacts
- Safe separation
- Standard SIRIUS switching devices are used
- SIRIUS accessories can be used
- The units have their own terminals for sensor cables (terminal designations according to EN 50042)
- Compact type of construction 120 mm distance between tiers possible
- Certified as complete unit

The SIGUARD Safety Pilot for Electronic Devices

SIGUARD safety combinations – device versions



Device type	Connection: 1-channel	Connection: 2-channel	Auto start	Monitored start	EMERGENCY STOP	Protective door	Electronic sensors	Cascading input 24 V DC	Safety mats	Category acc. to EN 954-1: B	1	2	3	4
3TK28 40	■	■	■	■	■	■	–	–	–	■	■	■	■	–
3TK28 41	■	■	■	■	■	■	■	1	■	■	■	■	■	■
3TK28 42	■	■	■	■	■	■	■	1	■	■	■	■	■	■
3TK28 45	■	■	■	■	■	■	■	1	■	■	■	■	■	■
3TK28 50	■	■	■	■	■	■	–	–	–	■	■	■	■	–
3TK28 51	■	■	■	■	■	■	–	–	–	■	■	■	■	–
3TK28 52	■	■	■	■	■	■	–	–	–	■	■	■	■	–
3TK28 53	■	■	■	■	■	■	■	1	■	■	■	■	■	■
3TK28 56	–	–	–	–	–	–	–	1	–	●	●	●	●	●
3TK28 57	–	–	–	–	–	–	–	1	–	●	●	●	●	–

SIRIUS 3R load feeders with integrated safety technology

Device type	Description	1-channel	2-channel	Auto start	Monitored start	EMERGENCY STOP	Protective door
3RA7100-5AA26-...	Basic device, Category 3	■	■	■	–	■	■
3RA7110-5AA26-0AB4	Basic device, Category 4	■	■	■	■	■	■
3RA7120-5AA26-0AB4	Expansion devices	–	–	–	–	–	–
3RA7130-5AA26-0AB4, 3RA7140-5AA26-0AB4	Expansion devices with time delay	–	–	–	–	–	–
3RA710	Basic device, Category 3	■	■	■	■	■	■
3RA711	Basic device, Category 4	■	■	■	■	■	■
3RA712	Expansion devices	–	–	–	–	–	–
3RA713, 3RA714,	Expansion devices with time delay	–	–	–	–	–	–

■ = Available
– = Not available
● = Corresponds to the basic device
1) At V = 230 V
2) At V = 24 V
3) The outputs are only safe in conjunction with an external contactor
4) An enable circuit can be used as signaling circuit
5) Corresponds to the basic device
6) An enable circuit can be used as signaling circuit
7) At Ve = 400 V 50 Hz
8) Dependent on the contactor; maximum values are specified
9) Possible using SIRIUS auxiliary contact for circuit-breaker and contactor

Enable circuit, floating		Enable circuit, electronic			Switching capability		Rated operating voltage			Rated control supply voltage			Control inputs
Stop Category 0	Stop Category 1	Stop Category 0	Stop Category 1	Signaling circuit[4]	AC-15[1]	DC-13[2]	24 V DC	230 V AC	600 V AC	24 V DC	115 V AC	230 V AC	24 V DC
–	–	2[3]	–		–	0,5 A	■	–	–	■	–	–	–
–	–	2	–	–	–	2 A	■	–	–	■	–	–	–
–	–	1	1	–	–	2 A	■	–	–	■	–	–	–
1	1	1	1	–	2 A	2 A	■	■	–	■	–	–	–
3	–	–	–	–	6 A	10 A	■	■	■	■	■	■	–
2	–	–	–	1 NC	6 A	10 A	■	■	■	■	■	■	–
6	–	–	–	1 NC	6 A	10 A	■	■	■	■	–	■	–
3	–	1	–	–	6 A	10 A	■	■	■	■	–	–	1
6	–	1	–	1 NC	6 A	10 A	■	■	■	■	–	–	1
–	3	1	–	–	6 A	10 A	■	■	■	■	–	–	1

Category acc. to EN 954-1										Switching capability			Rated control supply voltage	
B	1	2	3	4	Electronic sensors	Cascading input	Operational switch 24 V DC	Electronic enable contact	Signaling circuit	AC-1[7]	AC-3[7]	Rated operating voltage 690 V AC	24 V DC	230 V AC
■	■	■	■	–	–	–	–	–	[9]	40 A	25 A	■	■	■
■	■	■	■	■	■	■	1	1	[9]	40 A	25 A	■	■	■
[5]	[5]	[5]	[5]	[5]	–	■	1	1	[9]	40 A	25 A	■	■	–
[5]	[5]	[5]	[5]	[5]	–	■	1	1	[9]	40 A	25 A	■	■	–
■	■	■	■	–	–	–	–	–	[9]	[8]	[8]	■	■	■
■	■	■	■	■	■	■	1	1	[9]	[8]	[8]	■	■	–
[5]	[5]	[5]	[5]	[5]	–	■	1	1	[9]	[8]	[8]	■	■	–
[5]	[5]	[5]	[5]	[5]	–	■	1	1	[9]	[8]	[8]	■	■	–

Selection and ordering data for SIGUARD 3TK284/5 electronic safety combinations

	Enable circuits, floating, Stop Category 0	Enable circuits, floating, Stop Category 1	Enable circuits, electronic Stop Category 0	Enable circuits, electronic Stop Category 1
Safety combinations, electronic 				
Basic device	–	–	2[1]	–
Standard device	–	–	2[3]	–
Standard device tv	–	–	1	1, tv = 3 sec.
	–	–	1	1, tv = 30 sec.
Multi-function device	1	1	1	1, tv = 3 sec.
	1	1	1	1, tv = 30 sec.
	–	–	2	–
Safety combinations, electronic with auxiliary contactors 				
Basic device	3	–	–	–
	3	–	–	–
	3	–	–	–
Basic device	2	–	–	–
	2	–	–	–
	2	–	–	–
Basic device	6	–	–	–
	6	–	–	–
Basic device	3	–	1[3]	–
Expansion device	6	–	1	–
Expansion device tv	–	3, tv = 3 sec.	1	–
	–	3, tv = 30 sec.	1	–

– = Not available

1) Outputs are only safe in conjunction with external contactors
2) An enable circuit can be used as signaling contact
3) Suitable for electronic sensor input
tv = Drop-out delay
0.05–3 seconds
0.5–30 seconds
4) Corresponds to the basic device

Signaling circuit	Achievable category acc. to EN 954-1	Rated control supply voltage	With screw connections Order No.	With cage-clamp terminal Order No.
–	B, 1, 2, 3	24 V DC	3TK2840-1BB40	3TK2840-2BB40
2)	B, 1, 2, 3, 4	24 V DC	3TK2841-1BB40	3TK2841-2BB40
–	B, 1, 2, 3. 4	24 V DC	3TK2842-1BB41	3TK2842-2BB41
-	B, 1, 2, 3, 4	24 V DC	3TK2842-1BB42	3TK2842-2BB42
2)	B, 1, 2, 3, 4	24 V DC	3TK2845-1BB41	3TK2845-2BB41
2)	B, 1, 2, 3, 4	24 V DC	3TK2845-1BB42	3TK2845-2BB42
2)	B, 1, 2, 3, 4	24 V DC	3TK2845-1BB40	3TK2845-2BB40
–	B, 1, 2, 3	24 V DC	3TK2850-1BB40	3TK2850-2BB40
–	B, 1, 2, 3	115 V AC	3TK2850-1AJ20	3TK2850-2AJ20
–	B, 1, 2, 3	230 V AC	3TK2850-1AL20	3TK2850-2AL20
1 NC	B, 1, 2, 3	24 V DC	3TK2851-1BB40	3TK2851-2BB40
1 NC	B, 1, 2, 3	115 V AC	3TK2851-1AJ20	3TK2851-2AJ20
1 NC	B, 1, 2, 3	230 V AC	3TK2851-1AL20	3TK2851-2AL20
1 NC	B, 1, 2, 3	24 V DC	3TK2852-1BB40	3TK2852-2BB40
1 NC	B, 1, 2, 3	230 V AC	3TK2852-1AL20	3TK2852-2AL20
–	B, 1, 2, 3, 4	24 V DC	3TK2853-1BB40	3TK2853-2BB40
1 NC	4)	24 V DC	3TK2856-1BB40	3TK2856-2BB40
–	4)	24 V DC	3TK2857-1BB41	3TK2857-2BB41
–	4)	24 V DC	3TK2857-1BB42	3TK2857-2BB42

3.3 Load Feeders with Integrated Safety Technology

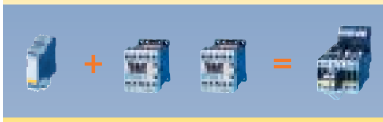
The safe load feeder is another highlight in the Safety Integrated "safety package." This combines the already described features of the electronic safety technology with the advantages of the modular SIRIUS system. A complete, pre-mounted, pre-wired, tested and certified load feeder, with coordination type 2[1] is obtained by combining a circuit-breaker and two contactors connected in series. Depending on the particular version, these load feeders can achieve Category 3 or 4 acc. to EN 954-1.

Load feeders, Category 3 involve a simple and favorably-priced solution. The advantage in this case is the high switching power of the contactors, which, in addition to the AC-3 switching power of 25 A, can also switch a DC-1 current of up to 35 A. This means that even larger loads can be switched without any additional equipment.

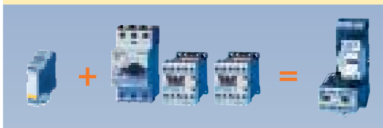
In addition to the high switching power for AC and DC, the load feeders, Category 4 acc. to EN 954-1 can also provide functions such as operational switching - they can also be cascaded and expanded.

1) Coordination types, refer to Page 3/77

From 3 to 1



From 4 to 1



Advantages of the load feeders

- Can be used up to Category 4 acc. to EN 954-1
- Stop categories 0 and 1 possible
- Can be expanded and cascaded
- Electronic EMERGENCY STOP elements can be directly connected
- Integrated overload and short-circuit protection
- Short circuit protection up to 50 kA
- AC-1, AC-3 switching capability
- Feeders up to 11 kW, coordination type 2, up to 5.5 kW, weld-free
- No additional wiring required (minimizes faults, reduces costs)
- No wear in the contactor control, therefore high lifetime
- Controlled from a PLC
- Floating enable contacts
- Standard SIRIUS switchgear devices are used
- The SIRIUS accessories can be used
- Dedicated terminals for sensor cables (the same terminal designation, in accordance with EN 50042)

For small processing machines with only one motor, e.g. for simple milling machines, the safe load feeder combines the function of a motor starter with that of an EMERGENCY SWITCHING-OFF circuit. The circuit-breaker protects the motor against overload and short-circuit and the operating personnel as a result of the EMERGENCY SWITCHING-OFF.

If several motors are being used, e.g. in panel saw systems, then several safe load feeders can be used in a group. These are then actuated, in a group circuit, from an EMERGENCY STOP switch. In this case, the safe signal is then transferred from the first safe load feeder to the next.

If larger machines, with several processing areas, for example, feed, processing and discharge of the material, are protected using safe load feeders, then these areas can be monitored, both as a whole or also individually. A higher-level EMERGENCY STOP can shut down the complete machine in a safety-related fashion. Additional protective elements, for example, protective door monitoring functions, only handle the protection for a specific assigned area and then, where relevant, shut this down in a safety-related fashion. This means that the processing areas, which are not directly involved in the potential hazard, can continue to operate, of course assuming that this does not represent hazardous situation for humans.

Safety logic functions can be quickly and simply established by cascading and expanding. This means that the flexibility of the processing machine can be increased.
Further, the "single-wire connection" reduces the cabling costs to a minimum which not only saves costs but also time.

In order that the drives are not only optimally protected, but can also be switched, the load feeders have the "operational switching" option already integrated.

Selection and ordering data SIRIUS load feeders with integrated safety technology

Standard 4-pole 3-phase motors at 400 V AC — Rated power P kW	Motor current I A	Setting range, thermal overload release A	MRPD / designation VA with circuit-breaker and contactors — Order No.	Size
Coordination type 2 to Iq = 50 kA (also fulfills coordination type 1)*				
		0.11...0.16	3RA71☐1-0AA17-0AB4	S00
		0.14...0.2	3RA71☐1-0BA17-0AB4	
0.06	0.2	0.18...0.25	3RA71☐1-0CA17-0AB4	
0.09	0.3	0.22...0.32	3RA71☐1-0DA17-0AB4	
		0.28...0.4	3RA71☐1-0EA17-0AB4	
0.12	0.4	0.35...0.5	3RA71☐1-0FA17-0AB4	
0.18	0.6	0.45...0.63	3RA71☐1-0GA17-0AB4	
0.25	0.8	0.55...0.8	3RA71☐1-0HA17-0AB4	
		0.7...1	3RA71☐1-0JA17-0AB4	
0.37	1.1	0.9...1.25	3RA71☐1-0KA17-0AB4	
0.55	1.5	1.1...1.6	3RA71☐1-1AA17-0AB4	
0.75	1.9	1.4...2	3RA71☐1-1BA17-0AB4	
		1.8...2.5	3RA71☐2-1CA26-0AB4	S0
1.1	2.7	2.2...3.2	3RA71☐2-1DA26-0AB4	
1.5	3.6	2.8...4	3RA71☐2-1EA26-0AB4	
		3.5...5	3RA71☐2-1FA26-0AB4	
2.2	5.2	4.5...6.3	3RA71☐2-1GA26-0AB4	
3	6.8	5.5...8	3RA71☐2-1HA26-0AB4	
4	9	7...10	3RA71☐2-1JA26-0AB4	
5.5	11.5	9...12.5	3RA71☐2-1KB26-0AB4	
7.5	15.5	11...16	3RA71☐2-4AA26-0AB4	
		14...20	3RA71☐2-4BA26-0AB4	
		17...22	3RA71☐2-4CA26-0AB4	
Contactor safety combination				
11			3RA71☐0-5AB26-0AB4	S0

For separate mounting or with fuses

- Safety electronics as basic device up to Category 3 — 0
- Safety electronics as basic device up to Category 4 — 1
- Safety electronics as expansion device — 2
- Safety electronics as expansion device, time-delayed 0.05-3s — 3
- Safety electronics as expansion device, time-delayed 0.5-30s — 4

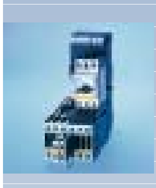
24 V DC rated control supply voltage for 35 mm mounting rail circuit-breaker, contactors and safety electronics are pre-wired and certified up to Category 4 acc. to EN 954-1. As a result of the modular system, the auxiliary contacts can be easily plugged onto circuit-breakers and contactors

* **Coordination types acc. to DIN EN 60947-4-1**

For **coordination type "1",** neither the contactor nor the starter may represent a hazard to personnel and plants/systems when a short-circuit occurs and **does not have to be suitable** for continuing operation (without first repairing and replacing parts).

For **coordination type "2"**, neither the contactor nor the starter may represent a hazard to personnel and plants/systems when a short-circuit occurs and **must be suitable** for continuing operation. There is a danger that the contacts could weld.. The manufacturer must provide service/maintenance instructions for this particular situation.

Standard 4-pole 3-phase motors at 400 V AC Rated power P kW	 Motor current I A	Setting range thermal overload release A	MRPD / designation VA with circuit-breaker and contactors Order No.	Size
Coordination type 2 to Iq = 50 kA (also fulfills coordination type 1)*				
		0.11...0.16	3RA7101-0AA17-0AL2	S00
		0.14...0.2	3RA7101-0BA17-0AL2	
0.06	0.2	0.18...0.25	3RA7101-0CA17-0AL2	
0.09	0.3	0.22...0.32	3RA7101-0DA17-0AL2	
		0.28...0.4	3RA7101-0EA17-0AL2	
0.12	0.4	0.35...0.5	3RA7101-0FA17-0AL2	
0.18	0.6	0.45...0.63	3RA7101-0GA17-0AL2	
0.25	0.8	0.55...0.8	3RA7101-0HA17-0AL2	
		0.7...1	3RA7101-0JA17-0AL2	
0.37	1.1	0.9...1.25	3RA7101-0KA17-0AL2	
0.55	1.5	1.1...1.6	3RA7101-1AA17-0AL2	
0.75	1.9	1.4...2	3RA7101-1BA17-0AL2	
		1.8...2.5	3RA7102-1CA26-0AL2	S0
1.1	2.7	2.2...3.2	3RA7102-1DA26-0AL2	
1.5	3.6	2.8...4	3RA7102-1EA26-0AL2	
		3.5...5	3RA7102-1FA26-0AL2	
2.2	5.2	4.5...6.3	3RA7102-1GA26-0AL2	
3	6.8	5.5...8	3RA7102-1HA26-0AL2	
4	9	7...10	3RA7102-1JA26-0AL2	
5.5	11.5	9...12.5	3RA7102-1KA26-0AL2	
7.5	15.5	11...16	3RA7102-4AA26-0AL2	
		14...20	3RA7102-4BA26-0AL2	
		17...22	3RA7102-4CA26-0AL2	
Contactor safety combination				
11			3RA7100-5AA26-0AL2	S0



For separate mounting or with fuses

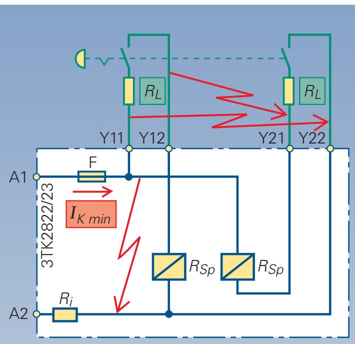
24 V DC rated control supply voltage for 35 mm mounting rail circuit-breaker, contactors and safety electronics are pre-wired and certified up to Category 4 acc. to EN 954-1. As a result of the modular system, the auxiliary contacts can be easily plugged onto circuit-breakers and contactors

* **Coordination types acc. to DIN EN 60947-4-1**

For **coordination type "1,"** neither the contactor nor the starter may represent a hazard to personnel and plants/systems when a short-circuit occurs and **does not have to be suitable** for continuing operation (without first repairing and replacing parts).

For **coordination type "2,"** neither the contactor nor the starter may represent a hazard to personnel and plants/systems when a short-circuit occurs and **must be suitable** for continuing operation. There is a danger that the contacts could weld.. The manufacturer must provide service/maintenance instructions for this particular situation.

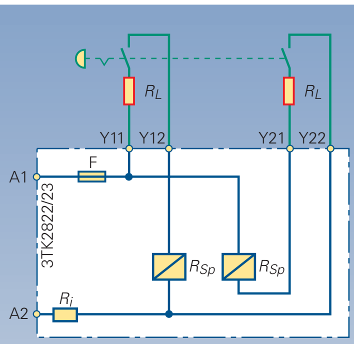
Cable lengths



$I = R_L \cdot A \cdot S \qquad R_L = \frac{U}{I_{K\,min}} - R_i$

I permissible cable length
R_L cable resistance
A cable cross-section
S conductivity of the cable
U rated supply voltage
$I_{K\,min}$ minimum short-circuit current
R_i input resistance of the unit
R_{Sp} coil resistance of the relay

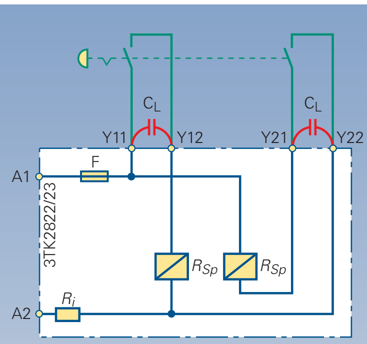
Fig. 3/61
Short-circuit shutdown



$I = R_L \cdot A \cdot S \qquad R_L = \frac{U \cdot R_{Sp}}{U_{Ab}} - R_{Sp} - R_i$

I permissible cable length
R_L cable resistance
A cable cross-section
S conductivity of the cable
U rated supply voltage
U_A response voltage
R_i input resistance of the unit
R_{Sp} coil resistance of the relay

Fig. 3/62
Safety switch-on



$C_L = \frac{I}{\omega \cdot R_L} \qquad R_L = \frac{U \cdot R_{Sp}}{U_{Ab}} - R_i$

I permissible cable length
R_L cable resistance
U rated supply voltage
U_{Ab} drop-out voltage
R_i input resistance of the unit
R_{Sp} coil resistance of the relay
C_L cable capacitance

Fig. 3/63
Safety shutdown

Cable lengths

In a machine or a system, generally several sensors, such as emergency stop switches and position switches, are used to monitor protective doors. Depending on the complexity of the machine or system, long cables may be required to connect the sensor systems. In order that the safety combinations operate error-free, it must be ensured that certain cable lengths are not exceeded.

The permissible cable length is dependent on 3 factors:

1. Short-circuit shutdown

When a short-circuit occurs between the sensor cables or a short-circuit in the device, the safety combination must safely shut down and the device may not be damaged.

2. Safety switch-on

The voltage available at the relay coils within the unit must be high enough, so that the response voltage is reliably reached. If this is not the case, then the safety combination cannot go into safe operation. The safe condition is not jeopardized, however, it is not possible to operate the plant or system.

3. Safety shutdown

The voltage at the relay coils inside the unit must be low enough so that the dropout voltage is safely fallen below. This is especially important for AC operation, where although the sensors are shut down, sufficient current can flow as a result of cable capacitances so that the relay cannot drop out. This is the reason that for relay safety combinations, the sensor cables are always fed with DC.

The following calculation uses as an example the 3TK28 23 relay combination:

Assumed values: Cable: 2 x 2.5 mm^2
Voltage drop: 5%
Specific conductivity for Cu: 49.3 Sm/mm^2 (at 55°C)
Cable capacitance: 170 nF/km

1. Cross-circuit shutdown

$$R_L = \frac{22.8\,\text{V}}{0.55\,\text{A}} - 22\,\Omega = 19.5\,\Omega$$

$$I = 19.5\,\Omega \cdot 2.5\,\text{mm}^2 \cdot 49.3\,\frac{\text{Sm}}{\text{mm}^2} = 2403\,\text{m}$$

2. Safety switch-on

$$R_L = \frac{22.8\,\text{V} \cdot 400\,\Omega}{20.4\,\text{V}} - 400\,\Omega - 22\,\Omega = 25\,\Omega$$

$$I = 25\,\Omega \cdot 2.5\,\text{mm}^2 \cdot 49.3\,\frac{\text{Sm}}{\text{mm}^2} = 3081\,\text{m}$$

3. Safety shutdown

$$C_L = \frac{1}{\omega \cdot R_L}$$

$C_L = \infty$ as, at 24 V DC, the frequency f = 0 Hz

Result

To determine the single cable length, the lowest value of the 3 possibilities shown above should be used.
In this case, it involves an outgoing and incoming cable.

The maximum single cable length for this particular example is $I = \frac{2403\,\text{m}}{2} = 1200\,\text{m}$

Fig. 3/64
Example to calculate the cable length

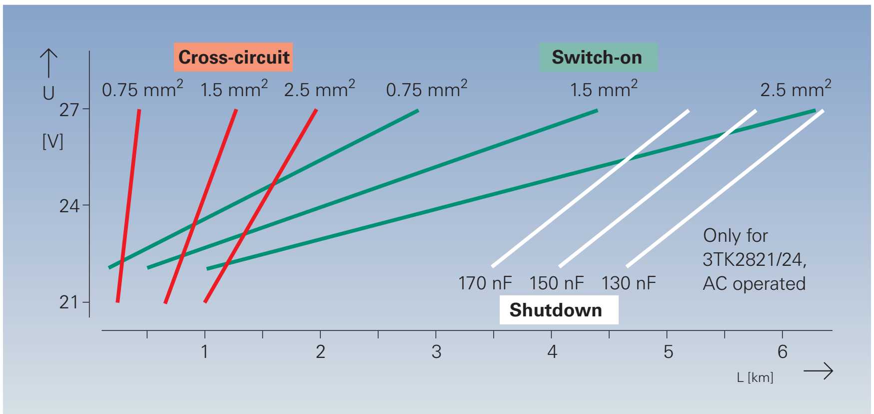


Fig. 3/65
Possible single cable lengths for sensors
for 3TK28 21–28, 34, 35

3.4 SIRIUS NET Motor Starter for AS-Interface and PROFIBUS-DP

3

However, safety technology does not stop at motor starters connected to AS-Interface and PROFIBUS DP. Integrated safety technology is, in this case, a modular component of the overall system.

The advantages of the reduced amount of wiring, as a result of using an energy bus instead of many parallel cables, the transparent plant/system structure and the modular machine design are just some of the reasons for the success of the communications-capable motor starter. We recommend motor starters are used with a fieldbus interface for AS-Interface compact starters or PROFIBUS-DP for example, SIMATIC ET200X and ET200S.

Depending on the particular application, either devices for mounting in a cabinet (IP 20) can be selected or devices which require no enclosure. These can then be mounted directly in or at the machine (IP 65).

Depending on the requirements, there are various concepts for SIRIUS NET motor starters in the area of safety-related applications. These concepts will be subsequently described.

Detailed descriptions and application examples can be taken from the applicable Manual.

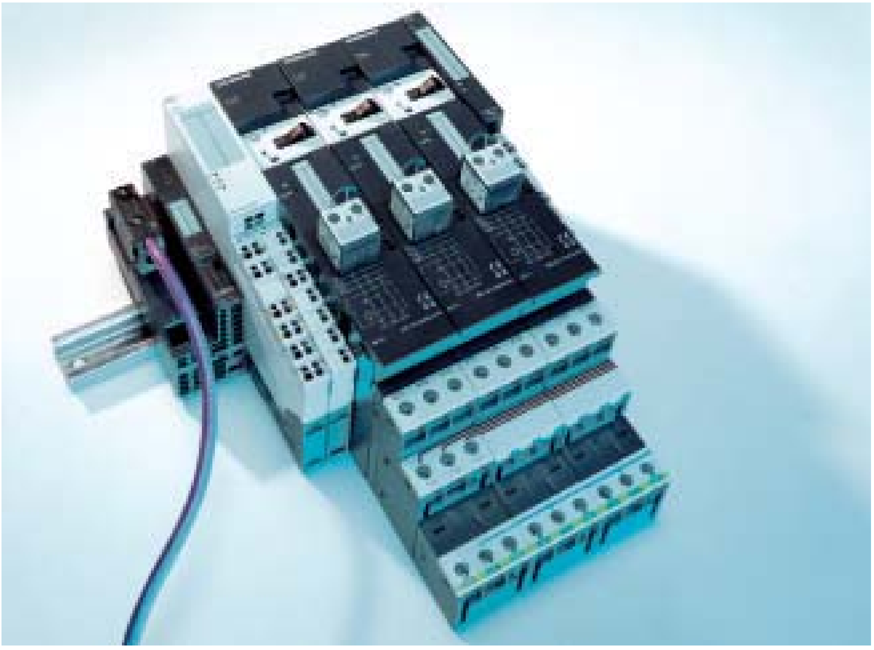


Fig. 3/66
The SIMATIC ET 200S family of devices offers the combination of finely modular I/O modules with motor starters

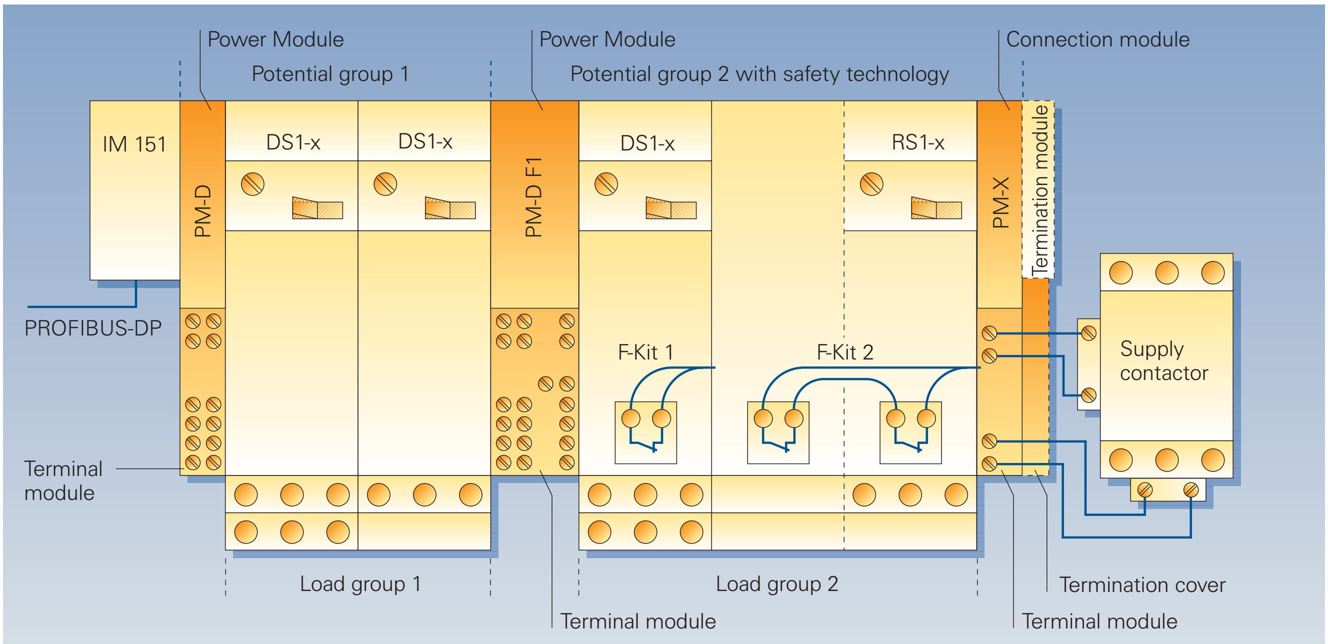


Fig. 3/67
Structure of a safety-related motor starter

3.4.1 SIMATIC ET 200S SIGUARD

Integrated safety technology in distributed I/O devices has clearly proven itself in the market - and that for some time now.

For users, the most important features include the modularity, short mounting and installation times, ease of use and service, high functionality, and quality at an acceptable price.

With the development of the ET 200S system, the demands for a modern distributed system regarding technology, functionality and user friendliness are fulfilled. By integrating the motor starter and safety technology, the cost was significantly improved over existing distributed systems.

An ET 200S station can be configured in modular stages by flexibly combining I/O and technology modules and motor starter.

What advantages does this system offer?

- The *"permanent wiring"* guarantees a *high degree of availability.*

  "Permanent wiring" means that the purely electro-mechanical, so-called terminal modules and the functional components, such as electronic modules, or motor starters, are separated from one another.

  The terminal module supports the process wiring and guarantees the mechanical and electrical connections between the peripheral modules and the IM 151 interface module (interface to PROFIBUS-DP).

  The electronics module defines the function of the peripheral module and is inserted on the terminal module.

The same applies for a motor starter, which is simply plugged onto a terminal module.

If the module fails, the overall system continues to run. As a result of the "permanent wiring," it is possible to replace modules quickly without having to use tools. This is even true in operation without having to release the wiring (control, auxiliary and main circuits). This functionality also applies to the ET 200S motor starter.

- **Integrated bus connection**

  The system can be connected to the PROFIBUS-DP fieldbus. This is realized using the IM 151 interface module, which is connected to the PROFIBUS system via a connector or via an integrated fiber-optic cable.

Optimum adaptation using finely-graded modularity

The 1, 2 or 4-channel I/O modules allow the system to be adapted to the local requirements for I/O channels and avoids having to over-dimension the system. In addition to digital and analog I/O, technological modules with e.g. counter functions or serial interface are also available.

- **Integrated motor starter**

  The ET 200S system integrates the power module of a cabinet into a distributed family of peripheral devices. The PLC I/O, circuit-breakers, contactors and terminal strip, which have been used up until now in conventional cabinets, are replaced by ET 200S using communications-capable motor starters. Further, using the 40 A energy bus (Standard Starter) or 50 A energy bus (High Feature Starter) on the 400 A side can significantly reduce the power cabling costs.

- **ET 200S SIGUARD with integrated safety functionality**

  Even safety-related circuits can be implemented using integrated SIGUARD safety combinations. It goes without saying that the associated standards are maintained (e.g. EN 60204-1). The SIGUARD safety combinations have been certified by the German Trade Association (BG) and the Germany Statutory Industrial Accident Insurance Association (BIA) for the highest possible Category 4 in accordance with EN 954-1. Fig. 3/67 illustrates how a safety-related motor starter can be configured.

Diagnostics on PROFIBUS for fast service

The SIGUARD power module, in addition to its function as safety relay, is also an active module from the perspective of the ET 200S. This means that all of the status signals can be interrogated via PROFIBUS-DP. Faults, e.g. a cross-circuit fault in the sensor circuit or a safety trip, automatically generate a diagnostics alarm. This can be evaluated using a PLC and displayed at the OP using the TIA capable Operator Panel – and that without any complex programming. The engineering costs, which can be high, are thus reduced to a minimum. The clear fault and system messages, provided with the particular station and module addresses, provide maintenance and service personnel with the most important information for fast troubleshooting. All of the operating and fault statuses are directly displayed at the SIGUARD power module using LEDs.

The system structure allows additional cost savings to be realized for external safety combinations and redundantly configured power contactors. The reduced amount of wiring also reduces the number of possible error sources, thus increasing the reliability of the plant or system.

The overview in Fig. 3/68 shows a comparison of the reduced cabling costs for Category 4.

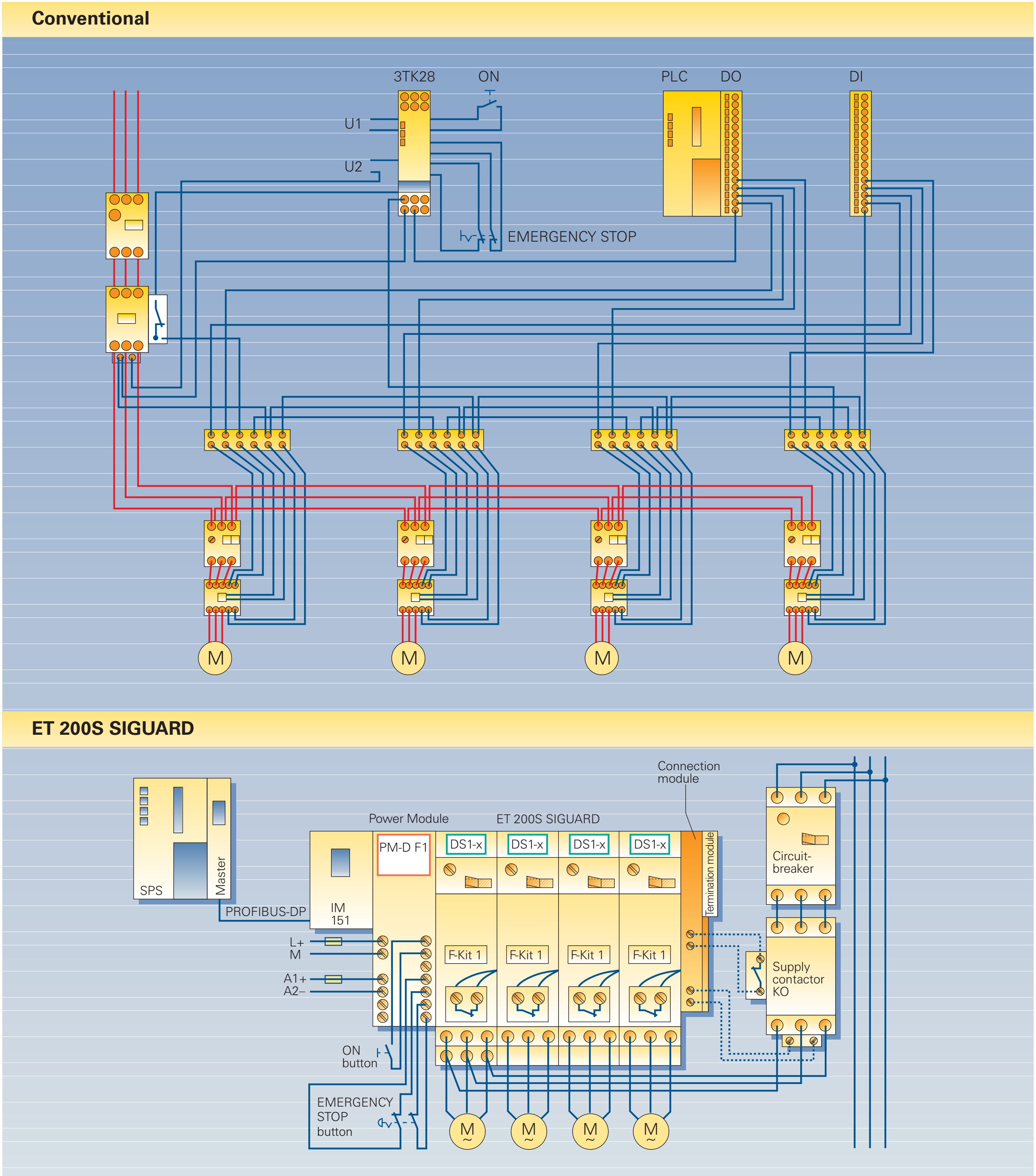


Fig. 3/68
Comparison of wiring for a conventional configuration and using ET 200S SIGUARD acc. to Category 4 in compliance with EN 954-1, EMERGENCY STOP

High plant availability using hot swapping

In operation, a maximum of one function module can be replaced without the ET 200S station having to be shut down. This applies for the electronic modules as well as also for the motor starters. The availability of the plant or machine is maintained at a high level by being able to quickly replace these components.

Structure and functionality of ET 200S SIGUARD

The following modules are available:

- Power Module PM-D F1 for emergency stop shutdown operations or PM-D F2 for protective door monitoring functions
- Power Module PM-D F3 (contact multiplier with time delay)
- Power Module PM-D F4 (contact multiplier for multi-tier designs)
- Power Module PM-D F5 (contact multiplier with floating contacts)
- Standard direct starter or reversing starter up to 5.5 kW switching power with snapped-on F-Kit (this is required for the feedback circuit of a safety circuit)
- High Feature direct or reversing starter with 7.5 kW switching power where the F-Kit is already integrated from the side
- Connection module to control and monitor the feeder contactor or to terminate the safety circuit.
- Feeder contactor, designed for the maximum possible current of the load group (max. 40 A or 50 A).

These safety-related Power Modules distinguish themselves as a result of the following features:

- SIGUARD safety functionality is integrated in the ET 200S system
- Suitable for EMERGENCY STOP shutdown operations and protective door monitoring functions (stop Category 0)
- Can be used for stop Category 1 (controlled shutdown with integrated time delay)
- Fulfills the requirements of the highest Category 4 acc. to EN 954-1
- Harmonized and certified by the most important certification bodies
- Redundant circuit design with diversity and with self-monitoring functionality
- 2-channel sensor interrogation
- Cross-circuit safety
- Ground fault proof
- Integrated feedback circuit of the actuators
- 2 electrically isolated enable circuits and NO contact
- For each ON-OFF cycle of the load to be switched, the switching contacts are checked for correct opening and closing
- When a short-circuit develops in the EMERGENCY STOP circuit, an internal electronic device fuse responds (short-circuit proof))
- Replaces conventional safety technology. This means
  – lower wiring costs (up to 80% saving)
  – reduced space requirement (up to 50% space saving)
- Cost saving
- Can be integrated into existing safety concepts.

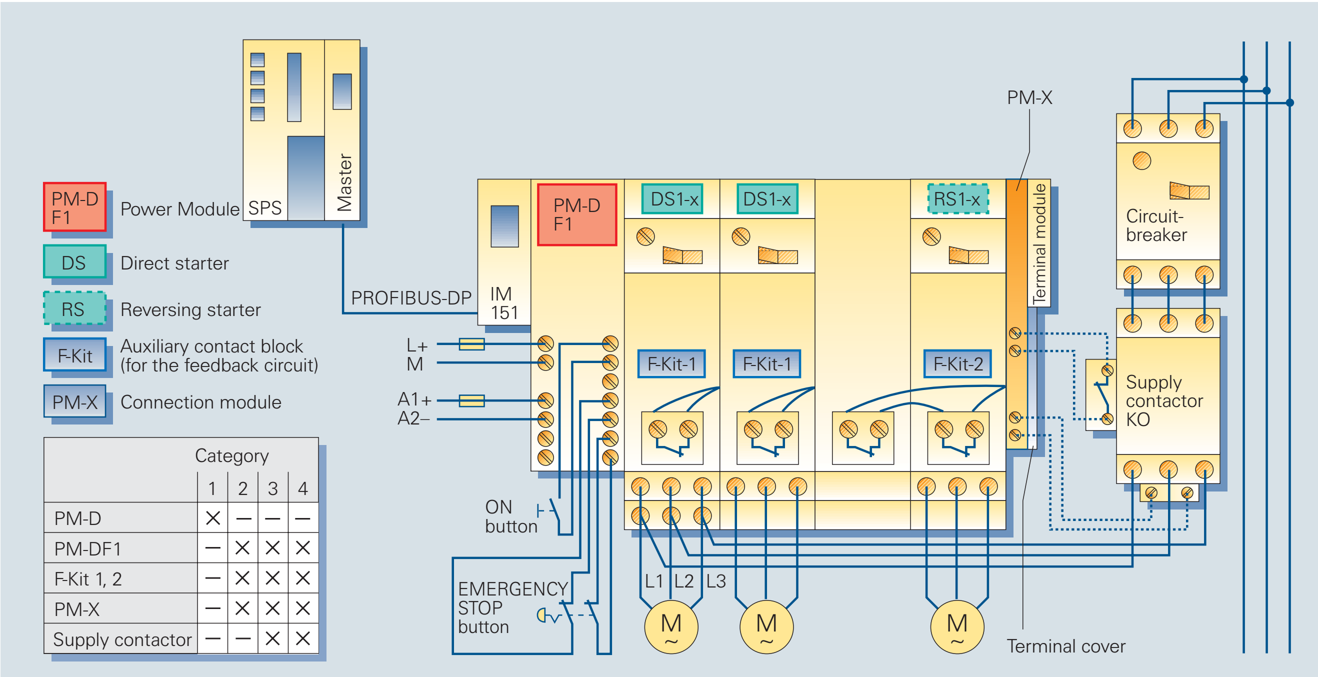


Fig. 3/69
EMERGENCY STOP shutdown with monitored start, Category 4

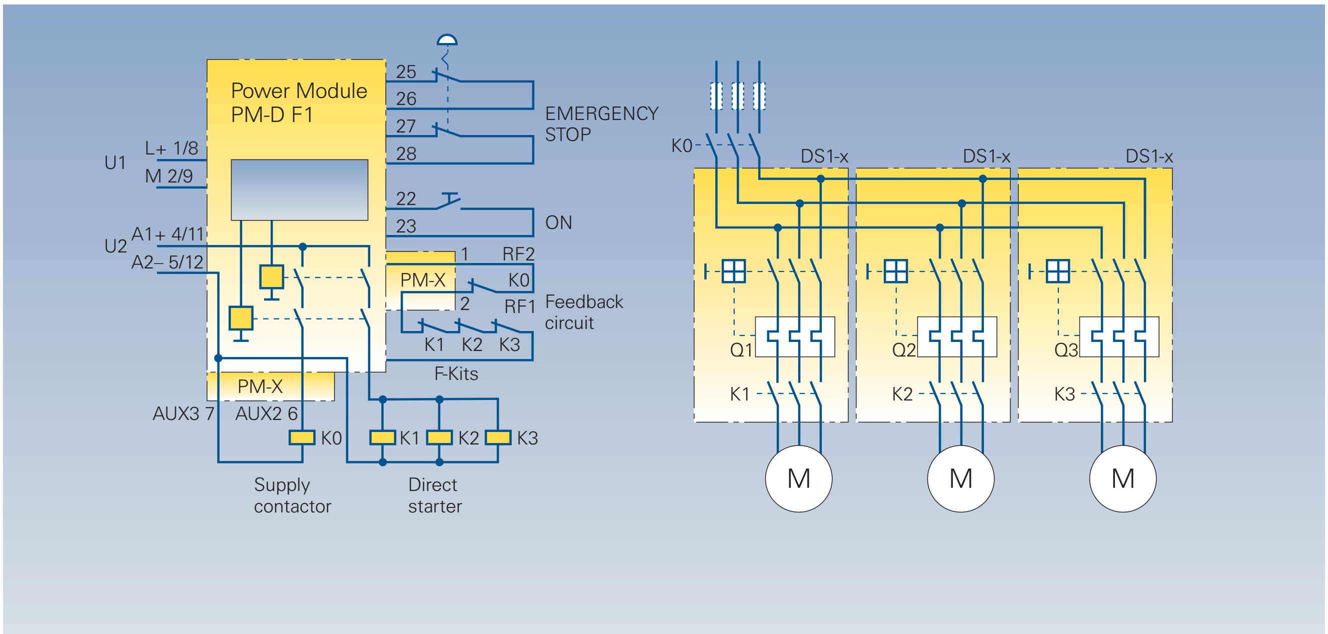


Fig. 3/70
Monitoring the motor starter, EMERGENCY STOP, stop Category 0, monitored start, Category 4. The motor starters are monitored by switching the contactor NC contacts (F-Kit) in series to the ON button as "feedback circuit."

Status and fault displays

LEDs				Safety relay	EMERGENCY STOP switch	ON button	Status/fault cause/ remedy
SF	PWR	CON	STAT				
off	green	green	green	on	not pressed	pressed once	Normal operation
red	green	green	green	on	1)	1)	Bus error
red	green	green	off	off	not pressed	not pressed	Safety relay switched-out. Press the ON button to start.
red	green	green	red	off	pressed	1)	Not possible to switch-on: Release the EMERGENCY STOP. If the status LED is still lit red, then there is a cross-circuit fault in the EMERGENCY STOP circuit (remove the external fault) or the Power Module is defective (replace the unit).
red	green	green	red	off	not pressed	1)	EMERGENCY STOP released for a closed ON circuit or the Power Module is defective: Replace the device.
red	off	green	red	off	1)	1)	Power supply voltage V_1 for the electronics missing.
red	green	off	1)	1)	1)	1)	Power supply voltage V_2 for the motor starter missing.
red	off	off	red	off	1)	1)	Power supply voltages V_1 and V_2 missing.

1) Not relevant

SF	Group fault	red
PWR	Power (electronics power supply V_1)	green
CON	Contactor (contactor supply V_2)	green
STAT	Status display for the safety relay	red/green

Fig. 3/71
Status and fault/error displays using LEDs on the SIGUARD Power Module PM-D F1 (EMERGENCY STOP circuit with monitored start)

Status and fault displays

LEDs				Safety relay	EMERGENCY STOP switch	ON button	Status/fault cause/ remedy
SF	PWR	CON	STAT				
off	green ■	green ■	green ■	on	closed	press once (bridged)	Normal operation
red ■	green ■	green ■	green ■	on	1)	1)	Bus error
red ■	green ■	green ■	off	off	closed	not pressed	Safety relay switched-out. Press the ON button to start.
red ■	green ■	green ■	red ■	off	open	1)	Not possible to switch-on: Close the protective door. If the status LED is still lit red, there is a cross-circuit fault in the sensor circuit (remove the external fault) or the Power Module is defective (replace the device).
red ■	green ■	green ■	red ■	off	closed	1)	Power Module defective: Replace the device.
red ■	off	green ■	red ■	off	1)	1)	Power supply voltage V_1 for the electronics missing.
red ■	green ■	off	1)	1)	1)	1)	Power supply voltage V_2 for the motor starter missing.
red ■	off	off	red ■	off	1)	1)	Power supply voltages V_1 and V_2 missing.

1) Not relevant

SF	■	Group fault	red
PWR	■	Power (electronics power supply V_1)	green
CON	■	Contactor (contactor supply V_2)	green
STAT	■■	Status display for the safety relay	red/green

Fig. 3/71
Status and fault/error displays using LEDs on the SIGUARD Power Module PM-D F2 (protective door with auto start)

Status and fault displays

LEDs				Safety relay	Status/fault cause/ remedy
SF	PWR	CON	STAT		
off	green ■	green ■	green ■	on	Normal operation
red ■	green ■	green ■	green ■	on	Bus error
red ■	green ■	green ■	off	on/off	Time expired or safety relay switched out.
red ■	green ■	green ■	red ■	off	Power Module defective: Replace the device.
red ■	off	green ■	red ■	off	Power supply voltage V_1 for the electronics missing.
red ■	green ■	off	1)	1)	Power supply voltage V_2 for the motor starter missing.
red ■	off	off	red ■	off	Power supply voltages V_1 and V_2 missing.

1) not relevant

SF	■	Group fault	Red
PWR	■	Power (electronic power supply V_1)	Green
CON	■	Contactor (contactor supply V_2)	Green
STAT	■■	Status display for safety relay	Red/Green

Fig. 3/72
Status and fault/error displays using LEDs on the SIGUARD Power Module PM-D F3 (expansion with time delay)

Status and fault displays

LEDs				Safety relay	Status/fault cause/ remedy
SF	PWR	CON	STAT		
off	green ■	green ■	green ■	on	Normal operation
red ■	green ■	green ■	green ■	on	Bus error
red ■	green ■	green ■	off	off	Safety relay switched out.
red ■	green ■	green ■	red ■	off	Power Module defective: Replace the device.
red ■	off	green ■	red ■	off	Power supply voltage V_1 for the electronics missing.
red ■	green ■	off	1)	1)	Power supply voltage V_2 for the motor starter missing.
red ■	off	off	red ■	off	Power supply voltages V_1 and V_2 missing.

1) not relevant

SF	■	Group fault	Red
PWR	■	Power (electronics power supply V_1)	Green
CON	■	Contactor (contactor supply V_2)	Green
STAT	■■	Status display for safety relay	Red/Green

Fig. 3/73
Status and fault/error displays using LEDs on the SIGUARD Power Module PM-D F4 (to integrate additional ET 200S rails)

Status and fault displays

LEDs		Safety relay	Status/fault cause/	remedy
SF	PWR	STAT		
off	green	green	on	Normal operation
red	green	green	on	Bus error
red	green	off	off	Safety relay switched-out.
red	green	red	off	Power Module defective: Replace the device.
red	off	red	off	Power supply voltage V_1 for the electronics missing.

SF	■	Group fault	red
PWR	■	Power (electronics power supply V_1)	green
STAT	■■	Status display for the safety relay	red/green

Fig. 3/74
Status and fault/error displays using LEDs on the SIGUARD Power Module PM-D F5 (to connect up to 4 additional external safety circuits)

Controllers: Fail-Safe Control Systems (SIMATIC)

kapitel4

4.1 Introduction

Fail-safe systems are used wherever the highest degree of safety must be guaranteed for humans, machines and the environment. This means that accidents and damage as a result of a fault must be avoided at all costs.

SIMATIC fail-safe control systems immediately go into a safe condition after a fault occurs, or they remain in a safe condition. They combine the standard operating automation and safety technology in a single system. The safety-related and standard communications between the central CPU and the safety-related and standard I/O modules are established through PROFIBUS DP and the PROFIsafe profile.

The SIMATIC range has various fail-safe control systems:

- SIMATIC S7-400F/FH for larger applications in the production and process industries
- SIMATIC S7-300F for central and distributed applications with the focus on production technology and furnace controls
- SIMATIC ET 200S PROFIsafe-CPU for distributed applications with the focus on production technology

The range of fail-safe control systems has been expanded by distributed fail-safe I/O modules. The fully harmonized system solution comprises a fail-safe CPU, appropriate F signal modules of the distributed ET200 remote I/O, fail-safe F motor starters and special drivers which are used to couple other safety-related field devices.

Communications

The safety-related and standard communications between the central controller (CPU) and I/O are established via PROFIBUS DP. The PROFIsafe profile is characterized by the fact that the safety functions are implemented in the safe end terminals, using standard PROFIBUS functions.

The net data of the safety function and the safety measures are in a standard data telegram. No additional hardware components are required. Standard communications and safety-related communications therefore use the same hardware platform: The automation and safety technology grow close together.

PROFIsafe is transferred independently of the data transfer medium, e.g. using copper or fiber-optic cables.

Totally Integrated Automation

The safety technology (Safety Integrated) is a component of Totally Integrated Automation fully integrated with the safety and standard automation (SIMATIC S7).

Where today, standard automation (classic PLCs) and safety automation (electromechanical systems) are separate, with these systems, both of these environments are merging to form a unified, integrated overall system.

This means that Siemens can clearly present itself as a full-line supplier for automation technology - where the safety technology is a fully integrated component of the standard automation. This guarantees a high degree of unification and integration across the complete system.

There are some significant advantages when compared to conventional solutions by integrating the safety technology into the standard automation. Machinery construction companies (OEMs, plant builders) as well as plant and system operating companies (end customers) can benefit from these advantages.

Advantages

Some basic benefits are obtained due to the fact that the fail-safe control systems essentially comprise standard components and are part of Totally Integrated Automation (TIA).

The following table indicates the essential advantages for machinery construction OEMs and plant operating companies when using fail-safe SIMATIC control systems.

Advantages	For machinery construction OEMs	For plant operating companies	Highlights of the SIMATIC solution for fail-safe control systems with distributed peripherals (remote I/O)
Significantly faster mounting/installation / commissioning	X		• PLCs for standard and safety automation and communications via the standard bus system PROFIBUS and PROFIsafe profile instead of using a dedicated an F-PLC for the fail-safe program with its own separate wiring • Up to 90% less control/safety wiring due to the safety technology integrated in the ET 200 and the data-related coupling to S7-300F via PROFIsafe (only for S7-300F) • Extremely fast ET 200S installation with the energy bus which establishes itself
Low configuring and engineering costs	X		• The STEP7 standard tool is used for programming- and parameterization and to incorporate programs of non-safety-relevant systems • All of the control functions are configured using the PLC • Pre-configured programming examples for the safety functions • No separate safety relay technology
Simpler, more favorably-priced acceptance procedures (Machinery Directive)	X	X	• Function blocks and programming examples certified by the German Inspectorate (TÜV) (F library)
Siimipler service/ maintenance and configuring changes	X	X	• The STEP7 standard tool is used to implement software solutions and parameterization instead of additional wiring (electromechanical system) or programming (F-PLC)
Less costs for spare parts inventory		X	• Fewer components for the safety functions (instead of many electromechanical components, proportional to the complexity of the F functions, there are just a few components, independent of the complexity of the F functions)

S7-400F/FH

The SIMATIC S7-400F/FH implements the safety-related functions using an F-CPU as well as fail-safe modules for the distributed ET 200M I/O system. A special library includes basic function blocks which have been certified by the German Inspectorate (TÜV). A function is programmed by interconnecting the blocks from the F library using CFC.

The S7-400F/FH is based on the fault-tolerant S7-400H. This means that extremely simple fail-safe systems with high availability can be configured.

S7-300F

The SIMATIC S7-300F implements the safety-related functions using an F-CPU as well as fail-safe modules, which can be used both in the S7-300 as well as in the distributed ET 200M and ET 200S I/O systems. A special library includes basic function blocks which have been certified by the German Inspectorate (TÜV). The standard programming languages are LAD and FBD.

Fail-safe motor starters with connection to ET 200S ideally complement the S7-300F in distributed applications.

In the future, the S7-400F will also be able to be connected to the ET 200S PROFIsafe. Not only this, but we will also extend the existing range by a fail-safe IM 151/F-CPU interface module.

4.2 SIMATIC S7-400F/FH

4.2.1 Introduction

Fig. 4/1
Fail-safe S7-400F

The safety-relevant functions of the S7-400F/FH are incorporated in the F range of the CPUs and in the fail-safe signal modules. Further, in addition to the fail-safe modules, standard modules can also be used in the S7-400F/FH. This means that it is possible to create a fully integrated control system for a plant where there are both safety-related and standard areas. The whole plant can be configured and programmed using the same standard tools.

This means that the SIMATIC S7-400F/FH can now be used in automation environments which were, up to a few years ago, the exclusive domain of electromechanical controllers, e.g. automobile shell construction with presses and robots, burner management systems, transportation of persons on cableways and, last but not least, process automation.

The S7-400F/FH fulfills the following safety requirements:

- Safety Requirement Class: SIL 1 to SIL 3 acc. to IEC 61508
- Category: 2 to 4 acc. to EN 954-1
- Requirement Class: AK 1 to AK 6 acc. to DIN V 19250/DIN V VDE 0801

4.2.2 Hardware

The hardware of the S7-400F/FH is based on the CPUs of the fault-tolerance, redundant SIMATIC S7-400H which is supplemented by an F library. This F library contains pre-configured basic function blocks which have been approved by the German Inspectorate (TÜV) as well as a parameterization tool for the fail-safe I/O modules. In order to be able to run the S7-400F/FH, the "F Copy License" needs to be loaded into the CPU.

The CPU checks that the controller is running properly by means of regular self-test routines, instruction tests and a program execution test. The resulting safety functions enable response times from 100 ms upwards, which is completely adequate for most applications in the process industry and for many applications in the manufacturing industry with manually actuated Emergency Stop devices.

The S7-400F/FH also incorporates safety-related modules for the SIMATIC ET 200M distributed I/O system. These fail-safe I/O modules are parameterized using the parameterization tool, connected to PROFIBUS and controlled using the new PROFIsafe PROFIBUS profile for safety-related applications.

At the present time, 4 modules are available:

- Digital input modules: 24 x 24 V
- Digital input modules: 8 x NAMUR
- Digital output modules: 10 x 24 V/2 A
- Analog input modules: 6 x 13 bit

These modules can diagnose internal and external faults/errors and have complete internal redundancy, i.e. outputs have, for example, a second integrated disconnection facility.

Using the "Safety Protector" fail-safe and standard modules can be used together in one rack.

4

4.2.3 Programming

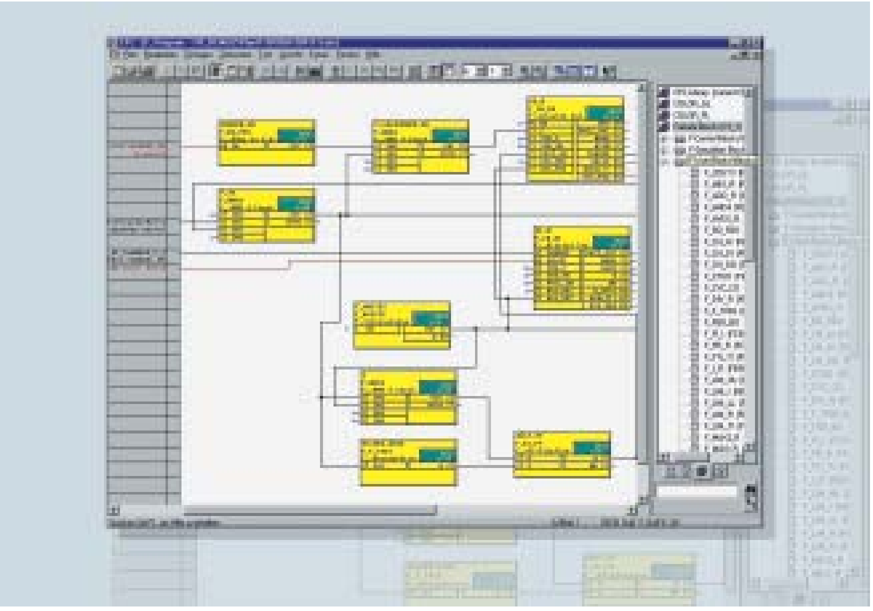


Fig.4/2
Graphic configuring of the S7-400/FH using the CFC Engineering Tool

The S7-400F/FH is programmed in exactly the same way as a standard S7-400. The normal automation functions for the cyclic processing level (OB1) are programmed using standard programming languages.
For CPUs 414-4H and 417-4H, the CFC and SCL "Engineering Tools" are required to call blocks from the F library and to interconnect them.

These blocks are called in a time level (OB35) at a parameterizable time interval for reproducible disconnection times. The use of CFC makes configuring and programming the plant, and the final acceptance test significantly easier.

For programmers, there is a distinct advantage in the fact that they can concentrate on configuring the safety-related application. This noticeably reduces engineering costs, especially in conjunction with other components, e.g. other programmable controllers or control and monitoring devices.

In the future, the S7-400F with the CPUs 414-4H and 417-4H will also be able to be easily connected to the ET 200S PROFIsafe distributed I/O.

In the immediate future, the CPU 416F will be available which will be able to be programmed, just like the S7-300F using the STEP7 languages LAD and FBD.

4.2.4 Configuration

The S7-400F/FH has two basic configurations:

- Fail-safe S7-400F automation system (refer to Fig. 4/3): When a fault/error develops in the control system, the production process is brought into a safe condition and interrupted.
- Fail-safe and fault-tolerant S7-400FH automation system (refer to Figs. 4/4 and 4/5): When a fault/error develops in the control system, redundant control components are involved and continue to control the production process.

The plant requires a fail-safe controller. Fault tolerance is not required. The following are needed:

- 1 CPU 417-4H or CPU 414-4H with F Copy License
- 1 PROFIBUS DP line
- ET 200M with IM 153-2
- Fail-safe signal modules in a non-redundant design

In the event of a fault, the I/O is no longer available. The fail-safe signal modules are passivated.

Comment: This combination already fulfills SIL 3, Cat. 4, AK 6.

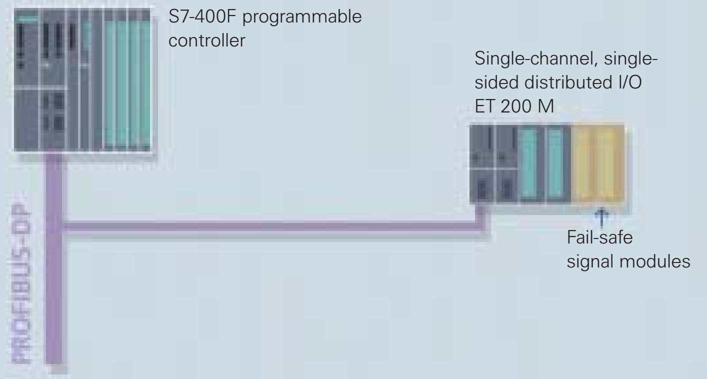


Fig. 4/3
SIMATIC S7-400F with single-channel, single-sided I/O

The plant requires a fail-safe controller. Fault tolerance is required on the CPU side. The following are needed:

- 2 CPU 417-4H or CPUs 414-4H with F Copy License
- 2 PROFIBUS DP lines
- 1 ET 200M with 2 IM 153-2 (redundant)
- Fail-safe signal modules in a non-redundant design

If the CPU, IM 153-2 or the PROFIBUS DP line fails, the control is still available. If the fail-safe signal modules or the ET 200M fails, the I/O is no longer available. The fail-safe modules are passivated.

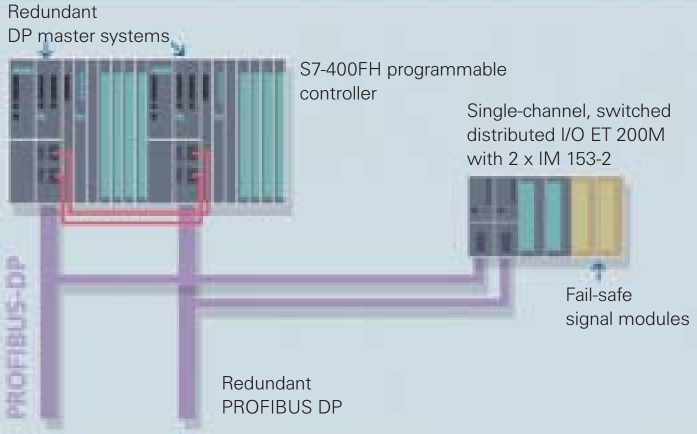


Fig. 4/4
SIMATIC S7-400FH with single-channel switched I/O

The plant requires a fail-safe controller. Fault-tolerance is required on the CPU side and the I/O side. The following are needed:

- 2 CPU 417-4H or CPUs 414-4H with F Copy License
- 2 PROFIBUS DP lines
- 1 ET 200M with 2 IM 153-2 (redundant)
- Fail-safe signal modules in a redundant design

The controller is still available even if the CPU, IM 153-2, PROFIBUS DP line, fail-safe signal modules or the ET200M fail.

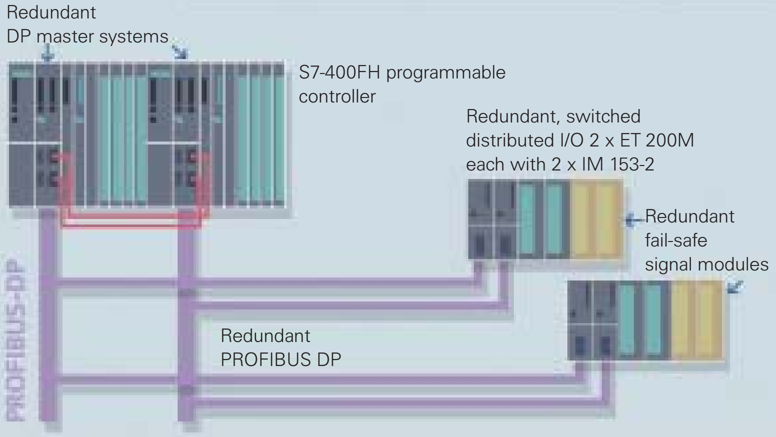


Fig. 4/5
SIMATIC S7-400FH with redundant, switched I/O

4.2.5 Technical data

CPU	CPU 417-4H	CPU 414-4H
Main memory		
Integral (program/data)	2 Mbyte each	384 Kbyte each
Expandable (program/data)	8 Mbyte each	-
Load memory		
Integral	256 Kbyte RAM	256 Kbyte RAM
expandable FEPROM	up to 64 Mbyte	up to 64 Mbyte
expandable RAM	up to 64 Mbyte	up to 64 Mbyte
FBs/FCs, max.	6144/6144	2048/2048
Data blocks, max.	8191	4095
I/O address range	16/16 Kbyte	8/8 Kbyte
of which, distributed		
• MPI/DP interface	2/2 Kbyte	2/2 Kbyte
• DP interface	8/8 Kbyte	6/6 Kbyte
Process image (adjustable)	16/16 Kbyte	8/8 Kbyte
Default setting	1024/1024 byte	256/256 byte
Digital channels	131072/131072	65536/65536
of which, centralized	131072/131072	65536/65536
Analog channels	8192/8192	4096/4096
of which, centralized	8192/8192	4096/4096
1st interface		
MPI	yes	
DP master	yes	
DP slave	no	
Default setting	MPI	
Isolated	yes	
2nd interface		
DP master	yes	
DP slave	no	
Point-to-point	no	
Default setting	DP master	
Isolated	yes	
Programming languages	STEP® 7 V5, from SP1 (LAD, FBD, STL); SCL, CFC, GRAPH, HiGraph®	
Order No. group	6ES7417-4H...	6ES7414-4H...

SM 326 F fail-safe digital input module	
Number of inputs	24 (single-channel), 12 (two-channel)
Input voltage	24 V DC
Alarms	Diagnostics alarm
Order No. group	6ES7326-1BK...

SM 326 F fail-safe digital output module	
Number of outputs	10
Output voltage	24 V DC
Alarms	Diagnostics alarm
Output current with "1" signal	2 A per channel
Order No. group	6ES7326-1BF...

SM 326 Namur fail-safe Ex input module	
Number of inputs	8 (single-channel) 4 (two-channel)
Input voltage	in accordance with DIN 19234 or NAMUR
Alarms	Diagnostics alarm
Output current with "1" signal	2 A per channel
Order No. group	6ES7326-1RF...

SM 336 F fail-safe analog input module	
Number of inputs	6, with voltage measurement max. 4 (single-channel), 3/2 (two-channel)
Alarms	Diagnostics alarm
Integration time	20/16.66 ms
Resolution	13 bits + size
Order No. group	6ES7326-1HE...

Option packages for S7 F systems	
F library	Approx. 50 certified basic function blocks
F Tool	To parameterize fail-safe SMs
Requirements	• STEP 7 from V5.1 • CFC from V5.2 • S7-SCL from V5.0 • S7 H Systems V5.1 (option for S7-400FH)
Order No. group	6ES7833-1CC...

4.3 SIMATIC S7-300F

4.3.1 Introduction

The fail-safe control system comprises fail-safe controllers and fail-safe distributed I/O modules. All of these components communicate through PROFIBUS DP with the PROFIsafe profile. The system is programmed using LAD and FBD.

The new solution with SIMATIC S7-300F and fail-safe SIMATIC ET 200® S PROFIsafe signal modules or fail-safe ET 200M signal modules has been specifically developed for distributed safety-related applications in the production environment. Thanks to the finely scalable F I/O modules, safety technology only has to be used where it is actually required. Even third-party systems can be easily connected. This solution replaces traditional electromechanical components and distinguishes itself as a result of the following properties and features:

- Freely programmable safe linking of sensors with actuators
- Selective safe shutdown of actuators
- Mixed configuration of F (fail-safe) modules and standard modules in one station
- 1-bus concept, F signals and standard signals are transferred using one bus medium (PROFIBUS DP)

Fig. 4/6
SIMATIC S7-300F with fail-safe distributed ET 200S remote PROFIsafe I/Os

The main applications for SIMATIC® S7-300® F are in the following industries:

- Automobile industry
- Standard machinery construction
- Machine tools (in conjunction with SINUMERIK/SIMOTION)
- Special machinery construction
- Conveyor systems
- Logistics (airports, warehouses)
- Burner management systems

The S7-300F with the fail-safe ET 200M or ET 200S PROFIsafe I/O modules fulfill the following requirements:

- IEC/EN 61508 (SIL 1 to SIL 3)
- EN 954-1 (Cat. 2 to Cat. 4)

4.3.2 Typical configurations

All of the field devices are directly connected to PROFIBUS. The standard I/O modules are shown in blue and the safety-related modules in yellow. It is important to note that the motor starter is also a safety-related device. (details: refer to Page 4/13). The PROFIsafe safety-related profile is used to communicate via PROFIBUS.

S7-300F with CPU 315F

The CPU 315F-2 DP is based on a standard CPU, whose operating system was expanded by various protective mechanisms to permit safety related user programs to be run.

There are no restrictions when it comes to processing standard programs.

Third-party field devices can be directly connected to PROFIBUS using generic drivers.

ET 200S PROFIsafe CPU

The ET 200S PROFIsafe CPU (IM151/F-CPU) can be used to implement distributed safety-related tasks. The PROFIBUS master CPU views this CPU as slave. Several IM151/F-CPUs can be operated in a PROFIBUS line.

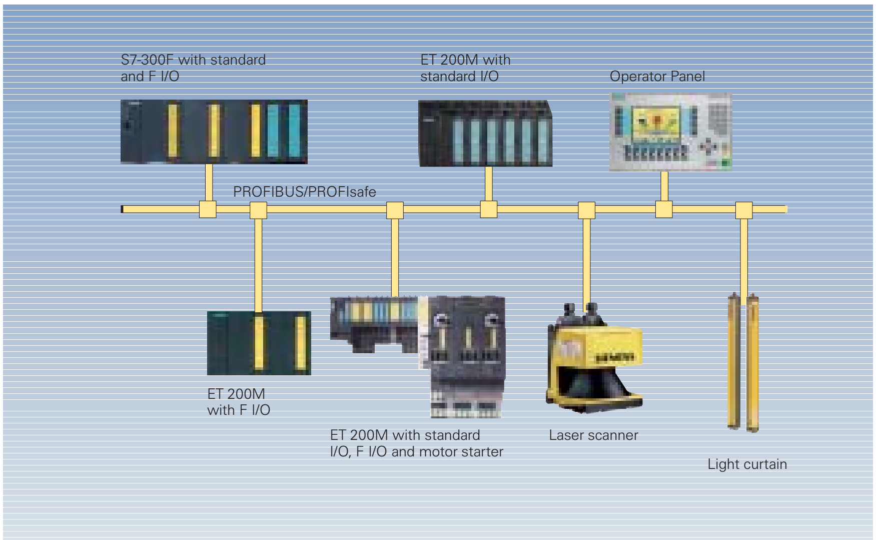


Fig. 4/7
Example of a configuration (F I/O is yellow, standard I/O is blue)

Structure

The S7-300 with the fail-safe CPU 315F couples the distributed ET 200S PROFIsafe I/O via PROFIBUS DP.

Further, the fail-safe ET 200M I/O can be connected in both central and distributed configurations.

PROFIsafe

Communication between I/O modules and the CPU takes place exclusively via PROFIBUS DP. Data is encapsulated in accordance with the PROFIsafe profile, so that it can be transmitted via the standard fieldbus without being corrupted by any standard devices connected to the bus.

Diagnostics and messaging concept

The S7-300F offers the same diagnostic and messaging functions as a standard SIMATIC PLC. None of the devices are subject to diagnostic restrictions.

4.3.3 Fail-safe I/O ET 200S / ET 200M

ET 200S and ET 200M F modules include fail-safe input and output modules as well as fail-safe motor starters:

- Fail-safe input modules detect information from sensors.
- Fail-safe output modules control actuators.
- Fail-safe motor starters control and monitor drives.

All F modules can diagnose internal and external errors and are configured with internal redundancy. They have dedicated self-test functions and meet the relevant safety requirements.

I/O modules are available in the ET 200S / ET 200M packaging design. The ET 200S electronic modules are 30 mm wide and are marked with a yellow labeling strip and have two internal channels. They can be withdrawn and plugged-in during live operation.

The following fail-safe ET 200S modules are available:

- **4/8 F-DI** 24 V DC, fail-safe digital input with 4 inputs, 2-channel, SIL 3 sensors (Cat. 4) or 8 inputs, 1-channel, SIL 2 sensors (Cat. 3) for 24 V
- **4 F-DO** 24 V /2 A DC, fail-safe digital output with 4 outputs for 24 V and 2 A (up to SIL 3/Cat. 4)
- **PM-E F** 24 V DC, Power Module with 2 (SIL 3, Cat. 4) outputs for 24 V/2 A and an additional relay output (max. 10 A, SIL 3, Cat. 4), which is available at 2 terminals and also provides the load power supply for subsequent modules (SIL 2, Cat. 3)
- **PM-D F**, fail-safe Power Module PROFIsafe with 6 integrated safe shutdown rails (SIL 3), 24 V and 3 A to safely shut down downstream fail-safe motor starters/contact multipliers when internally controlled via PROFIsafe
- **PM-D F X1**, Power Module (supply terminal module) with 6 integrated safety-related shutdown rails (SIL 3), 24 V and 2 A to safely shut down downstream fail-safe motor starters/ contact multipliers when shut down using external safety-related switching devices with electrically isolated contacts (e.g. 3TK28, Monitor from AS-Interface *Safety at Work*). In this case, a PROFIsafe connection is not required.
- **F-CM**, fail-safe contact multiplier with 2 (SIL 3) outputs for 24 V and 2 A
- **F-MS**, fail-safe direct and reversing starter up to 7.5 kW switching power with redundant electrical isolation

The following fail-safe I/O modules are available for the ET 200M:

- Digital input module 24 x 24 V DC
- Digital input module 8 x NAMUR (Ex area)
- Digital output module 10 x 24 V DC/2 A
- Analog input module 6 x 4-20 mA/13 bit

4.3.4 Programming

The “Distributed Safety” software package is indispensable when programming. It includes all of the functionality which you require when engineering your application. The STEP 7 languages LAD and FBD are used to program the safety-related programs for the CPU 315F. It is important to note that this restricts the scope of functions in terms of operations and data types. A safety-oriented program is generated using a special input during compilation. In addition to the fail-safe program, a standard program, which is not subject to any restrictions, can also run in parallel on the CPU (co-existence).

An additional integral component of this software package is the F library with pre-configured programming examples with safety functions which have been approved by the German Inspectorate (TÜV). The user may modify these programming examples; however, these modifications must be re-certified.

Programming example

The example opposite shows how stop functions can be set-up to take immediate effect (Category 0) or to take effect after a delay (Category 1). The acknowledge button serves as the start input.

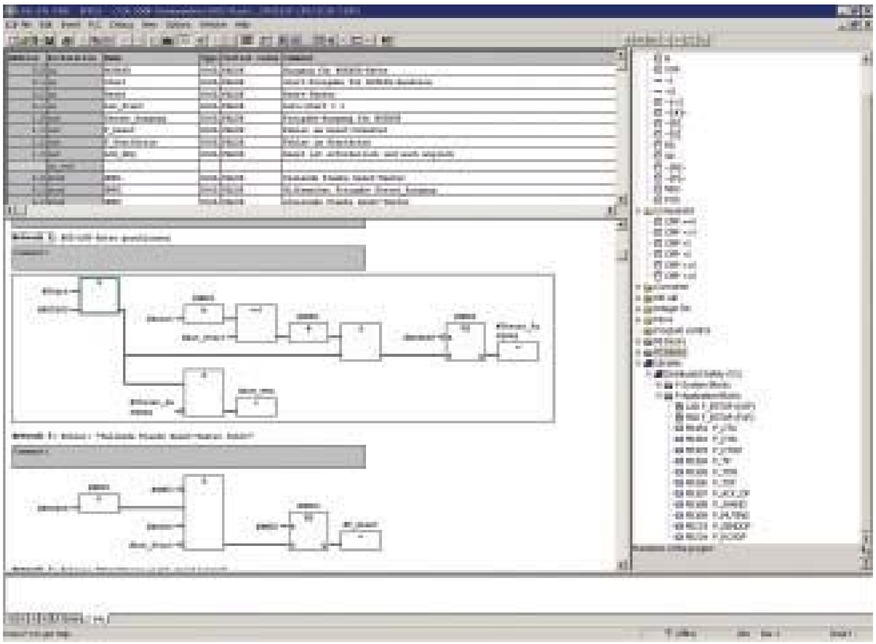


Fig. 4/8
Programming using the function block diagram (FBD)

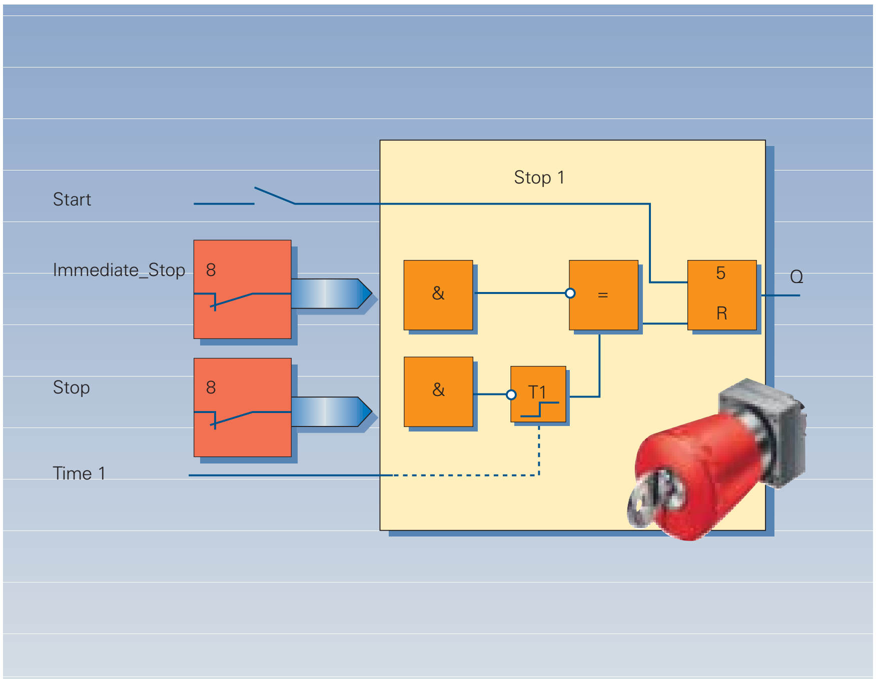


Fig. 4/9
“Emergency Stop” programming example

4

4.3.5 ET 200S fail-safe motor starter

The new fail-safe motor starter is based, regarding the performance features, on the "High Feature" motor starter.

The difference between the conventional ET 200S "High Feature" motor starter is the fact that in addition to a contactor - circuit-breaker combination, a safe electronic evaluation circuit has also been integrated to detect errors.

If, in the event of an EMERGENCY STOP, the contactor to be energized fails, the evaluation electronics will detect this as an error and safely trigger the circuit-breaker in the motor starter. The redundant second triggering element is therefore no longer the main contactor, as would usually be the case, but instead the circuit-breaker integrated in the motor starter.

The ET 200S fail-safe motor starter is predestined for use with **ET 200S PROFIsafe**. An additional application is in conjunction with **AS-i *Safety at Work*** or **safety relay**.

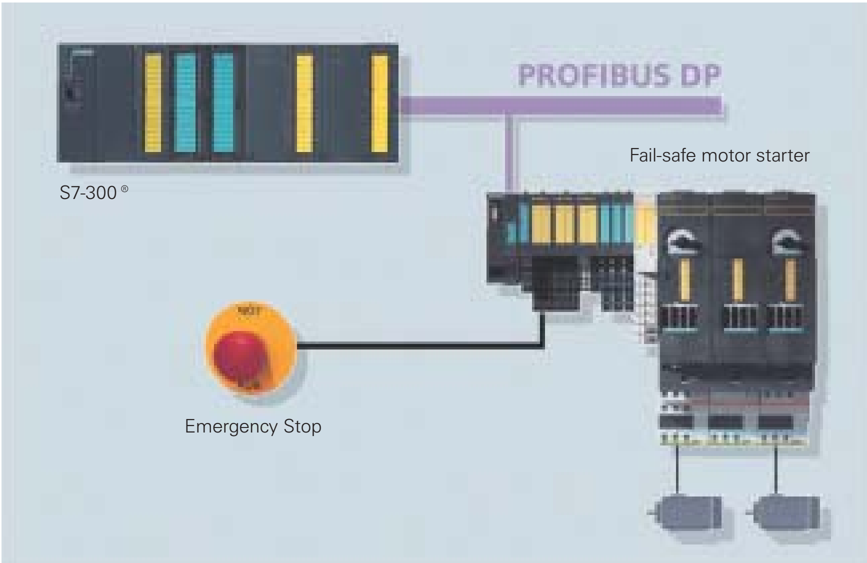


Fig. 4/10
Direct control of motor starters through ET 200S PROFIsafe

Safety technology with a high degree of flexibility

- Fail-safe motor starters for PROFIsafe: For emergency stop applications, fail-safe motor starters are selectively disabled using the upstream PROFIsafe PM-D F Power Module. A total of 6 trip groups can be generated for each Power Module. In the first delivery phase, the secure connection between the assigned safety sensors is generated via the SIMATIC controllers safe freely-programmable combinational logic. The ET 200S PROFIsafe is interfaced to systems with conventional safety technology via the Fail-safe Contact Multiplier F-CM with 4 floating contacts.
  The emergency stop signals are routed through safety-oriented inputs (ET 200S or ET 200M). These evaluate the selective shutdown of the fail-safe motor starters via the Power Module PM-D F PROFIsafe; the shutdown conditions can be programmed using blocks from the program library or in free code. (refer to Fig. 4/10)

- Fail-safe motor starter with safety relay (variant 1) or AS-i *Safety at work* (variant 2):
  Safety-related signals can be input into the ET 200S via an input terminal module PM-D F X1 using the enable circuit of the AS-i Safety Monitor or the safety relay. This means that the fail-safe motor starter can be controlled which selectively shuts down the connected motors (refer to Fig. 4/11).

Advantages in comparison to conventional safety technology

- The number of components required can be considerably reduced (less hardware)
- Lower assembly and installation costs
- The motors starters are fail-safe and have a high degree of availability
- Simple coordination/coding of the motor starters on one of the 6 trip groups (Safety Groups)

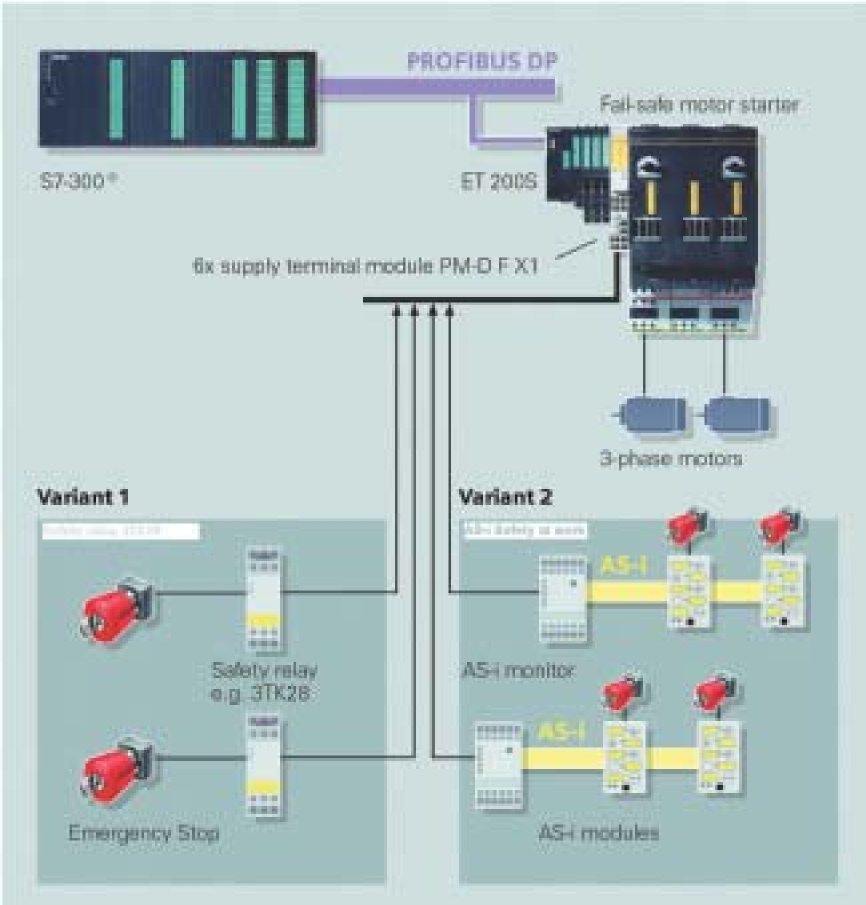


Fig. 4/11
Fail-safe motor starters with safety relays (var. 1) or AS-i Safety at Work (var. 2)

4

4.3.6 Technical data

CPU 315F - 2DP	
Integrated RAM	170 Kbyte *)
Pluggable load memory	64 Kbyte up to 4 Mbyte
Command execution times	>= 0.1 ms
Alarm response time	400 ms
Bit memories/timers/counters	2048, 256, 256
Total I/O address space	3072 bytes each
Total digital I/O	1000/1000
Total analog I/O	248/124
MPI interface	187.5 kbits/s, max. 32 stations
PROFIBUS DP interface	12 Mbits/s, max. 32 stations, master /slave changeover
Dimensions (W x H x D)	40 x 125 x 130 mm
Order No. group	6 ES7315-6F..-

*) In comparison with a standard program, the number of fail-safe operations is limited due to the fail-safe-specific overheads; depending on the type of programming, approx. 34 K fail-safe operations are possible.

Fail-safe ET 200S modules	Digital input 4/8 F-DI	Digital output 4 F-DO	Power Module PM-E F
Number of inputs/outputs	4 (2-channel for SIL 3 sensors) 8 (1-channel for SIL 2 sensors)	4 at 24 V/2 A	2 SIL 3 outputs for 24 V/2 A 1 relay output (10 A max.)
Input/output voltage	24 V DC	24 V DC	24 V DC
Order No. group	6ES7138-4FA..-	6ES7138-4FB..-	6ES7138-4CF..-

Fail-safe ET 200M modules	Digital input SM 326 F	Digital output SM 326 F	Ex-input module SM 326 NAMUR	Analog input module SM 336 F
Number of inputs/	24 (1-channel) 12 (2-channel)	10	8 (1-channel) 4 (2-channel)	6 (2-channel)
Input/output-voltage	24 V DC	24 V DC	acc. to DIN 19234 or NAMUR	
Interrupts	Diagnostics interrupt	Diagnostics interrupt	Diagnostics interrupt	Diagnostics interrupt
Input/output current	-	2 A per channel for a “1” signal	-	4-20 mA
Order No. group	6ES7326-1BK..-	6ES7326-2BF..-	6ES7326-1RF..-	6ES7326-1HE..-

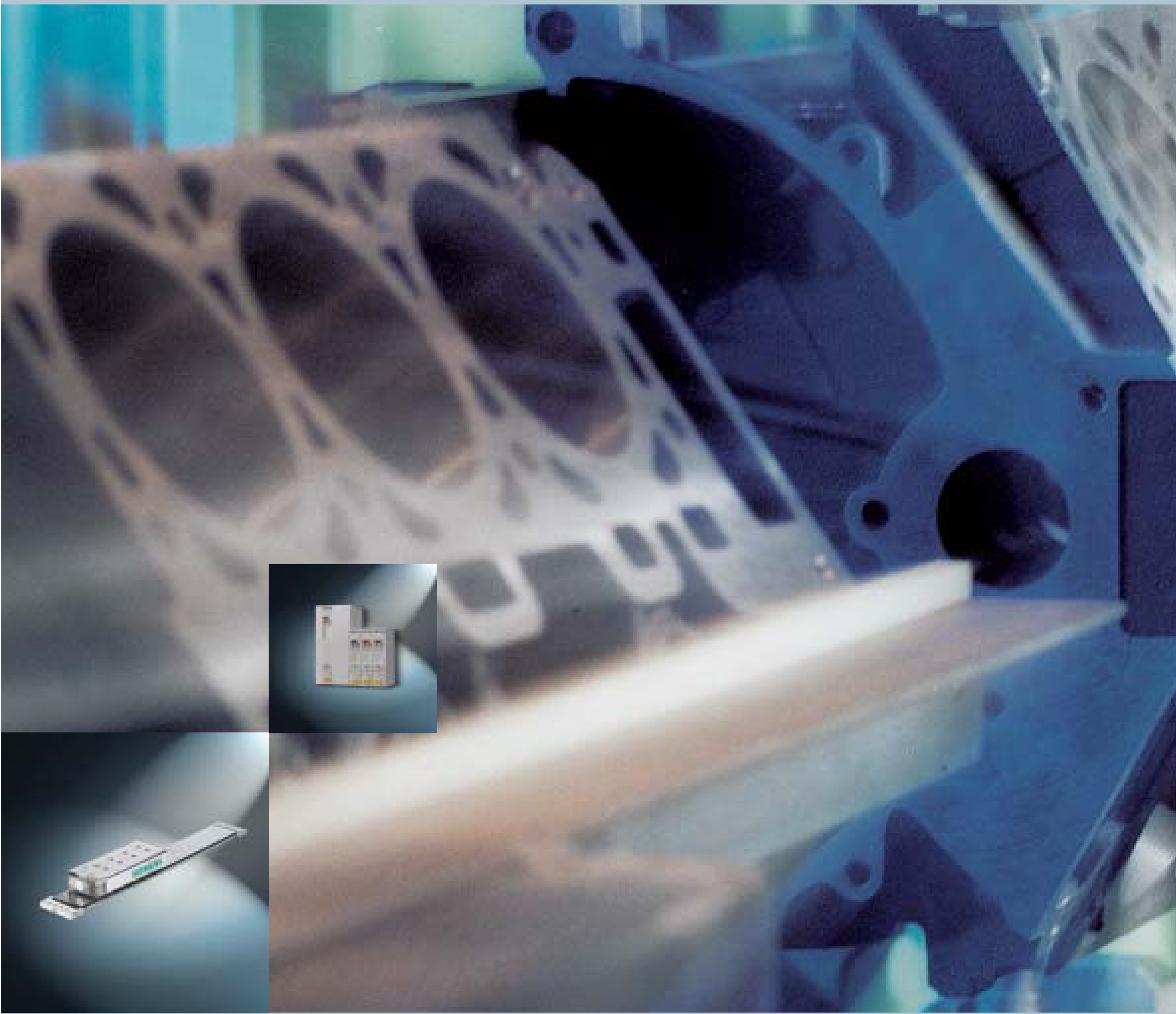
ET 200S fail-safe motor starter	
Power at 500 V	7.5 kW
Rated operating current	16 A
Short-circuit-breaking capacity	50 kA at 400 V
Coding	Assignment to 1 of 6 trip groups
Diagnostics	The coding is displayed using an LED on the motor starter
Tripping class	Class 10/20, can be parameterized
Coordination type	2 (16 A)
Order No. group, motor starter Order No. group, terminal module	3RK1301-0.B13-.AA2 3RK1903-3A..
Power Module PM-D F	
No. of internal trip groups	6
Total current of the outputs	5 A
Order No..	3RK1903-3BA00
Fail-safe Contact Multiplier F-CM	
Contacts	4 NO
Diagnostics	Power failure, device error
Switching capacity	1.5 A / 24 V
Order No.	3RK1903-3CA00
Power Module PM-D F X1 (Supply terminal module)	
Operation	Stand alone with external safety technology
Double terminals for trip groups	6
Self-diagnostics	Power failure
Order No. group	3RK1903-3DA00
Engineering Tools	
Distributed Safety software package	
Order No.	6ES7883-1FC00-0YX0

4

Motion Control Systems -

Safe, Innovative Motion Control

kapitel 5



Introduction

We have extremely high demands to fulfill when it comes to our Motion Control systems and variable-speed drives for machine tool and production machines: They integrate all of the requirements relating to production, market and industry sector. For our customers, this plays a significant role in increasing quality and productivity. Certified safety functions represent an integral component of our standard products and in addition to affording highly effective protection for man and machine, they also have a significant positive impact on increasing the productivity of our customers.

Test and certification

(excerpt from [Reinert, D.; Schaefer, M.; Umbreit, M.: Antriebe und CNC-Steuerungen mit integrierter Sicherheit. In: ETZ-Heft 11/98], Fachaufsatz der Berufsgenossenschaft)

There is no mandatory test which must be applied for drive systems with integrated safety. This applies for applications in the area of machine tools, robots, automated production systems, food and beverage machinery etc. However, for specific machines which come under Annex IV of the Machinery Directive (e.g. presses, woodworking machines), it may be mandatory that the machine is tested which in turn means that it is necessary to test the drive system.

Independent of this, tests can be made on a voluntary basis. Generally, the users and machinery construction companies request that an independent testing body tests these components even if testing is not mandatory. The reason for this is the complexity of the drive systems with integrated safety functionality. Users themselves cannot simply evaluate whether the systems are in compliance with the protective goals of the Machinery Directive and the appropriate Standards.

Tests carried-out on these types of complex systems should always accompany development. This means that they should already start in the conceptual phase. This avoids development mistakes and the testing costs are reduced.

Hazardous analysis and risk evaluation

In accordance with the Machinery Directive 98/37/EEC, the manufacturer or organization marketing a specific machine or a safety component is responsible in carrying-out a hazard analysis. The objective of this is to determine all of the hazards associated with the machine or the safety component. The manufacturer must design and build the machine or safety component taking into account his analysis. A risk evaluation indicates the remaining risks which must then be appropriately documented.

5.1 SINUMERIK Safety Integrated
The Safety Package for Machine Tools

5

Drives and CNC control systems with integrated safety

Safety measures must be provided on machines to protect personnel against potentially hazardous machine motion. These are mainly used to prevent hazardous machine movement when protective devices are in the open position. These functions include monitoring positions, e.g. end positions, monitoring speeds and stopping or shutdown in hazardous situations.

Up until now, external devices were mainly used to implement these safety measures. These include contactors, switches, cams and monitoring devices. When a hazardous situation is identified, these devices generally result in switching operations using contacts in the power circuit, which stop the potentially hazardous motion - refer to Fig. 5/1.

When integrating safety functions, drive systems and CNC controls are used to realize safety tasks in addition to the actual machine function. Extremely short response times can be achieved due to the short data path from sensing the safety relevant information, e.g. speed or position, up to evaluation. Generally, systems with integrated safety technology respond extremely quickly when limit values are exceeded or violated, e.g. position or speed limit values. This can be extremely significant for the required monitoring result. The integrated safety technology can directly control the power semiconductors in the drive control unit without using electro-mechanical switching operations in the power circuit. This also means that the system is less prone to faults and disturbances. The wiring and cabling costs are reduced as a result of the integration.

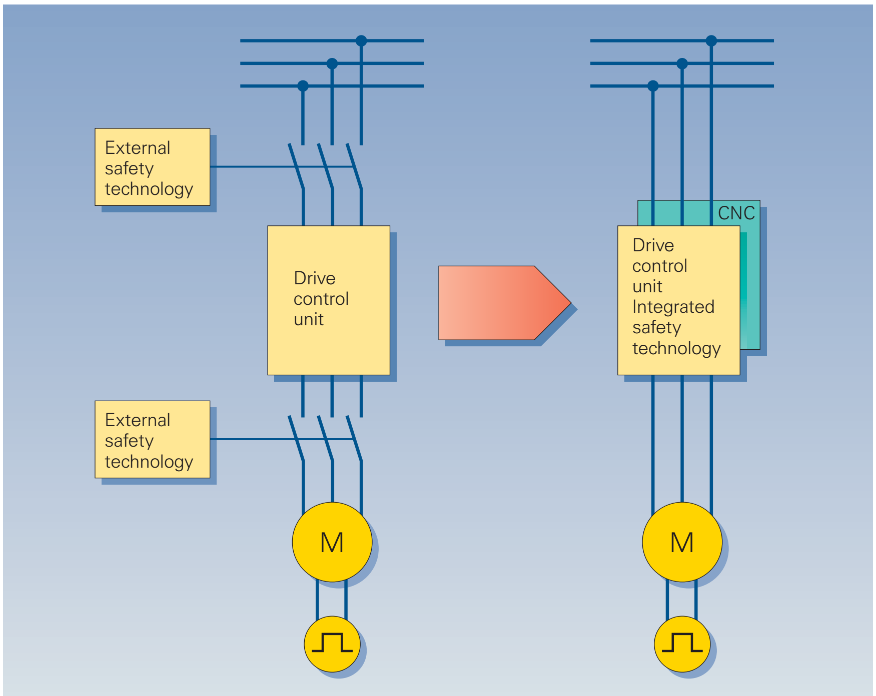


Fig. 5/1
External safety technology, integrated safety technology

Fig. 5/2
The basic SINUMERIK/SIMODRIVE system

5.1.1 Brief description

Additional current information is also provided in the Description of Functions for SINUMERIK 840D Safety Integrated.

Functional scope

"SINUMERIK Safety Integrated" offers prototype-tested safety functions. These are used to implement highly-effective protection for both personnel and machines and that in a practical way. All of the safety functions fulfill the requirements of control Category 3 according to EN 954-1 and are a permanent part of the basic system, also refer to Fig. 5/1. Neither additional sensors nor evaluation units are required.

This means:

Lower installation costs at the machine and a low-profile electrical cabinet.

The functionality includes:

- Functions to safely monitor speed, standstill and position
- Functions to safely logically combine and interlock signals

Sensors and actuators, for example, EMERGENCY STOP pushbuttons, light curtains, valves or brakes, can be directly coupled to a two-channel I/O or to fail-safe modules. The logical combination and the responses are realized internally using safety-related technology. All safety-relevant system errors always result in the potentially hazardous motion being safely brought to a standstill, or the power feed to the motor is quickly and contactlessly disconnected. The drives are always stopped, optimally adapted to the operating state of the machine. For example, in the setting-up mode, with the protective door open, the drive is stopped as quickly as possible (this is the optimum procedure for personnel protection), and in the automatic mode with the protective door closed, the machine is shut down in a path-related fashion (this is optimum for machinery protection).

In all of the operating modes, the safety functions are available and can communicate with the process itself via safety-related input/output signals. The complete functional scope was certified in the form of a prototype test by the BIA [German Statutory Industrial Accident Insurance Association] in St. Augustin.

Also refer to Section 8.7 "BG test certification - prototype test certificates."

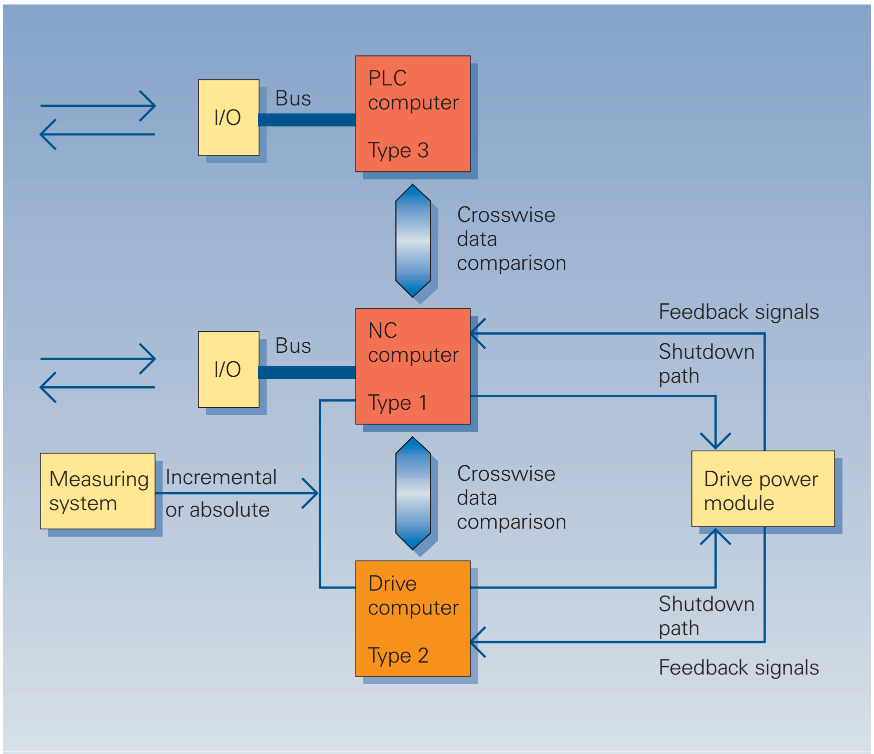
This means the following:

A high degree of personnel protection in the setting-up mode and additional protection for the machine, tool and workpiece in the automatic mode.

These safety functions offer an intelligent system intervention, previously unknown, directly down to the electrical drives and measuring systems. Reliable function, fast response and a broad acceptance mean that these certified safety systems are highly effective.

Basic structure

A two-channel system structure with diversity is created using the existing-multi-processor structure. The safety functions are redundantly incorporated in the NC, drive and internal PLC. The process quantities and safety-relevant system data are cross-monitored; also refer to Fig. 5/3.



Graphic 5/3
The CPUs form a two-channel system structure with diversity.

Safety-related software and hardware functions are tested at defined time internals using an automated forced checking procedure. Also refer to Section 5.1.11. “Basic information on the application.”

The special feature of this safety concept is that Category 3 acc. to EN 954-1 can be implemented with just one measuring system - the standard motor measuring system. A second sensor is not required. However, it can be incorporated as an additional direct measuring system (e.g. linear scale).

Safer and more flexible

Using this innovative safety technology, it has been shown that new machine operator control concepts can be implemented in line with those required in practice. This means that a new standard of machines has been created, which is safer and more flexible in operation and which increases the plant availability.

The new safety concept is the result of close cooperation with the “Iron and Metal II” Committee of the German Trade Association in Mainz and the “German Statutory Industrial Accident Insurance Association” BIA in St. Augustin and Siemens AG, Motion Control Systems Division, in Erlangen.

5.1.2 Equipment components

The Motion Control Systems business division belonging to the “Automation and Drives Group” develops, manufactures and markets numerical controls and drive systems under the SINUMERIK and SIMODRIVE product names. These systems are especially used for complex and high-dynamic motion control and positioning applications when special demands are placed on precision.

CNC control SINUMERIK 840D – compact high technology

SINUMERIK 840D is a CNC control for up to 31 axes. It is an integral component of the modular SIMODRIVE 611 drive system. Thus, communications with the drive modules are realized through the shortest path.

Based on the modular SIMODRIVE 611 system, a module has been conceived in the form of SINUMERIK 840D, which provides significant technical advantages over comparable individual solutions.

The highlights include:

- Up to 31 axes can be positioned
- Precision better than 1 µm
- Integrated SIMATIC S7-300-CPU with PROFIBUS-DP interface
- Only 50 mm wide in the SIMODRIVE 611digital packaging design
- Scalable processor performance
- Integrated, certified safety functions

Fig. 5/4
SINUMERIK 840D – NCU and NCU box

SIMODRIVE 611 digital AC drive converters

SIMODRIVE 611digital is a flexible configurable drive converter system, which is fully aligned to the technical requirements placed on state-of-the-art machines, both economically as well as ecologically. With SIMODRIVE 611 digital, Siemens is offering a drive converter system with digital closed-loop control, which is guaranteed to fulfill the highest requirements regarding dynamic performance, speed control range and smooth running characteristics.

As a result of the modular drive converter system design, drive configurations with almost any number of axes or main spindles can be implemented. The axis modules are designed for 1FT6, 1FK6, 1FK7 and 1FN feed motors as well as 1PH main spindle and 1FE built-in synchronous motors.

The SIMODRIVE 611digital drive converter system offers the following advantages:

- It fulfills the requirements for the EMC Directive and EMC compatible supplies
- Low line supply stressing as a result of sinusoidal current operation and regenerative feedback
- Compact design using low-loss power semiconductors
- High level of functionality in the smallest space using highly integrated control electronics

The digital control modules of the SIMODRIVE 611digital are used in conjunction with the 1FT6/1FK6/1FK7 SIMODRIVE AC servomotors and 1FN linear motors for feed drives and 1FE and 1PH motors for main spindle drives. They evaluate the optical sine-cosine encoders, which are integrated in the 1FT6/1FK6/1/FK7 or 1PH motors. This means that up to 4.2 million increments/motor revolutions can be achieved as measuring circuit resolution. For 1FN motors, a linear incremental or absolute-coded measuring system with EnDat interface is required to sense the position, speed actual value and pole position. 1FE motors require a hollow shaft encoder with sinusoidal-cosinusoidal signals for the closed-loop speed and position control. For control modules with direct position sensing, a direct measuring system can be connected. The certified safety functions are available for all encoder versions.

Fig. 5/5
SIMODRIVE 611digital drive converter system

Fig. 5/6
Digital control module

Various drive-related versions can be implemented using the modular SIMODRIVE 611digital drive converter system, and combined as required in a drive group.

1FK6/1FK7 and 1FT6 servomotors

These represent the optimum solution when the highest dynamic performance and precision are demanded. Users hold simple and good controllability, combined with features such as freedom of maintenance and high overload capability in especially high esteem.

1FK6/1FK7 and 1FT6 three-phase servomotors are compact permanent-magnet synchronous motors, which have been especially developed for operation with the SIMODRIVE 611-digital drive converter system. The fully digital closed-loop control and the new integrated encoder system (motor measuring system) fulfill high demands placed on the dynamic, speed control range, smooth running and positioning accuracy.

Special speed-controlled 1PH induction motors

Based on the Transvector control (field-vector control), which was developed and patented by Siemens, an induction motor can be just as simply controlled as a DC motor. An induction motor controlled by SIMODRIVE 611digital has many advantages over DC motors, such as freedom of maintenance and full availability of the rated torque even at standstill. 1PH motors are equipped with a high-quality encoder system for closed-loop speed control and positioning.

1PM main-spindle motors with hollow shaft

The 1PM4 liquid-cooled motors and the 1PM6 air-cooled motors are especially designed so that they can be directly mounted onto mechanical spindles. The hollow shaft allows the feed of cooling-lubricating medium for internally cooled tools. The motors have an integrated hollow-shaft measuring system to detect the motor speed and indirect position.

1FN linear motors

1FN three-phase linear motors, together with SIMODRIVE 611digital, form a harmonized linear drive system for the requirements of the machine tool industry. The motors consist of a primary section and a secondary section with rare-earth magnets. When suitable measuring systems are used, the motors can be positioned in the nanometer range. The high traversing velocities and the extremely high dynamic performance which can be achieved with the motors, are just some of the highlights worth mentioning.

1FE build-in synchronous motors

1FE motors are water-cooled synchronous motors, which are supplied as components. They are predominantly used for main-spindle applications. These motors are mainly used together with the SIMODRIVE 611digital drive module where the highest demands are placed on the machining quality, precision, smooth running characteristics and extremely short accelerating times.

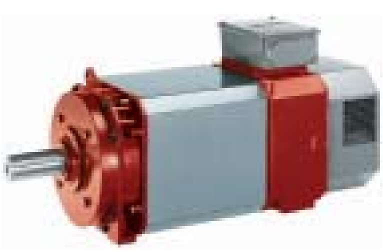


Fig. 5/11
1PH7 induction motor

Fig. 5/7
1FT6 servomotors

Fig. 5/8
1PH build-in induction motor

Fig. 5/9
1FN3 linear motor

Fig. 5/10
1FE build-in synchronous motor

Fig. 5/12
System components and connection systems

Accessories

The Siemens SINUMERIK and SIMODRIVE automation systems are designed for all types of machine tools and processing equipment. With its family of MOTION-CONNECT cables, Siemens is offering the matching pre-assembled cables, cables sold by the meter and connectors which are ideally suited to the particular application.

The customer benefits of Siemens pre-assembled cables include:

- System functionality and compatibility are guaranteed
- EC EMC Directives are fulfilled
- Insulation in accordance with VDE
- In conformance with DESINA
- No mounting problems
- No special tools are required
- MOTION-CONNECT 800, 700, 500 provide a tailored solution for every application
- Perfect functioning of the complete system is guaranteed

The supplementary system components such as encoders, hand wheels, operator control and handheld programming devices are also harmonized with the overall system.

SIMODRIVE sensor measuring systems for measuring distances, angles and velocities are available from Siemens as either incremental encoders or absolute encoders. For the incremental encoders, the interfaces are harmonized with the particular control system. Absolute-value encoders are available in versions with SSI, EnDat and PROFIBUS-DP. The encoders can be quickly and easily commissioned as they can be parameterized. High machine availability is achieved using system-tested components.

The original Siemens accessories are an essential component of SINUMERIK Safety Integrated applications.

5.1.3 System requirements

Also refer to Section 5.1.12 “Ordering data and documentation” and the Function Description SINUMERIK Safety Integrated.

SIMODRIVE 611digital

- Safety Integrated is available for digital drives
- The Performance and well as the Standard 2 control of 611digital can be used
- The control boards must always be ordered with DMS measuring circuit
- At least one measuring system must always be used

SINUMERIK

For SINUMERIK, Safety Integrated is available for the 840C and 840D types in conjunction with SIMODRIVE 611 digital. In this particular case, all of the CPU versions can be used.

- Inputs/outputs for safety-related signals (safety-related I/O).
  1. NC and PLC peripherals (I/O) form a 2-channel I/O structure, or
  2. Fail-safe modules are coupled through PROFIBUS with the extended PROFIsafe protocol (not with 840C)
- SINUMERIK Safety Integrated is a software option and comprises a basic and an axis option. In this case, the basic option already has the axis option for 4 drives.
- For the SI functions, CPU system resources (NC, PLC, drive) are required, which are dependent on the scope of the functions used and the number drives. In borderline cases, it may be necessary to use a higher performance NC-CPU.

Encoders and measuring circuit

- Generally, every measuring system can be used which fulfills the measuring circuit specifications of SIMODRIVE 611digital.
- 1-encoder concept: At least one measuring system is required, which is generally covered using the indirect motor measuring system (IMS) as either incremental or absolute encoder.
- 2-encoder concept: A second measuring system is not required; however, it can be integrated as direct measuring system (DMS).
- The measuring circuit cables must be in conformance with the SIMODRIVE 611 digital specifications. This means that they must have twisted and shielded pairs.

SIMATIC

- All of the standard SIMATIC components can be used.
- I/O for safety-related signals (safety-related I/O).
  1. NC and PLC peripherals (I/O) form a 2-channel I/O structure
  2. Fail-safe modules are coupled through PROFIBUS with the extended PROFIsafe profile

HMI

- The operator and display units (OPs) are not embedded in the safety concept. They are only used to display safety-relevant data for diagnostics and commissioning.

5

5.1.4 Safe stopping process

The safe stopping process is not an autonomous function, but describes a procedure which can be implemented using “SINUMERIK Safety Integrated” functions. The safe stopping process safely stops the motion and brings the drive to a standstill when a monitoring function or a sensor responds (e.g. light curtain).

All safety-relevant faults and errors in the system or if an appropriate sensor responds, always result in a coordinated, safe shutdown of the hazardous motion. Depending on the system engineering specifications, the power to the motor can be quickly disconnected. This power disconnection between the drive converter and motor, required in special cases (where the drives go into a torque-free condition), is realized contactlessly and can be initiated on an axis-for-axis basis with extremely short response time. Thus, it is no longer necessary to discharge the DC link in the drive. The drives are always shut down in an optimum fashion, according to the actual operating status of the machine.

The integrated functions are supplemented by activating external braking mechanisms, and, for safety shutdown, results in the shortest possible braking travel. External braking mechanisms can include, for example:

- External mechanical brake, holding or operating brake
- External electrical brake, such as armature short-circuit brake.

Principally, the line contactor is no longer required if the machine has a main switch, which allows it to be electrically disconnected from the supply.

Stop responses

A high degree of fail-safety is obtained as a result of the two-channel monitoring structure with its permanent cross-monitoring. If differences occur between the two monitoring channels, alarms and stop responses are automatically initiated. The stop responses should safely shut down the drives corresponding to the particular requirements at the machine. A differentiation is made between the stop versions, STOP A, B, C, D, E, F and the test stop. The system can specify a preset stop response type when a fault/error occurs or the machine OEM can configure the required response. When the limit values, defined using the machine data are violated, the stop responses of the machine OEM can be initiated. Stops A, C, D and E can also be selected externally, event-related using safety-relevant inputs (SGE). The stop versions are implemented as follows:

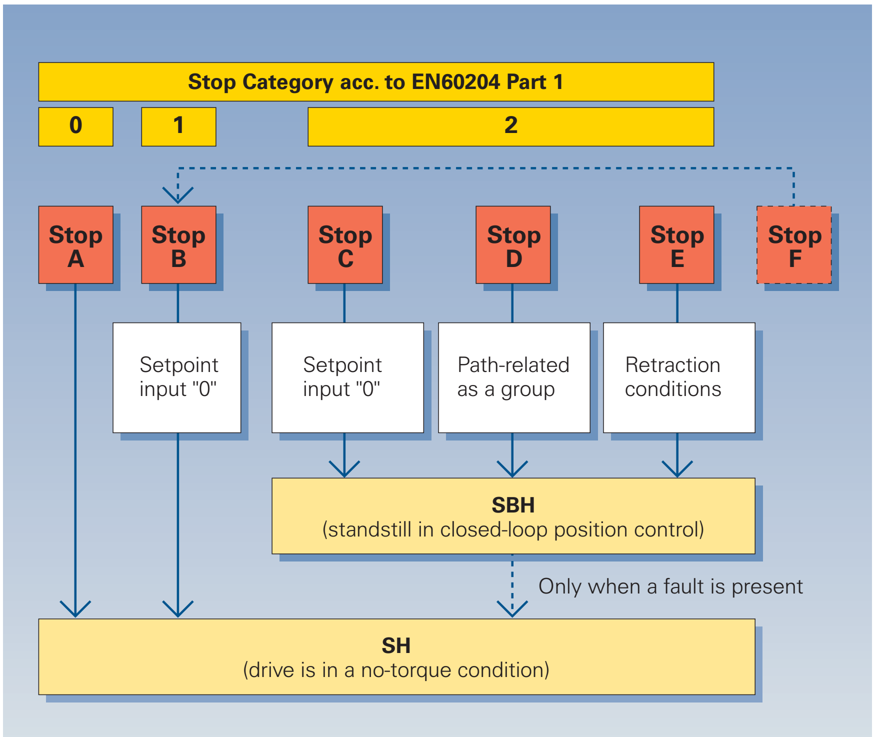


Fig. 5/13
Stop versions for different stopping types

• **Stop A**

Using Stop A (this corresponds to Stop Cat. 0 acc. to EN 60204, without electrical isolation), the drive can be directly switched into a no-torque condition using the "Safe Standstill" function. A drive that is at standstill can no longer undesirably start. A drive which is still moving coasts down. This can be prevented by using an external braking mechanism such as armature short-circuit, holding and operating brakes. The axis-specific alarm results in a mode stop which means that as a result of the response in one axis, all of the axes and spindles in a mode group are also shut down. At the end of Stop A, the axis is at a "safe standstill."

• **Stop B**

The drive is braked along the current limit in the closed-loop speed controlled mode and goes into the "safe standstill" state (this corresponds to the stop Category 1 according to EN 60204, without electrical isolation).

• **Stop C**

The drive is braked along the current limit in the closed-loop speed controlled mode and goes into the "safe operating stop" state.

• **Stop D**

The drive, as group, including the synchronous axes, is braked path-related and goes into the "safe operating stop" state.

• **Stop E**

The drive, as group, including retraction motion, is braked path-related and goes into the "safe operating stop" state.

• **Stop F**

The stop F response is permanently assigned to the cross-monitoring result and data comparison. This means that faults/errors in the drive and on the control side are detected. Depending on the configuration, a Stop B or A response is initiated. "Safe standstill" is effective at the end.

When configuring the stop responses, personnel protection has topmost priority. The optimum stop response for machine protection can be configured in the automatic mode with the protective door closed. The goal is always to optimally stop the machine in any particular situation.

Example 1: Grinding machine with open protective door (setting-up operation):

- Feed drives with Stop C:
  The drives, for each individual axis, are braked along the current limit as quickly as possible and then go into the "safe operating stop." Thus, they remain in the closed-loop position controlled mode.
- Grinding wheel drive with external Stop A:
  In this particular mode, the drive is always maintained in a torque-free condition via the external Stop A with "safe standstill."

Example 2: Grinding machine in the automatic mode:

- Feed drives with Stop E:
  The drives, as a group, execute a retraction movement (cut themselves free) and are braked along the contour via a ramp and go into the "safe operating stop" state. They remain in the closed-loop position-controlled mode.
- Grinding wheel drive with Stop D:
  The drive is braked along a ramp and is therefore held by the torque load below the sparking limit. The drive goes into the "safe operating stop" state and is kept in the closed-loop position-controlled mode.

Safe standstill – SH

When a fault occurs or in conjunction with a machine function, the "safe standstill" is used to safely disconnect the power feed to the motor. This is realized for each axis and the power is disconnected contactlessly. The basis for the "safe standstill" function is the safe pulse cancellation, which is integrated in the SIMODRIVE 611digital drive modules.

The machine OEM must take the appropriate measures to stop axis movement after the power feed has been disconnected from the motor (e.g. to prevent hanging axes dropping).

Features

- A motor cannot accidentally start.
- The power feed to the motor is safely interrupted.
- The motor is neither disconnected from the drive module nor from the drive converter DC link.

Fig. 5/6 shows four basic possibilities of bringing a motor into a no-torque condition. These differ in their principle of operation.

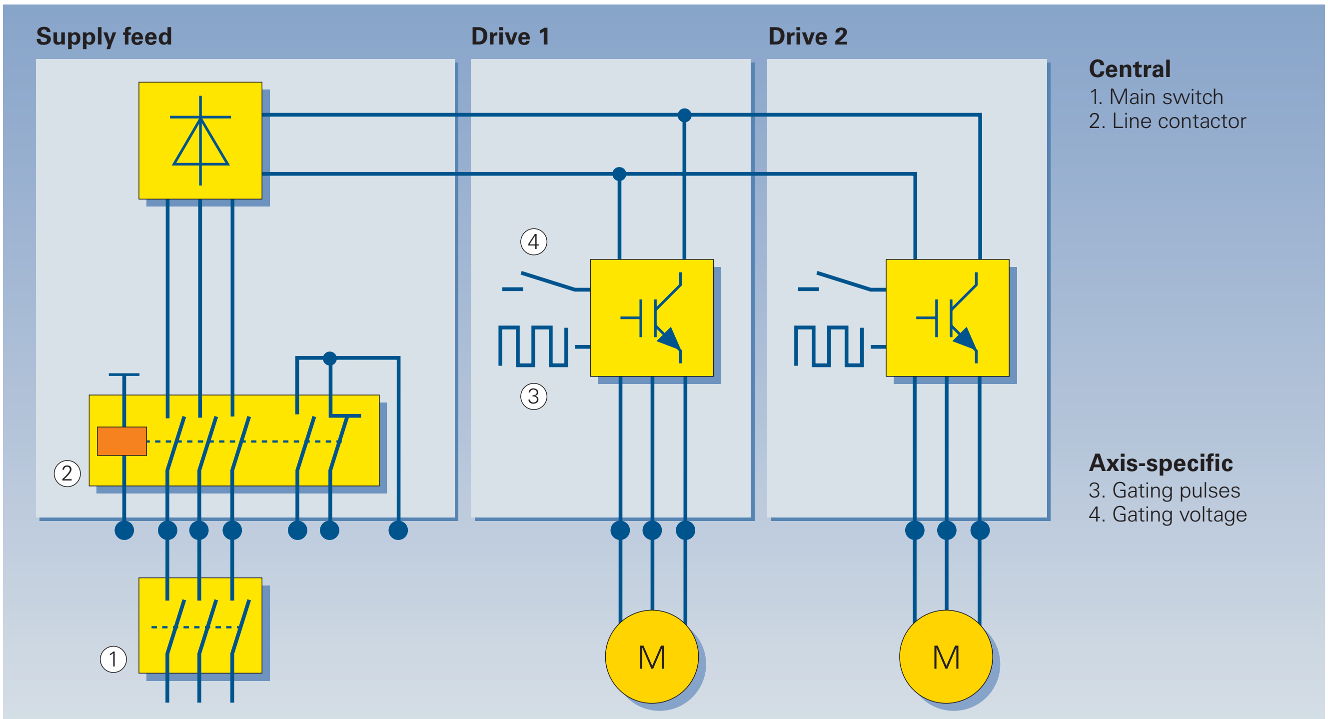


Fig. 5/14
Safe standstill - the power is electronically disconnected

① **Main switch:**
Mode of operation ➩ central
Every machine must be equipped with at least one switch that permits the machine to be completely electrically isolated from the line supply. This is generally realized using the main switch. This measure protects personnel working on the equipment against electric shock. When open, this switch must be secured so that it cannot be accidentally closed.

② **Integrated line contactor:**
Mode of operation ➩ central
The complete drive converter can be electrically isolated from the line supply using the line contactor in the rectifier/feed module. With reference to the drive converter, this measure represents a Category 0 Stop. In the past, with an integrated line contactor, for EMERGENCY STOP, the drive converter was brought, in conjunction with a Category 1 Stop, into a no-torque condition. However, electrical isolation is not mandatory for EMERGENCY STOP.

(Also refer to the Application Manual, Section 1, Page 1/14)

③ **Pulse cancellation in the gating unit**
Mode of operation ➩ axis-specific
The fastest way to bring individual axes into a no-torque condition is to cancel the pulses using the gating unit. However, this measure when applied on its own, is not safety-relevant.

④ **Control voltage of the optocoupler**
Mode of operation ➩ axis-specific
When the control voltage of optocouplers is disconnected, when a fault condition occurs, gating unit pulses which are still present cannot be converted into a torque in the drive power section. However, this measure is, when applied by itself, not safety-relevant. It is not possible to electrically isolated the drive converter DC link (600 V) from the motor. This is also not required for "functional safety".

Conclusion:
Measures 3 and 4 are physically decoupled and together form an effective and safety-relevant method of cancelling the drive converter pulses on an axis-for-axis basis. They form the basis for "safe standstill" and can be independently initiated from the drive and the NC. The concept is rounded-off by integrating into cyclic tasks (forced checking procedure).

This means that a total safety-related concept is created from individual measures, which completely fulfills the requirements for EMERGENCY STOP. It is no longer mandatory to open the line contactor.

However, when carrying-out work (e.g. service, maintenance...) on live components, the equipment must always be isolated from the line supply.

Comment regarding Emergency Stop in the US

The NFPA 79 has been recently revised and has been in force since the middle of 2002. For the first time, NFPA 79 permits software, electronics and bus systems to be used for Emergency Stop. However, contrary to the EEC, for stop Category 1, it is also necessary to subsequently electrically isolate the equipment from the line supply. This can be simply engineered as a US version.

Safe operating stop - SBH

This function is used to safely monitor the standstill position of an axis or spindle. In this case, the drives remain fully functional in the closed-loop position controlled or closed-loop speed controlled mode.

Features

- The axis remains in the closed-loop controlled mode.
- Standstill tolerance window which can be parameterized.
- Configurable stop response when the monitoring function responds (Stop B or A).

Safe braking - SBR

With this function, the expectation that after a stop command, the actual velocity must be reduced, is used as basis (the speed characteristic is monitored).

When a stop command is initiated, the current velocity plus a velocity tolerance, specified using a machine data, is activated as velocity limit. This limit is compared with the actual velocity (must be less than or remain the same) and is cyclically corrected. This means that the system quickly detects if the axis re-accelerates during braking; a subsequent response is then initiated.

Features

- If an axis re-accelerates during braking, then this is detected as quickly as possible.
- The “safe braking ramp” is automatically activated if a Stop B or C was initiated..
- When the “safe braking ramp” responds, Stop A is directly initiated.

Example, Emergency Stop

Safety-related signals and the required responses are logically combined internally using safety-related technology. The electric drives are safely shut down and are then disconnected from the power source via the electronics. An undesirable restart is also safely prevented. External potentially hazardous energy sources, for example, hydraulic systems or lasers etc. can be switched-out using safety-related outputs associated with the integrated EMERGENCY STOP logic and downstream actuators (power contactors, valves). The coordinated safe stopping process prevents or reduces subsequent damage (e.g. crash) when shutting down and also permits a fast, simple restart.

Test stop

With the test stop, for each monitoring channel, the complete shutdown path is tested with the external circuitry.

When executing the test, the comparators and stop modules of the two monitoring channels, which are responsible for the stop function, are executed one after the other. Also refer to Section 5.1.11 on the subject of forced checking procedure.

5.1.5 Monitoring speed and position

Safely reduced speed - SG

The “safely reduced speed” function is used to safely monitor the speed of a drive.

To realize this, the actual speed of the drive is cyclically compared, in the monitoring clock cycle, with the speed limit, selected via safety-related inputs. The speed limits are defined in the machine data.

Various applications and operating statuses at the machine can be monitored using the speed limits for safely-reduced speed 1, safely-reduced speed 2, safely-reduced speed 3 or safely-reduced speed 4. Further, the limit values safely-reduced speed 2 and safely-reduced speed 4 can be graded in 16 steps using “safety-related inputs” (4 bits). The entry is made in % (1 to 100%) and is saved in a table in the machine data. Thus, a total of 34 freely selectable speed limits are available for each drive. This allows personnel and machine protection to be implemented in the setting-up mode and also in the automatic mode.

Comment: For changeover gearboxes, the correct gearbox ratio must be selected!

Features

- Safe monitoring of the load side speed limits.
- The monitoring limits are adapted to various operating statuses (e.g. test, setting-up, automatic mode).
- Configurable safely reduced speed-specific stop responses.

5

Safely reduced speed-specific setpoint limiting

With this function, for the first time, in addition to the speed actual value, the speed setpoint is also taken into consideration. The "safely reduced speed-specific setpoint limiting" automatically limits the setpoint to the currently effective limit of the safely reduced speed. If this value changes for a drive, then the setpoint limit is automatically corrected. If the drives operate in a group, then the function acts on all of the coupled drives. This means that the machined contour is always maintained.

Applications

- When testing NC programs (operating mode 3), e.g. when the protective door is opened. This means that no test-specific changes have to be made to program parameters.
- If, for example, a safety zone is entered using the traversing keys, where lower safely reduced speed limits are active, the axis is not stopped, but the speed is automatically reduced to the speed setpoint which is effective there.

Features

- The setpoint is limited in one channel in the NCK.
- This is effective when traversing the drives using traversing keys or when executing NC programs.
- The limit value lies X% below the active safely reduced speed limit.
- The axes involved are instantaneously accelerated or braked, interpolating.
- This function is only executed if the programmed setpoint lies above the active safely reduced speed limit.
- If the programmed setpoint is less than the active safely reduced speed limit, then the drives traverse as specified in the program.

Safe software limit switch - SE

A working zone/protective zone demarcation or traversing range limiting can be implemented for each axis using this "safe software limit switch." This means, for example, that hardware limit switches are not required on the mechanical system. Two limit switch pairs per axis are available. Each limit switch pair consists of a positive switch (safe limit switch 1+ and safe limit switch 2+) and a negative switch (safe limit switch 1– and safe limit switch 2–). It is possible to toggle between safe limit switch 1 and safe limit switch 2 via the safety-related inputs.

Features

- End positions can be safely defined and evaluated per software.
- Configurable stop responses when end positions are reached.
- Stop response when passing end positions is realized internally in the software.

Safe software cam - SN

Safe range identification can be implemented for each axis using the safe software cam function. This means that today's "hardware solution" can be replaced

4 cam pairs (safe software cam 1 to safe software cam 4) are available for each axis. Each cam pair comprises a positive cam (safe software cams 1+, 2+, 3+ and 4+) and a negative cam (safe software cams 1–, 2–, 3– and 4–). Each cam signal can be individually configured via the machine data. The cam signals are output via safety-related outputs.

Features

- Cam positions can be safely defined and evaluated using software.
- Safety ranges are defined.
- Safe cam-dependent changeover of safety functions (e.g. safe position-dependent changeover) of the safely reduced speed stages

5.1.6 Logically combining safety-related process signals

Safe programmable logic - SPL

The "safe programmable logic" allows, for the first time, safety-related sensors and actuators to be directly connected and logically combined. The logic is redundantly incorporated in the NC and in the internal PLC. This means that all safety-related sensors and actuators, e.g. EMERGENCY STOP or interlocking concepts for protective doors can be configured using the SINUMERIK Safety Integrated software. EMERGENCY STOP, in conjunction with "safe standstill," can now be implemented by the evaluation logic up to power disconnection, contactlessly and using safety-related technology. Discrete hardware contacts can be eliminated which is reflected in a simplified cabinet design. Only the power contacts (e.g. contactors) are required to directly control the external actuators.

Features

- Universal, programmable logic utilizing safety-related technology
- The logic is immediately activated after run-up
- Cyclically executed, independent of the user program
- Integrated timer for forced checking procedure
- Effective in all operating modes.

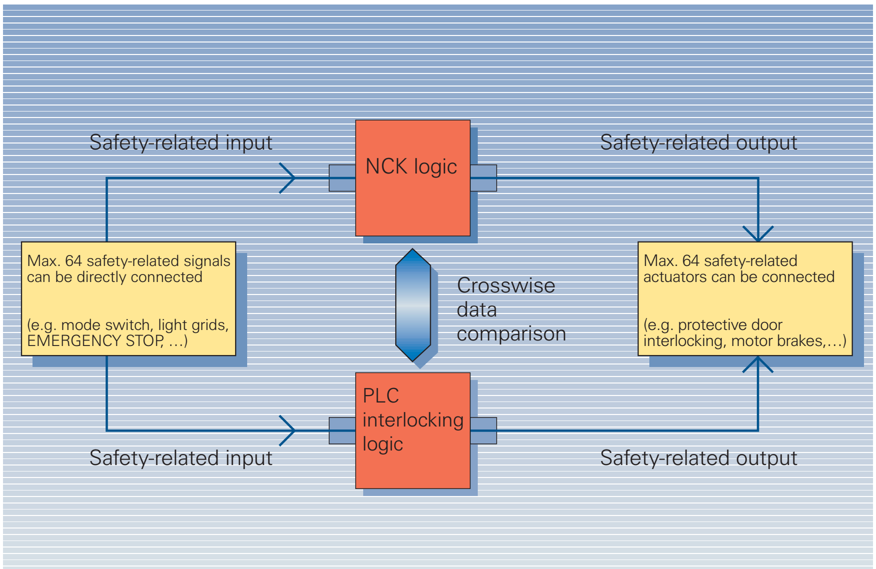


Fig. 5/15
Basic structure - safe programmable logic

Safety-related I/O - SGE/SGA

The safety-related input and output signals represent the interface to the process. They are digital signals which are entered into the system or are output from the system through two channels. The safety-related inputs and outputs need not be routed via hardware terminals.

In conjunction with the safe programmable logic, when required, they can be internally processed as software signal.

Features

- Safety-related functions can be selected and canceled
- Limit values can be selected and changed-over
- Status signals can be fed back
- Cam signals can be output
- Sensors can be directly connected
- Actuators can be directly connected.

5.1.7 Integrating sensors/actuators - basics

In order to integrate sensors and actuators in a safety-related fashion, their process signals must be fed to the “safe programmable logic” SPL for further processing.

The following connection types are available:

1. Using separate hardware I/O from the PLC and NC with degree of protection IP20
2. Via PROFIsafe with the ET 200S-PROFIsafe I/O modules with degree of protection IP20
3. Via PROFIsafe as direct, safe communications with a safety-related PROFIsafe sensor / actuator

This applies for process signals from:

- Sensors, for example, switches, protective door contacts, EMERGENCY STOP pushbuttons, light curtains, laser scanners
- Actuators, for example, load contactors, valves, interlocking solenoids, brakes

These are directly connected without using any external evaluation devices and transferred to the “SINUMERIK Safety Integrated” platform.

Signal encoder versions for the sensors

1. Monovalent concept with NC / NC contacts

   This version is predominantly used for de-activation, for example for emergency stop or protective door contacts. The signals are checked for plausibility.

2. Monovalent concept with NO / NO contacts

   This version is predominantly used for activation. For example, for an enable button. When the enable button is pressed, safety functions, for example, are activated or drives are enabled. The signals are checked for plausibility.

3. Antivalent concept with NC / NO contacts

   This version allows sensors to be combined which both activate as well as de-activate such as those which are used as traversing buttons for drives. The signals are checked for plausibility.

An advantage of this version is that a short-circuit or broken conductor results in a non-plausible state.

Version 3, the antivalent concept, covers the requirements of versions 1. and 2.This is recommended in the VDW DESINA project.

Comments regarding the mechanical sensor design

A differentiation must be made between the following cases:

1. The sensor (e.g. safety interlocking) is a safety-related component and is certified.
   This means that a fault situation can be excluded - no additional measures are required.

2. The sensor is a component, which has been well-proven in operation, in accordance with EN 954-2
   A fault can be excluded under the following conditions:

   - Regular maintenance according to the manufacturers specifications
   - A sensor is regularly replaced after its product lifetime has expired
   - Fault detection is realized using downstream electronics with cyclic tests using dynamic update by the process (e.g. protective door), or using a forced checking procedure.

3. The sensor is a standard component.
   A fault cannot be excluded.

   - The two signal-generating elements (e.g. switching contacts of a pushbutton) of the sensor must be mechanically de-coupled – or two separate sensors must be used.
   - Faults are detected using the downstream electronics with cyclic tests using dynamic update by the process (e.g. protective door), or using a forced checking procedure.

Comments on the mechanical actuator design

A differentiation should be made between the following cases:

1. The actuator (e.g. safe motor starter) is a safety-related component and is certified.
   This means that a fault situation can be excluded - no additional measures are required.
2. The actuator is a component, which has been well-proven in operation, in accordance with EN 954-2 (e.g. valve)
   A fault can be excluded under the following conditions:

- Regular maintenance according to the manufacturers specifications
- An actuator is regularly replaced after the product lifetime has expired
- Fault detection is realized using downstream electronics with cyclic tests using dynamic update by the process (e.g. protective door) or using a forced checking procedure.

3. The actuator is a standard component.
   A fault cannot be excluded.

- Two separate mechanically decoupled actuators are required.
- Faults are detected using the downstream electronics with cyclic tests using dynamic update by the process (e.g. protective door), or using a forced checking procedure.

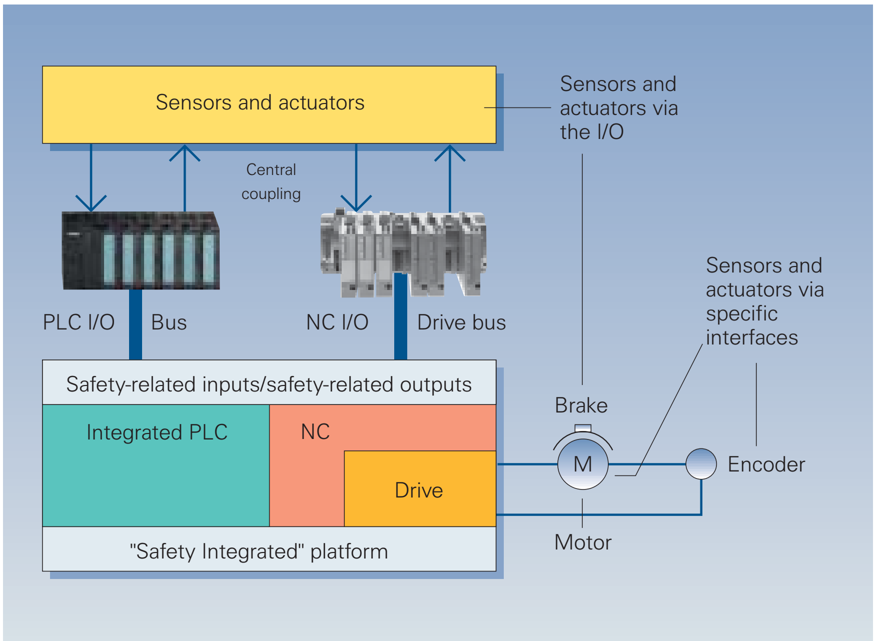


Fig. 5/16
Sensor-actuator integration via the S7 I/O and the DMP module of the NC

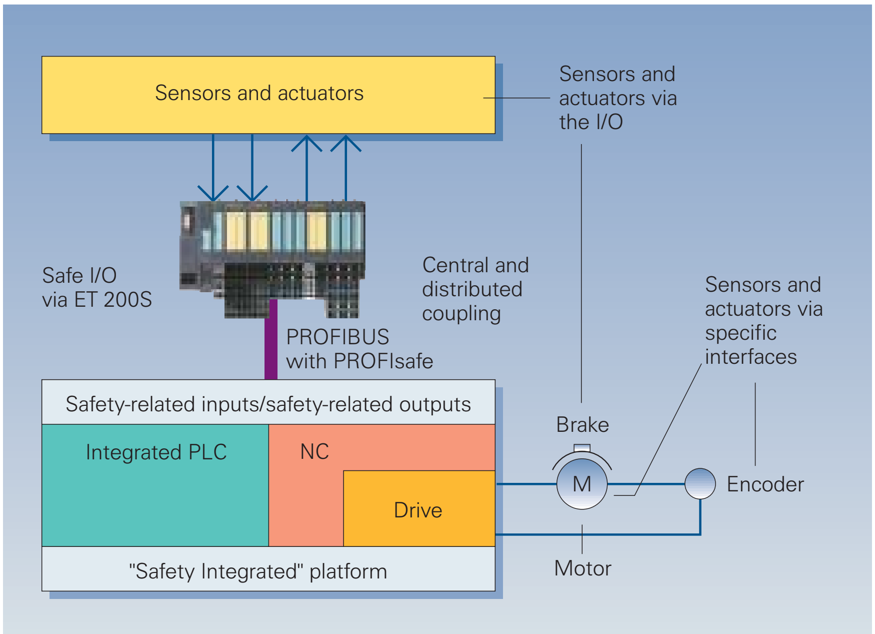


Fig. 5/17
Sensor-actuator iintegration via ET 200S PROFIsafe

5.1.8 Sensor-actuator integration via separate hardware I/O from the PLC and NC

Basic structure

The sensors and actuators are directly coupled to the standard I/O modules of the PLC and NC without using any external evaluation units. The signals are then available to the "SINUMERIK Safety Integrated" platform via separate buses. The 2 from 2 evaluation is always used when integrating sensors.

Features

- Standard I/O modules
- Separate hardware channels
- Separate buses

Sensor-actuator integration according to the 3-terminal concept

Integrating sensors

For sensors which are connected via the I/O of the PLC and NC, a 3-terminal concept can be used as basis. If the signals are read from a sensor through 2 channels, then a single-channel test output for control Category 3 is sufficient. Thus, to integrate the sensor in a safety-related fashion, three terminals at the I/O periphery are required.

2 inputs + 1 test output

Integrating actuators

For actuators which are connected through the I/O of the PLC and NC, a 3-terminal concept can also be used as basis. If an actuator is controlled through 2 channels, then it is sufficient to read back the process signal through one channel

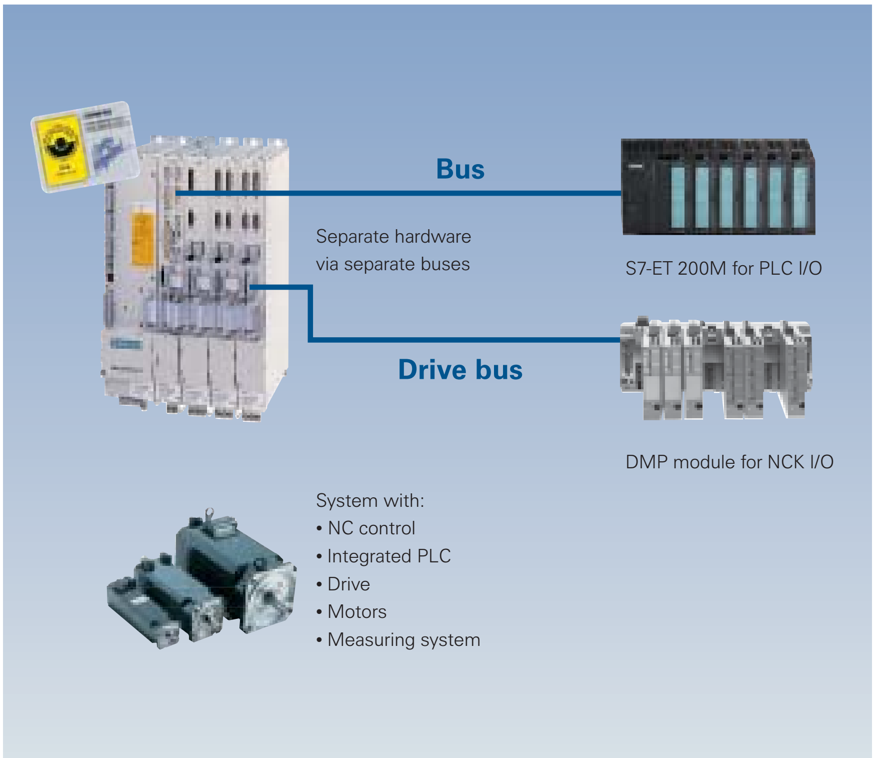


Fig. 5/18
Sensor-actuator integration via the S7 I/O and the DMP module of the NC

to fulfill control Category 3.This means that 3 terminals are also required at the I/O peripherals in order to integrate the actuator in a safety-related fashion.

2 outputs + 1 test input

Cross-circuit fault safety

If the connecting cables are routed, protected in the cabinet or parts of the system, then it can be assumed that faults are extremely improbable (short-circuit, cross-circuit,...). As defined in EN 954-2, so-called fault exclusion can be assumed for the connecting cable. This means that it is completely adequate if the sensor is connected-up accordance with the 3-terminal concept.

The measures applied for cross-circuit fault safety are independent of the control category (3 or 4).

Safety-related hardware input signals

All safety-related process signals (sensors, e.g. EMERGENCY STOP, protective door, light curtain...) must be configured redundantly and separately connected as "safety-related inputs" to the 2-channel inputs of the PLC and NC. In this case, it is not permissible that the input terminals are directly jumpered.

Application example: Emergency Stop

Features

- The sensor is controlled from a PLC test output with 24 V through a common connection and fed to the safety-related control via the two inputs channels 1 and 2.
- Faults (P and M short-circuit) can be detected in the connecting cables in conjunction with the crosswise data comparison and the forced checking procedure.
- A pure short-circuit between the two inputs from channel 1 and channel 2 cannot be detected using the 3-terminal concept.

It must be ensured that the signal state of the "safety-related inputs" does not differ. Depending on the tolerance timer (approx. < 1 sec.) when the tolerance time is exceeded, a monitoring function responds and the machine is automatically shut down.

Comment 1:

For sensors, which only have pure electronic outputs, i.e. no contacts, which is partially possible for light curtains, the circuit at the PLC and NC inputs stays the same. However, the test output of the PLC is directly connected to the special test input at the sensor. The 3-terminal concept is essentially kept.

Comment 2:

If a safety component (e.g. Emergency Stop button) is not used as sensor, then the two signal-generating elements (e.g. switching contacts for a pushbutton) must be mechanically de-coupled.

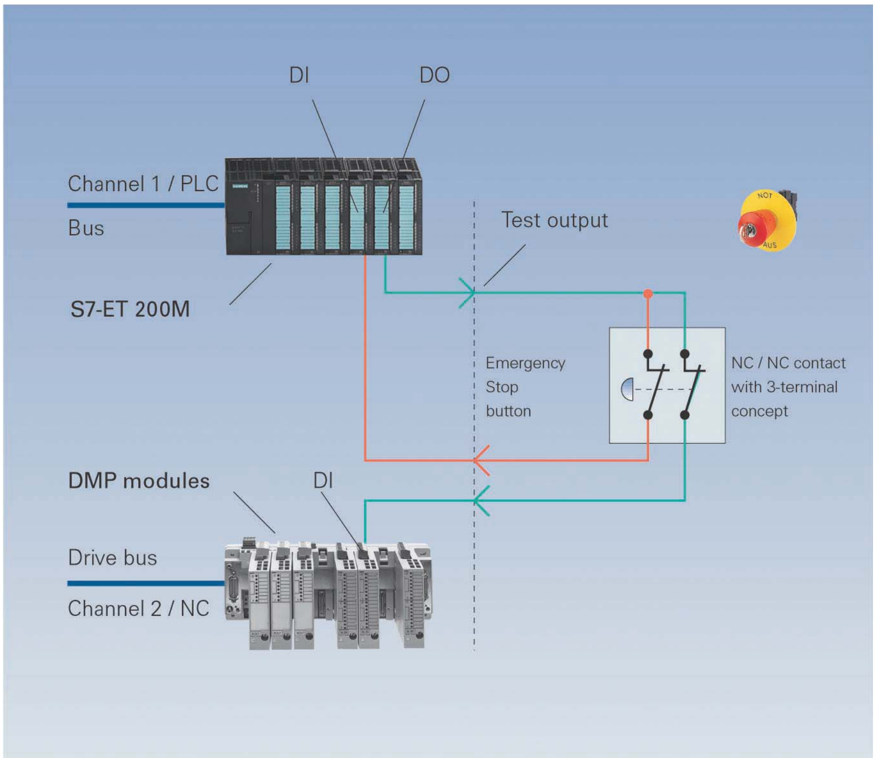


Fig. 5/19
Sensor integration using the 3-terminal concept – example for Emergency Stop

Sensor integration according to the 4-terminal concept

If it cannot be completely guaranteed that the connecting cables are protected against crushing (e.g. cables for HHUs), or if higher requirements are demanded as a result of the particular application, then a pure cross-circuit fault (neither P nor M short circuit) must be assumed in the hazard analysis. This means that the sensor must be connected using the 4-terminal concept. In this case, two separate cables are connected to the two signal-generating elements (e.g. contacts). 4 terminals are required at the I/O periphery to integrate the sensor in a safety-related fashion.

2 inputs + 2 test outputs

Cross-circuit fault safety

Using this technique, with standard modules, it is possible to implement complete fault detection functionality for the sensor connecting cables. The connecting cables do not have to be routed in any special way.

Safety-related hardware input signals

The basic principle corresponds to that of the 3-terminal concept. The extended measures are designed to detect a cross-circuit fault (i.e. no connection to M or P potential) between the two cables.

Application example: Emergency Stop

Features

- The sensor is directly controlled from two PLC test outputs, each with 24 V and is fed to the safety-related control through the two input channels 1 and 2.
- Test output 1 is delayed with respect to test output 2 by tx. This results, as expected response, in a unique signal characteristic at the input channels 1/2.
- A 1-channel test routine in the PLC checks this expected response. This test can be made as part of the forced checking procedure.
- In conjunction with the crosswise data comparison and the forced checking procedure, all faults (P and M short-circuit) including a pure short-circuit (cross-circuit fault) can be detected in the connecting cables.

Comment 1:

The concept presented here can only be used with sensors using contacts and in closed conductor circuits (closed-circuit principle). For electronic signals, the sensor must implement the cable monitoring function.

Comment 2:

If a safety component (e.g. Emergency Stop button) is not used as sensor, then the two signal generating elements (e.g. switching contacts for pushbuttons) must be mechanically de-coupled.

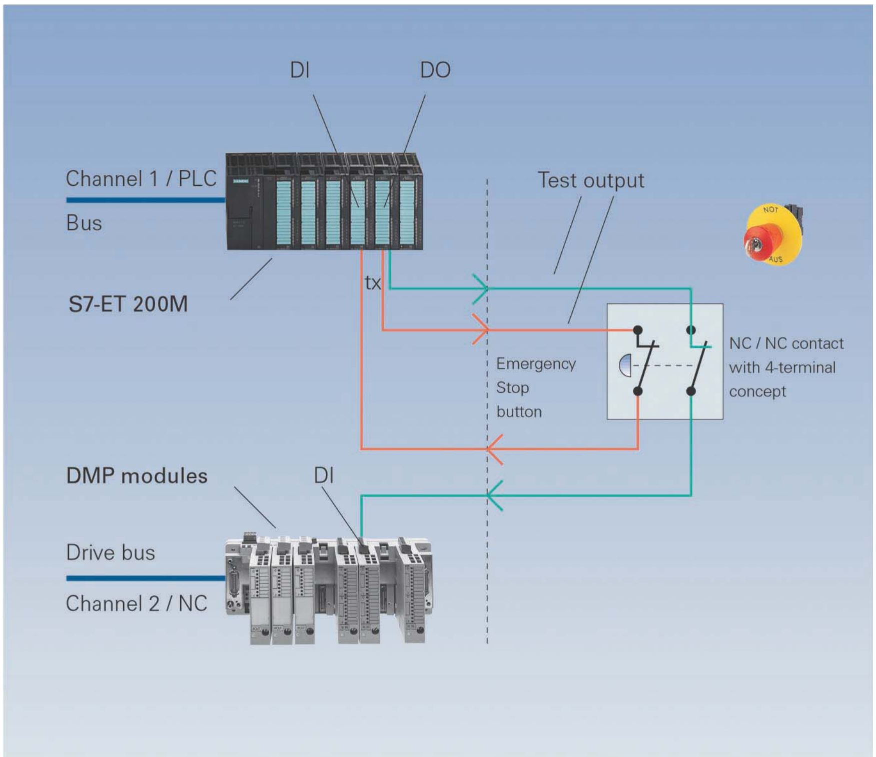


Fig. 5/20
Sensor integration using the 4-terminal concept – example for Emergency Stop

Safety-related hardware output signals - P/P switching

For P/P switching versions, two actuators always switch in series in the load circuit. Both channels (NC and PLC) control the actuators with a positive voltage (24 V) (positive-positive switching). Commercially available contactors with positively-driven feedback signal contacts can be used, for example to switch motors.

The feedback signal from the load circuit should be derived as directly as possible from the actual process quantity. For example, it is preferable to use a feedback signal from the hydraulic pressure using a pressure sensor or a checkback signal from the moved mechanical system (endstop) using a Bero instead of using an indirect feedback signal from the hydraulic value.

Application example:
400 V load voltage

- The 400 V load voltage of standard induction motors is safely disconnected
- The 400 V load voltage of distributed units is safely disconnected

Features

- The load circuit is always controlled through two channels
- There are always two actuators - this means that the load is always interrupted or switched through two channels
- Commercially available (standard) components can be used as actuators, e.g. contactors, valves as two devices are always used.
- The positively-driven checkback signal contacts (NC contacts) of the actuators are permanently connected to 24 V, are switched in series and are read back from the PLC through one channel.
- Faults in the control and at both of the actuators can be detected in conjunction with the forced checking procedure
- When an actuator fails, the load can still be disconnected through the second channel
- The actuator can be switched purely via the PLC through one channel dependent on the process.

Safety-related hardware output signals – P/M switching

For P/M switching versions, only a single actuator switches the load circuit. The NC channel controls the actuator with a positive voltage (24 V); the PLC channel controls the actuator with M potential (positive M switching). This control version is always required if there is only one solenoid to directly control the load circuit. This is, for example, the case for:

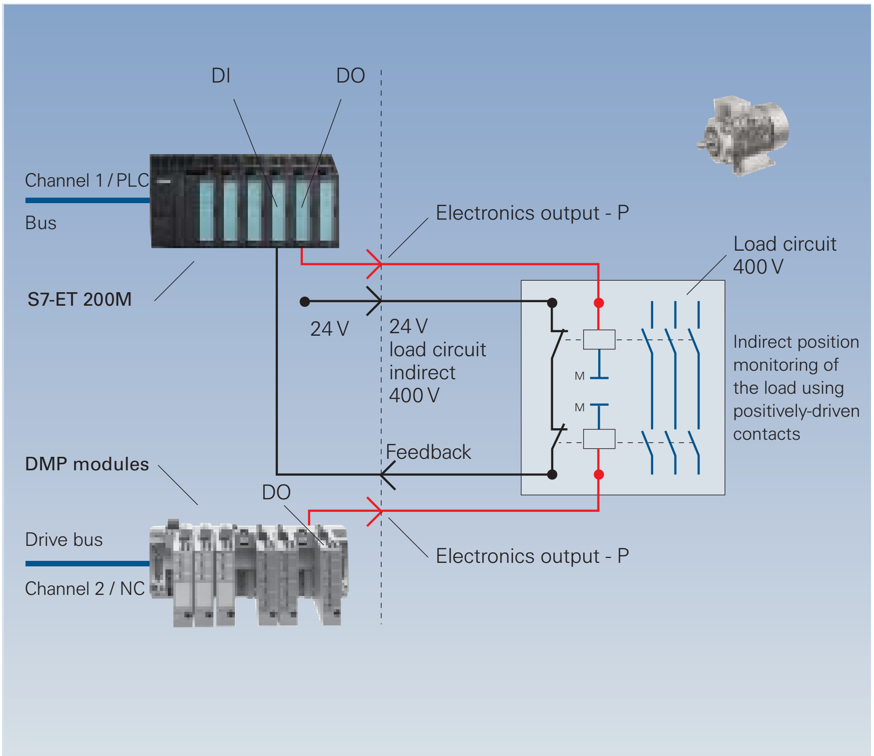


Fig. 5/21
400 V load circuit – P/P switching – example of a standard asynchronous motor

- Tumbler solenoids on protective doors
- Holding brakes integrated in motors
- Operating brakes hydraulically controlled through valves (e.g. for linear motors)

The feedback signal from the load circuit should be derived as directly as possible from the actual process quantity. For example, it is preferable to use the direct feedback from the hydraulic pressure using a pressure sensor or the feedback signal of the moved mechanical system (endstop) using a Bero instead of using the indirect feedback signal from the hydraulic valve. If there is only one actuator in the load circuit, as is the case here, then additional measures are required, for example, the actuator must be subject to a cyclic function test.

Comment:

If there is no feedback signal contact available, then it is possible to proceed as described in the application example "safe brake control – P/M switching."

- In conjunction with the forced checking procedure, faults in the control and at the actuator can be detected.
- If the actuator fails, the load can no longer be safely shut down through the specific path. In this particular case, depending on the hazard analysis and the type of actuator, additional measures must be applied; these can include, e.g. central shutdown or extended test measures.
- The actuator can be solely switched via the PLC through a single channel, depending on the process.

Application example: Safety-related brake control – P/M switching

The basic principle is described in the Section “Safety-related hardware output signals – P/M switching.”

The “safe brake control” is part of the “safe brake management” function.

For a description, also refer to Section 5.1.10 “Protection against vertical axes dropping."

Features

- The load circuit is always controlled through 2 channels.
- There is only one brake (actuator). The process quantity, in this particular case, the braking torque, is only applied through one channel.
- The feedback signal is formed from the ground-side connection of the solenoid coil. This means that M and P short-circuits can be detected. This also means that the 3-terminal concept can be used.
- The output from channel 1 is switched with a delay tx with respect to channel 2. This results, as expected response, a clear signal characteristic at the feedback signal input.
- A single-channel test routine in the PLC checks this expected response and this could be executed as part of the forced checking procedure.
- A safe brake test is provided as extended test measure. This tests the actual braking torque available. This function is available with the “safe brake management.” The brake torque test is incorporated in the forced checking procedure for the test stop (testing the shutdown paths).
- During power failures or when cables are interrupted, the brake is mechanically brought into a safe condition as a result of the return springs.
- Only components, proved in operation in compliance with EN 954-2 may be used as actuators.

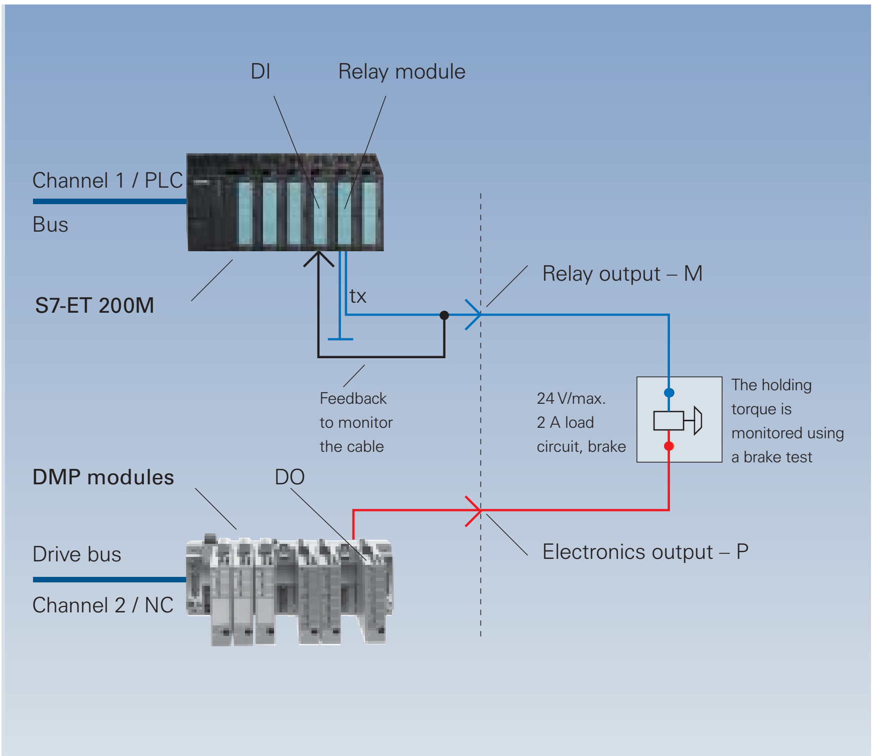


Fig. 5/22
24 V load circuit – P/M switching – example of Safe brake Control

Safety-related hardware output signals – P/M switching with intermediate relay stage

With this example, contrary to the previously described direct P/M switching version, the load circuit is controlled through an additional intermediate relay stage to amplify the current. The intermediate relay stage must be used if there is no 2 A output module of the NC I/O and/or no S7 relay module available or if the load current to be switched is > 2 A.

The outputs used in the NC and PLC are standard outputs where the intermediate relay stage is switched P/P.

Caution!

When using the intermediate relay stage, in comparison to the best case (fast, contact-free NC path switching), the response time is extended by the relay switching time. This results in longer response times which in turn means that the axes drop further (sag) when faults develop.

Application example: 24 V load voltage > 2 A

- Load power supply from distributed units with > 2 A
- Brakes with > 2 A

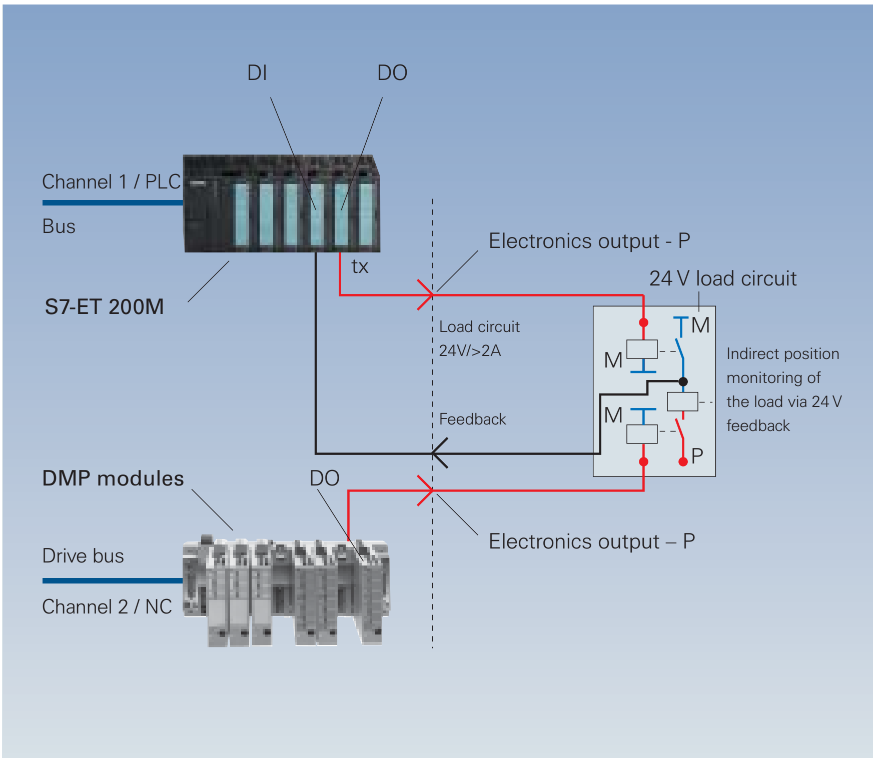


Fig. 5/23
24 V load circuit – P/M switching with intermediate relay stage for > 2 A

Features

- Principally, the same features apply as for the direct P/M switching control.
- The control in the 24 V load circuit remains P/M switching as shown in Fig. 5/22.
- It is not absolutely necessary to integrate positively-driven checkback signal contacts of the intermediate relay stage. This means that standard relays can be used which do not have positively driven feedback signal contacts. However, in this case, the prerequisite is that the feedback signal from the M potential of the load circuit is incorporated.
- Erroneous functions in the load circuit path are detected as a result of the direct feedback signal from the M potential, e.g.
  - if the relay does not switch/ drop-out (e.g. because the relay, contacts do not open)
  - short-circuits on the 24 V control cables and the load circuit.

5.1.9 Sensor/actuator integration through the fail-safe ET 200S PROFIsafe modules

Basic structure

The sensors and actuators are directly connected, without any external evaluation units, to the safe inputs and outputs of the ET 200S PROFIsafe. The signals are then available to the "SINUMERIK Safety Integrated" platform through safe communications with PROFIsafe. The sensor/actuator integration is significantly simplified by using ET 200S PROFIsafe.

It is:

- Simpler to install
- Has a modular design
- Can be more flexibly used
- Has more transparent documentation

Features

- Fail-safe ET 200S modules for F-DI inputs, for F-DO outputs and for group shutdown operations using the PM-E F Power Module
- Safe communications via PROFIBUS-DP using the PROFIsafe profile
- Standard design concept where, for control Category 3, safety-related and non-safety-related modules can be used together
- Fail-safe motor starter through the PM-D F Power Module with 6 load groups
- "Distributed Safety" engineering tool from SIMATIC S7

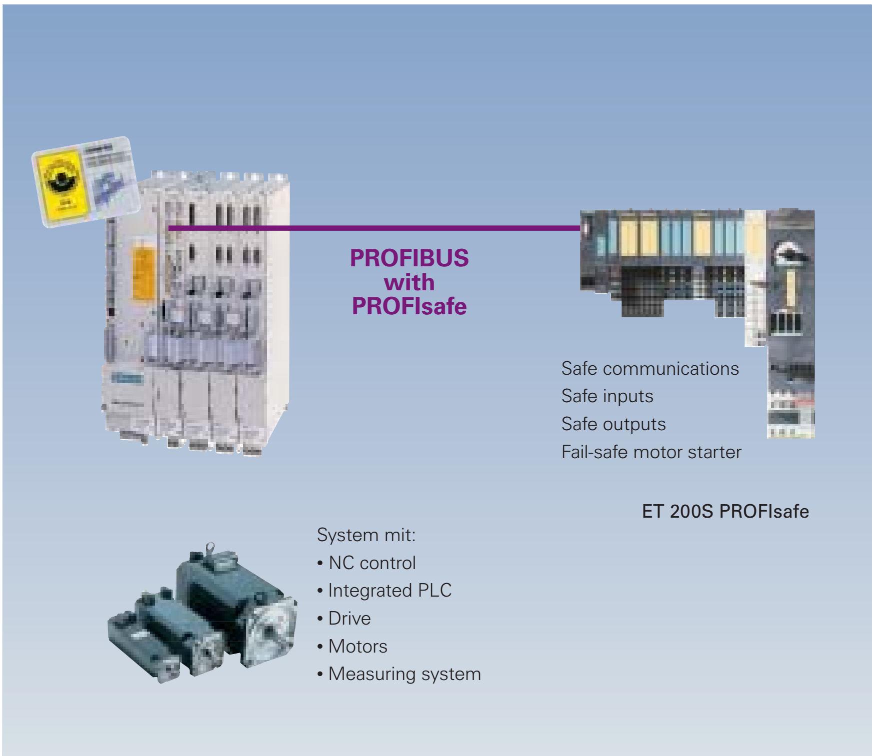


Fig. 5/24
Sensor-actuator integration through ET 200S PROFIsafe

Sensor integration using fail-safe inputs of an F-DI (2-from-2 evaluation)

A 2-from-2 evaluation means that the sensor has two signal-generating elements (e.g. contacts) which are processed using a two-channel evaluation logic.
For each F-DI, up to 4 sensors can be connected (e.g. Emergency Stop pushbuttons).
Connection system: 2 inputs + 2 test outputs

Application example: Emergency Stop and enable

- Emergency Stop pushbutton with NC/NC contact
- Enable button with NO/NO contact

Features

- The F-DI supplies the sensor from redundant voltage sources with 2 test outputs and reads back the sensor signals via inputs.
- The F-DI checks the plausibility of the signals and monitors the cables/conductors to the sensor. After it detects a fault/error, F-DI outputs a fault signal.

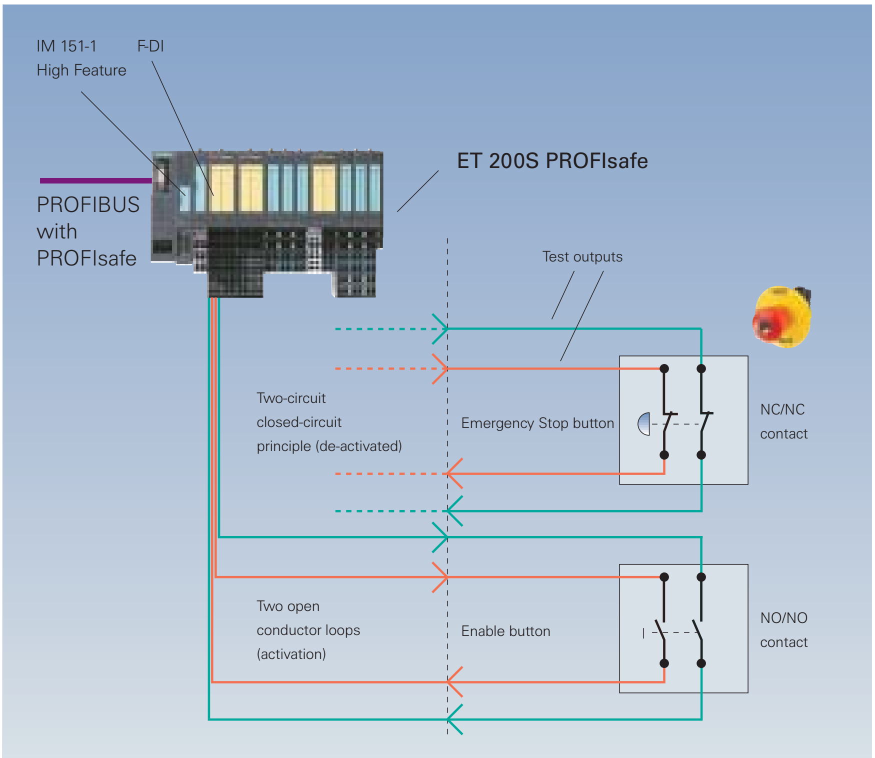


Fig. 5/25
Sensor integration via fail-safe inputs – example of Emergency Stop and enable button

Actuator integration through fail-safe outputs of an F-DO up to 2A (P/M switching)

P/M switching (positive-ground switching) using an F-DO means that the load circuit is redundantly controlled through electronic outputs. This is implemented using actuators, e.g. load contactors, which are generally available twice and therefore safely interrupt the load circuit in a series circuit configuration. The feedback signal from the load circuit should be derived as directly as possible from the process quantity. For example, the direct feedback signal of the hydraulic pressure through a pressure sensor or the feedback signal of the moved mechanical system (end-stop) using a Bero is preferred over an indirect feedback signal from the hydraulic valve. If there is only one actuator in the load circuit (e.g. for a holding brake, valve for a hydraulic operating brake), then additional measures are required, for example, the actuator should be subject to cyclic function tests.

For each F-DO, up to 4 actuators can be connected using this connection system.

Connection system: 2 outputs + 1 test input or as an equivalent, extended function tests

Application example: 400 V load voltage

- The 400 V load voltage of a standard asynchronous motor is safely disconnected
- The 400 V load voltage of a distributed unit is safely disconnected

Features

- The F-DO controls the actuator with the positive potential (24 V) with one channel and the ground potential (0 V), with the other channel. This means that it is positive-ground switching

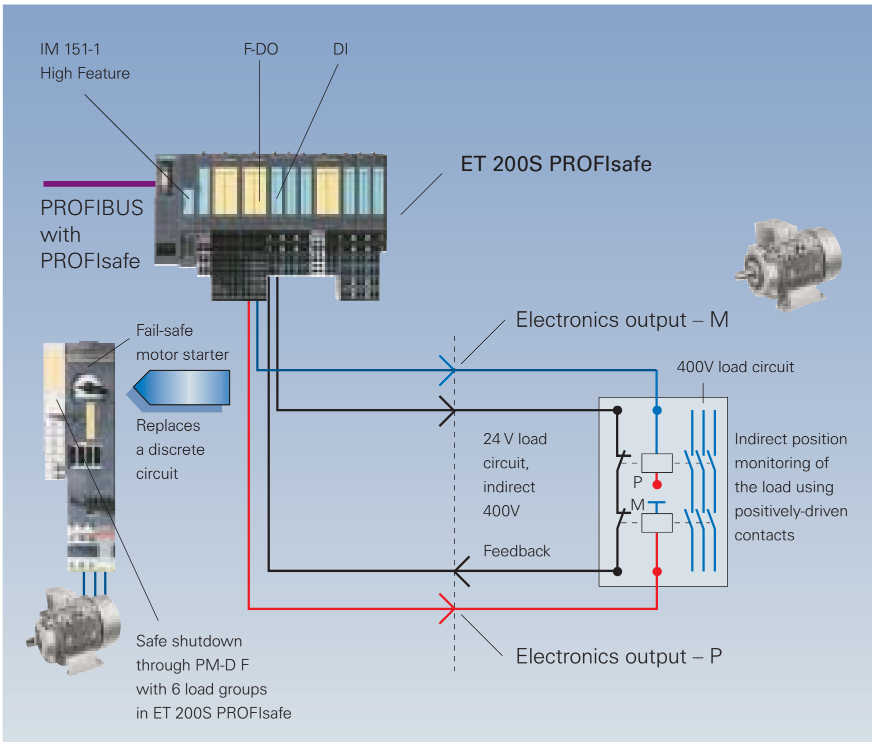


Fig. 5/26
400 V load circuit – P/M switching / motor starter – example of a standard asynchronous motor

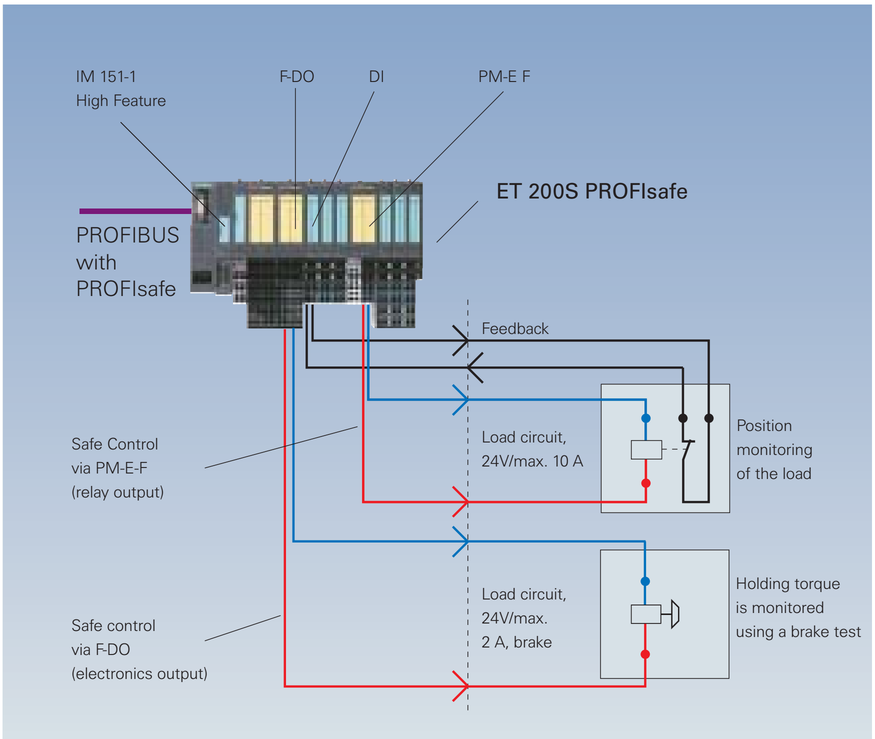


Fig. 5/27
24 V load circuit – P/M switching up to 2 A and up to 10 A

- The feedback signal (test input) of the positively-driven contacts is realized through a standard input of a DI of the ET 200S.
- The expected response can be checked, for control category 3 in the PLC through 1 channel.
- The F-DO monitors the control cables/conductors of the actuator - when a fault/error develops, the outputs are switched into a safe condition.
- When a contactor fails, the load can be disconnected using the second channel.

Versions:

- The two load contactors can also be controlled in parallel directly between the P and M channels.
- A motor starter in ET 200S PROFIsafe can completely replace the discrete circuit through two load contactors.

Application example:
24 V load voltage

- The 24 V load voltage of actuators up to max. 2 A is safely disconnected - e.g. for brakes
- The 24 V load voltage of distributed units or load groups up to max. 10 A is safely disconnected

Feature – 24 V load voltage up to max. 10 A

- Using the two channels, the PM-E F controls the actuator directly, P/M switching. The 24 V / 10 A backplane bus is available externally at terminals.
- The feedback signal (test input) of the positively-driven contacts is realized via a standard input of a DI of ET 200S.
- The expected response can be checked, for control category 3, in the PLC through 1 channel.

Features – safety-related brake control up to max. 2 A

- The F-DO directly controls the two channels of the actuator P/M-switching.
- There is no feedback signal for the holding torque. This is the reason that a safety-related brake test is provided as extended test measure. This checks the available braking torque. This function is available with the "safe brake management." The braking torque check is incorporated in the forced checking procedure for the test stop (testing the shutdown paths).

  Also refer to Section 5.1.11.
- During power failures or when cables are interrupted, the brake is mechanically brought into a safe condition as a result of the return springs.
- Only components, proved in operation in compliance with prEN 954-2 may be used as actuators.

Application example: Protective door

The special feature of an application with a protective door is the coupling with additional process signals using "safe programmable logic." Generally, the release must be safely prevented until all of the process parameters are in a safe condition.

For instance, the protective door may only be opened, if

- A spindle which is coasting down is at a low, non-hazardous speed or is at a standstill.
- A vertical axis, after the brake test with defective brake is moved into a safe position (clamped position).
- A unit with hazardous energy levels is brought into a safe condition, for example, a laser or a hydraulic system

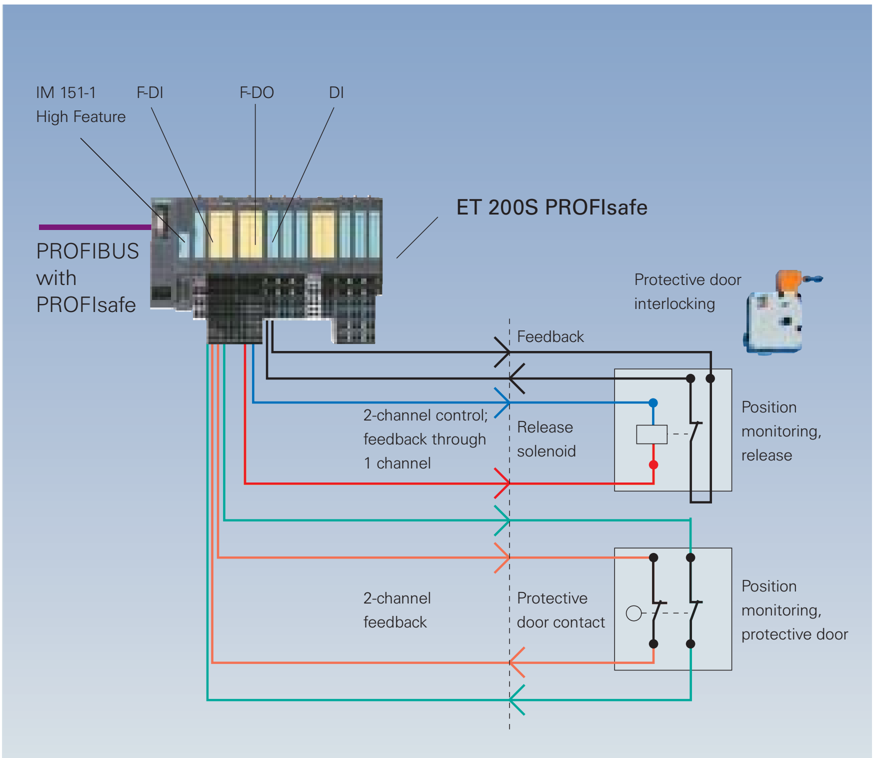


Fig. 5/28
Sensor-actuator integration using protective door interlocking as an example

Features

- The release solenoid is directly and safely controlled from the F-DO (P/M switching)
- The position monitoring of the release mechanism is fed back through one channel and a standard DI
- The expected response can be checked, for control Category 3 in the PLC through 1 channel
- The protective door position is entered through two channels via the F-DI.

Actuator integration through fail-safe outputs of a PM-E F up to 10 A (P/M switching)

Using a PM-E F, 24 V load voltages up to 10 A can be switched through an internal, safe relay combination, P/M switching:

- Through the 24 V backplane bus and standard DOs as load group inserted located to the right of the PM-E F
- Through terminals for distributed load groups

In addition, the PM-E F has two safety-related electronic outputs, each 2 A, comparable to F-DO.

This results in a total module current of max. 14 A: 10 A relay output (24 V backplane bus/terminal) + 2 x 2 A electronic outputs

Application example: 24 V load voltage for a valve group up to 10 A

Generally, valves do not have a direct checkback signal. This means that extended measures are required to secure the process sequence, for example:

- Feedback signal of the hydraulic pressure, controlled by the valve, using a pressure sensor
- Checkback signal from the mechanical system moved by the valve (end-stop) e.g. using a Bero proximity switch

Depending on the hazard analysis, it may also be necessary to connect two valves in series - comparable to contactors in the 400 V load circuit - or to use a safety valve.

However, the basic control principles remain.

Also refer to Fig. 5/17 "24 V load circuit - P/M switching up to 2 A and up to 10 A"

Features

- The valves are selectively controlled through standard DOs.
- The PM-E F shuts down the standard DOs, supplied by it, through the 24 V backplane bus (P/M switching).
- The feedback signal (test input) from the process sequence can be realized using sensors, which are connected through a standard input (DI).
- The expected response can be checked, for control Category 3 in the PLC through 1 channel.
- Erroneous functions in the load circuit path are detected by the PM-E-F and the feedback signal, e.g.
  - When the valves do not switch/ drop-out (they jam)
  - Short-circuits on the 24 V- control cables and the load circuit.

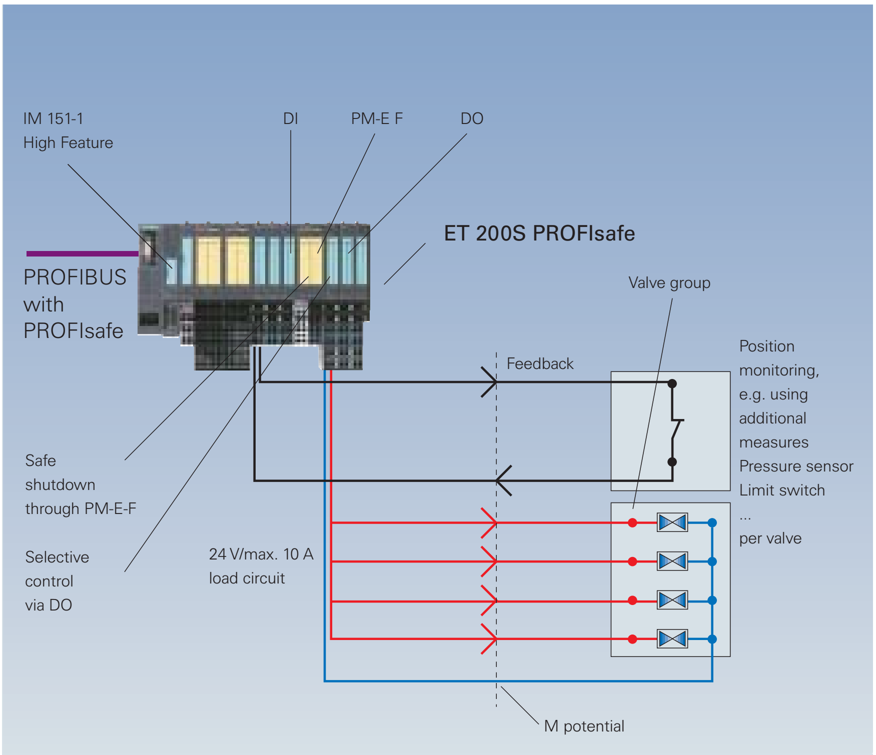


Fig.5/29
24 V load circuit with group shutdown up to 10 A – example of a valve block

5.1.10 Protection against vertical axes falling

General requirements

When drives are shut down, axes or mechanical systems can drop due to gravity. With vertical linear axes (hanging axes) or for rotary axes or spindles with a non-symmetrical weight distribution, this can therefore result in potentially hazardous movement. This means that these axes and mechanical systems must be safely held at standstill using suitable measures. Measures to achieve this can include, for example:

a) Sometimes active

Holding brake
Operating brake
Electric drive

b) Permanently active

Mechanical weight equalization

c) Active in exceptional cases

Locking studs
Various types of supports

The measure or measures which is/are selected depends on the type of work which is to be carried-out in the hazardous area. Is work to be directly carried-out under a suspended load or only close to it? Also the time spent in the hazardous area must be taken into account in the design phase as this may make it necessary to combine several measures. The hazard analysis always forms the basis and this must be carefully carried-out for every machine. The overall concept must be designed so that it fulfills the requirements for personnel protection according to the EEC Machinery Directive.

Comment:

When carrying-out work on live parts and components (with the exception of safety extra-low voltage), electrical isolation from the line supply is always required.

Requirements from the German Trade Association data sheet (EM II, Mainz)

The requirements placed on machines with the appropriate hazard potential are described in this data sheet.

Here are some of the most important requirements as excerpt:

- Safe, redundant holding system to "protect against vertical axes falling"
- Test of the mechanical brakes (control Category 2 acc. to EN 954-1)
- Protection against undesirable restarting of the electric drive (control Category 3 acc. to EN 954-1)
- Acceptance test using a form sheet

The actual document can be viewed in the Internet under

www.smbg.de/sites/institutionen/fachausschuss.htm

Concept to protect against vertical axes falling

The existing systems - electrical drive and mechanical brake - form together the safe, redundant holding system. The safety concept of SINUMERIK Safety Integrated integrates these standard components so that their effect is safety-relevant.

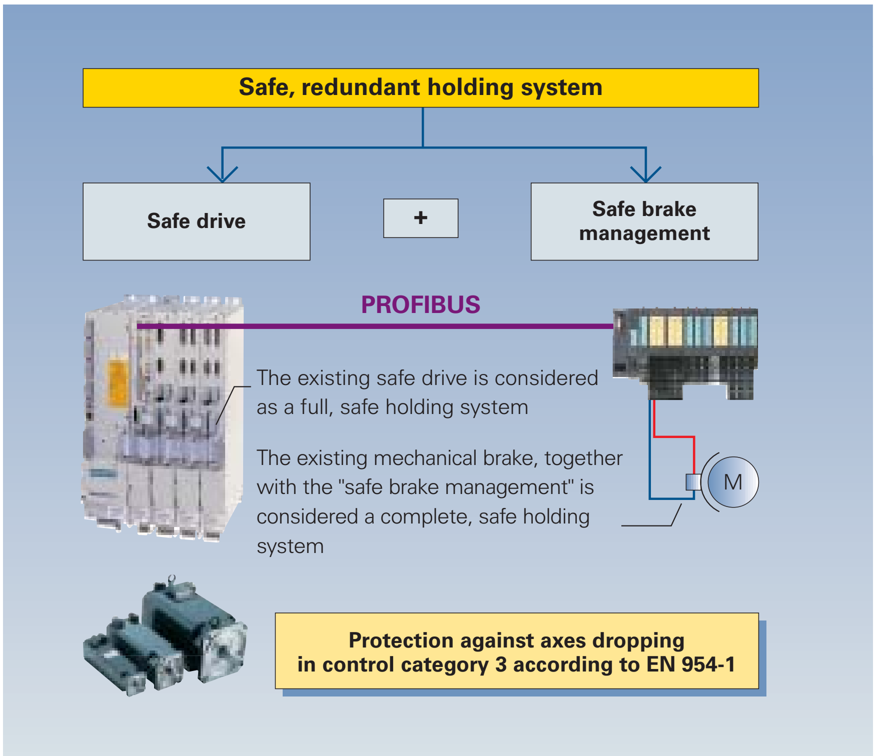


Fig. 5/30
Protection against vertical axes falling

1. A safe drive is achieved using safety functions, e.g.:
   - "Safe stopping process"
   - "Safe operating stop"
   - "Safely reduced speed"

2. A safe brake function is achieved using the "safe brake management" with the subfunctions:
   - "Safe brake control"
   - "Safe brake test"

The safe drive forms the 1st holding system and is mainly active - the mechanical brake forms, as safety-related brake function, the 2nd holding system and is (open) in the standby mode.

When the drive fails, the brake is automatically and safely activated and assumes the function of holding the mechanical system. It is not absolutely necessary to use a second brake.

This means, that for the first time, there is an extensive and integrated solution available to provide "protection against vertical axes dropping" (as well as rotary axes or spindles with non-symmetrical weight distribution).

With this functionality, the risk when working with hanging loads, is significantly reduced therefore playing an important role in personnel protection. Not only this, machine damage as a result of dropping axes is essentially avoided and the availability of machines and systems increased.

Depending on the particular requirement, the safe redundant holding system can be used in the following applications:

1. The drive is active, the brake is open and in the standby-mode
   Objective: The distance that the axis drops is minimized to < 25 mm

   - the drive can move or is stationary
   - The brake is automatically and safely closed as soon as the drive fails, e.g. as a result of a system fault

   Result:
   Depending on the speed/ velocity, direction of motion, system response time, brake closing time and friction of the mechanical system, an unavoidable sagging of the vertical axis occurs.

2. The drive and the brake are simultaneously active (drive with adapted control parameters/ filters)
   Objective: Minimize the distance that the axis drops to < 1 mm

   - The drive is stationary, the brake is closed
   - Automatic signal as soon as one of the two holding systems fails
   - The holding system, which is still intact, now exclusively holds the mechanical system

   Result:
   The vertical axes do not drop through any significant distance which is relevant for personnel protection.

Comments:

- Acceptance certificate
  The distance which an axis drops should be measured and documented in the acceptance certificate!
- Drive shutdown as a result of the operation
  The drive is also shut down as a function of the operation, independent of system faults. For example, for an Emergency Stop. In this case, the brake is closed before the drive is shut down and the vertical axis is mechanically clamped. This involves a specific operation which means that the vertical axis does not drop by a value which is significant regarding personnel protection (< 1 mm).

Safe brake management - SBM

The reliability of a mechanical brake is a significant component when protecting vertical axes from dropping. Analyses of accidents indicated that both faults in the control as well as in the mechanical system of the brake were responsible for vertical axes dropping. The analysis also indicated that these accidents could have been avoided by using safety technology.

With this as background, we are offering our customers a solution with "safe brake management."

The "Safe Brake Management" SBM (Safe Brake Management) comprises two function elements:

1. Safe brake control
   SBC (Safe Brake Control)
2. Safe brake test
   SBT (Safe Brake Test)

Brakes which are generally used today are not safety-related components. By integrating the standard brake (a component proven in operation) in the safety concept of SINUMERIK Safety Integrated, a safe brake function is obtained.

The brake is safely controlled and is subject to a forced checking procedure. Extended test measures are required as there is no feedback signal for the holding torque. The safe brake test can fulfill this requirement. Faults in the control and in the brake mechanical system can be detected using the extended test measures.

Depending on the result of the hazard analysis, there are various ways of mounting the brake:

1. A brake in the motor
   - mechanical transmission elements with an overload factor > 2 (German Trade Association EM II, Mainz)
2. A brake at the load
   - Mechanical transmission elements with an overload factor < 2
3. A brake in the motor
   - and a brake at the load for special requirements

In case of doubt, the preferred solution is to mount the brake at the load, e.g. on the linear guide instead of mounting it in or on the motor.

Safe brake control

The brake (operating or holding brake) is, in control Category 3 (acc. to EN 954-1) safely and electrically controlled. Control is realized through 2 channels (P/M switching) with:

- Safety-related outputs with separate PLC and NC hardware
- Fail-safe F-DO outputs in ET 200S PROFIsafe

Using these two versions, it is possible to detect faults on the control lines, for example, short-circuits, broken cable etc. Even if a channel fails, the brake can still be controlled.

Also refer to Sections 5.1.8 and 5.1.9.

Comment:

Intermediate relay stages increase the response time when controlling the brake - this increases the distance that the vertical axis drops. This is the reason, if possible, that a direct electronic control is preferred. This is possible up to 2 A.

Safe brake test

The safe brake test cyclically tests as to whether the expected holding torque is still available. In this case, the drive deliberately moves against the closed brake and subjects this to a test torque - when successful without the axis moving. However, if the axis moves, then it can be assumed that the brake holding torque is no longer sufficient to hold the vertical axis. The test is canceled and a fault signal is output. The axis should then be traversed into a safe position and the vertical axis disengaged or clamped using the appropriate studs. This can also be automatically realized. The protective door remains interlocked until the "clamped position has been reached. This can be interrogated using "safe software cams". The brake must be serviced if all conditions are fulfilled.

The safe brake test is executed as part of the forced checking procedure before testing the shutdown paths. If a brake defect is detected, the shutdown path test, which would result in a pulse cancellation, is no longer initiated, and a fault message is output.

The safe brake test is realized in control Category 2.

Comment regarding stop Category 1 according to EN 60204 for Emergency Stop

After regenerative braking, the standard requires that the electric drives are isolated from the power source as protection against undesirable restart. However, Emergency Stop has the goal of providing protection against potentially hazardous motion and not to protect against electric shock. EN 60204 does not taken into account that safe drives for Emergency Stop with stop Category 2 must at least guarantee the same quality. For a stop Category 2, safe drives after stopping, go into the "safe operating stop" and remain fully functional in the closed-loop controlled mode.

The following scenario with conventional technology will clearly show this:

1. For a vertical axis, the holding torque of the mechanical holding brake is zero as a result of a fault (control/mechanical system).
   An Emergency Stop is configured with stop Category 1 acc. to EN 60204.
2. For conventional safety concepts, faults in the brake control as well as in the mechanical brake system are not detected – it therefore involves a "dormant fault".
3. An operator now presses Emergency Stop!
   Result:
   The holding brake is defective and the drive is disconnected from the power source as a result of stop Category 1. This means that the vertical axis drops down and, in conjunction with Emergency Stop, results in a potentially hazardous movement!

Here is the same scenario using safe drives

1. For a vertical axis, the holding torque of the mechanical holding brake is zero due to a fault in the mechanical system (a fault in the brake control is immediately and directly detected and the brake is closed through the second channel). Emergency Stop is configured, according to EN 60204 with stop Category 1 .
2. The fault is detected using a brake test. An appropriate fault signal is displayed.
   The protective door remains interlocked and the axis must be moved to a safe position.
3. An operator now presses the Emergency Stop before the safe position is reached!
   Result:
   In spite of the fact that the Emergency Stop is activated, the drive with the defective brake is not disconnected from the power source, but is safely stopped and then the standstill state is safely monitored using the safe operating stop. There is no potentially hazardous motion.

5.1.11 Basic application principles

Forced checking procedure, general

(taken from [Reinert, D.; Schaefer, M.; Umbreit, M.: Drives and CNC controls with integrated safety. In: ETZ Magazine 11/98], Technical Article of the German Trade Association)

A forced checking procedure must be carried-out for all steady-state (static) signals and data. Within the requested time (8 h), a state must change from a logical 1 to logical 0 or vice versa. If the state, when a fault develops, remains static, then this is detected, at the latest at the forced checking procedure and the subsequent comparison.

A forced checking procedure must be provided, e.g. for all of the components required for shutdown (e.g. contactors and power semiconductors), the so-called shutdown path and for the stopping condition itself. Generally, the shutdown condition, e.g. if a limit value criterion is violated, cannot be tested using another measure, such as cross-comparison, if the machine is in the "good" condition. This also applies to faults in the complete shutdown path including the associated hardware and software and the power switching elements. By providing a test stop in an 8-hour cycle with comparison, and an appropriate expectation response, faults can be reliably detected, even when the machine is in the "good" condition (in this case, good condition means that the operator has not identified a machine fault).

Forced checking procedure with SINUMERIK Safety Integrated

The forced checking procedure is used to detect faults in the software and hardware of the two monitoring channels. In this case, the safety-relevant components in the two channels must be processed at least once within a defined time period and in all safety-relevant branches. A fault in a monitoring channel results in deviations and is detected by the crosswise data and result comparison.

The user must initiate the forced checking procedure of the shutdown path (test stop) or it must be automatically integrated into the process, and, more specifically as an example:

- With the axes stationary after the system or plant has been powered-up,
- When the protective door is opened,
- In a specified frequency (e.g. in an 8-hour cycle),
- In automatic operation, time and event-dependent.

The forced checking procedure also includes testing safety-relevant sensors and actuators. In this case, the complete signal change, including the "safe programmable logic" is checked for its correct functioning.

Comment:

For the duration of automatic operation (with the protective door closed), the fixed 8-hour cycle isn't mandatory. In this case, the forced checking procedure can be logically combined, after 8 hours have expired, the next time that the protective door is opened. As a result of the crosswise comparison, errors are detected in the safety-relevant data of the two monitoring channels. For "changing" data, there are tolerance values specified by the machine data. The results of the two channels can deviate within these tolerances, without a response being initiated. An example is the tolerance for crosswise comparison of the actual positions. Faults and errors, which are detected as a result of the forced checking procedure and crosswise comparison, result in a Stop F response and initiate additional stop responses (refer to Section 5.1.4 "Stop Responses").

Acceptance test

(taken from [Position Paper DKE 226.0.3: Safety-related functions of electric drive systems in machines. Status 1/98.], Position paper DKE – AK 226.03)

- Acceptance test, complete
  For a complete acceptance test, all of the safety functions provided (i.e. maintaining the limit values, functions of the control transmitters, functions of the actuators) are checked. In so doing, the fault response becomes physically effective. It is checked that the safety functions operate correctly.
- Acceptance test, partial
  For a partial acceptance test, those safety functions are checked which are involved when safety-relevant data is changed.

According to the DKE position paper, the machinery manufacturer (OEM) must carry-out an acceptance test of the activated safety functions. During the acceptance test, the entered limit values of the enabled SI functions are deliberately exceeded in order to check the correct function and the associated response.

The activated safety functions and the results of the acceptance test should be entered in an acceptance certificate. A form for the acceptance certificate as well as also integrated functions to generate the acceptance certificate are available

* Deadman operation

This term originally comes from the railways.

Significance: The function only remains effective as long as the actuating element (button) is pressed. If the actuation element is released, the function is interrupted and the potentially hazardous motion is stopped.

Application examples

By combining "SINUMERIK Safety Integrated" safety functions, completely new operator control concepts can be implemented at machines - fulfilling the widest range of requirements.

- Setting-up operation with the protective door open
  With the protective door open, feed or spindle drives can be operated with a safely reduced speed or are safely monitored at standstill. The drives are always monitored by the electronics and do not have to be disconnected from the power source. Working and protective zones can be implemented using safety-related technology with functions to identify ranges and limit traversing ranges. An enabling switch in conjunction with SINUMERIK Safety Integrated is not mandatory. However, depending on the requirement, it can be used, e.g. to change over safety functions. In the standard case, the drives may only be moved using jog keys in deadman operation*.
- Test operation with the protective door open
  For the first time, a program can be run in the test mode where the complete program or program parts are executed with safely reduced speed in a so-called "dry-run." In this case, the operator ensures that the program is continually executed by pressing a button, generally the start button. If a program error is identified when testing, then the operator can hold the program by releasing the start button or by pressing the EMERGENCY STOP button. During this test phase, the safety functions are active. They respond when limit values are violated, and automatically shut down the drives.
- Integrated, contactless EMERGENCY STOP
  The EMERGENCY STOP button can be connected directly to the redundant input periphery of the PLC and NC or to the fail-safe ET 200S PROFIsafe input modules through its two contacts without having to use additional evaluation logic. The logical combination and the required responses are realized internally using safety-related technology. The electric drives are safely shut down and are then contactlessly isolated from the power via the electronics. A restart is safely prevented. External power sources, for example, hydraulic systems or lasers etc., can be shut down using safety-related technology via the redundant or fail-safe output periphery from the integrated EMERGENCY STOP logic and downstream actuators (power contactors, valves, ...).
- Comment regarding EN 60204:
  The new national foreword of EN 60204 in principle allows EMERGENCY STOP to be implemented using software and electronics. However, it must be proven that the new specific standards, such as e.g. EN 954-1 or IEC 61508, are maintained. This means that the national foreword of EN 60204 now makes it possible to use innovative safety technology bypassing Section 9 of EN 60204, which is in some instances no longer up-to-date.

Increased availability using integrated safety technology

Completely new operator concepts can be implemented at machines with the widest range of requirements by combining the safety functions which were listed and described from Section 5.1.4 onwards. This means that an operator can intervene, e.g. in the magazine or at the re-equipping station (setting-up) in parallel to ongoing production.

However, topmost priority is to provide optimum protection for the operator.

The correct use and operation of the machine, specified as a result of the process, must remain.

The machine protection (machine itself, workpiece, tool, ...) can benefit to a high degree as a result of these new possibilities.

As a result of the integrated safety technology, the trend is away from solutions which are distinguished by pure hardware and electromechanical concepts, to software and electronics. This means that the safety technology with parts and components which are subject to wear, will be successively replaced.

Furthermore, integrated safety technology allows an intelligent system intervention directly down to the sensors and actuators which was previously unknown. Completely new diagnostic possibilities are created which permit preventive fault detection and identification.Even for faults which suddenly occur during production, the risk of personnel injury or machine damage can be significantly reduced by quickly detecting the fault and stopping in a coordinated, safety-related fashion.

Integrated safety technology permits:

- Process operations to be optimized
- Sub-processes can run in parallel
- Simpler machinery infrastructures
- Machine operator control concepts in-line with those required in practice.

Impact on the availability:

- Reduced fault potential
- Longer production uptimes
- Shorter production downtimes.

When consequentially used, integrated safety technology offers a significant potential to increase system availability.

5

5.1.12 Ordering data and documentation

Software	
Software option for SINUMERIK Safety Integrated	
• Basic function for up to 4 axes/spindles	6FC5250 – 0AC10 – 0AA0
• Expansion function from the 5th axis/spindle	6FC6250 – 0AC11 – 0AA0
• Axis/spindle package for an additional 13 axes/spindles	6FC5250 – 0AC12 – 0AA0

Hardware	
NCU modules	
• NCU 561.2	6FC5356 – 0BB11 – 0AE0
• NCU 571.3	6FC5357 – 0BB11 – 0AE1
• NCU 572.3	6FC5357 – 0BB22 – 0AE0
• NCU 572.4	6FC5357 – 0BB23 – 0AE0
• NCU 573.4	6FC5357 – 0BB34 – 0AE0
SIMODRIVE 611 digital (closed-loop controls)	
• Standard 2 - 2 axis	6SN1118 – 0DM23 – 0AA0
• Performance 1 - 1 axis	6SN1118 – 0DG23 – 0AA0
• Performance 1 - 2 axis	6SN1118 – 0DH23 – 0AA0
• High Standard - 2 axis	6SN1118 – 0DM33 – 0AA0
• High Performance - 1 axis	6SN1118 – 0DJ23 – 0AA0
• High Performance - 2 axis	6SN1118 – 0DK23 – 0AA0

Please refer to Catalogs NC 60 and ST 70 for the Order Nos. for the I/O modules and additional accessories.

Documentation	
Function description	
• German	6FC5297 – 6AB80 – 0AP1
• English	6FC5297 – 6AB80 – 0BP1
• French	6FC5297 – 6AB80 – 0DP1

5.2 Safely Operating Universal Drives

Protection against unexpected starting

For machines and plants, where undesirable starting can represent a danger for an operator when manually intervening in the hazardous area (e.g. during setting-up or service work), protection against hazardous motion according to EN 60204-1 Section 5.4, "Equipment to avoid unexpected starting" must be provided.

Safe standstill provides effective protection

The "SIMODRIVE 611 universal" and "SIMOVERT MASTERDRIVES" drive series supports this specified function using a safety relay integrated in the AC drive. The "safe standstill" function can be implemented using this integrated relay in conjunction with an external circuit (refer to Section 7.3).

The "safe standstill" function, implemented for the SIMOVERT MASTERDRIVES and SIMODRIVE 611 universal drive units has been certified by the German Trade Association and fulfills the requirements of Category 3 acc. to EN 954-1.

The user enjoys the following benefits:

- The safety requirements can be simply implemented
  - Using the integrated relay and the defined external circuit
  - Certified solution to avoid unexpected starting
- Cost and space saving
  - Contactors on the motor side are no longer required
  - Reduced engineering and wiring costs
  - Less space is required in the cabinet
- Time saving
  - Machinery acceptance procedures by the various testing bodies are simplified as the circuit principles have already been certified

Fig. 5/31
SIMOVERT MASTERDRIVES Compact PLUS

Fig. 5/32
SIMOVERT MASTERDRIVES Compact

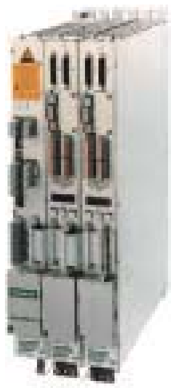


Fig. 5/33
SIMODRIVE 611 universal

5.3 SIMOTION Safety Unit
The safety package for metal forming technology

5

Measures have to be applied to all production machines - especially on presses - to protect the operating personnel. These measures eliminate any potential hazards in the operating process.This can be realized by securing the machines using protective doors or light grids. However, if the operator must frequently intervene in the production process, the machine responses must be checked, for example, using speed monitoring functions. For control and mechanical system failures, caused by faults, this then avoids potentially hazardous motion of the machine.

The SIMOTION Safety Unit TM 121 was developed in order to be able to handle such requirements.

It has been designed so that the following safety requirements are fulfilled:

- EN 954-1 safety-related parts of control systems
  In this case, Category 4 is maintained
- IEC 61508 Functional Safety of electrical/electronic/programmable safety-related systems.
  SIL 3 is, in this case, fulfilled.
- EN 61496 Safety of Machinery, contactless protective devices. Excerpts from this have been taken into account, i.e. a higher severity level, e.g. for mechanical loads or EMC.

This means that the prerequisites to implement safety functions at the machine, including manually operated presses, are fulfilled and that throughout Europe.

Release for general availability: 1st quarter 2003

Fig. 5/34
SIMOTION Safety Unit TM121C

Redundant (two-channel) electronic processor system with:

32 safety-related inputs, 24 V
8 safety-related outputs, 24 V, 2 A
8 standard outputs, 24 V, 0.5 A
2 safety-related frequency display, 24 V, 500 Hz

Supply:

24 V DC

Mechanical strength

A higher degree of severity is fulfilled than for mechanical loads in accordance with EN 61496

Fig. 5/35
SIMOTION Safety Unit - technical data

Standard blocks are permanently incorporated in the control which are required to secure against hazards for all types of machines. These include, to name but a few, protective grids or protective door monitoring functions as well as emergency stop circuits. In addition, special versions have been implemented, which are used for specific types of machines, such as **mechanical hydraulic presses or edging presses** .

These blocks are interconnected using a parameterizing tool supplied with the equipment.

Example:
Function blocks for mechanical presses

- 2-hand operations
- Safety-related cam inputs (run-up, run-down, transfer)
- Operating mode selection
- Emergency stop (“disconnect to bring into a no-voltage condition”), engage inhibit
- Coupling-brake combination control (with monitoring)
- Protective door/protective grid/light curtain
- Run monitor check (via a frequency input)

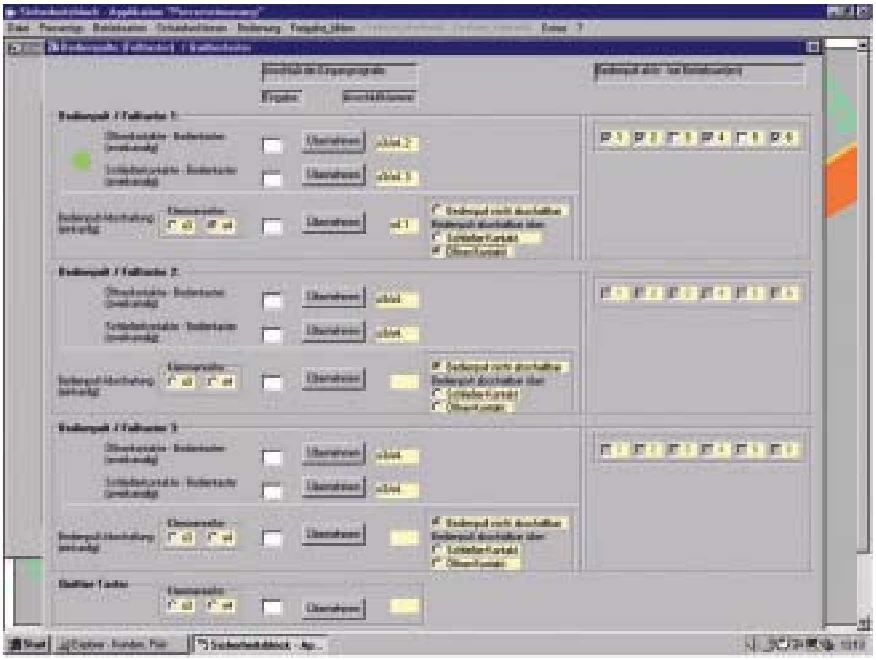


Fig. 5/36
Typical parameterizing software mask

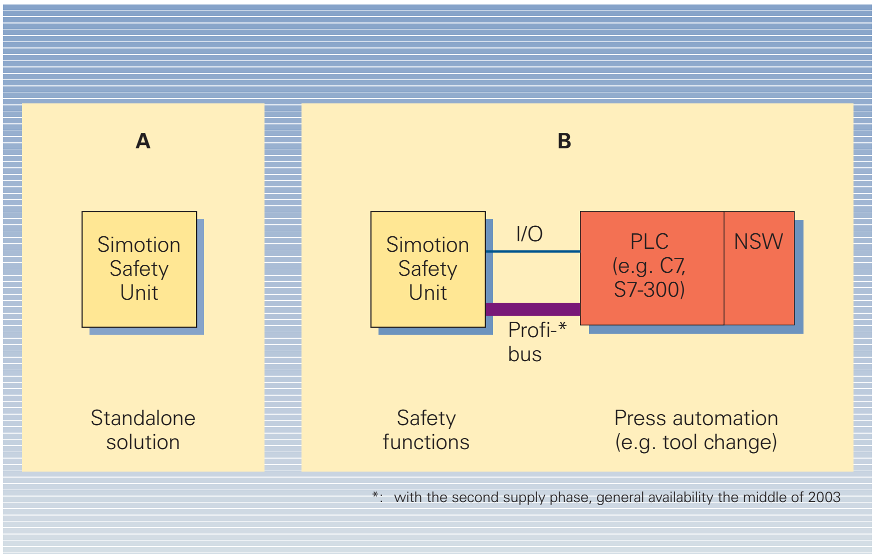


Fig. 5/37
Safety Unit - topology

5.4 Technical Support & Engineering for Safety Integrated - Motion Control Systems

5

Spectrum of systems, products and services (for machine OEMs and end customers)

Service/description

Concept generation
Starting from the hazard analysis and the required customer operator control philosophy, the safety functions are adapted to the machine.

This involves, for example:

- Mode types
- Safety functions with the protective doors closed
- Safety functions with the protective doors open
- EMERGENCY STOP concept
- Investigation of safety-relevant, external signals and elements

Standard configuring/engineering

Starting from the concept generation, the following standard functions are integrated in the machine circuit diagrams

- Safe standstill, safe operating stop
- Safely reduced speed
- Safe software limit switches
- Safe software cams

In this case, external safety elements (e.g. door interlocking functions, EMERGENCY STOP pushbuttons) are either conventionally configured or they are logically combined using (safe programmable logic).

Configurable safe programmable logic

Starting from the standard software, the following objects are generated for the safe programmable logic:

- Function chart
- Logic program for the PLC area
- Logic program for the NC area
- Required data blocks (e.g. DB18)

These objects are embedded in the overall system.

Commissioning

Starting from the configured software which was generated, safety functions are commissioned. The customer provides the machine so that the drives can be traversed (moved) and the cabinet is wired-up according to the engineering documentation.

Acceptance certificate

Starting from the existing engineering documentation and completed commissioning, an acceptance certificate is generated for the various safety functions.

These include:

- Description of the machine (name, type, ...)
- Description of the safety and operator control concepts
- Description of the axis-specific safety functions
- Testing all of the safety functions including the safe programmable logic
- Documenting the test results

The customer receives the acceptance certificate as hard copy and electronically on a data medium.

Approval procedure

Support when administering and backing-up an approval procedure from approved bodies (e.g. German Trade Association/German Statutory Industrial Accident Insurance Association) or large end customers.

Workshop

Workshops on the subject of machine safety are modified in line with individual customer requirements and, when required, can be held at the customers facility.

Possible contents can include:

- Machinery Directive, general Standards
- C-standards (machine-specific))
- Hazard analysis, risk evaluation
- Control Categories (according to EN 954-1)
- SINUMERIK Safety Integrated – function and system description
- Configuring, machine data
- Commissioning
- Acceptance certificate

Hotline

For acute problems during commissioning, experts on “SINUMERIK Safety Integrated” can be reached under the SINUMERIK Hotline No. (refer to Section 8.4).

Local service

Experts analyze faults and problems locally.

The causes are removed and a solution concept is drawn-up and when required, implemented.

Applications

kapitel 6

6.1 Fail-Safe Communications using Standard Fieldbuses

6.1.1 Two birds with one stone

***"Safety at Work"* in the main Miele plant in Gütersloh, Germany**

Corresponding to the company slogan "always better" in addition to their own products, the production equipment and the logistical infrastructure must be continually adapted to ensure that it represents state-of-the-art technology. This was the reason that when renewing the hoisting units to distribute material in the Gütersloh plant, Miele - the domestic appliance manufacturer - selected AS-Interface *"Safety at Work"*.

Miele has a long history of success, from the milk centrifuge to modern washing machines. The quality, long lifetime and reliability of this brand have been well-known for over a 100 years - and not just with housewives. In the main Gütersloh plant, appliances for professional use and high-quality domestic appliances are manufactured using innovative technology. One of the main issues is the production of washing machines and dryers which are marketed throughout the world.

In order to secure efficient production with high unit quantities, smooth material transport within the plant is absolutely mandatory. Various suspended electric vehicles move through the complete plant to supply and distribute materials for production. Three hoisting units move the vehicles, with a net load of 1.3 tons, to a different floor through a distance of 7 meters. Velocities of up to 60 meters per minute are achieved. The three hoisting units move over 2000 times each production day.

Fast, flexible – and simply safe

When it became necessary to mechanically and electrically overhaul these units, Miele selected the electrical equipment with AS-Interface *"Safety at Work"* for the modernization. The decision for this network system at the actuator-sensor level was made especially due to the low installation and wiring costs. The simple wiring reduces the number of potential faults so that Miele was not only able to quickly commission the new system themselves, but it was also extremely straightforward. System flexibility for subsequent expansions as well as the high availability were additional benefits of the AS-Installation for Miele. However, what was finally decisive for the application was the ability, using *"Safety at Work"* safety functionality, to transfer standard and safety-related data along one and the same bus system without requiring any additional resources.

The electrical equipment - a quick overview

Busbars with a total of six contact conductors were installed up and down the complete height of the floors. These are used to distribute the power and data for AS interface: Four contact wires are used for the power transmission and two to transfer the AS interface signals. The AS-Interface protocol is structured so that the complete system is extremely insensitive to noise and disturbances and no signal amplification is required via the contact wires. The hoisting units are positioned using closed-loop frequency controlled drives. The individual positions are detected using Bero proximity switches. Before the required position is reached, the drive is braked and then slowly moves to its final position.

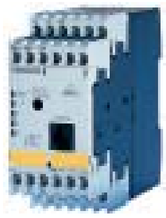
A SIMATIC S5-135U controller acts as the higher-level plant control. It communicates with a SIMATIC S7-315-2DP controller through a DP/DP coupler. As AS-Interface master, this controls the three hoisting units. Three DP/AS-i links are used to couple the actuator-sensor level to PROFIBUS. The three independent AS-Interface bus lines guarantee a high plant availability.

The hoisting unit itself is equipped with Siemens K45 compact modules with M12 connection system in degree of protection IP 65/67 as well as cabinet modules in degree of protection IP 20. The high switching power using relay technology really comes into its own for the cabinet modules. A rotary drive is controlled and the 3RT SIRIUS motor protection circuit-breaker interrogated using two slim-line modules, which are mounted onto the moving part of the hoisting unit. Further, two contactors are controlled which switch the 230 V traversing command on the busbar for the transporting vehicle. The safety-related K45F modules, also with degree of protection IP 65/67, are used to sense the safety-related signals for shutdown at the end positions.

"Safety at Work" **guarantees safety**

By using theAS-Interface to implement the control functionality, the specified safety functions were able to be integrated without any additional cabling. The safety-related applications are in compliance with Category 2 (EN 954-1). SIGUARD 3SE position switches signal the safety end position shutdown signals for the two directions to the Safety Monitor via a safety-related K45F module. Position switches, mounted onto the moving part of the hoisting unit, monitor the drive belts. A Siguard position switch also interrogates the stopping device at the drive.

The safety functionality for AS-Interface *"Safety at Work"* is achieved using additional signal transmission between the safety-related compact modules and the Safety Monitor.
The Safety Monitor expects a specific telegram from each compact module each cycle which continually changes according to a defined algorithm. If the expected telegram is not received because the limit switch has responded or because of a fault, then after a maximum of 25 milliseconds, the Safety Monitor disconnects the enable circuit and therefore disconnects the drive. This can only be released and moved away from this position using a key-actuated switch. This makes the AS-Interface an extremely cost-effective and safe system which couples simple installation with high availability and flexibility when it comes to future expansions. By expanding the *"Safety at Work,"*system, i.e. supplementing a standard AS-Interface configuration with a Safety Monitor and safe slaves, it is possible to transfer standard and safety-related data along a common AS-Interface bus cable so that complicated cable routing, as was the case for the old Miele hoisting units, is truly a thing of the past.



6.2 Safety-Related Low-Voltage Switching Devices and Sensors

6.2.1 SIGUARD light curtains - used in the automobile industry

SIGUARD light curtains are used in many industrial areas. As already explained in Section 3, protection of operating personnel can only be guaranteed if the SIGUARD light curtains are correctly mounted and installed.

This will be illustrated using the following application in the automobile industry.

Fig. 6/1 shows the production hall of an automobile manufacturer.

There is a split conveyor system in the foreground that is moved together when the vehicle body has been finished so that it can be transported to the next station.

Fig. 6/1
Production hall in the automobile industry

This area is also a transit area for operating personnel. In order to guarantee their safety, the dynamic conveyor system is equipped with light curtains (Fig. 6/2). These light curtains prevent the conveyor system halves from being moved together if somebody is in the hazardous area.

Fig. 6/2:
Master-slave combination with a total length of 5.4 m

This application clearly shows that SIGUARD light curtains can be used for applications other than just providing static protective fields. SIGUARD light curtains can also be mounted onto moving machine parts, which means that dynamic protective fields can also be generated.

The muting function of the evaluation devices (Fig. 6/3) allows the hazardous area to be entered or passed through without shutting down the plant as long as there is no danger.

Fig. 6/3
Safe shutdown and muting using the space-saving evaluation devices with muting function

6

In industry, hazardous zones and areas often need to be entered as part of the process.

Mostly, it is neither possible to block these off nor bypass them as a result of the plant layout.

The safest and generally also the most cost-effective solution is to secure these hazardous areas using contactless protective systems.

It is precisely here that SIGUARD light grids and light curtains provide a safe alternative.

Fig. 6/4
Safely moving a vehicle body

6.2.2 SIMATIC ET 200S SIGUARD in the Food Industry

Finely modular PLC I/O with integrated safety functions protects man and machine

The higher the degree of automation of a plant or system, the more it is necessary to ensure the safety of man and machine. This demands innovative solutions where fail-safe solutions can be simply implemented and at a favorable price. This is the reason that safety technology is already an integral part of the SIMATIC ET 200S SIGUARD distributed I/O from Siemens. Thanks to its finely modular design and the comprehensive range of modules, the ET 200S I/O system is suitable for a wide range of applications. Motor starters which are used to protect and switch standard three-phase motors are an important component of the system.

All of the modules can be individually combined so that a totally integrated solution can be obtained for every application. This means that every ET 200S station is essentially an identical mechanical layout. At the same time, the concept also provides space for subsequent expansion so that the user can supplement or adapt the I/O at any time. The motor starters can also be equipped with safety technology without incurring high costs. This makes the devices ideally suited for Category 4 applications in compliance with EN 954-1.

The starters only have to be supplemented by a fail-safe kit. The motor starters, together with the ET 200S SIGUARD power module, can be combined to form a safety group. In addition, for Categories 4 and 4, there is a connection for a redundant, second shutdown device.

For this group, the motor starter function is automatically monitored at each cycle so that every defect can be reliably detected and a restart inhibited

after a safety-related shutdown. Beyond this, the higher-level PLC can interrogate all of the status signals and messages via PROFIBUS-DP. The fault messages and signals always have the appropriate station and module number so that faults can be quickly pinpointed and resolved.

Customized safety

Depending on the type of application, the safety group can execute various functions. These range from simply interrupting the power feed up to monitored shutdown where the power feed is maintained until the drives have been braked down to standstill. By selecting different terminal modules, cascaded safety groups can be easily implemented, e.g. a higher-level emergency stop with monitored start function and several lower-level protective door-monitoring functions with auto start.

The advantages of an integrated safety solution are quite clear. The wiring is already integrated in the system so that the wiring costs normally incurred are completely eliminated. The motor starters only have to be plugged onto the terminal modules. Connecting-up and commissioning is reduced to a minimum, as only the sensor circuit has to be conventionally connected to the emergency stop control devices. Of course, the same is also true for configuring and testing these types of systems. This means that the completion time – from planning up to the start of production – can be drastically reduced.

In the meantime, the new system has already come through numerous tests in the field with flying colors. One of the plants where ET 200S SIGUARD is ensuring higher safety is at Kraft Food Production GmbH in Fallingbostel, Germany. The Fallingbostel plant is the company's largest food plant in Europe and has approximately 900 employees. The plant produces, among other things, dairy products, salad dressings and noodle sauces as well as well-known brands like Miracle Whip and Miracoli. 436 different products are manufactured from 313 different raw ingredients.

A large majority of these products go through the so-called wet mixing area as part of the production process. Here, all of the liquid ingredients, for example milk, soya oil, vinegar and a lot more, are processed to create the widest range of salad dressings, ketchup, mayonnaise and other delicatessen products. In this processing stage, herbs, thickening agents and other ingredients are transported from the storage silos into the mixing containers using a screw conveyor system.

Generally, all of the ingredients are ground down to form a fine powder, which then tends to stick to the walls of the troughs or conveyor system elements. From time to time, this blocks the system, which means that it has to be opened and manually cleaned. In order to avoid injury, it must be guaranteed that the conveyor comes to an immediate standstill when the cover is opened. Recently, an ET 200S station with SIGUARD power module was installed to handle this important task.

Small and compact

"on/off engineering GmbH" at home in Wunstorf, Germany, was awarded the contract to engineer and commission the new process automation. This engineering office for automation and drive technology, founded back in 1988, used the ET 200S for the first time for this Kraft project. Ludger Alberding, responsible with "on/off engineering" for the modernization of the automation technology in the wet mixing area is especially impressed about how simple it is to handle ET 200S stations. "The ET 200S distributed I/O system has some enormous benefits, especially for distributed plant structures as in the case of Kraft. On one hand, the system is extremely compact and requires very little space – this is a huge benefit when used in the field. The small electrical enclosures with the ET 200S stations can be directly installed in the plant so that the sensors and actuators can be connected to the distributed I/O through the shortest possible paths. This significantly reduces the cabling costs. Not only this, but the individual motor starters are already prewired and plugged-on to the terminal modules so that they are immediately ready to run. This saves an enormous amount of time in the installation phase."

Predestined for plant expansions and retrofits

It was possible to avoid having to expand the cable ducts thanks to the new automation and safety concept. This meant that only slight modifications had to be made to the existing switchgear during the retrofit. Furthermore, ET 200S stations can be easily

integrated into existing automation structures using PROFIBUS-DP. When expanding existing plants or also when retrofitting individual process sections, it is an important advantage that such a plant can also be modernized step by step.

One of the arguments for selecting ET 200S SIGUARD for Kraft was the fact that a special safety bus was not required to safely switch the screw conveyor system. “Using the SIGUARD module, it was possible to save a lot of time and in turn, also money,” explained Mr. Werner Badtke, project manager with Kraft, “this is because individual drives or plant sections can be quickly equipped with safety technology without requiring any complex retrofitting work.”

Also the right selection in the future

Both Kraft Food Production GmbH and “on/off engineering” are more than satisfied with the new distributed automation solution. They are especially enthusiastic about the ability to be able to safely switch individual drives without having to have a special safety bus. Both parties are clear about one thing - ET 200S SIGUARD will be used in the future.

Fig. 6/5
The raw ingredients are transported to the mixing containers via the screw conveyor system controlled and safeguarded using ET 200S motor starters

Fig. 6/6
The majority of raw ingredients are transported from the storage silos into mixing containers via the screw conveyor system

Fig. 6/7
Just like the I/O modules of the ET 200S, motor starters can also be replaced during production, which has a positive impact on increasing overall plant availability

6.2.3 SIMATIC ET 200S - innovative electrical cabinet construction

E+H Gross GmbH uses SIMATIC ET 200S with integrated motor starters and safety functions

Electrical and electronic cabinet components must not only be able to be more quickly installed and therefore more favorably priced - no that is not enough, they should be even more compact and packed with even more functions and features.

E+H Gross GmbH at home in Ditzingen, Southern Germany, are following this trend with the distributed SIMATIC ET 200S remote I/O with integrated motor starters and SIGUARD safety technology.

E+H Gross is a well-known cabinet builder which supplies completely wired cabinets for the widest range of applications in machinery construction - also to a large automobile manufacturer in the region. A compact design and fast installation are especially important, especially in panel building. For some time now, E+H Gross has been using new concepts when building its cabinets. SIMATIC ET 200S perfectly fulfills the requirement for less space and less wiring: The space requirement is almost reduced to half.
The wiring costs have been reduced by 80% using plug connections and completely wired motor starters. SIMATIC ET 200S combines extremely simple installation with a high degree of flexibility.

Finely modular PLC I/O in the electrical cabinet

ET 200S is the distributed remote I/O system which is connected to PROFIBUS-DP. E+H Gross and its customers are extremely enthusiastic about the straightforward, easy installation. The so-called terminal modules are simply snapped onto the standard mounting rails to the right of the interface module and are shifted to the left. The module automatically latches to its adjacent module. Contacts are simultaneously established when the modules latch together. Tools are not required. Sensor and actuator systems can now be connected to the terminal modules as permanent wiring without having to use any additional terminals. The electronic modules, which are available either as two or four-bit digital module, two-channel analog module or technological module, are inserted on the terminal module. A Power Module in front of each group provides the power supply. This means that individual load groups of I/O modules or motor starters can be easily formed. The motor starters to protect and switch three-phase motors are a fixed component of the system.

The distributed architecture has already proven itself for some time in plants and systems which are spread over a wide area, for example, in conveyor systems. The input and output signals between the control system and drive are exchanged via PROFIBUS-DP.

An additional consequential step in the same direction is that the electric power for the loads is distributed and switched in a distributed fashion with integrated safety technology through the ET 200S fieldbus components.

Cost-savings for cabinet builders and end customers

Electro-mechanical motor starters to control motors are also used in panels built by E+H Gross. The load feeders comprise a circuit-breaker - contactor combination from the well-proven Sirius 3R series and are designed as direct or reversing starter for load feeders up to 5.5 Kilowatt at 500 Volt. If the conventional wiring to control a motor for two directions of rotation is compared with a completely wired reversing starter, then the cost savings are crystal clear. A total of 37 terminal points are eliminated. This means, explained Marcus Groß "Mechanical design, engineering and installation costs are reduced by 37% and the end customer is happy that he also has 37 times less fault finding and maintenance." When using the reversing starter, only the motor has to be connected and the supply is connected at one point through the 40 Amp energy bus of the system.

SIMATIC ET 200S is especially installation-friendly as the terminal and electronics module are separated. Only the terminal modules are required in order to completely connect-up the load feeders. The motor starters only have to be specified according to the power, shipped and installed when the system is electrically commissioned. This represents a special advantage for customers, as the motor power is often only defined during commissioning. From experience, Hr. Groß certainly appreciates this from a cost-saving perspective.

Safety as it is required

Also when it comes to safety technology, savings can be achieved with respect to conventional wiring. The reason for this is that the motor starter can be equipped with the appropriate modules without incurring high costs. The units are optimally suited for use in applications of Safety Category 4 according to EN 954-1. The safety-related monitoring of the load feeders is ensured by using a special SIGUARD Power Module in front of the first load feeder and a so-called connection module after the last load feeder. The Power Module also ensures that the load feeder is shut down in plenty of time. It does not matter whether it involves cascaded, nested or overlapping Emergency Off circuits, all versions can be simply implemented in an ET 200S station by combining the various modules.

The next generation of ET 200S motor starters

However, development will continue. E+H Gross is already waiting for the next generation of ET 200S motor starters: The "High Feature Starter," which has been available since August 2001, is especially used where machine and plant failures result in high downtime costs (refer to the box).

"High Feature" – safety and diagnostics in one unit

The "High Feature" motor starter belonging to the distributed ET 200S I/O system is a pre-wired unit which can be remotely parameterized. It comprises circuit-breakers for starter protection for short-circuit protection at 50 kilo amps, electronic overload protection as well as with contactor - or for the first time also with a soft starter function. It switches load feeders with a power of up to 7.5 Kilowatt at 500 Volt. The new additional motor starter series can be easily parameterized and monitored via PROFIBUS. The motor can be started with either a clockwise or counter-clockwise direction and the brake can be controlled via the bus. The device can be remotely reset via the bus after an overload. In addition to "ready," an additional seven status and diagnostic signals, the actual current value is also available. This can, for instance, be used to monitor the upper and lower limit values. There are only three power versions with the setting range 0.3 - 3 Amps, 2.4 – 8 Amps and 2.4 – 16 Amps which means that, as an interesting spin-off, the stock inventory can be enormously reduced

E+H Gross is also monitoring the next innovation step with PROFIBUS-DP with considerable interest: Transferring safety-related signals using the PROFIsafe protocol. This means that in the future, it will be possible to extensively influence the Emergency Stop circuits between individual ET 200S stations via PROFIBUS without any additional wiring. This promises to reduce costs even more.

This means that the distributed ET 200S system will, also in the future, allow innovative panel builders such as E+H Gross to reduce their costs even further.

6.2.4 Cost effectiveness in crane construction with Safety Integrated

Ever since the pyramids were built in Egypt, humans have always been fascinated about transporting and lifting heavy loads. Today, state-of-the-art crane systems do this job quickly and easily. At the Axel Springer Verlag in Ahrensburg, Germany, the crane systems were able to be retrofitted at a reasonable price by creatively utilizing existing resources.

Initial situation

In order to make offset printing more efficient, old printing machines had to be replaced by new ones. The new machines were not only faster, but were also heavier and larger - especially as far as the height was concerned. Two cranes with load capacities of 20 t and 16 t respectively operate over the printing machines. They are essentially used to transport parts and for service but are now not powerful enough and are located too low over the machine.

At first sight it appeared that the height of the printing hall would have to be increased and a new crane system constructed. However, in order to optimally utilize the constructional situation, there was another alternative and that was to retrofit the two existing crane systems.

Retrofit

As a result of the increased load, it was necessary to couple the two crane systems (tandem operation) in order to be able to increase the total load to 45 t. This meant that guide rolls had to be installed and the lateral starting distance limited. In addition, the velocity in the tandem mode was limited in order to reduce dynamic loads.

Safety-related considerations

By raising the crane gantries, various safety regulations, corresponding to the valid accident prevention regulations, were no longer able to be maintained. This means that safety equipment was absolutely necessary to secure the zone before, after and above the cranes and between the crane gantries.

A working group, comprising the operating company, the German Trade Association and crane manufacturer selected the safety category which defines the potential hazard for personnel. After the local conditions were analyzed, safety Category 2 was defined for operating personnel protection.

This meant the following individual protective measures had to be implemented:

- The crane gangway secured with safety light grids
- The areas in front of and behind the crane secured using laser scanners
- The area between the crane gantries secured using safety light curtains
- The connecting rods in tandem operation secured using position switches with separate actuators
- Tandem crane operation secured using yellow flashing lights
- Optical and acoustic displays if warning and protective fields are violated
- The complete crane control adapted to the personnel protection measures

Personnel protection in the field

All of the safety-related components, as specified above, were supplied by Siemens. The project manager of the company doing the retrofit work, Alfred Unnasch von Stahl, explained the reason for this decision - the integrated concept for all protective tasks using SIGUARD and SIMATIC from the Safety Integrated safety program.

It did not make business sense to retrofit the old crane controls with the necessary safety level. This was the reason that a contract was awarded to the company CePLus from Magdeburg to engineer and construct two new crane control systems using fail-safe SIMATIC controls in conjunction with the 3TK28 EMERGENCY STOP relay.

The two cranes were equipped with a total of four laser scanners to protect personnel during crane operation - for example, on the service/maintenance platforms on the printing machines. The two opposing scanners are automatically changed-over to a smaller protective field when the cranes are operated in the tandem mode with therefore less clearance to the crane gantries.

An alarm field is set-up in front of the protective field to increase the level of personnel protection and system availability. If objects are detected in this field, the crane speed is reduced and the 8WD44 signaling column indicates this optically using a red flashing light. If the laser scanner detects objects in the protective field, the safety-related scanner outputs switch-off. The crane is immediately shut down and an acoustic signal is also output from the 8WD44 signaling column. The shutdown, initiated by the laser scanner, is saved in the fail-safe SIMATIC.
In spite of all of the safety technology implemented, the crane driver himself must be absolutely convinced that there is no object in the protective fields. Only then may he press an acknowledge button to cancel the saved fault. However, this is only possible if the laser scanner no longer detects any object in its protective – and warning fields. Crane operation can then be resumed.

All of the functions of both crane systems, such as hoisting gear and trolleys - including EMERGENCY STOP - are elegantly controlled, also in the tandem mode via a remote radio control.

Accidents aren't given a chance

Gangways are provided to replace platforms over the whole width of the cranes. Safe service/maintenance is possible even when considering the unfavorably conditions.
These gangways are accessed using a telescopic ladder. This ladder area is secured using position switches with separate actuator.
The gangways are secured by longitudinally and transversely arranged safety light grids in the foot area and other areas so that it is not possible to remain on the gangways when moving - either deliberately or accidentally.
Safety light barriers are used to provide personnel protection between the crane systems. Two transmitters and two receivers are precisely aligned for this purpose.

Safety Integrated – complete safety

This crane system not only offers an optimum which it comes to availability and construction costs, but also represents from a safety-related perspective, state of the art technology in compliance with the described protective measures.

A harmonized system from the modular safety integrated portfolio, including the fail-safe SIMATIC in conjunction with 3TK28 Emergency Stop relay and motor protection circuit-breakers and contactors from the SIRIUS series control and protect the crane system.
The new contactless SIGUARD sensor system with laser scanners, light curtains and light barriers is optimally incorporated in the protective concept in addition to the Emergency Stop pushbuttons and position switches.

6.3 Controllers: Fail-Safe Controls

6.3.1 SIMATIC S7-400F - application on an oil/gas platform

The “Oil & Gas Division” of Siemens AG in Norway provides worldwide service in the oil and gas and petrochemical industry. The“Offshore Center of Competence” in Oslo has been offering solutions for offshore applications since the late sixties.

The Offshore Center of Competence has considerable experience based on numerous projects in the North Sea, in Mexico, the Far East, America and Western Africa. Considerable significance is placed on a high degree of safety and state-of-the-art technology in order to fulfill the continually increasing requirements regarding electronics, communications and automation systems. This is the reason that the fail-safe, high-availability (FH) SIMATIC S7 controls, with safety communications via standard PROFIBUS (PROFIsafe), are used in the latest “Huldra” offshore project. “Huldra” is a gas platform belonging to the largest Norwegian mineral oil company “STATOIL” in the North Sea.

The project was supported throughout the complete engineering and test phase by the “H/F Competence Center”(Siemens AG, Dept. ATD TD INA BT) in order to facilitate fast implementation.

Tasks

The “Huldra” project is an unmanned platform that operates completely automatically. In addition to the generally used control matrix, there is also an additional identical matrix on the manned “Veslefrikk” platform approximately 15 km away. The complete system on Huldra is subdivided into 4 areas:
Fire & Gas (F&G), Process Monitoring, Process Shutdown, Emergency Shutdown System (ESD). It is especially in the areas of F&G and ESD that safety-critical requirements had to be fulfilled. Furthermore, fail-safe communications were established between the “Huldra” and “Veslefrikk” using PROFIsafe. While Safety Class SIL 2 had to be fulfilled for the ESD and F&G systems, the safety-related communications had to be in compliance with SIL 3.

Implementation

To fulfill the safety-critical requirements in the areas of F&G and ESD, autonomous safety-related and high-availability S7-400FH controls were used. These are connected in a fail-safe fashion to the associated control matrix and the fail-safe I/O modules via a redundant PROFIBUS using the PROFIsafe protocol. The signals from the input modules are displayed at the control matrix, evaluated by the S7-400F, and, where relevant, automatically initiate a defined shutdown level. All of the sensors and switching elements which are required for the safety-related shutdown are directly connected to the associated fail-safe modules. An S7-400F control can also be used to handle the safety functions. However, the high-availability FH solution was selected to further increase the availability. All of the control systems, both the fail-safe (S7-400FH) as well as the non-fail-safe (S7-400H), are connected with one another and to the servers of the process control system (SICOS) via redundant Ethernet buses.

Fire & Gas

The S7-400FH, used in this area, monitors the fire protection system. If a fire develops, the control initiates fire-fighting counter-measures. This S7-400FH control system monitors and controls approximately 1200 fail-safe inputs and 300 fail-safe digital outputs. In addition, it also processes the same number of non-fail-safe signals.

ESD

The ESD system evaluates the information from the Emergency Stop functions on Huldra as well as also information from the fire and gas monitoring and the process shutdown system. In an emergency situation, not all of the systems are automatically shut down, but only those areas that are determined by the severity, hazard and location of the particular fault. This minimizes process downtimes. In this case, a differentiation is made between hierarchic shutdown levels.
A higher level always trips all of the lower levels. A total of approximately 1800 fail-safe inputs and 450 fail-safe outputs are processed here.

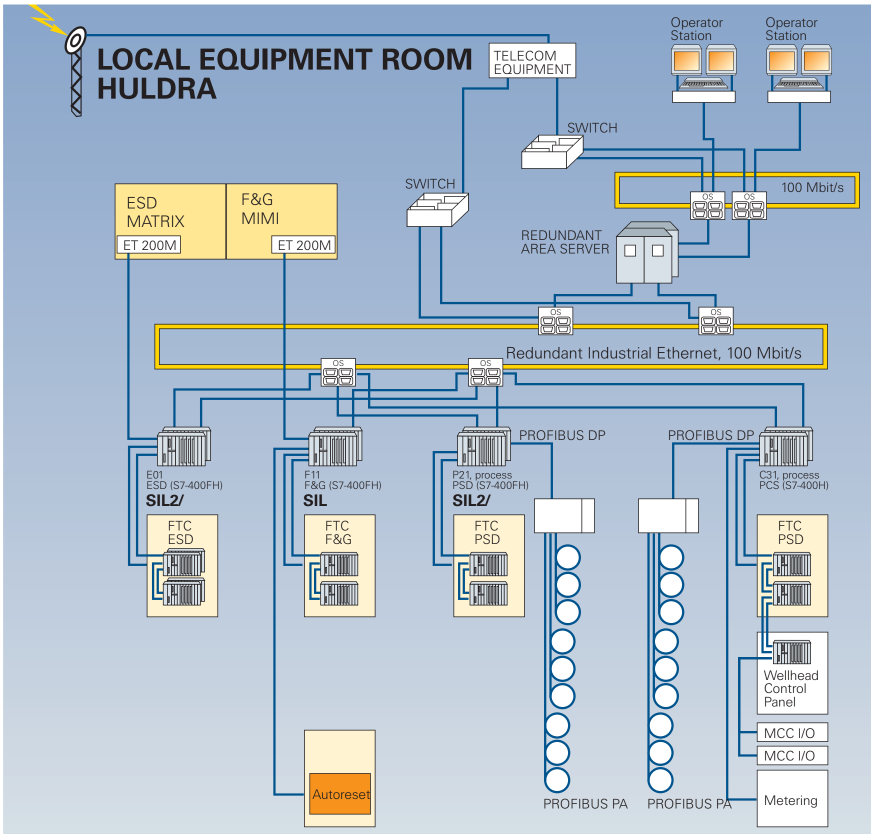


Fig. 6/8 Safety-related monitoring of an oil/gas platform with S7-400F

Communications

A radio transmission link is used between Huldra and Veslefrikk. The control matrix of Veslefrikk and the matrix of Huldra directly influence the process. For this reason, safety-related communications (SIL3) is mandatory. Such a data transmission link is possible as the PROFISafe safety mechanisms are embedded in the end stations and are therefore independent of the transmission medium. If communications are interrupted for a period of time (> 30 s), then the highest shutdown level is initiated and the complete platform is switched into the blackout mode. The complete shutdown process extends over several minutes and can still be reversed within a specific time window assuming that there is no longer any danger!

Advantages from the customer's perspective

- Low space requirement
- Simple engineering (the same engineering tools for the safety-related and the operational control system)
- Fail-safety and high availability in one system
- Straightforward acceptance and certification
- Easy fault detection using in-depth diagnostics
- Rewiring can be avoided
- Simple communications via widely established bus systems (PROFIBUS, Ethernet)
- Simple coupling to conventional supervisory control systems
- Can be easily copied for subsequent applications and projects

Technical data	
Geographic location	Norwegian sector of the North Sea (Block 30/2 ˆ Block 30/3)
Platform type	Unmanned wellhead platform
Platform size	Height 150 m above sea level water depth approx. 125 m
Platform weight	Approx. 8700 tons
Power generation	Two 1.8 MW diesel generators
Medium pumped	Natural gas and condensate
Gas reserves	Approx. 20 billion cubic meters of gas and 47 million barrels of condensate
Control	Remote monitoring from the control room of the Veslefrikk platform but also possible directly at the platform itself
Communications	Two diversely routed, safety-related radio links, each with a data rate of 155 Mbits/s

6.4 Motion Control Systems - Safe Motion Control

6.4.1 More safety in the automobile industry

The new flexible production line in the Renault plant in Cleon, in the North of France, has been operational since the end of 1998. Working around the clock, 40 machines in the plant produce 5000 cylinder heads every week. Each of the machines is equipped with a SINUMERIK 840D with Safety Integrated. We asked the head of the production line, Patrick Renault, about his experience with integrated safety technology from Siemens.

Mr. Renault, the new production line has been operational since September 1998.
What does the line consist of and what is it producing?

Patrick Renault: In addition to a total of 40 machines, there are also 13 loading gantries, entry and exit areas as well as assembly units, measuring stations and the labeling units. The line operates around the clock – the only exception is six hours on Sunday mornings. This line produces various cylinder heads for our 1.4 or 2.2 liter engines.

Fig. 6/9
GROB machining center in the production line

All of the 40 machines are equipped with Safety Integrated in conjunction with a SINUMERIK 840D. What made you decide to use Safety Integrated?

Patrick Renault: It was the machine OEM (Grob) who first recommended and implemented Safety Integrated. In the meantime, we are extremely happy about this decision. The reason is that the machines operate with high velocities – 60 to 70 meters per minute at the machining centers and 120 meters per minute at the loading gantries – this means that maximum safety is an absolute must - and we can achieve this with Safety Integrated.

What additional advantages does integrated safety have in comparison to conventional safety technology?

Patrick Renault: To start-off with, it has a significantly shorter response time as it is integrated in the SINUMERIK 840D numerical control. Furthermore, safely reduced speed is possible with Safety Integrated. This means that we can intervene with the protection doors open and the machine still running – and with 100% safety. Not only this, but the drives no longer have to be disconnected from the power source. In turn, this extends the drive lifetime – as you know, the lifetime is influenced by frequently powering-up and powering-down the DC link.

What were the reasons that made you decide to use integrated safety as standard on all of your production lines?

Fig. 6/10
Patrick Renault - head of the production line

Patrick Renault: Renault's goals are quite clear: We want to exclusively use machines which fulfill Category 3 of the relevant safety standards and which achieve a high degree of safety with fast response times. Today, Safety Integrated already fulfills these requirements

Are the operating personnel satisfied with integrated safety?

Patrick Renault: Patrick Renault: The possibility of manually intervening in the machine with the door open for service or when setting-up the gantries creates a lot of confidence. Furthermore, the use of Safety Integrated is quite transparent; this means that there are no problems during production. Operating personnel have clearly understood that Safety Integrated offers them more safety and security although the speed of these production lines is significantly higher.

Mr. Renault, thank you for the interview.

6.4.2 New standard for machine tools

For some time now, Alfing Kessler Sondermaschinen GmbH, at home in Aalen, Germany, has based its production on flexible production systems. The latest alloy-machining module is the ALFING 2-Spindler. In the near future, two additional machines of this type will be put into operation with VW Saxony in Chemnitz. One of the special features of these machines is the integrated safety technology from Siemens.

Instead of rigid transfer lines, flexible production systems and instead of special machines, standardized assemblies – which reflect the demand for state-of-the-art modular production equipment and systems. Standardized modular assemblies not only simplify service and maintenance and therefore increase availability. They also allow existing systems to be expanded and modified – also for the new machine modules, for example, the two-spindle machine from Alfing Kessler, which is used in flexible production systems to machine alloy parts and components.

Especially in vehicle construction, low-weight designs are increasingly demanding the use of alloys. It is not surprising that the ALFING 2-Spindler will in the near future be used by VW Saxony to machine cast aluminum cylinder head covers (aluminum die cast components).

Minimum idle times

For the ALFING 2-Spindler, the separately driven spindles operate independently of one another. While one of the spindles machines the workpiece, the second spindle picks up the next tool from the magazine allocated to each spindle (with 48-tool capacity). The second spindle is then immediately accelerated up to its rated speed. This means that the tool that has just been inserted is already rotating and can quickly start to machine. All of this is realized in a maximum of 1 second after the spindle is ready and the tool has been changed in the magazine. The extremely fast tool transfer with both spindles operational reduces the idle times. This drastically increases the productivity: A cylinder head cover is completely machined in just approx. 165 seconds. The 2-spindle design uses lightweight moving masses and heavy stationary masses. Only then can the required dynamic response and stability be achieved. The axis movements are distributed: The tool executes movements in the Y and Z axis while the workpiece moves along the X axis. The working range extends over 880 x 630 x 500 mm (X, Y, Z).

For the first time with SINUMERIK Safety Integrated

The machine is controlled from a SINUMERIK 840D and SIMODRIVE 611D. The machine is equipped with Safety Integrated, including safe programmable logic (SPL) – which is a first for a production facility of VW Saxony.

"For these types of high-speed machines, with acceleration rates of over 10 m/s2, in our opinion, it would be irresponsible not to use safety functions," explained Willi Diemer, the Head of the Electrical Design Department, regarding his decision to use SINUMERIK with Safety Integrated. And why integrated safety? Diemer: "Reduced speed can only be safely monitored using integrated safety technology. If it is not done this way, the software reduces the speed, but as soon as the machine develops a fault without safety function, it would simply start. And everybody knows what that can mean."

Fig. 6/11
Optimum operator control concept with SINUMERIK Safety Integrated

Fig. 6/12
Fewer relays mean fewer failures

Safety technology is also required in order to move the drives with safely reduced speed even with the protective door open, for example, if the machine has to be set up. Conventional safety technology can only disconnect the power. When a fault develops, Safety Integrated can shut down the machine faster and more safely. It is no longer absolutely necessary to disconnect the power. Only drives that really have become uncontrollable are automatically disconnected from the power supply. This provides more safety for the operator at the decisive instant and also reduces the stressing on the machine and process. "For Alfing, safe programmable logic triggered us to use this technology," reported Willi Diemer. "This is because this logic allows conventional switching devices to be eliminated - which has a positive impact - and not only on the price." A machine equipped with Safety Integrated and SPL can be offered at almost the same price as conventional technology. (However, one option is that the machine can be operated using the enable button.) Furthermore, fewer relays also mean fewer failures and therefore a higher degree of safety and higher machine availability. For instance, if an important relay, for example the relay that enables the pulses or controller for the drive, fails, then the machine can no longer brake in a controlled fashion. The motor coasts down and there is a chance that the machine could be badly damaged.

Convincing concept

For the customers of VW Saxony, Safety Integrated with SPL was a new technology that they first wanted to carefully check out. Alfing Kessler was able to convincingly present the machine, configured according to the Siemens specification together with the safety functions, to those responsible at VW Saxony, VW production planning and representatives from t he Germany Trade Association Mainz (Eisen Metall II). The two-channel configuration for all of the safety components in compliance with the Siemens specifications was especially impressive. These safety components included, for example, the protective doors and Emergency Stop. For this machine, even the cross-circuit monitoring of the two safety channels was implemented using the "4-terminal concept."

For VW, it was also important that the machine could be operated with the protective doors open. Using Safety Integrated, the machine operator concept can be optimally harmonized to the requirements of the operating personnel and the process itself. This makes it far easier to set up the machine. Tampering, which unfortunately still occurs today, is prevented by the basic concept itself. Additional machines utilizing the same concept will now be built for VW Kassel, SKODA Auto and DaimlerChrysler.

Willi Diemer is clear about one thing: "For our high-speed machines, we will always use integrated safety technology from Siemens."

Safety functions

The SINUMERIK Safety Integrated Safety functions are available in all of the operating modes and fulfill the requirements of Safety Category 3 (in compliance with EN 954–1). Functions to safely monitor speed, standstill and position are part of the basic range. These include:

- **Safe standstill**
  The drive pulses are cancelled and the power feed is safely and electronically disconnected.
- **Safe operating stop**
  Drives are monitored at standstill to ensure that they stay within an adjustable tolerance window. The drives remain fully functional in the closed-loop position control mode.
- **Safe stopping process**
  When a monitoring function or a sensor responds (e.g. light barriers), the drives are safely brought to a standstill.
- **Safe braking ramp**
  Monitors the drive while braking.
- **Safely reduced speed**
  Monitors configurable speed limits.
- **Safe software limit switch**
  Variable traversing range limits.
- **Safe software cams**
  Variable area/range identification.
- **Safe programmable logic**
  All of the safety-relevant signals are directly connected and internally logically combined.
- **Safety-related input/output signals**
  Interface to the process.

When external brakes are activated, this supplements the integrated functions and, when safely shutting down, results in the shortest possible braking travel. With SINUMERIK Safety Integrated, a new standard is achieved for machine tools, which makes them safer and more flexible and at the same time increases system availability.

6.4.3 Safety technology tests safety technology

The Berufsgenossenschaftliche Institut für Arbeitssicherheit (BIA) not only checks safety-relevant products but also uses these, depending on the requirement, to check and test other safety-relevant products. For instance, SINUMERIK 840D Safety Integrated automatically checks the safety and reliability of sensor-controlled personnel protection systems.

Today, in the area of machine safety, high technology in production environments is no longer a rare occurrence. Where previously mechanical gates protected personnel from machines or a driverless transport vehicle, since the middle of the nineties, intelligent sensors in conjunction with safety logic are also handling safety-related tasks.

Whether ultrasonic sensors for outside or laser scanners for inside, a sophisticated measuring technique with the associated control is required to check the function of such intelligent contactless protective devices.

It was the obvious thing to do - use a SINUMERIK 840D with the "Safety Integrated" function to control the measurement set-up developed for a group headed up by Dr. Reinert. There was no question about it - the SINUMERIK 840D came through the exhaustive BIA tests with flying colors. "We check safety technology with safety technology," commented Dr. Reinert.

The measurement set-up involves a gantry machine with a large traversing range and open design. Three axes have to be driven and controlled: Two for the plane on which the sensor to be tested is traversed, and a vertical one on which the object approaches the protective area (in this case, the simulation of a human leg). As soon as the sensor detects the object, the SINUMERIK responds and measures the position.

The measurement arrangement is completely open which means that protective devices are required (contactless devices). These comprise two additional laser scanners that are mounted on the axis on which the object is traversed. Together with the SINUMERIK, the laser scanners initiate that the object is immediately stopped as soon as a person enters the protective area generated by the sensors.

The Safety Integrated features ensure that this is realized safely and fast enough.

Furthermore, for the first time, a SINUMERIK control with HPVEE, a graphic operator interface, has been used which is especially suitable for laboratory-based investigations.

Fig. 6/13
Generating the test program

Fig. 6/14
Test arrangement

6.4.4 Safety and speed of operation

Safety Integrated for complex special machine tools

Time is money. If you want to have a positive revenue flow when producing parts or you wish to reduce costs, then you must be fast. These sophisticated machine concepts from August Wenzler GmbH in Spaichingen, permit cycle times for their rotary transfer machines for machining large batches which some can only dream about. Innovative solutions are also in demand when it comes to safety technology. With the three large rotary cycle machines which Opel ordered from the Wenzler company, "Safety Integrated" celebrated a successful entry.

Using its technology, the Wenzler company produces precision, complex workpieces, for example, automobile chassis components. For the case being considered, wheel hub carriers and pivot axes are machined from aluminum with a unit machining time of only 17 seconds. This time is a real benchmark which, in addition to the other features such as a favorable price-performance ratio, the fact that the machines can be flexibly set-up and the experience which Wenzler had already gained in other projects in the automobile industry convinced Opel to award the Wenzler the three large rotary cycle machines to machine their chassis components. Not only this, each machine has 72 NC axes which also isn't an everyday occurrence - even for the high-tech Wenzler company.

The machine, in its present version, was developed in various phases over the last 20 years.
From 1983 onwards, the machine was equipped with a CNC control system which Wenzler themselves had developed.
At the end of the nineties, Wenzler changed-over to using Siemens control systems.
Today, Wenzler has about 70 employees and constructs between 8 and 10 machines per year. Most of these machines are supplied to the automobile industry. The value of such large machines can easily reach between 1.5 and 2.5 million Euro depending on the actual version.

High degree of productivity in the tightest space

The Wenzler MSC-8 B (multi-spindle center) is an 8-station machine. The 8 workpieces can be simultaneously machined by up to 14 tools.
The tools are mounted on satellite tables which can be swiveled so that 5-side machining or by automatically changing over, also 6-side machining is possible. Thanks to its rigid modularity, this flexible cell has the character of a standardized rotary interlinked machine with the performance of a special-purpose machine. Each movement is CNC controlled so that the full flexibility of the machine can be utilized in a machining cube of 400 x 400 x 400 mm.
The central element - the 8-corner drum - which supports the workpieces is suspended which guarantees optimum chip flow and good accessibility of the drum bearing and clamping equipment.
On the electrical side, the MSC-8B is equipped with the Siemens SINUMERIK 840D machine control, the matching SIMODRIVE 611digital drives, 1FT6 permanent-magnet synchronous motors and the Profibus fieldbus. This is complemented by a series of distributed units. Just recently, Wenzler is also using the integrated safety functions "SINUMERIK Safety Integrated".

Integrated safety technology

About five years ago, Siemens was the first drive manufacturer worldwide which integrated safety functions for personnel and machinery protection into its drive.

When integrating the safety functions, the drive system and the CNC control also handle the safety functions in addition to the control itself. The safety functions include safely monitoring the speed, standstill and position as well as functions to safely logically combine signals.

The logical operations and responses are realized within the system. All safety-relevant faults and errors in the system always result in the potentially hazardous motion being safely shutdown and the power to the motor being contactless interrupted. Motion is stopped, always optimally adapted to the state of the machine. When setting-up, this means a high degree of personnel protection and additional protection for the machine, tool and workpiece in the automatic mode.
Safety Integrated is already in use in over 7.000 machines with over 50.000 drives. Machinery manufacturers can access a considerable amount of knowhow when it comes to engineering new safety concepts.
For the Opel machines from Wenzler, this however, involved 72 CNC axes and a total of 99 drives per machine. This presented both Wenzler as well as Siemens with new challenges - especially because almost all of the Safety Integrated functions, including the safe brake management as protection against vertical axes dropping were to be implemented on these machines.

The Opel project

The Wenzler machines were used in the Opel project to produce aluminium hub carriers and pivot axes. The left/right versions of each type are simultaneously machined so that after 4 workpieces, the components required for 1 automobile have been produced. Aluminium hub carriers and pivot axes are relatively new in chassis construction. Previously, Opel manufactured these parts out of gray cast iron. The aim to reduce weight, especially the unsprung masses in vehicle construction result in an improvement in the performance and ride comfort. The new aluminum version was able to reduce the weight by 6.6 kg.

"The project was kicked-off in late Autumn 2000. In cooperation with Wenzler, initially a rough concept was drawn-up which indicated as to how such extensive safety integrated applications could be even approached," explained Ingrid Hölzer who was responsible on the Siemens side for this task. This concept used the control structure defined by the Wenzler company, which comprised eight NCUs. NCU1 was defined as master for the Safety Integrated functionality. The specialists from Wenzler - namely Ralf Rottler - wrote the necessary software for the NC and the PLC sections of the control. "This was extremely successful" explained Ingrid Hölzer. "Communications down to the level of the setting-up technicians was fantastic."

Higher degrees of protection and flexibility

The advantages which Wenzler now see, explained Jürgen Ruffieux, head of the electronics development department, "primarily in a higher degree of protection during the setting-up operation as well as in the higher flexibility for the setting-up personnel." Previously, safety devices and equipment had to be bypassed during setting-up - this is a thing of the past. The setting-up technicians are always protected.

Using Safety Integrated, Opel expected lower costs when installing the machine, shorter response times and more safety due to automatic self-diagnostics and the crosswise monitoring using the PLC and NC. The new machines went into series production in the first quarter of 2002.

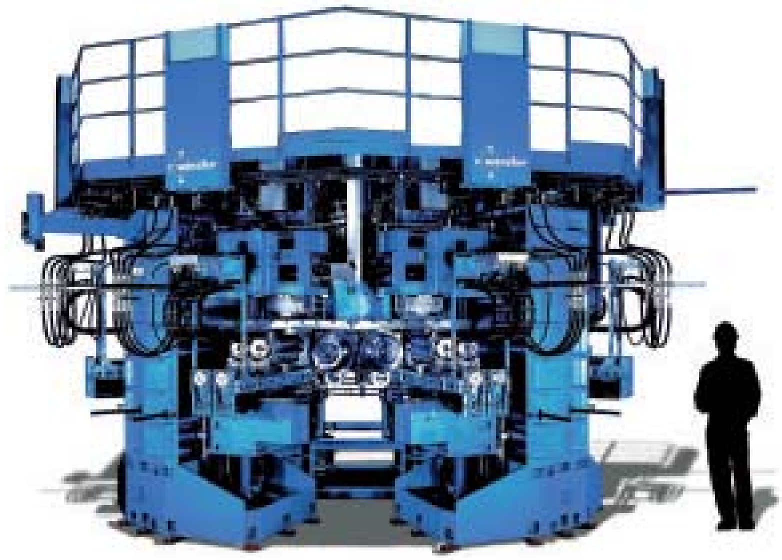


Fig. 6/15
The Wenzler MSC- 8B - a modular rotary cycle machine - which has 72 NC axes in the Opel version. The "naked" machine shows the design comprising individual similar basic elements.

Fig. 6/16
Aluminum reduces the weight of an automobile. this Opel application, aluminium hub carriers and pivot axes reduce the weight by 6.6 kg with respect to previous gray caste iron parts.

6.4.5 Safe standstill in the printing industry

Increasing productivity improvements and a high degree of cost consciousness in the printing machine industry are resulting in the fact that classic mechanical solutions (for example the line shaft) are being replaced by electronic drive technology (mechatronics). On the other hand, this places higher demands on the safety technology which is used to monitor the drive. Previously, only a few drives had to be monitored from the safety side whereas today, new concepts mean that many drives have to be incorporated in the monitoring system.

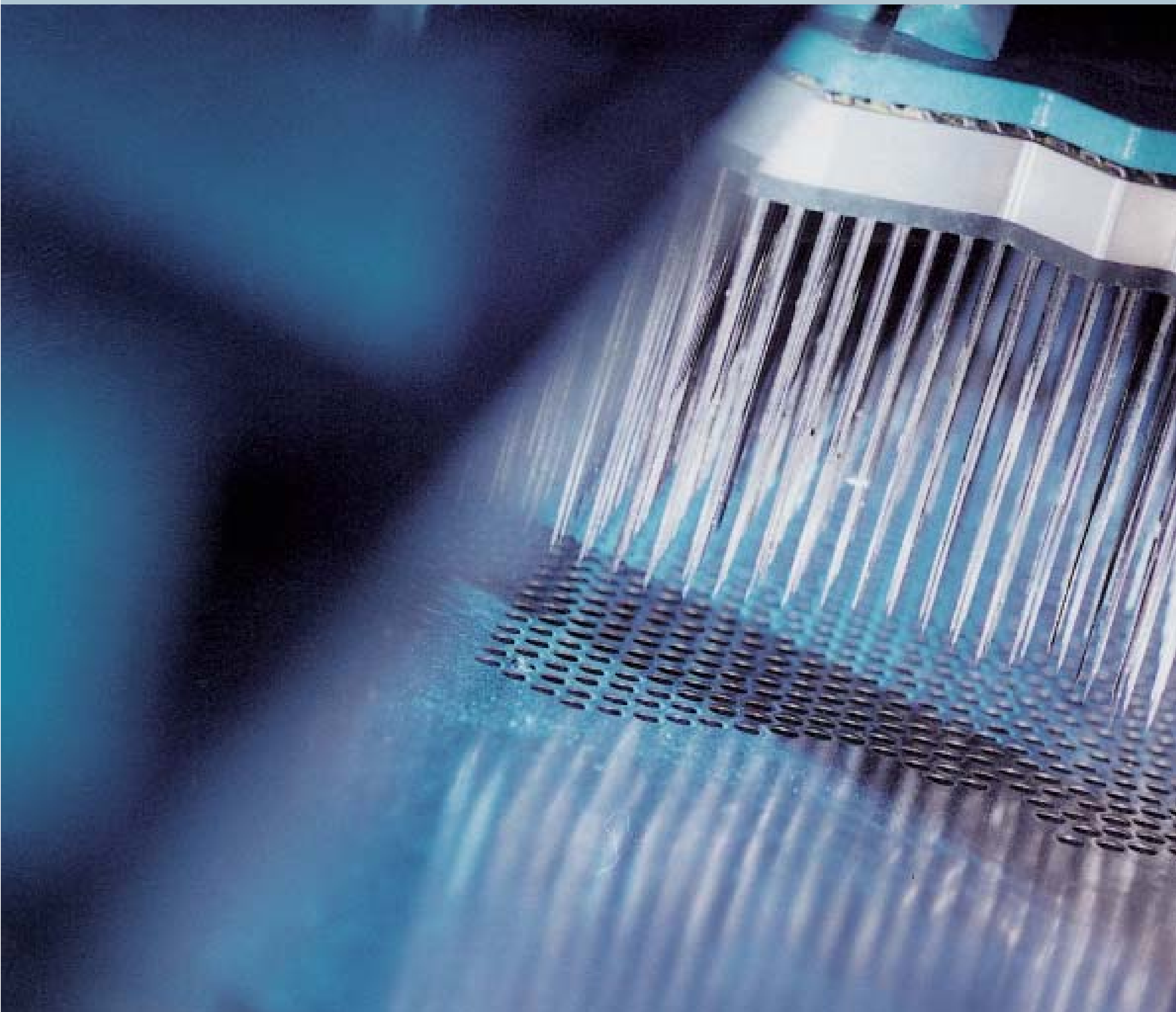
An especially high potential hazard is when operating personnel have to work on a printing machine with the protective devices open. Here, legislation demands that personnel must be protected, using suitable devices, against the drives undesirably starting.

The SIMOVERT MASTERDRIVES drive series supports this protective function. This prevents drives undesirably starting, using an integrated safety relay. This means that the contactor on the motor side can be eliminated. In the printing machine industry, systems with well over 100 drives are no longer a seldom occurrence. Significant time and cost savings were achieved by eliminating material and installation costs and due to the less space required in the control cabinet.

6

Circuit Examples

kapitel7



7.1 Safety-Related Low-Voltage Switchgear and Sensors

7.1.1 Switch safely

The following circuit examples have been checked with the German Trade Association (BG) and have been approved.

- Contactor circuits
- SIGUARD safety combinations

suitable for:

- EMERGENCY STOP
- Protective door monitoring functions
- Press controls

EMERGENCY STOP circuits for extremely simple machines

EMERGENCY STOP switch

The EMERGENCY STOP function may only be routed through an EMERGENCY STOP switch for extremely simple machines, depending on the result of the risk analysis. In this particular case, only Stop Category 0 is possible. Such an EMERGENCY STOP switch, contrary to usual EMERGENCY STOP pushbutton, interrupts the main circuit (Fig. 7/1).

An EMERGENCY STOP switch must be configured so that

- There is only one EMERGENCY STOP switch;
- The EMERGENCY STOP switch is located in the supply to those circuits which can result in hazardous motion in the system. The complete power supply to all of the circuits does not have to be interrupted;
- The EMERGENCY STOP switch must be able to interrupt the current of the largest motor when the motor stalls;
- The sum of the currents of all of the loads, which must be disconnected using the EMERGENCY STOP switch, must be able to be safely interrupted.

An EMERGENCY STOP switch may

- be manually actuated;
- act on an undervoltage release via one or several EMERGENCY STOP control devices (circuit diagram 7/1);
- be provided with overload and/or short-circuit releases (version as circuit-breaker);
- be simultaneously used as main switch if it additionally fulfills the requirements for a main switch (however, a main switch must disconnect *all* circuits).

An example for such an EMERGENCY STOP switch for extremely simple machines is illustrated in Fig. 7/2

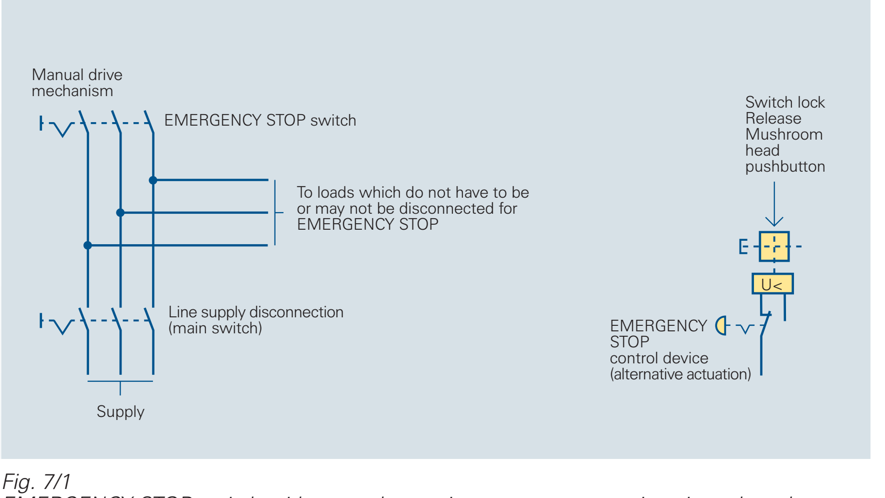


Fig. 7/1
EMERGENCY STOP switch with manual actuation or remote actuation via under-voltage release

EMERGENCY STOP contactor

Generally, a so-called EMERGENCY STOP contactor is not permitted. Such a contactor is only permissible in precisely defined exceptional cases: This contactor may only be used as an EMERGENCY STOP contactor in the branch to be shutdown. Additional contactors in series are not permitted. This means that this concept is restricted for applications on extremely simple machines (refer to circuit diagram 7/2).

An EMERGENCY STOP contactor must be configured so that

- each EMERGENCY STOP contactor must be immediately de-energized by the EMERGENCY STOP control device;
- there are no additional contactors in series.

Safety circuits using individual contactors

Configured using two auxiliary contactors

Safety circuits of any complexity can be configured using auxiliary contactors. Several years ago, the circuit with two auxiliary contactors and overlapping auxiliary contacts (Fig. 7/3) was considered to be state-of-the-art.

This circuit offers redundancy. However, due to the fact that the contacts are not positively driven, the two auxiliary contactors do not mutually monitor each other for correct functioning. This means that if a contact welds, this fault is not detected and the circuit still continues to function.

A subsequent fault in the second contactor could completely disable the combination. This would mean that the level of safety would no longer be guaranteed. Thus, today, this circuit is no longer used (Fig. 7/3).

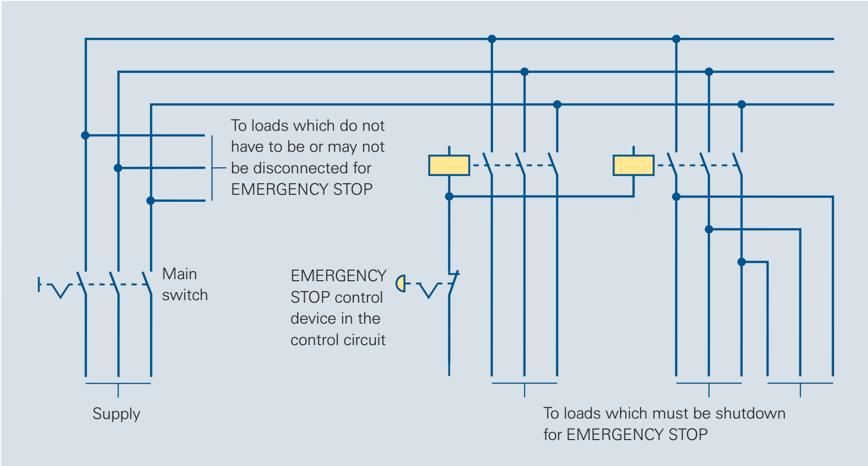


Fig. 7/2
Example of a machine control with 2 power contactors, only permitted with some restrictions

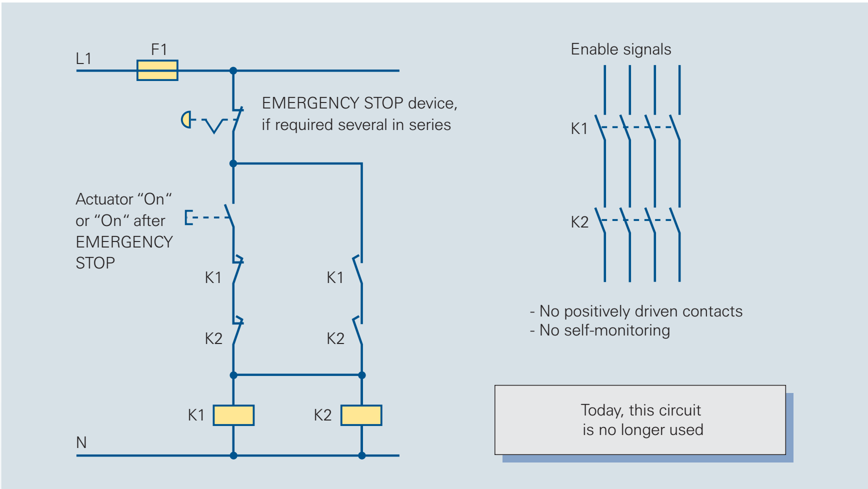


Fig. 7/3
This contactor combination consists of two auxiliary contactors with overlapping contacts (Category 2 according to EN 954-1)

Configured using three auxiliary contactors

Today, circuits with three auxiliary contactors represent state-of-the-art technology. Three auxiliary contactors with positively driven contacts are used, as shown in circuit diagram 7/4. The three auxiliary contacts guarantee redundancy and function monitoring. The positively driven contacts guarantee that the auxiliary contactors mutually monitor themselves. Faults are therefore detected and the circuit can no longer be closed after shutdown, therefore eliminating subsequent faults.

With this circuit, using today's state-of-the-art technology, it can be assumed that if the auxiliary contactors incorrectly function, this will not cause the system to go into a hazardous condition.

In the 3TK28 contactor safety combinations, which are complete devices, several auxiliary contactors are connected to form a safety circuit. These circuits can also be implemented using individual contactors.

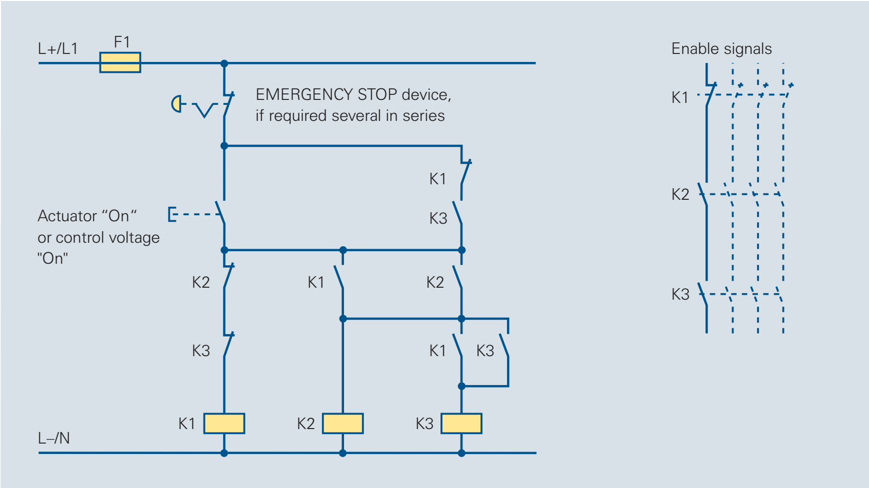


Fig. 7/4
Contactor combination using three auxiliary contactors with self-monitoring, single-channel, Category 3(4) acc. to EN 954-1

Connecting several EMERGENCY STOP control devices

In the previous circuit diagrams, only one EMERGENCY STOP device was shown. Generally, there are several EMERGENCY STOP control devices (e.g. at different locations) on a machine. The contacts of these EMERGENCY STOP control devices are then connected in series.

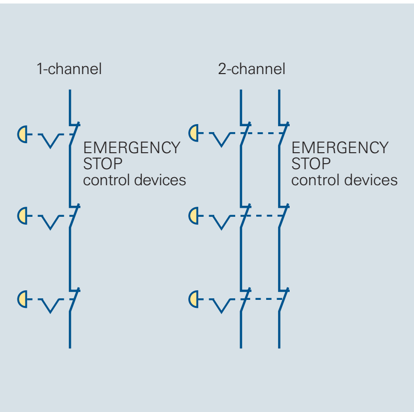


Fig. 7/5
Several EMERGENCY STOP control devices

Circuit examples to monitor protective devices

Circuits to monitor protective devices use position switches. Various possibilities of the different devices are shown in the examples for EMERGENCY STOP. These circuit examples will not be repeated here as the EMERGENCY STOP control device is only replaced by one or two position switches per protective device. The number of position switches which are required for each protective door can be taken from Section 3 of the Manual.

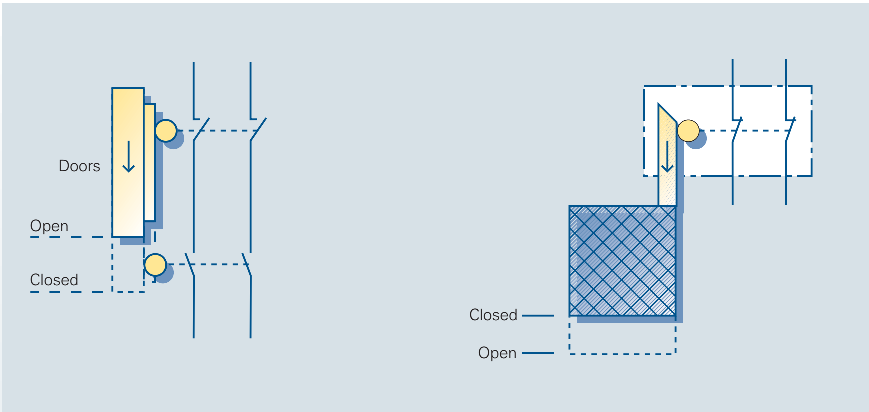
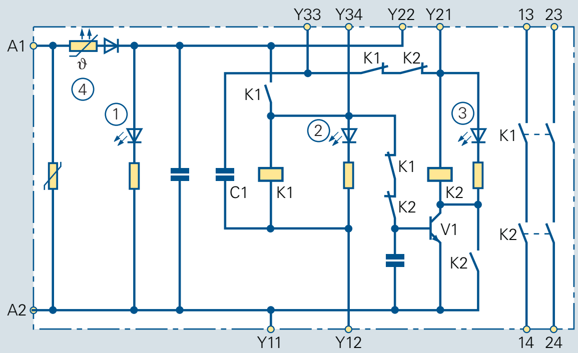


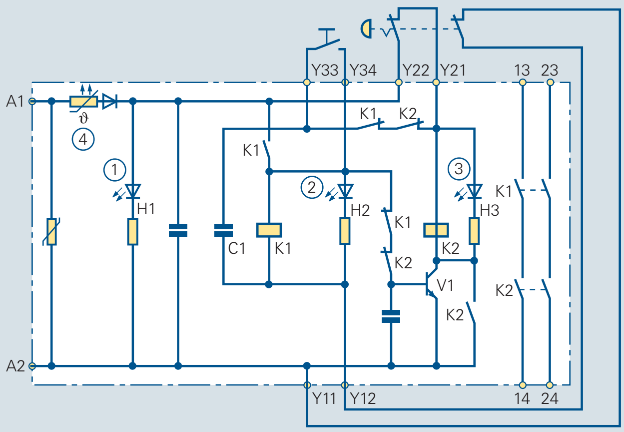
Fig. 7/6
SIGUARD position switches used to monitor moving protective equipment

7.1.2 SIGUARD 3TK28 Safety Combinations



A1/A2	Power supply
Y33/34	"Ready ON" feedback circuit
Y11/12	Sensor (e.g. EMERGENCY STOP pushbutton)
Y21/22	Sensor (e.g. EMERGENCY STOP pushbutton 2-channel)
13/14	Enable circuit
23/24	Enable circuit
1	"POWER" LED
2	"Channel 1" LED
3	"Channel 2" LED
4	PTC fuse

Fig. 7/7
Internal circuit diagram of the 3TK28 23



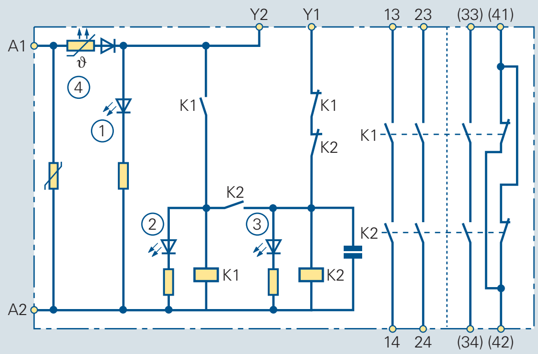
Function description

- Power on;
  Connect the power;
  The "Power" LED is lit, EMERGENCY STOP closed,
  C1 is charged, press ON,
  C1 starts to charge K1, V1 is energized,
  K2 starts, K1 + K2 latch,
  "Channel 1" and "Channel 2" LED's are lit.

- ON monitoring
  ON is pressed ⟶ fault!
  EMERGENCY STOP is closed,
  V1 immediately starts K2, C1 is not charged
  ⟶ K1 does not start.
  Only LED "Channel 2" is lit.

- Cross-circuit
  If EMERGENCY STOP 1 and EMERGENCY STOP 2 are short-circuited, a current flows through the PTC fuse.
  The PTC goes into a high-ohmic state.
  None of the LED's are lit.

Fig. 7/8
Function description of the 3TK28 23



A1/A2	Power supply via EMERGENCY STOP pushbutton
Y1/Y2	"ON" Feedback circuit
13/14	Enable circuit
23/24	Enable circuit
33/34	Enable circuit
41/42	Signaling circuit
1	LED "POWER"
2	LED "Channel 1"
3	LED "Channel 2"
4	PTC fuse

Fig. 7/9
Internal circuit diagram of the 3TK28 21/24

The following circuit diagrams have been checked with the German Trade Association (BG) and approved.
Connection designation:
The connection designations are in compliance with DIN EN 50042.

EMERGENCY SWITCHING-OFF (EMERGENCY STOP) circuits

Circuit diagrams

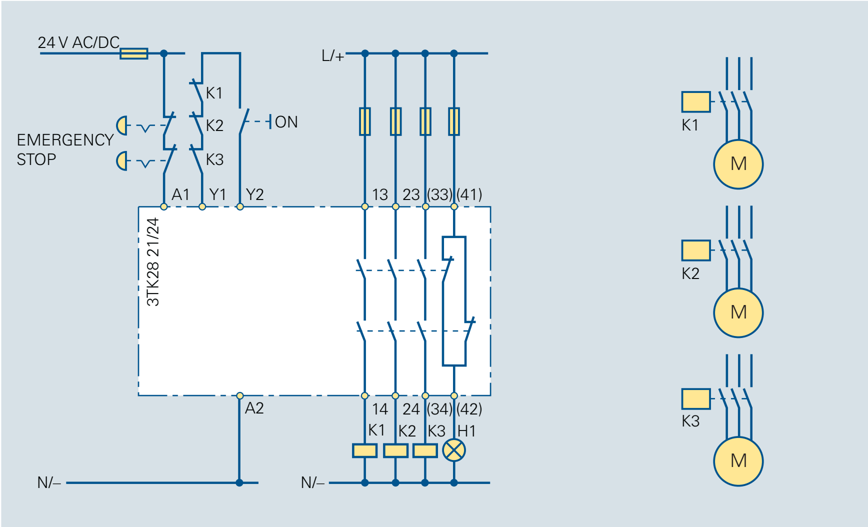


Fig. 7/10
3TK28 21/24 for EMERGENCY STOP, Category 2, single channel, with feedback circuit

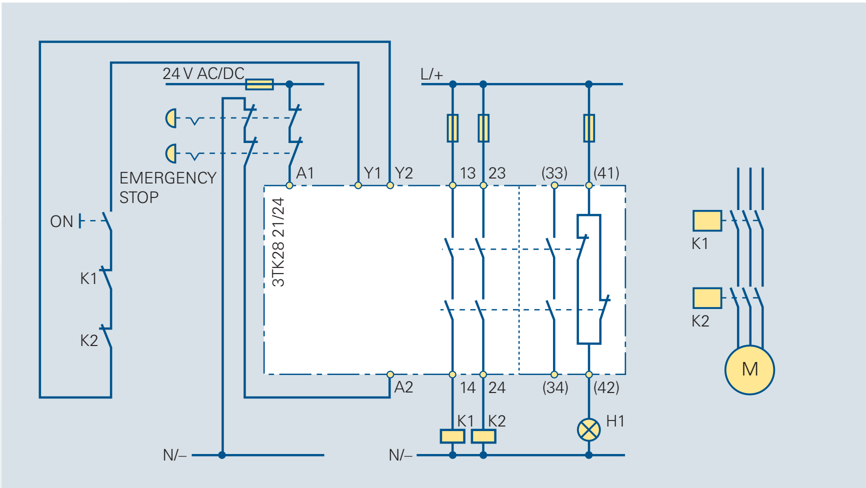


Fig. 7/11
3TK28 21/24 EMERGENCY STOP, Category 3 (4), two-channel with feedback circuit

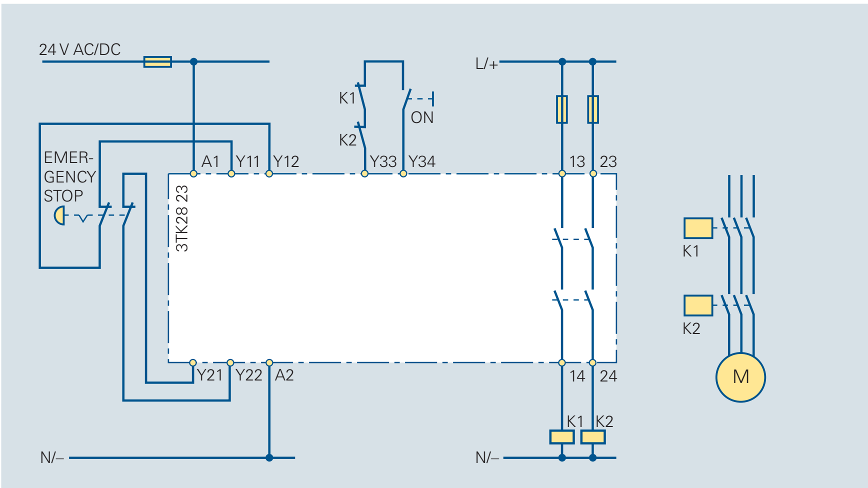


Fig. 7/12
3TK28 23 for EMERGENCY STOP, Category 4, two-channel, with feedback circuit, monitored start

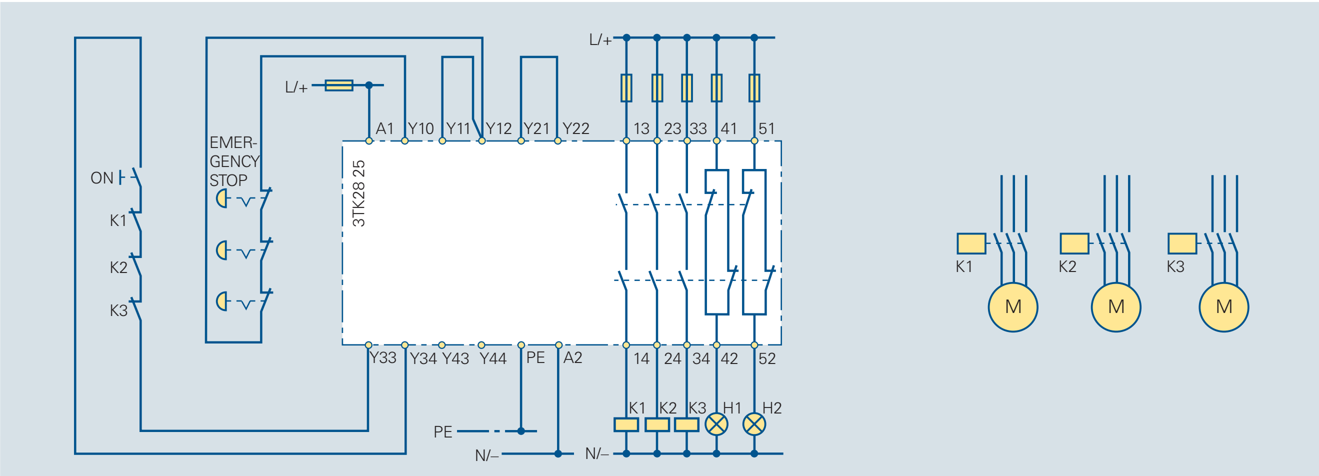


Fig. 7/13 3TK28 25 EMERGENCY STOP, Category 2, single-channel, according to EN 954-1, monitored start

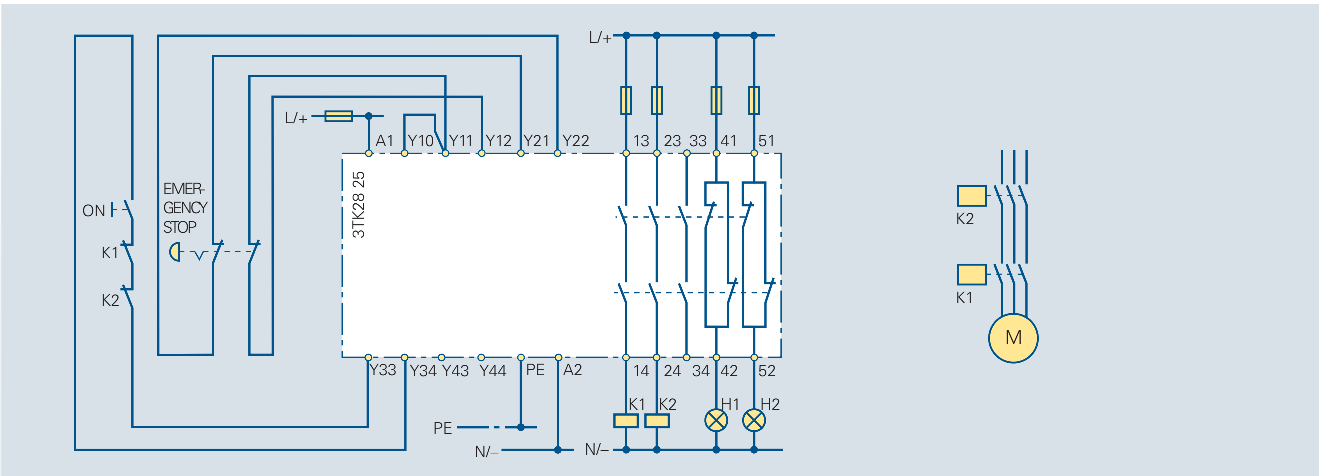


Fig. 7/14 3TK28 25 EMERGENCY STOP, Category 4, two-channel, according to EN 954-1, monitored start

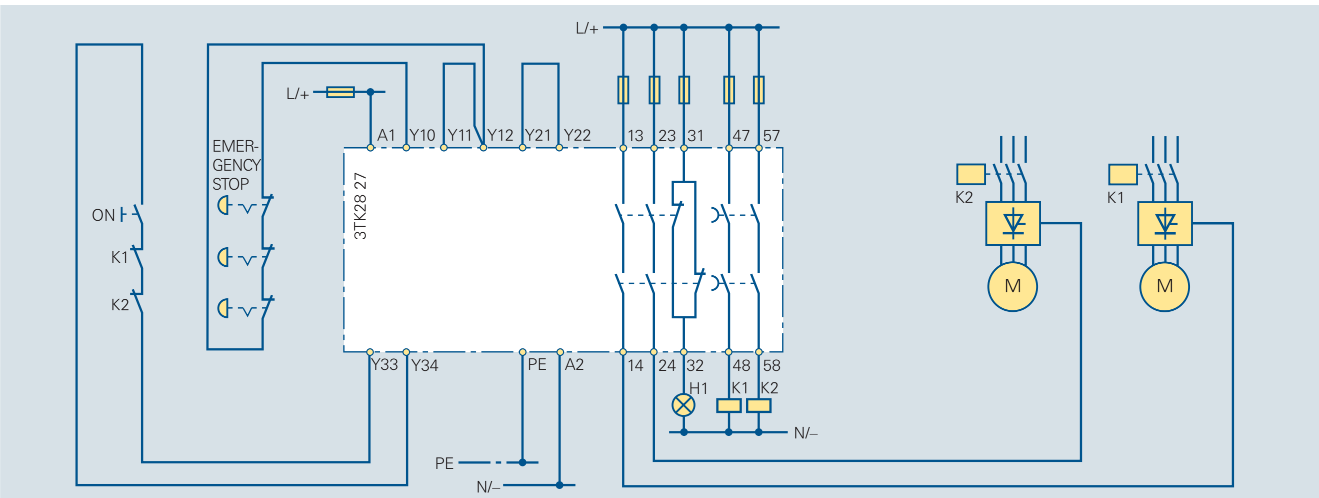


Fig. 7/15 3TK28 27 EMERGENCY STOP, Category 2, single-channel, according to EN 954-1, monitored start

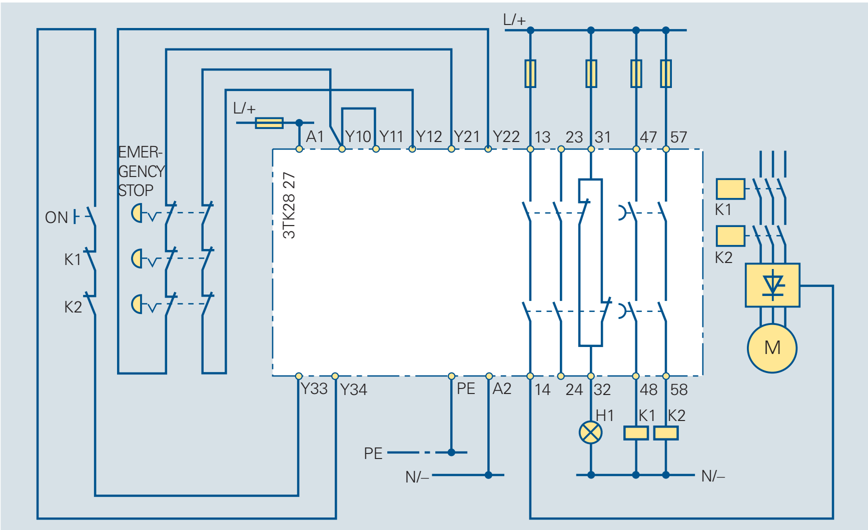


Fig. 7/16
3TK28 27 EMERGENCY STOP with shutdown, Stop Category 1, for Category 3 according to EN 954-1, two-channel, with feedback circuit, monitored start

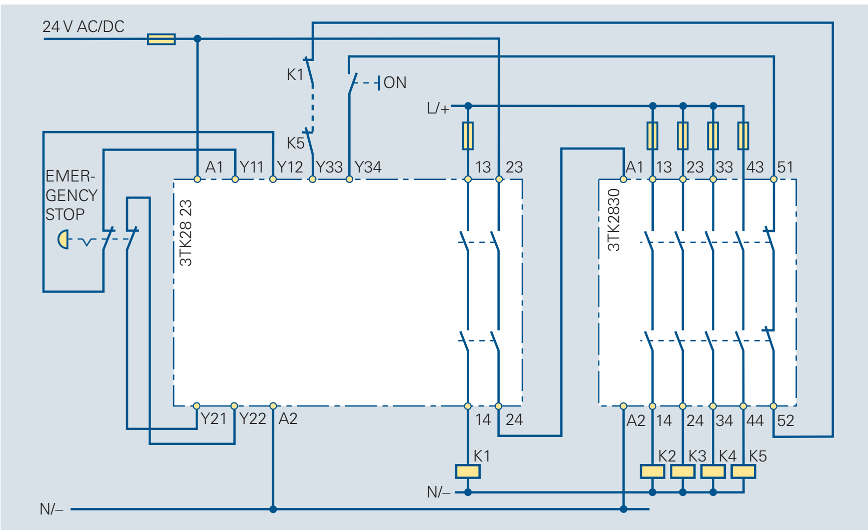


Fig. 7/17
3TK28 23 expanded with 3TK28 30 for EMERGENCY STOP, Category 4 acc. to EN 954-1, two-channel, with feedback circuit

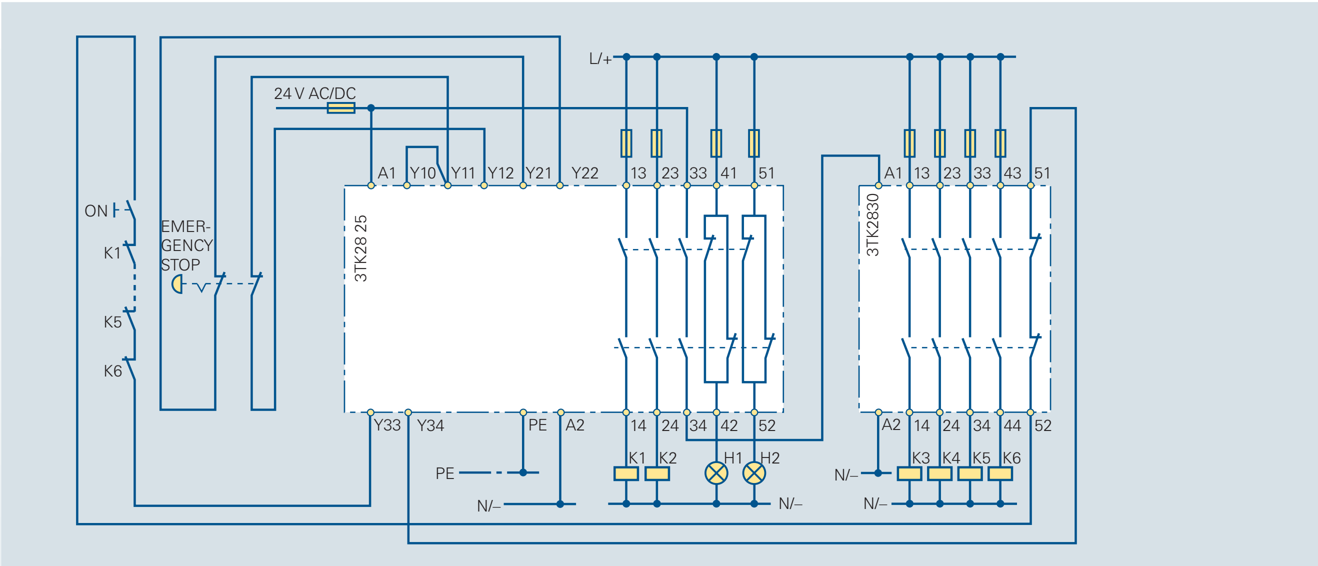


Fig. 7/18
3TK28 25 expanded by 3TK28 30 for EMERGENCY STOP, Category 4 acc. to EN 954-1, two-channel cc. to EN 954-1, monitored start

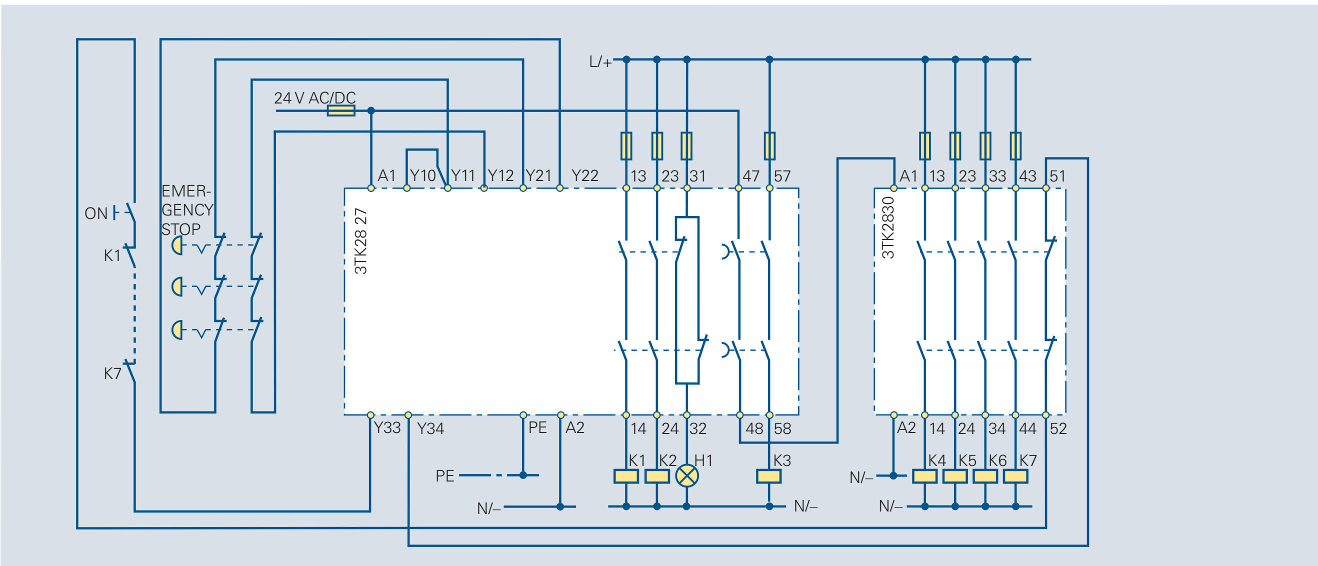


Fig. 7/19
3TK28 27 expanded by 3TK28 30 for EMERGENCY STOP, Category 4 (Category 3 for delayed contacts), two-channel, monitored start

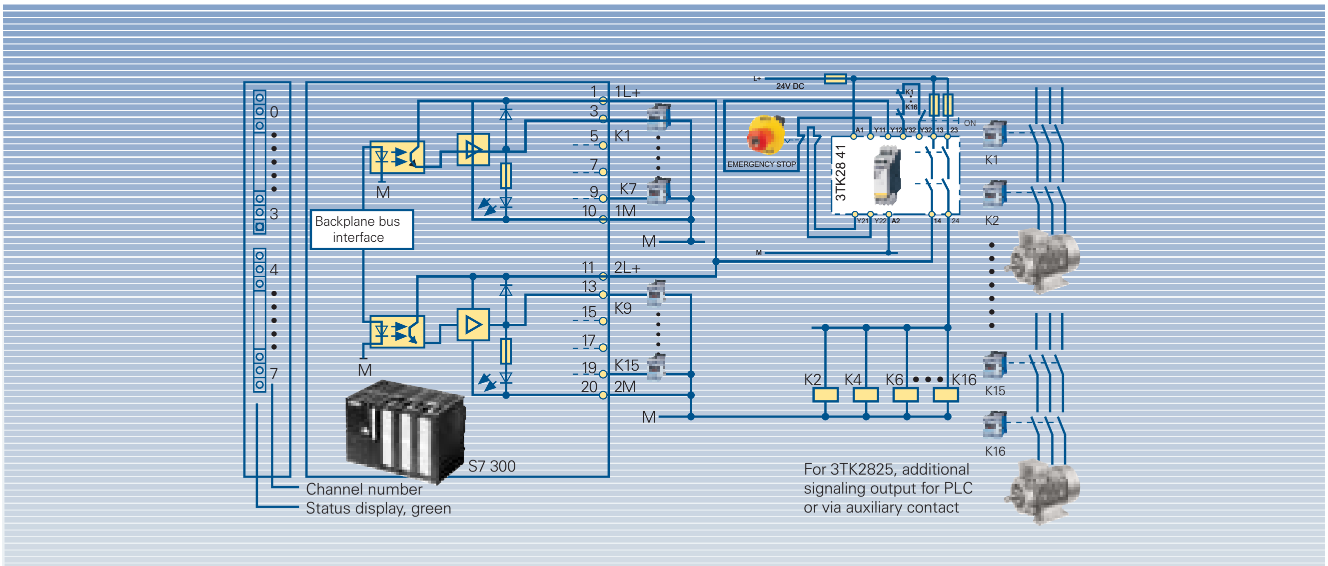


Fig. 7/20
EMERGENCY STOP, Category 4 acc. to EN954-1, 3TK2823(25) in conjunction with operational control of a standard PLC (SIMATIC S7-300/ET200M), load current for each enable circuit, max. 5 A. When using 3TK285.-.. max. 10 A for each enable circuit

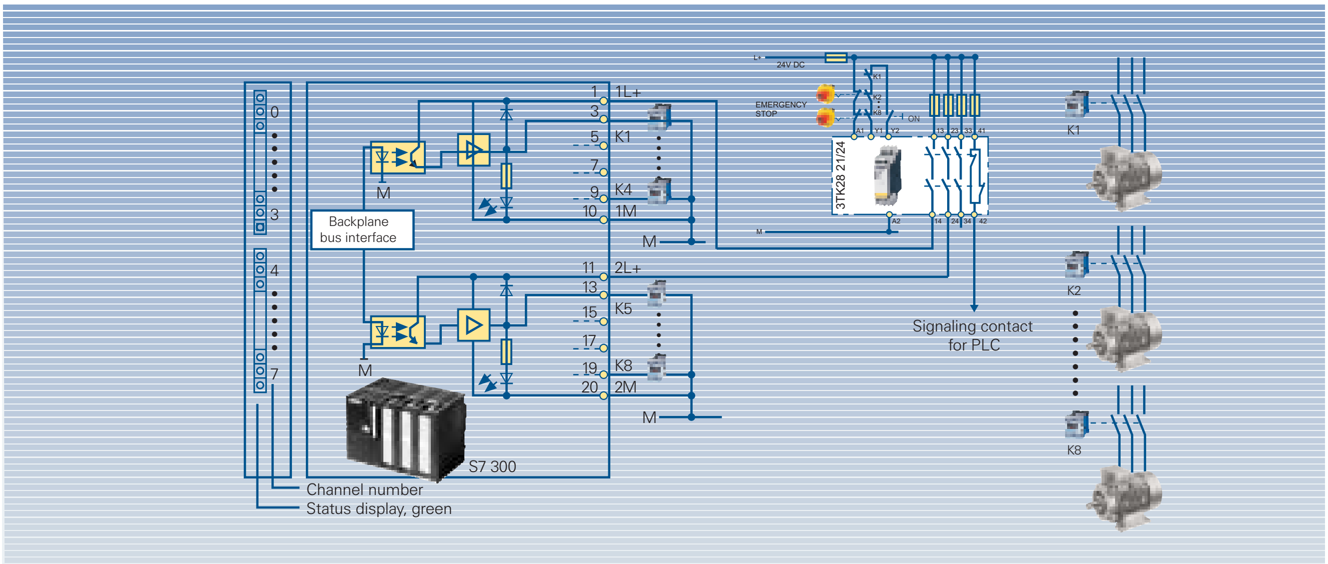


Fig. 7/21
EMERGENCY OFF, Category 2 acc. to EN954-1, 3TK2821 in conjunction with operational control of a standard PLC (SIMATIC S7-300/ET200M), load current, max. 5 A per output group (8 digital outputs)

Protective door monitoring

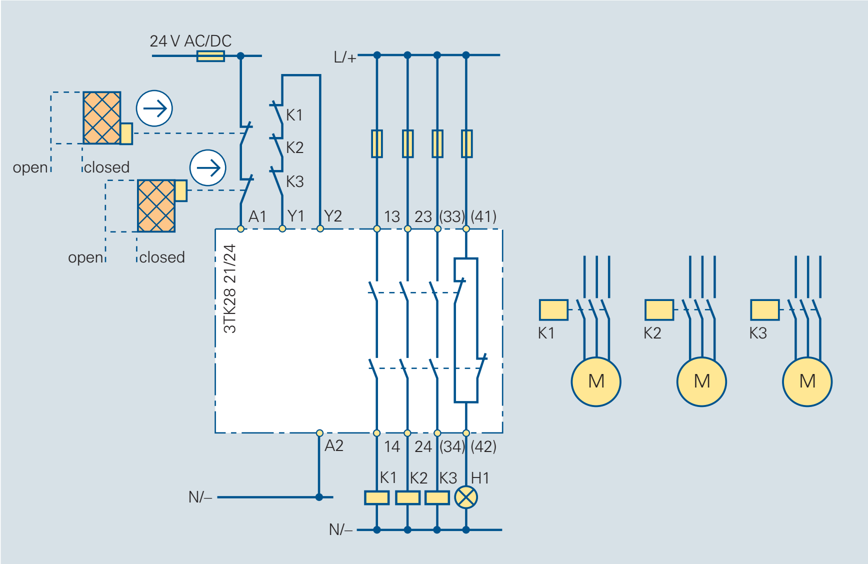


Fig. 7/22
3TK28 21/24 for protective door monitoring (2 protective doors are cascaded each with 1 SIGUARD position switch), Category 2 acc. to EN 954-1, single-channel, with feedback circuit, autostart

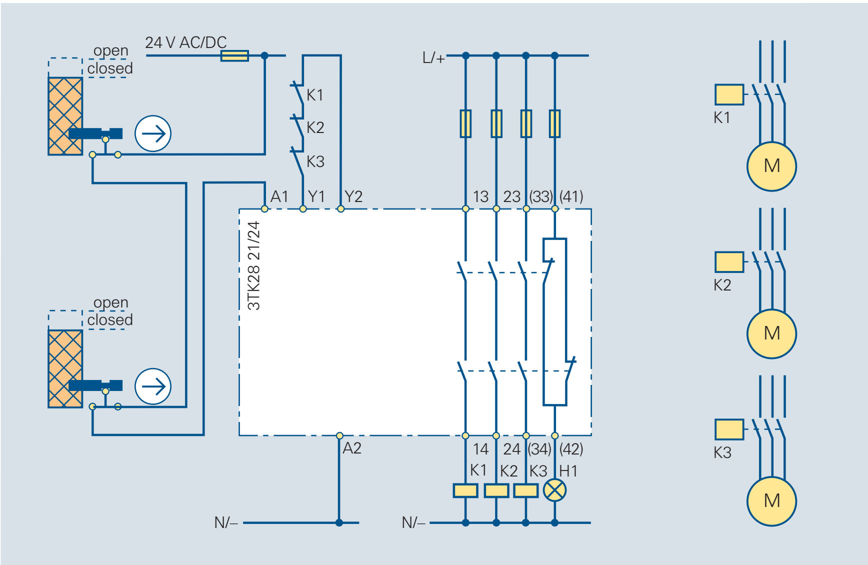


Fig. 7/23
3TK28 21/24 for protective door monitoring with tumbler (2 protective doors are cascaded, each with 2 SIGUARD position switches with tumbler) Category 2 acc. to EN 954-1, single-channel, with feedback circuit, autostart

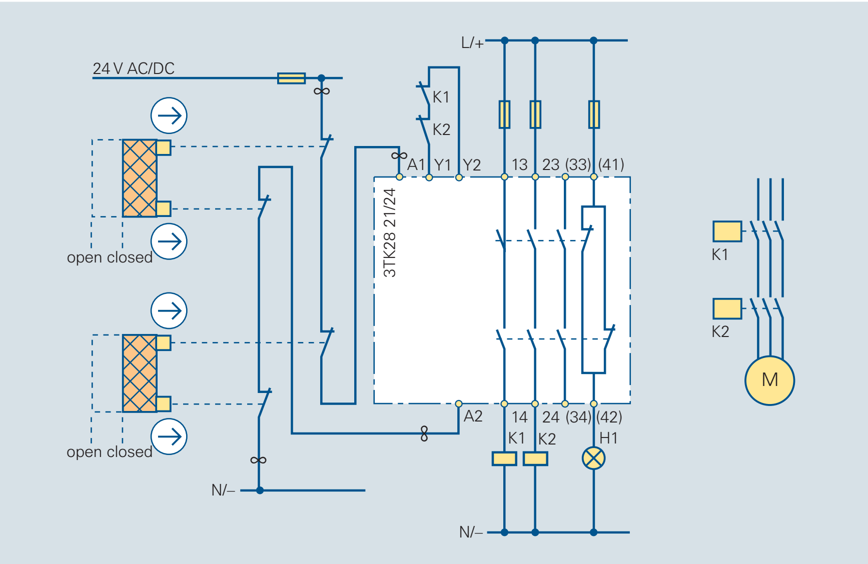


Fig. 7/24
3TK28 21/24 for protective door monitoring (2 protective doors are cascaded, each with 2 SIGUARD position switches), Category 3 (4) acc. to EN 954-1, two-channel, with feed-back circuit, autostart, (∞ for Category 4 - the cable has to be routed so that it is well protected). Sensors must be fail-safe.

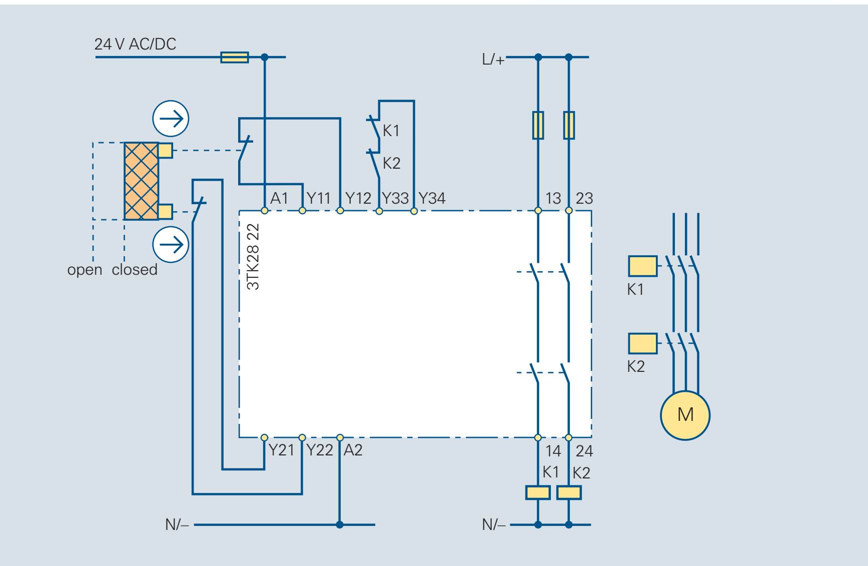


Fig. 7/25
3TK28 22 for protective door monitoring (protective doors, each with 2 SIGUARD position switches).
Category 4 acc. to EN 954-1,
two-channel, with feedback circuit, autostart

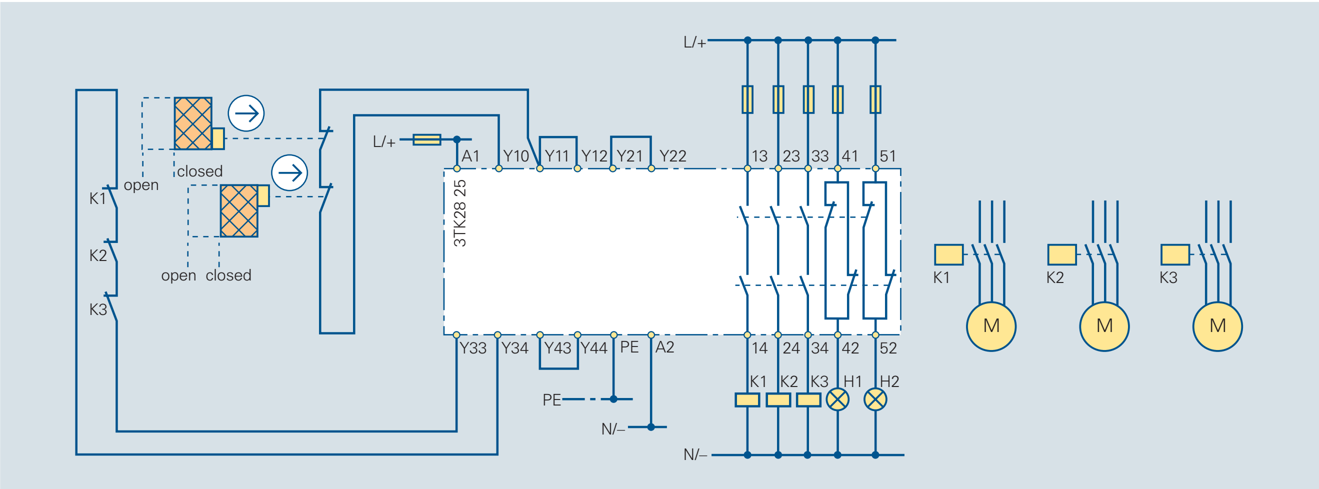


Fig. 7/26
3TK28 25 for protective door monitoring (2 protective doors are cascaded, each with 1 SIGUARD position switch), autostart, Category 2 acc. to EN 954-1, single-channel, with feedback circuit

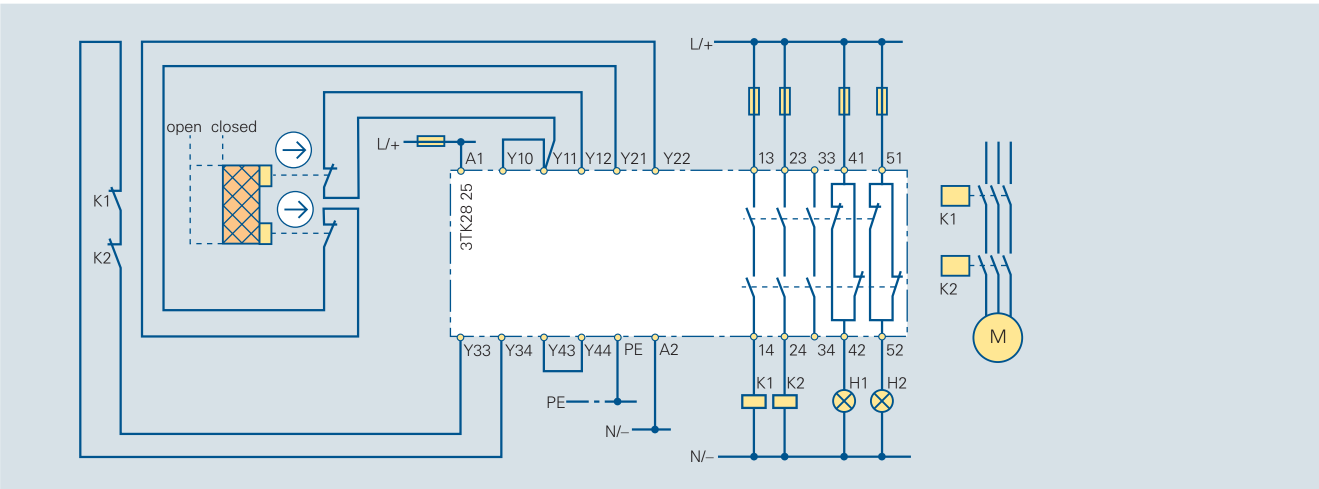


Fig. 7/27
3TK28 25 for protective door monitoring with 2 SIGUARD position switches, autostart, Category 4 acc. to EN 954-1, two-channel, with feedback circuit

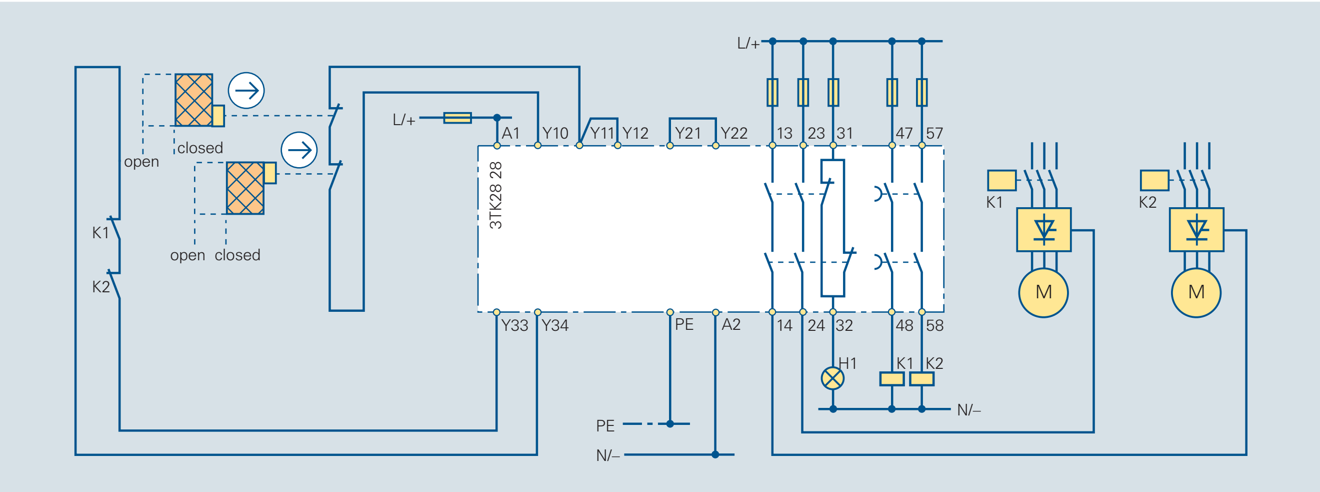


Fig. 7/28
3TK28 28 for protective door monitoring (2 protective doors are cascaded, each with 1 SIGUARD position switch), Stop Category 1, Category 2 acc. to EN 954-1, single-channel, with feedback circuit, autostart

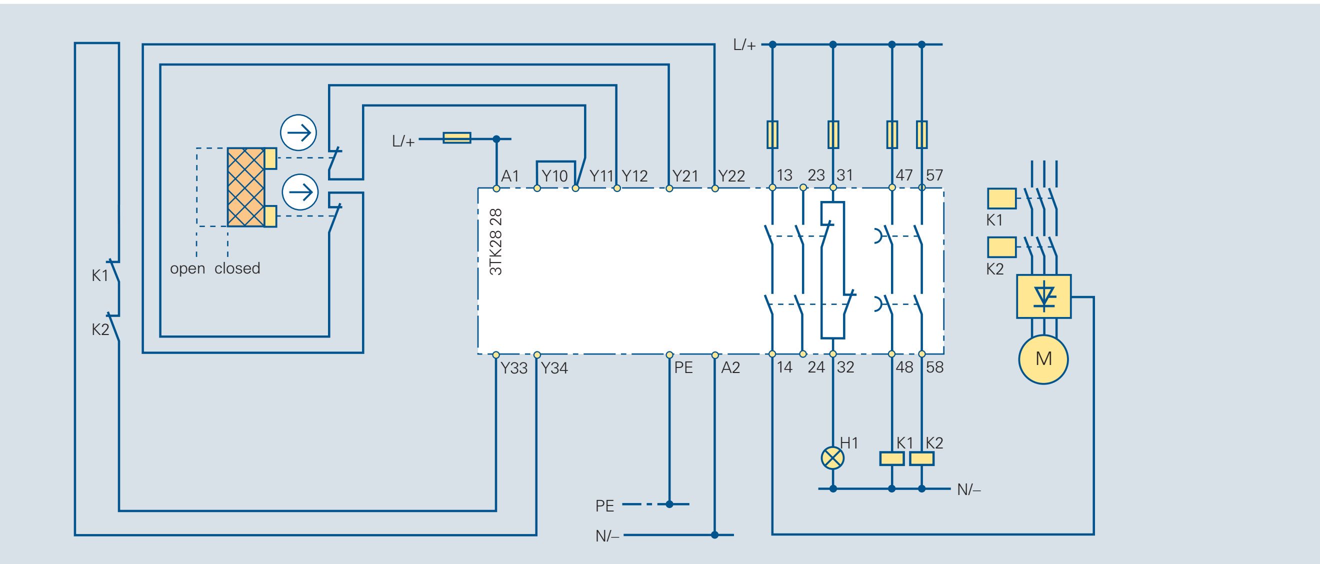


Fig. 7/29
3TK28 28 for protective door monitoring with 2 SIGUARD position switches, stop Category 1, Category 3 acc. to EN 954-1, two-channel, with feedback circuit, autostart

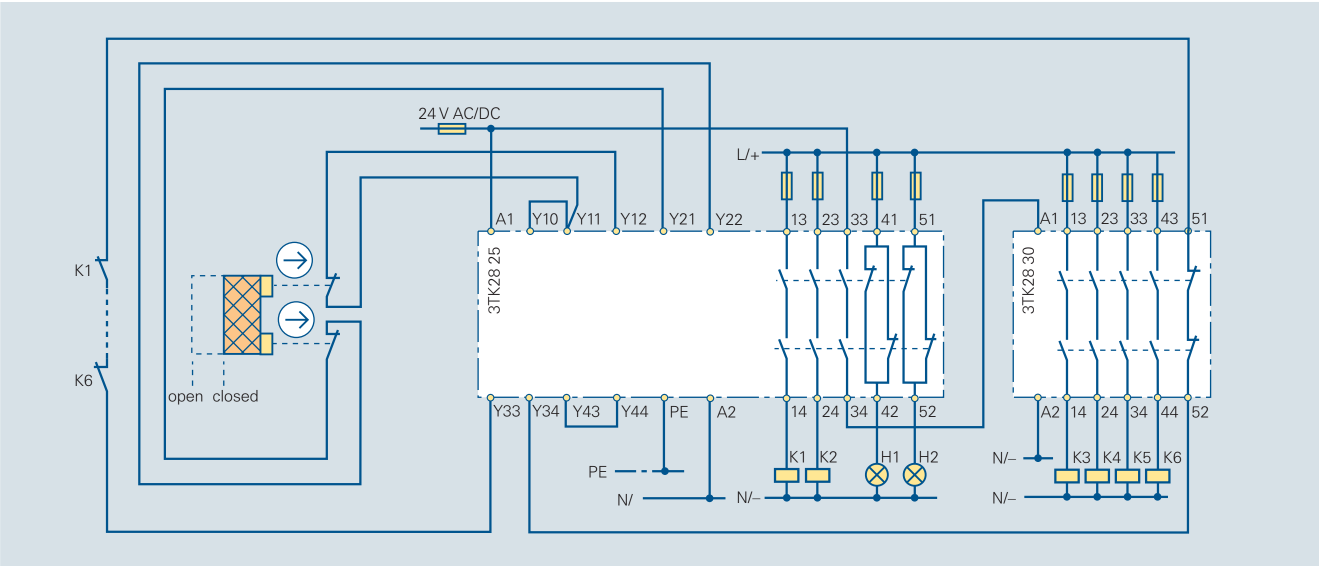


Fig. 7/30
3TK28 25 expanded by 3TK28 30 for protective door monitoring with 2 SIGUARD position switches, Category 4 acc. to EN 954-1, two-channel, with feedback circuit, autostart

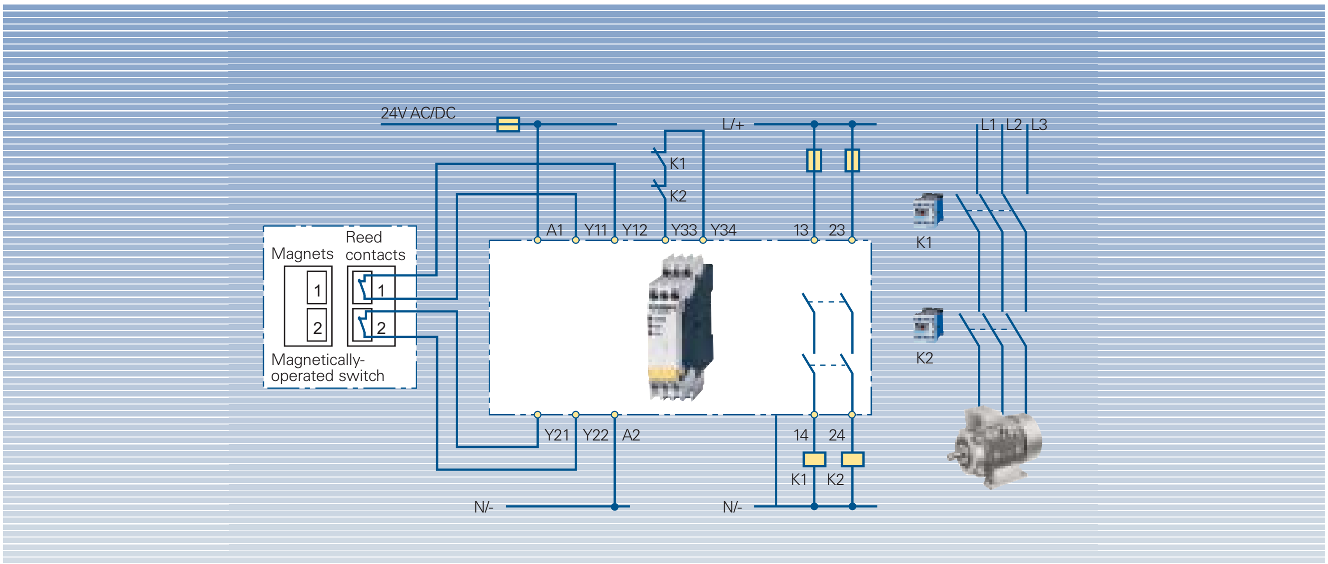


Fig. 7/31
Protective door monitoring with magnetically-operated switch, Category 3 acc. to EN 954-1, two-channel, with feedback circuit, autostart

Protective door monitoring with contactless SIGUARD magnetically-operated switches

Protective doors are monitored using an evaluation unit up to Cat. 3 acc. to EN 954-1 (Fig. 7/32).

The evaluation unit can be operated, both with automatic restart as well as with monitored start. The start button is not necessarily required.

Monitoring several protective doors with evaluation unit up to Cat. 3 acc. to EN 954-1

A maximum of eight SIGUARD magnetically-operated switches can be connected to the 3SE6808-6DB evaluation unit. If one of the eight magnetically-operated switches is actuated (the protective door is opened), then the unit shuts down.
There is a PLC signaling output (switching to p) for each input. The fail-safe shutdown is realized using two relay safety outputs.

If an input is not used, then the appropriate terminals of the NO contact must be bridged.

For limited safety requirements, the evaluation unit can also be used without a start button. For this particular application, contacts X1 and Y1 must be permanently bridged.

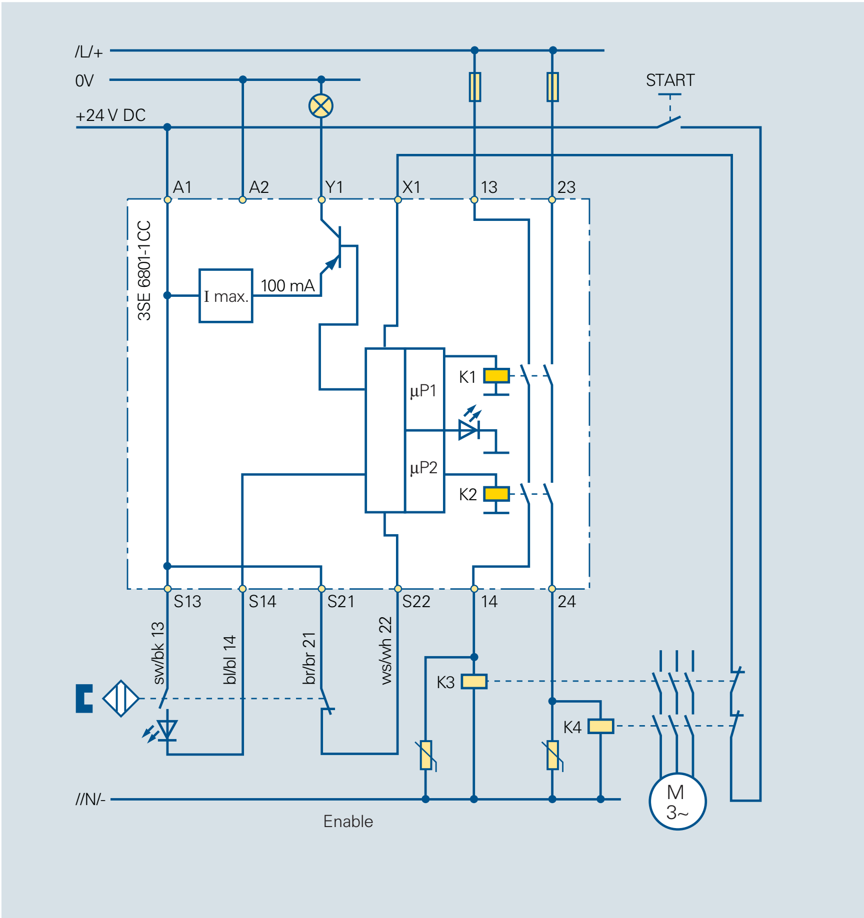


Fig. 7/32
SIGUARD magnetically-operated switch with 3SE6801-1CC evaluation unit for Category 3 acc. to EN 954-1

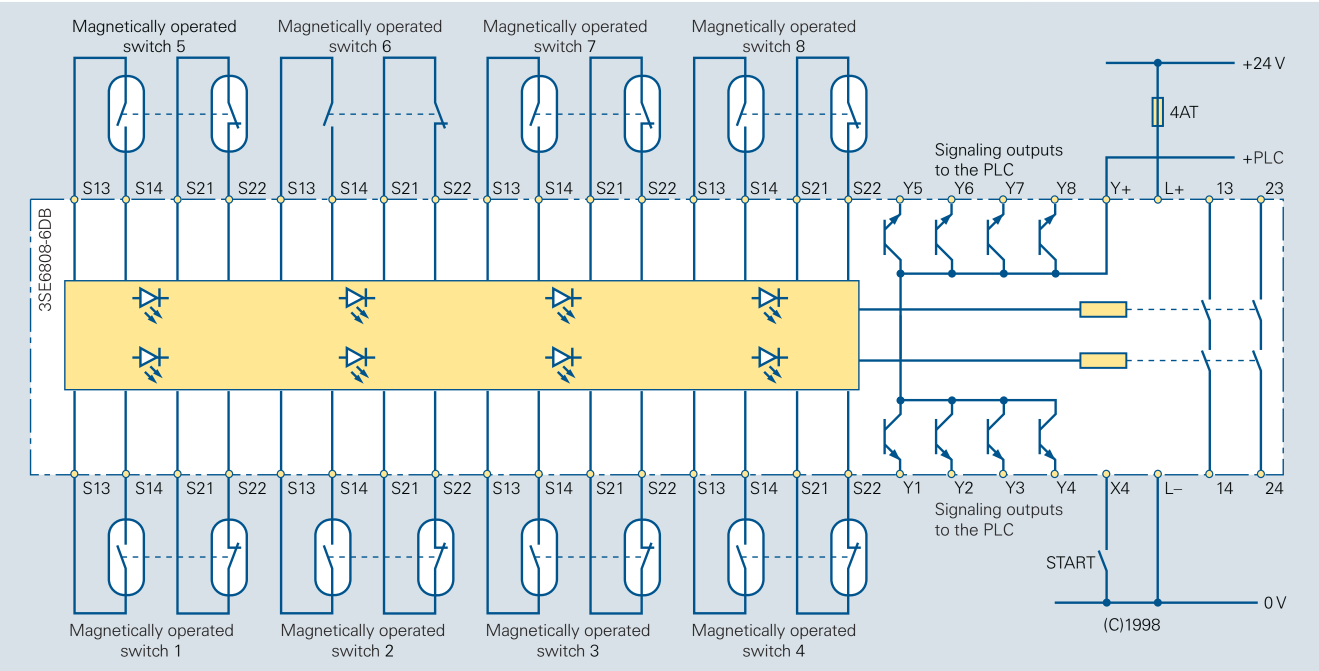
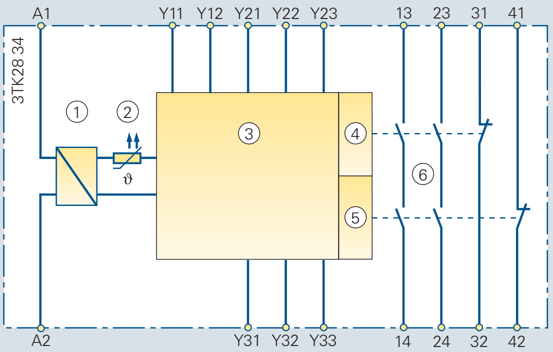


Fig. 7/33
A maximum of 8 protective doors can be monitored using SIGUARD magnetically-operated switches and evaluation unit 3SE6808-6DB for Category 3 acc. to EN 954-1

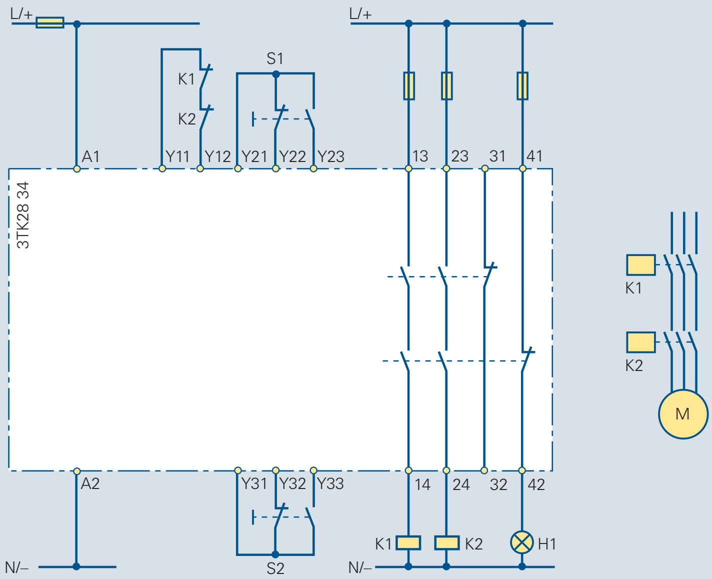
Press control devices

For press control devices with contactors also refer to Pages 7/14 and 7/15.



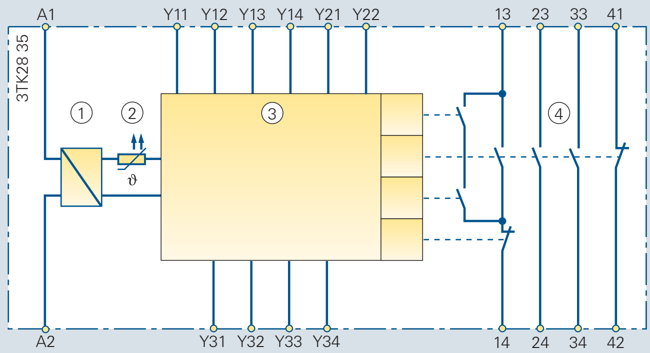
Operating voltage	A1	L/+	(1) Power supply unit
	A2	N/–	(2) PTC fuse
Outputs	13, 14	Enable circuit 1 (NO contact)	(3) Control logic
	23, 24	Enable circuit 2 (NO contact)	(4) Channel 1
	31, 32	NC contact	(5) Channel 2
	41, 42	NC contact	(6) Safety circuit
Inputs	Y11, Y12	Feedback circuit	
	Y21, Y22, Y23	Pushbutton S1	
	Y31, Y32, Y33	Pushbutton S2	

Fig. 7/34
Internal circuit diagram of the 3TK28 34 two-hand control device



S1, S2 button on the two-hand operating console
H1 signaling lamps
K1, K2 must be contactors with positively driven contacts

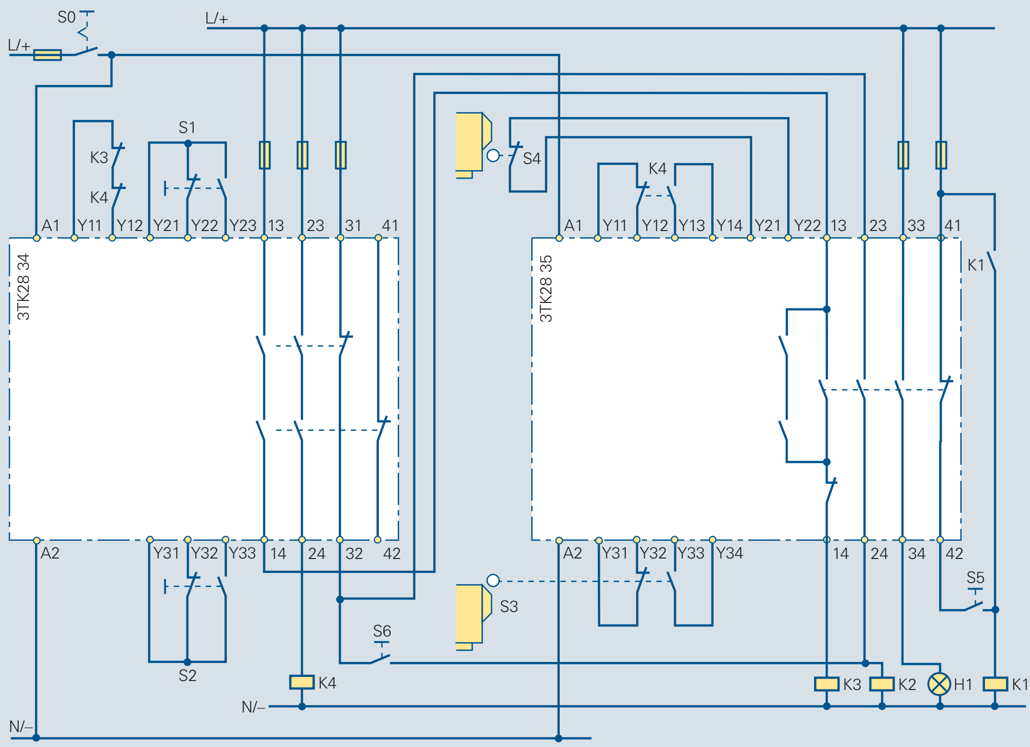
Fig. 7/35
3TK28 34 two-hand control device, Category 4 acc. to EN 954-1



Operating voltage	A1	L/+
	A2	N/–
Outputs	13, 14	Enable circuit (tool down)
	23, 24	NO contact (tool up)
	33, 34	NO contact (overtravel OK)
	41, 42	NC contact (hydraulic pump on)
Inputs	Y11, Y12, Y13, Y14	Feedback circuit (K4)
	Y21, Y22	Position switch (S4) for test cam
	Y31, Y32, Y33, Y34	Upper dead center, switch (S3)

1 Power supply unit
2 PTC fuse
3 Control logic
4 Safety circuit

Fig. 7/36
Internal circuit diagram of the 3TK28 35 overtravel tester



S0	Main switch
S1, S2	Button on the two-hand operating console
S3	Position switch at the upper dead center
S4	Position switch for test cams
S5	Hydraulic pump "ON"
S6	Tool "UP" (manual operation)
K1	Contactor for the hydraulic pump
K2	Tool "UP"
K3, K4	Tool "DOWN"
H1	Signal lamp

Fig. 7/37
3TK28 34 two-hand control device in conjunction with a 3TK28 35 overtravel tester to monitor the overtravel on linear hydraulic, pneumatic and spindle presses acc. to VBG 7 n 5.2 § 11, Category 4 acc. to EN 954-1

Sequence after the press has been powered-up:

1. The hydraulic pump is powered-up with S5, the ram is moved up to the upper dead center, if required, using S6.
2. Depress S1, S2 at the two-hand operating console until the position switch for the test cams (S4) opens.
3. Release S1, S2 .
4. Depress S1, S2 again: Signal lamp H1 lights up (bright) if the overtravel is OK
5. Release S1, S2: The ram returns to the upper dead center.
6. If the overtravel is OK, all of the outputs remain active until the control voltage is disconnected.

LED's		Operation
POWER	RELEASE	
		Overtravel OK
		Overtravel erroneous or test still not executed

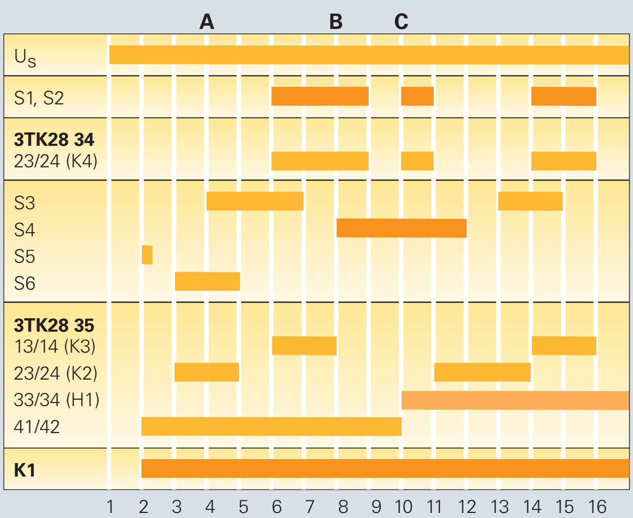
Fault situation

If the cam actuates position switch S4, then the signal lamp H1 is not lit up. The machine part, which is potentially hazardous, can then only be moved to the upper dead center using S6.

This press can then no longer be used. Contact the technician to check the press.

A more detailed description of the function of the 3TK28 34 two-hand control devices is provided in the Instruction Manual, Order No. 3ZX1012-0TK28-7CA1, for the overtravel tester 3ZX1012-0TK28-6CA1.

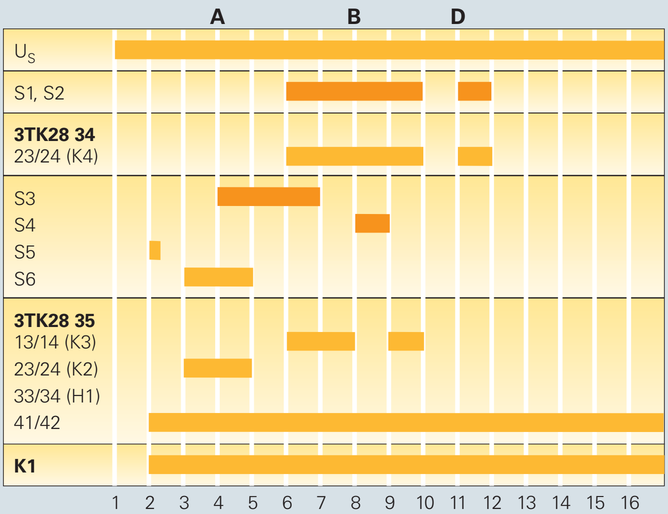
Fig. 7/38



Overtravel OK

1. Power (V_S) on
2. S5 is pressed, K1 pulls in (latches).
3. S6 is pressed, K2 pulls in (the ram moves upwards in the manual mode).
4. The upper dead center is reached, S3 is actuated.
5. S6 is released, K2 drops out.
6. S1 and S2 are pressed on the two-hand operating console, the two-hand control device 3TK2834 outputs an enable signal, K3 and K4 pull in.
7. The ram moves downwards, S3 is no longer actuated.
8. Test cams are reached, S4 is actuated, K3 drops out.
9. **The ram remains stationary**, S1, S2 are released, K4 drops out.
10. S1, S2 are pressed, K4 pulls in again, H1 lights up.
11. S1, S2 are released, K4 drops out. K2 pulls in, the ram moves upwards. S4 is no longer actuated.
12. Upper dead center is reached, S3 is actuated.
13. S1 and S2 are pressed; K2 drops out, K3 and K4 pull in.
14. The ram moves downwards, S3 is no longer actuated.
15. S1, S2 are released, K3 and K4 open. K2 pulls in.
16. Points 14 to 16 are repeated at each stroke of the press.

Fig. 7/39



Overtravel too long

1 Power (V_S) on
2 S5 is pressed, K1 pulls in (latches).
3 S6 is pressed, K2 pulls in (the ram moves upwards in the manual mode).
4 The upper dead center is reached, S3 is actuated.
5 S6 is released, K2 drops out.
6 S1 and S2 on the two-hand operating console are pressed, the 3TK2834 two-hand control device outputs enable signals, K3 and K4 pull in.
7 The ram moves downwards, S3 is no longer actuated.
8 Test cams are reached, S4 is depressed, K3 drops out.
9 **The ram does not remain stationary**, S4 is no longer actuated (is passed over), K3 pulls in.
10 S1 and S2 are released, K3 and K4 drop out.
11 S1, S2 are actuated, K4 pulls in again. Overtravel tester is inhibited.

Fig. 7/40

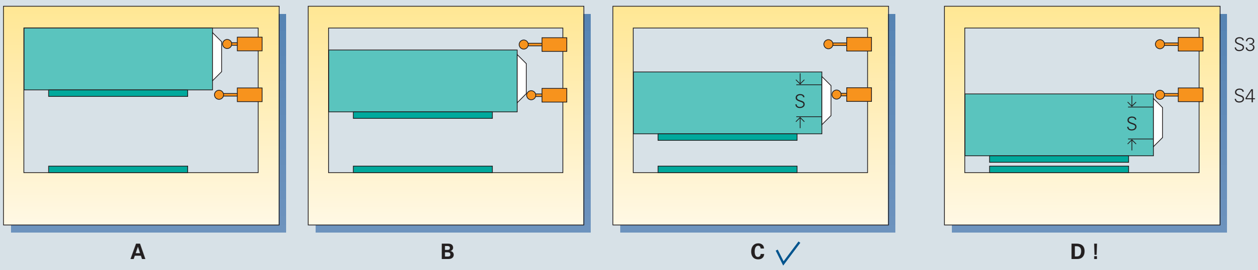


Fig. 7/41
Function schematic of the press control.
The permissible overtravel "s" corresponds to the length of the cam which actuates position switch S4.
According to ZH 1/456, the press manufacturer must define "s."

Circuit examples SIGUARD electronic safety combinations

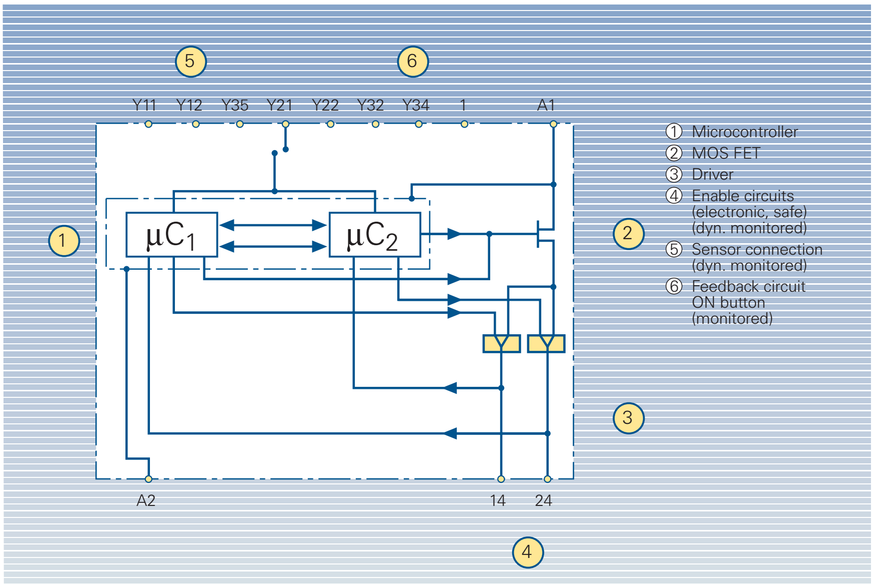


Fig. 7/42
SIGUARD 3TK28 41, internal circuit diagram, standard electronic device

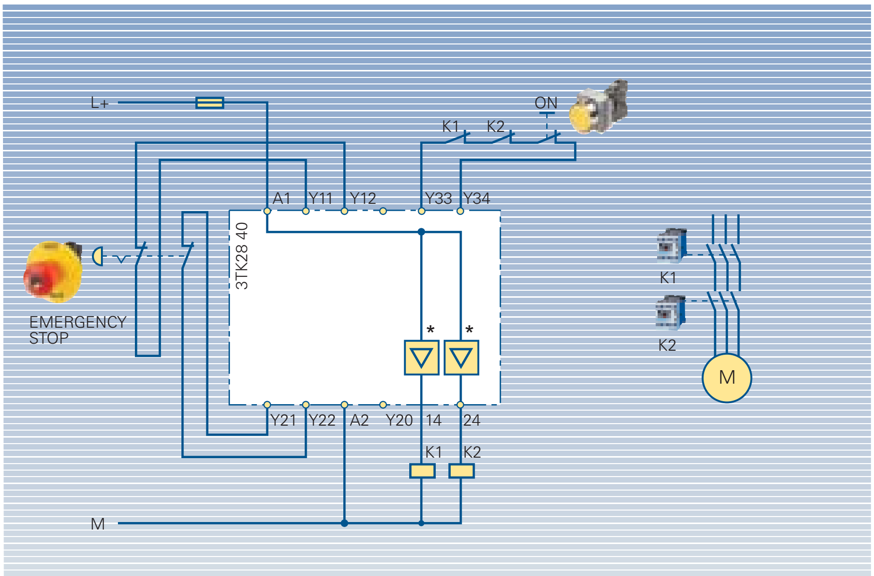


Fig. 7/43
SIGUARD 3TK28 40, basic electronic device, EMERGENCY STOP, 2-channel, Category 3 acc. to EN 954-1

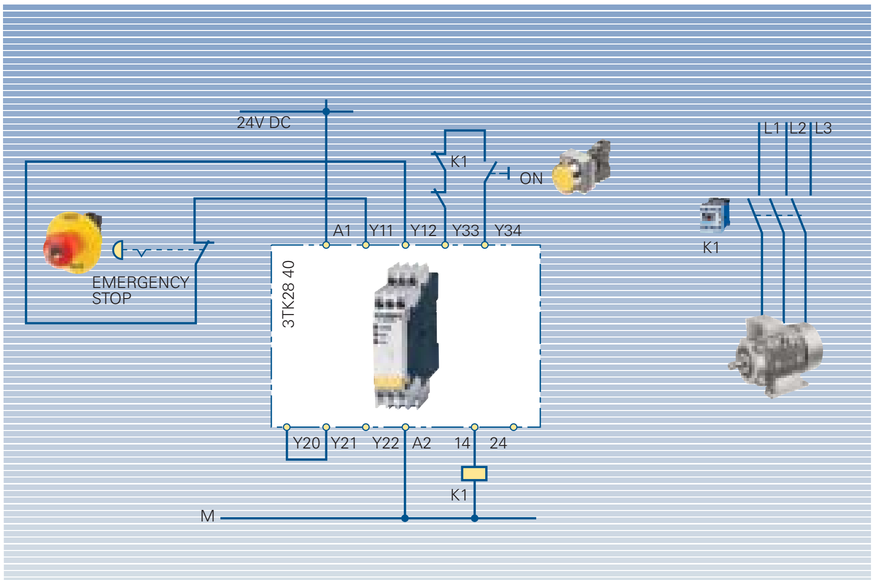


Fig. 7/44
SIGUARD 3TK2840, EMERGENCY STOP, Category 2 acc. to EN 954-1, single-channel, with feedback circuit

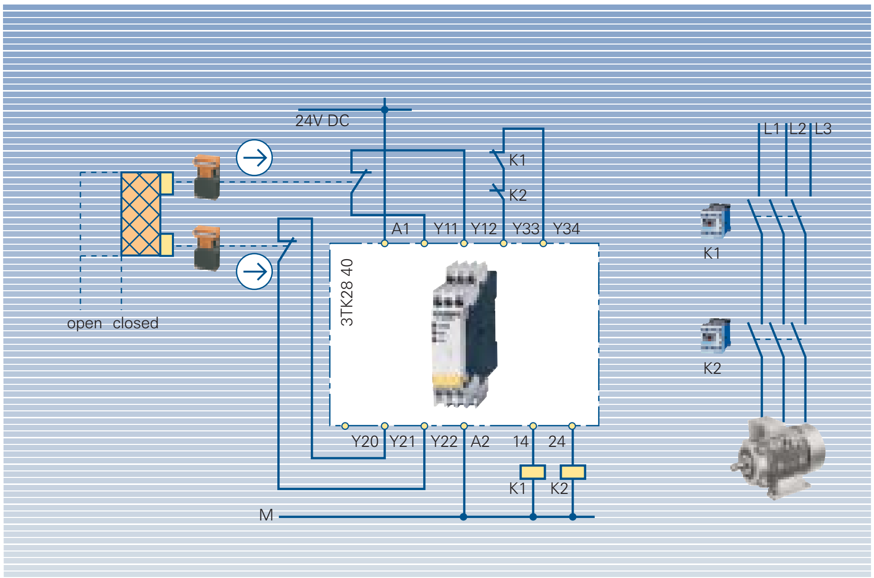


Fig. 7/45
SIGUARD 3TK2840, protective door monitoring, Category 3 acc. to EN 954-1, two-channel with feedback circuit

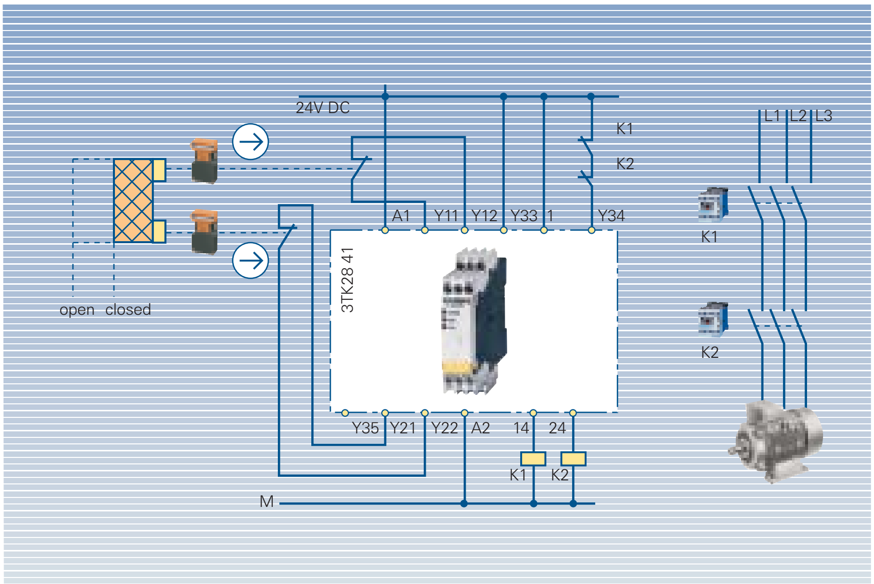


Fig. 7/46
SIGUARD 3TK2841, protective door monitoring,
Category 4 acc. to EN 954-1, two-channel with feedback circuit, autostart

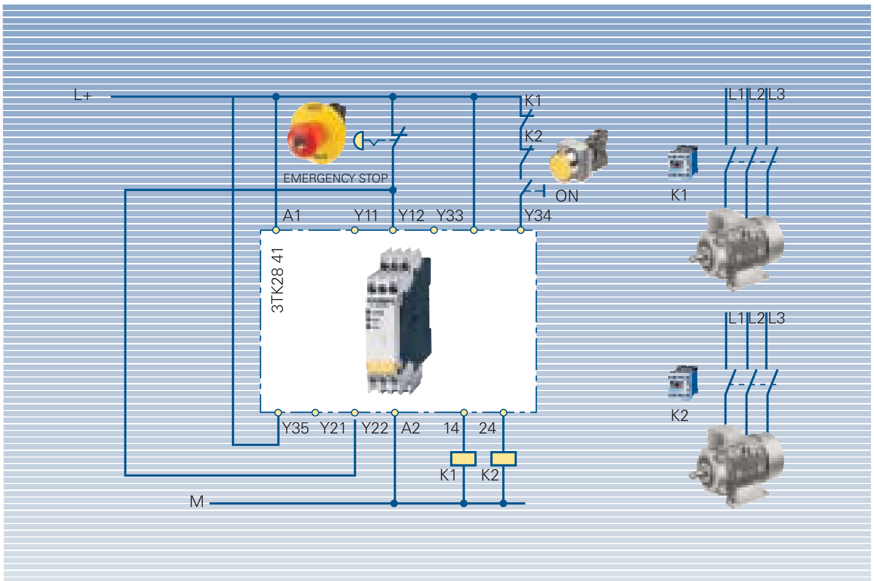


Fig. 7/47
SIGUARD 3TK2841, EMERGENCY STOP,
Category 2 acc. to EN 954-1, one-channel, with feedback circuit, monitored start

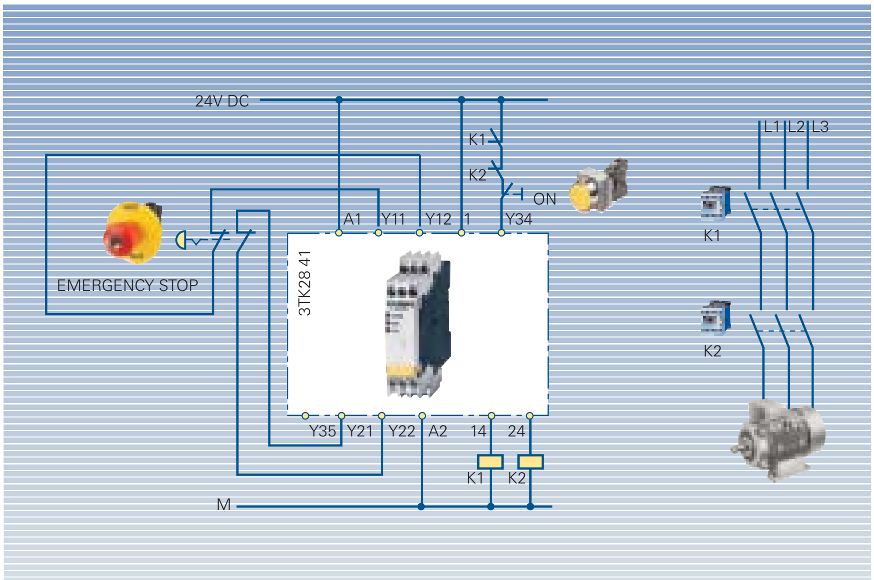


Fig. 7/48
SIGUARD 3TK2841, EMERGENCY STOP, Category 4 acc. to EN 954-1, two-channel, with feedback circuit, monitored start with "ON" button

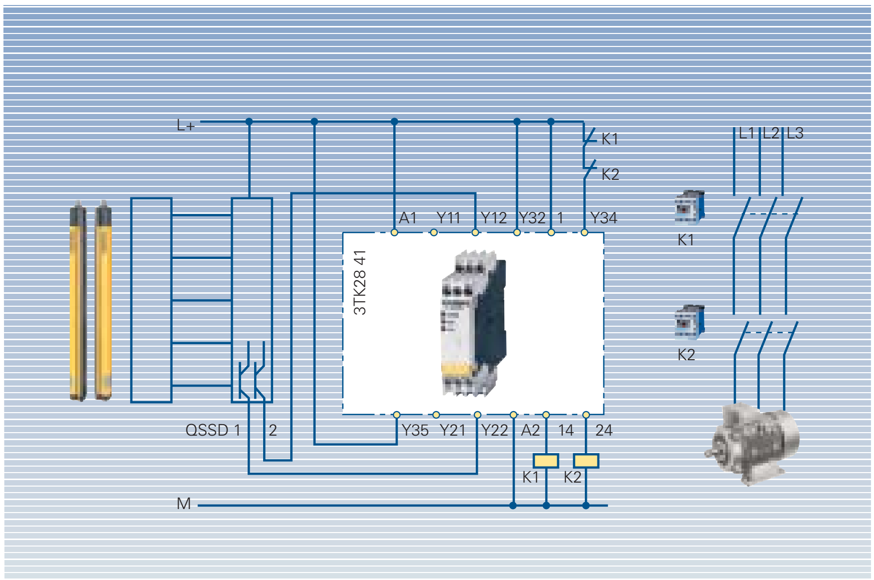


Fig. 7/49
SIGUARD 3TK2841, light grid monitoring, Category 4 acc. to EN 954-1, 2-channel, with feedback circuit, autostart

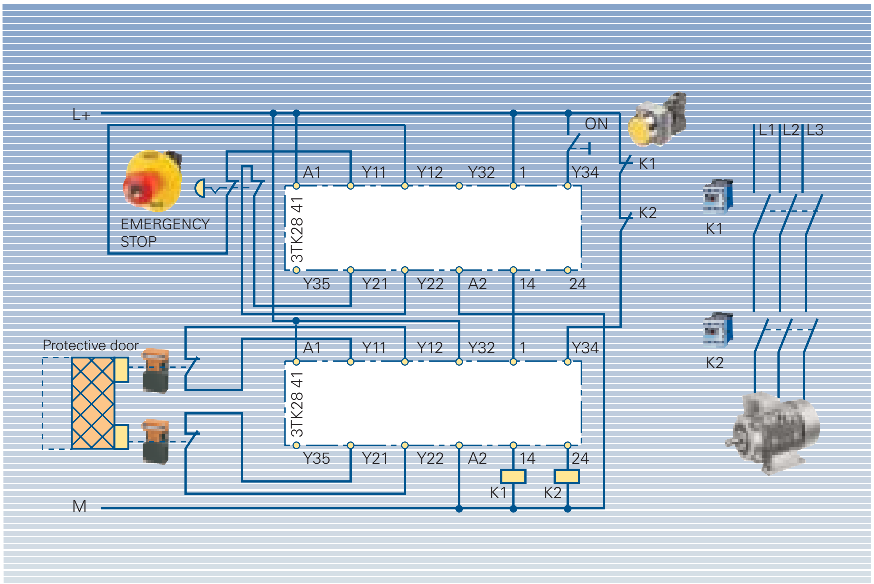


Fig. 7/50
SIGUARD 3TK2841, EMERGENCY STOP, 2-channel, monitored start, with additional on button and protective door monitoring, 2-channel, autostart, Category 4 acc. to EN 954-1

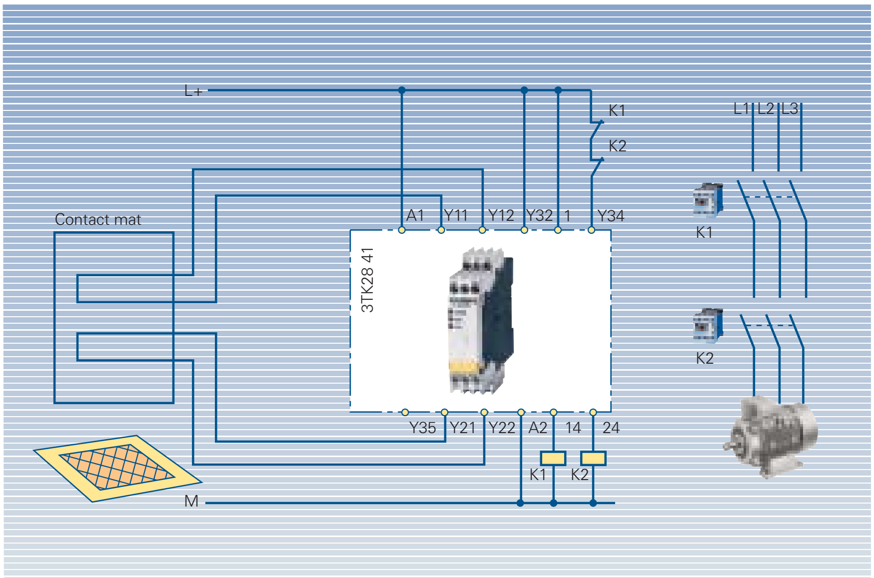


Fig. 7/51
SIGUARD 3TK2841, contact mat, Category 3 acc. to EN 954-1, 2-channel, autostart

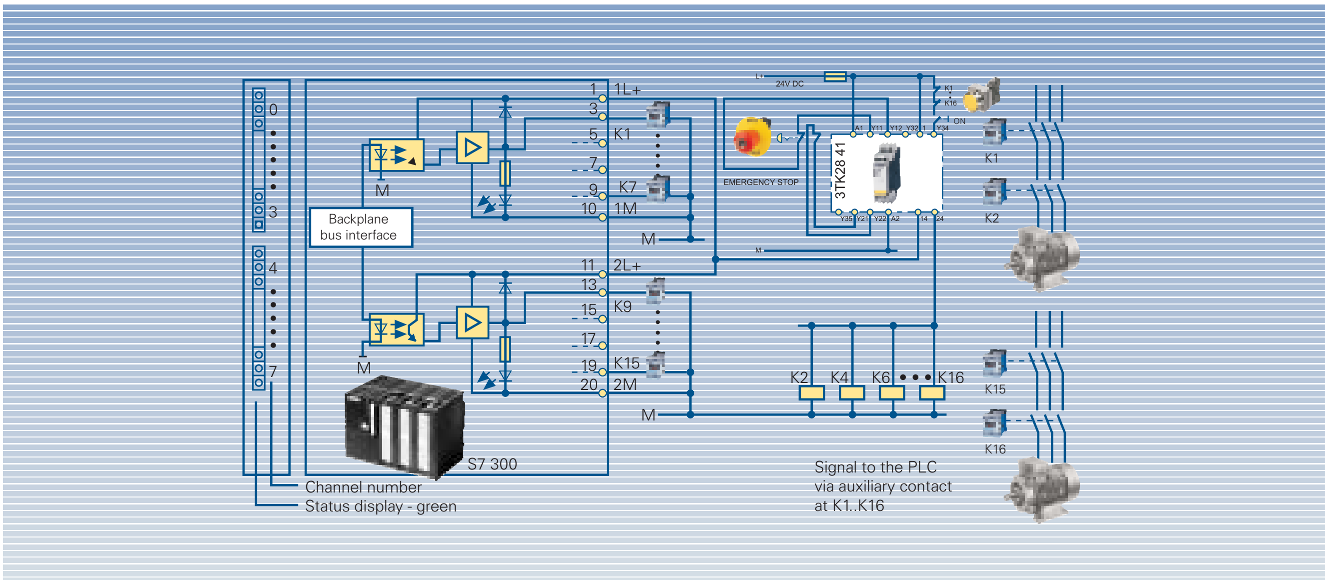


Fig. 7/52
SIGUARD 3TK2841, EMERGENCY STOP, Category 4 acc. to EN 954-1, in conjunction with operational control of a standard PLC (SIMATIC S7 300/ET200M) load current for each enable circuit, max. 2 A

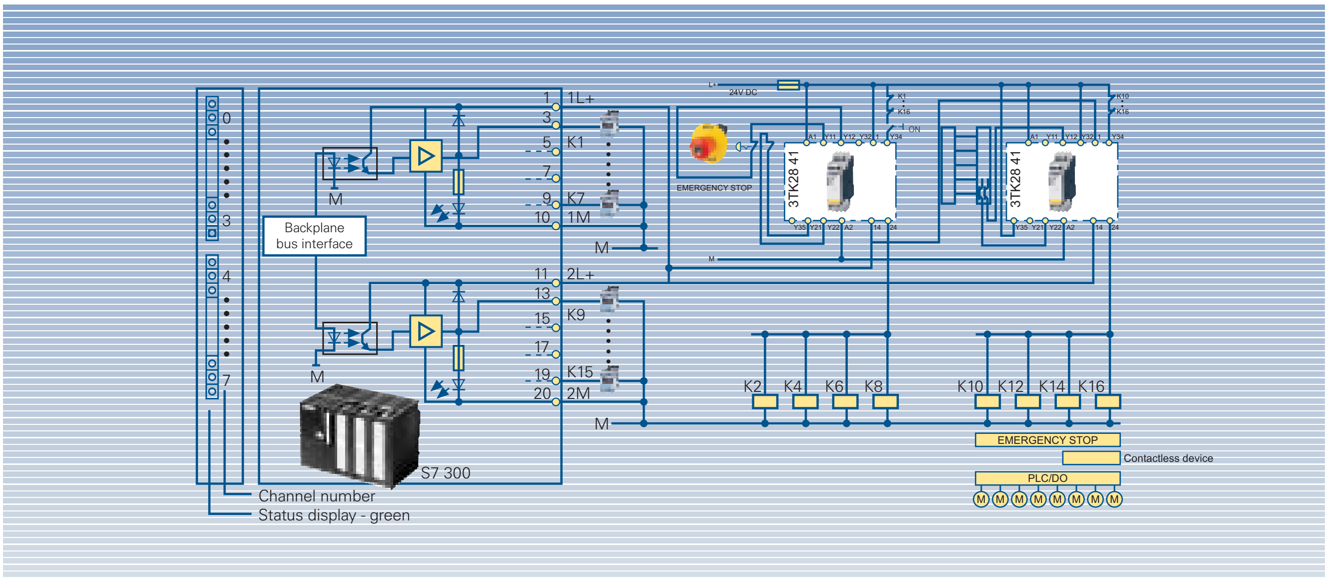


Fig. 7/53
SIGUARD 3TK2841, EMERGENCY STOP and light grid, Category 4 acc. to EN 954-1, cascaded with operational control of a standard PLC (SIMATIC S7 300/ET200M)

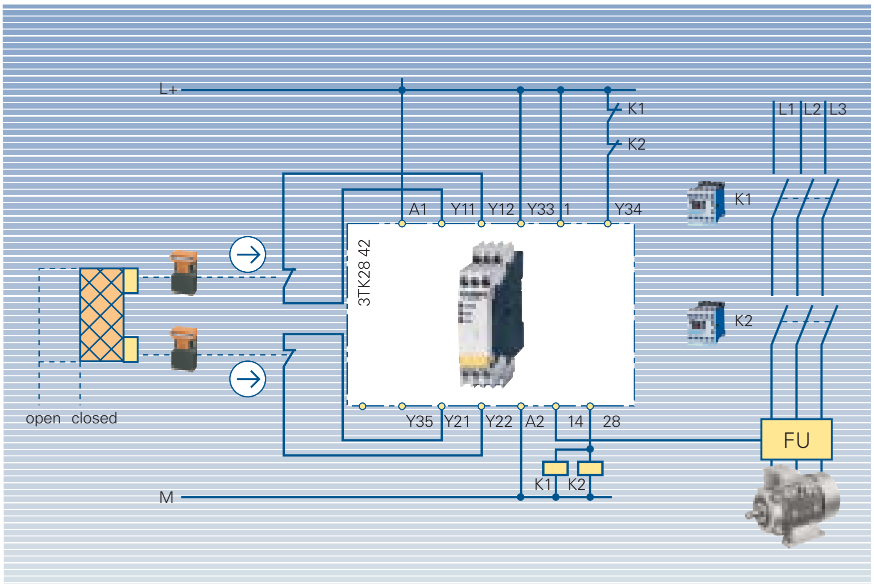


Fig. 7/54
SIGUARD 3TK2842, protective door monitoring, Category 4 acc. to EN 954-1, 2-channel, with feedback circuit with AC drive inverter and delayed shutdown, Stop Category 1

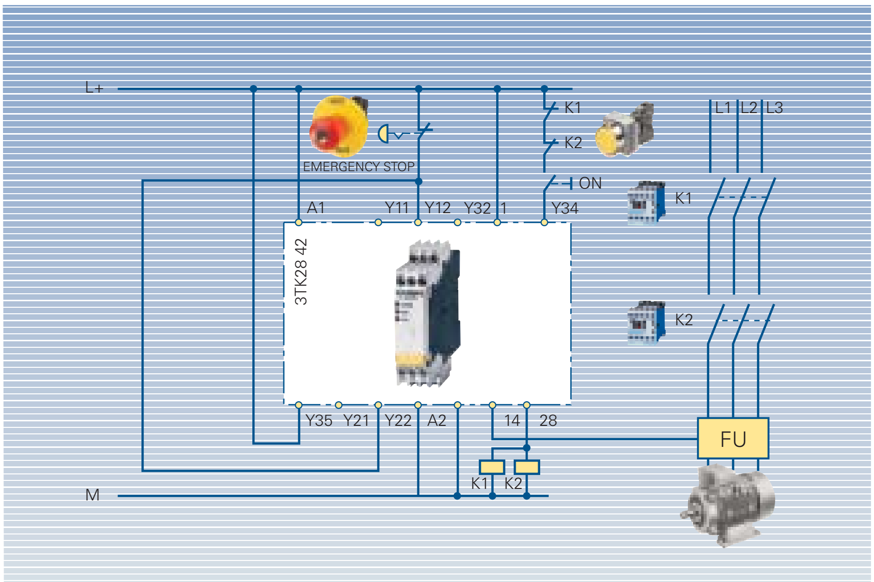


Fig. 7/55
SIGUARD 3TK2842, EMERGENCY STOP, Category 2 acc. to EN 954-1, 1-channel, monitored start with ON button with checkback circuit, with AC drive inverter and delayed shutdown, Stop Category 1

7

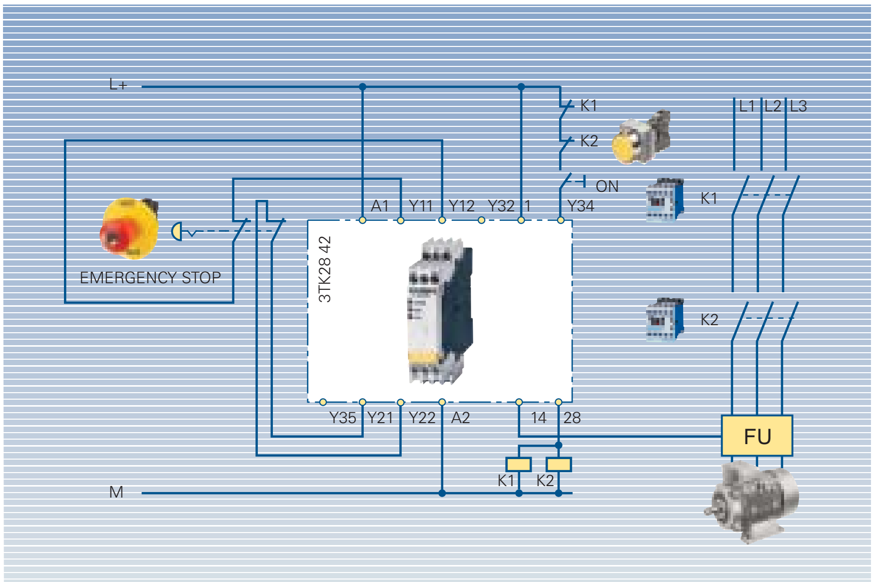


Fig. 7/56
SIGUARD 3TK2842, EMERGENCY STOP, Category 4 acc. to EN 954-1, 2-channel, monitored start with ON button, with AC drive and delayed shutdown, Stop Category 1

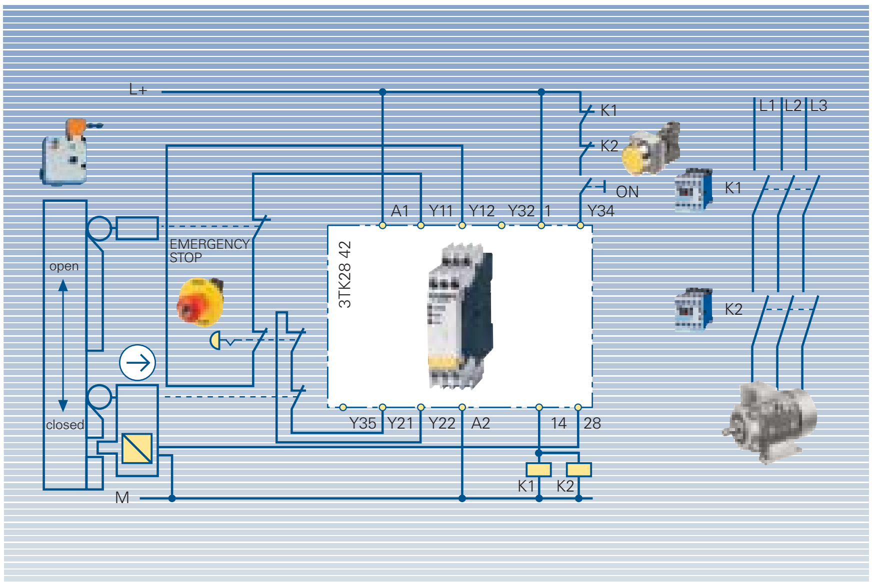


Fig. 7/57
SIGUARD 3TK2842, EMERGENCY STOP and protective door monitoring, Category 4 acc. to EN 954-1, 2-channel, with tumbler, monitored start

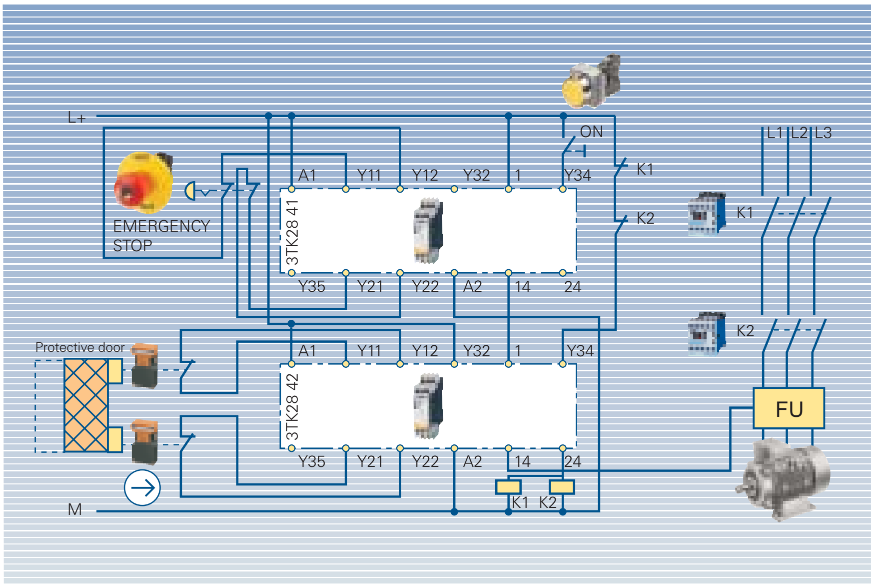


Fig. 7/58
SIGUARD 3TK2841, cascaded with 3TK2842 for EMERGENCY STOP, 2-channel, monitored start with ON button and protective door monitoring, 2-channel, autostart, Category 4 acc. to EN 954-1

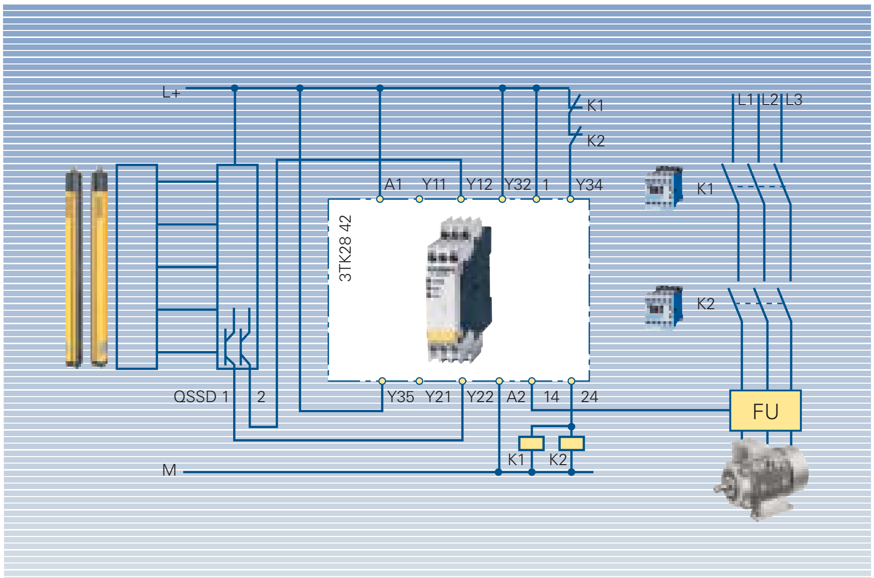


Fig. 7/59
SIGUARD 3TK2842, light grid monitoring, 2-channel, autostart, Category 4 acc. to EN 954-1

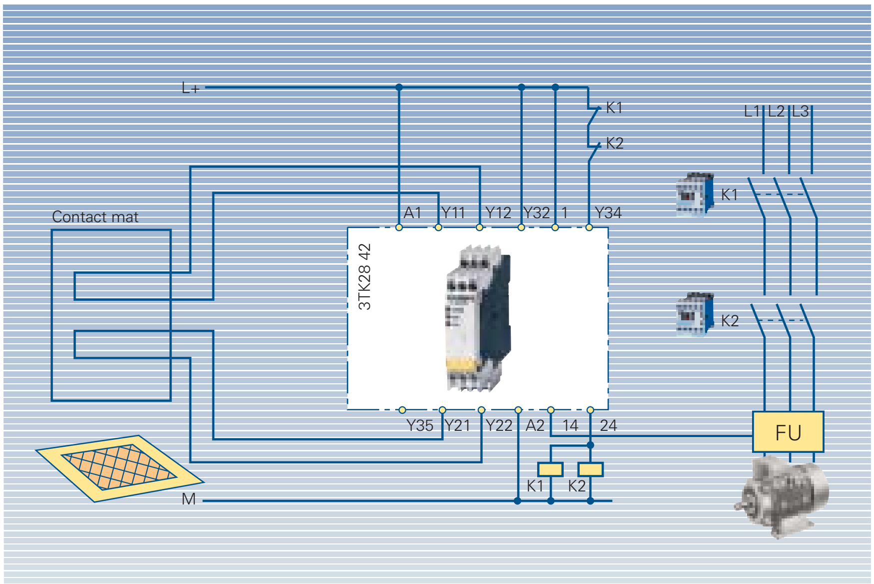


Fig. 7/60
SIGUARD 3TK2842, contact mat, Category 3 acc. to EN 954-1, 2-channel, autostart

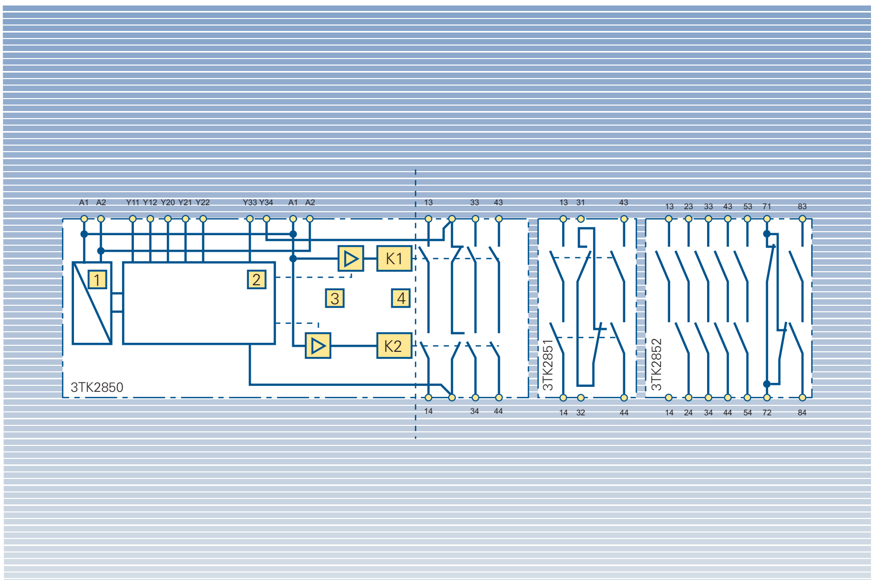


Fig. 7/61
SIGUARD 3TK2850, 51, 52, internal circuit diagram, electronic basic unit with auxiliary contactors, Category 3 acc. to EN 954-1

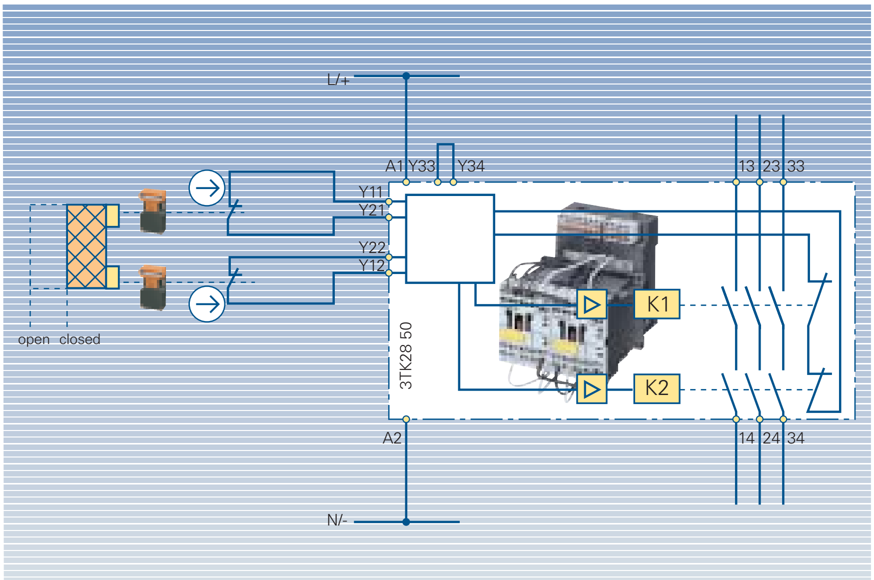


Fig. 7/62
The electronic basic 3TK2850 device with auxiliary contactors, protective door monitoring, 2-channel, autostart, Category 3 acc. to EN 954-1

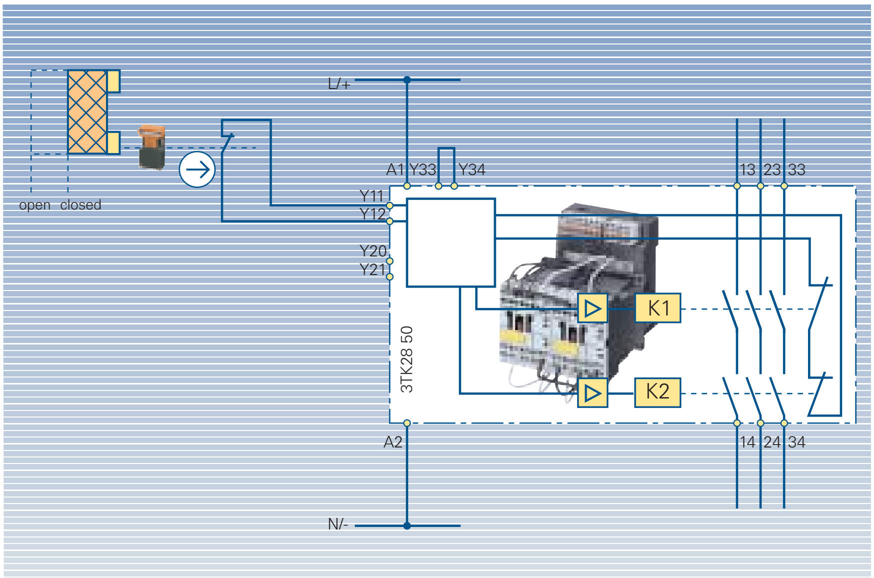


Fig. 7/63
The electronic basic 3TK2850 device with auxiliary contactors, protective door monitoring, 1-channel, autostart, Category 2 acc. to EN 954-1

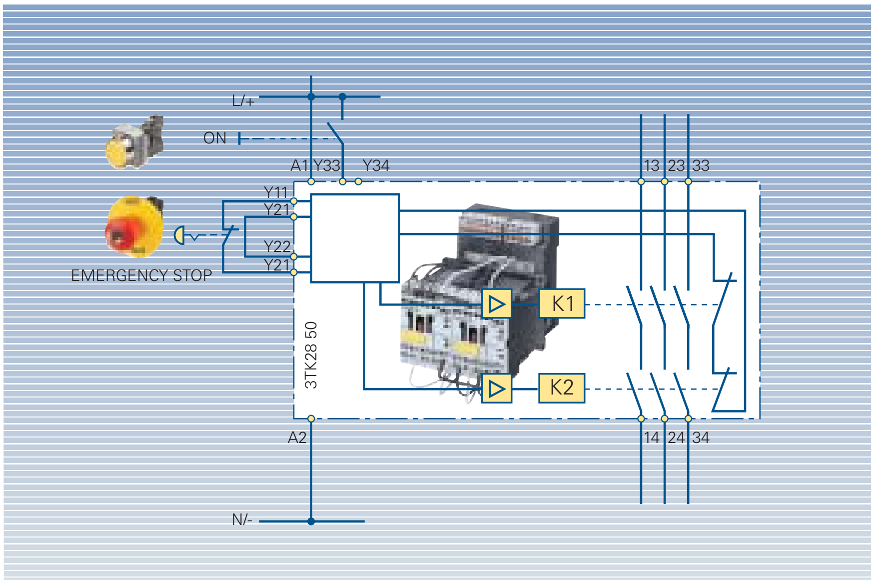


Fig. 7/64
The electronic basic 3TK2850 device with auxiliary contactors, EMERGENCY STOP, 1-channel, with additional ON button, Category 2 acc. to EN 954-1

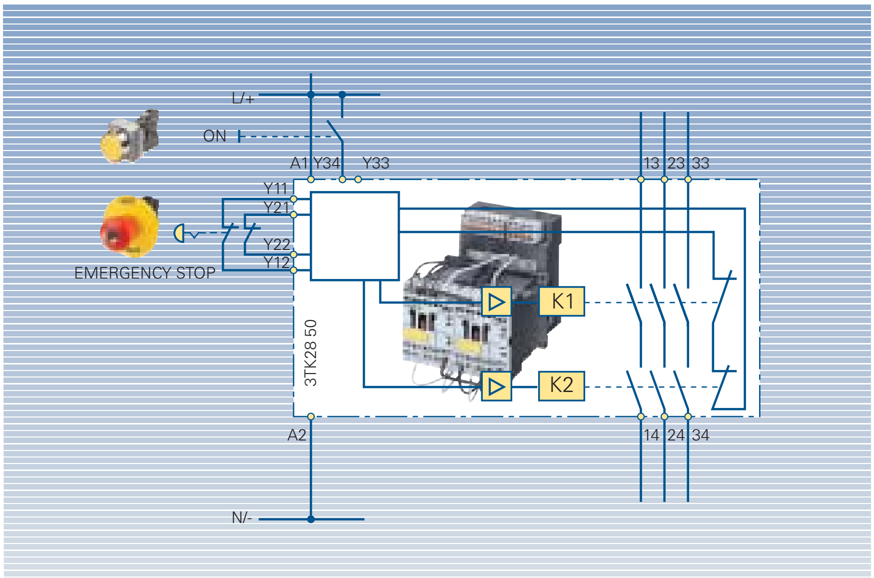


Fig. 7/65
The electronic basic 3TK2850 device with auxiliary contactors, EMERGENCY STOP, 2-channel, Category 3 acc. to EN 954-1

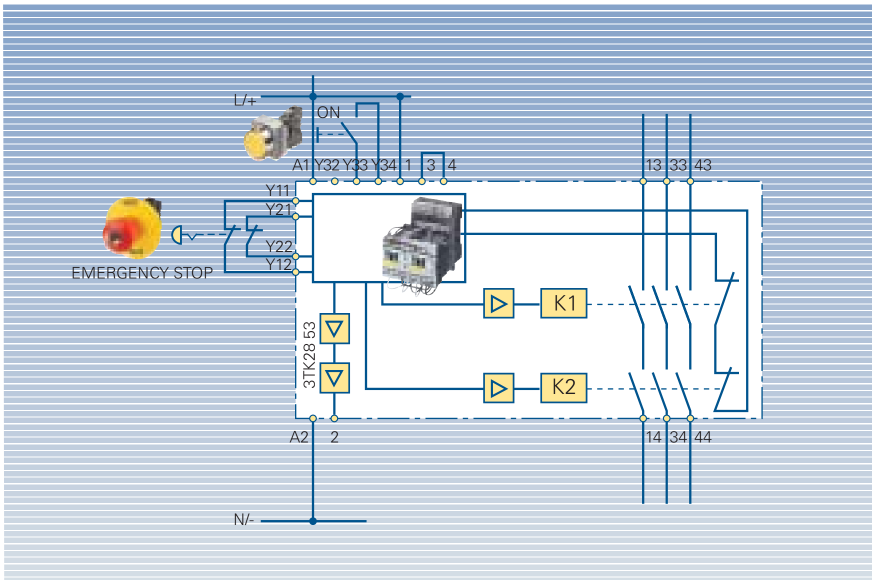


Fig. 7/66
The electronic basic 3TK2850 device with auxiliary contactors, EMERGENCY STOP, 2-channel, Category 4 acc. to EN 954-1 SIL 3

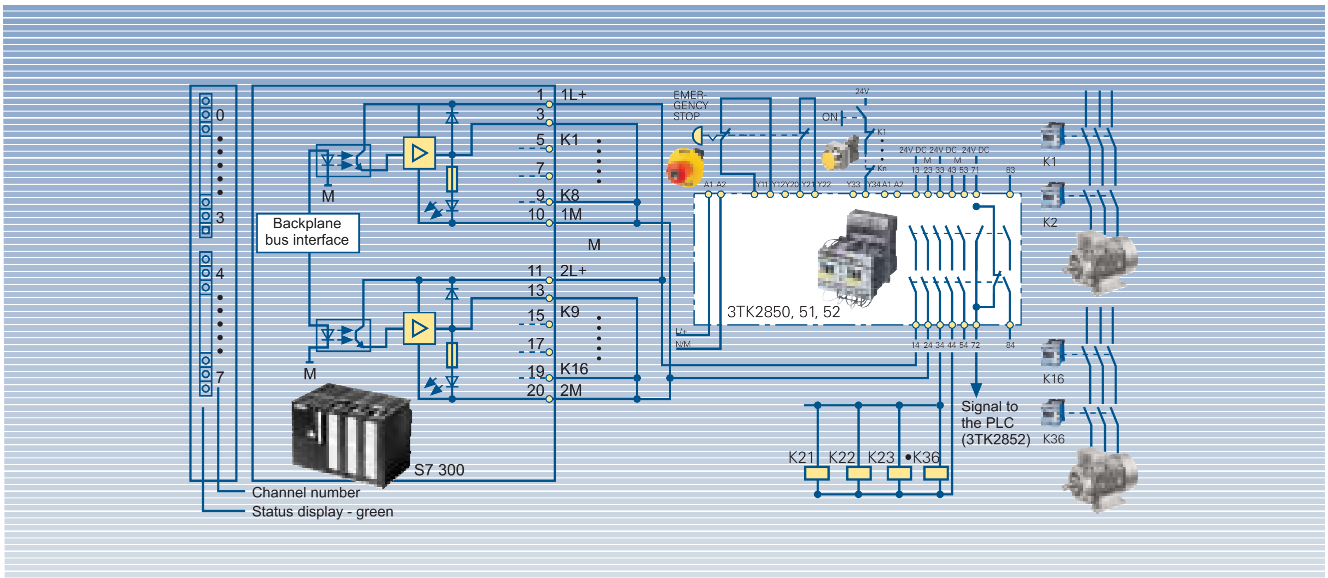


Fig. 7/67
3TK285.-.., EMERGENCY STOP, Category 4 acc. to EN 954-1, P-M switching in conjunction with operational control of a standard PLC (SIMATIC S7 300/ET200M), load current per enable circuit, 10 A

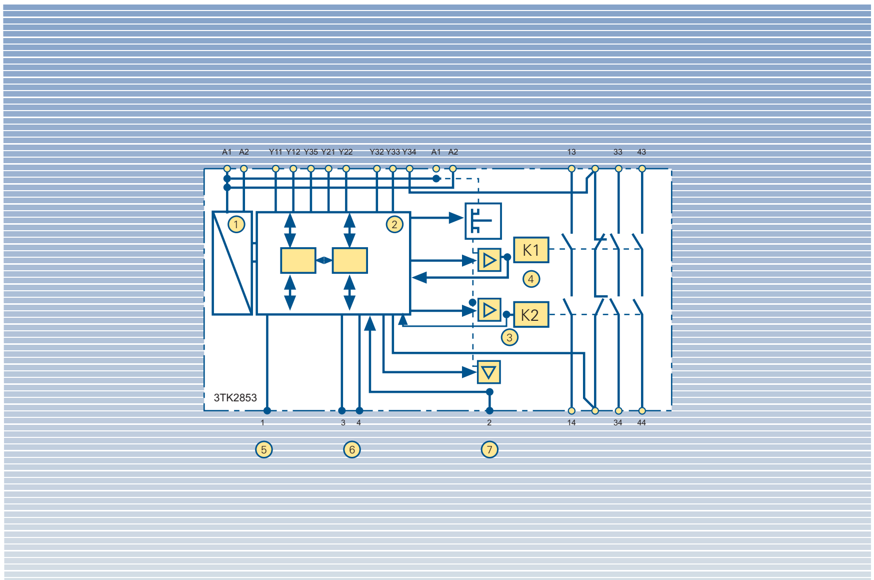


Fig. 7/68
3TK2853, internal circuit diagram, electronic basic device with auxiliary contactors, Category 4 acc. to EN 954-1

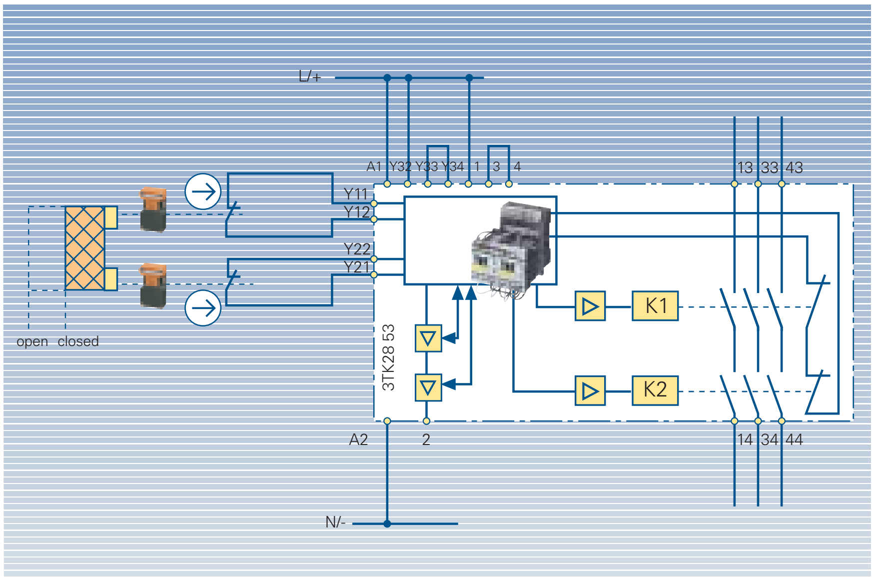


Fig. 7/69
The electronic basic 3TK2853 device with auxiliary contactors, protective door monitoring, 2-channel, autostart, Category 4 acc. to EN 954-1, SIL 3

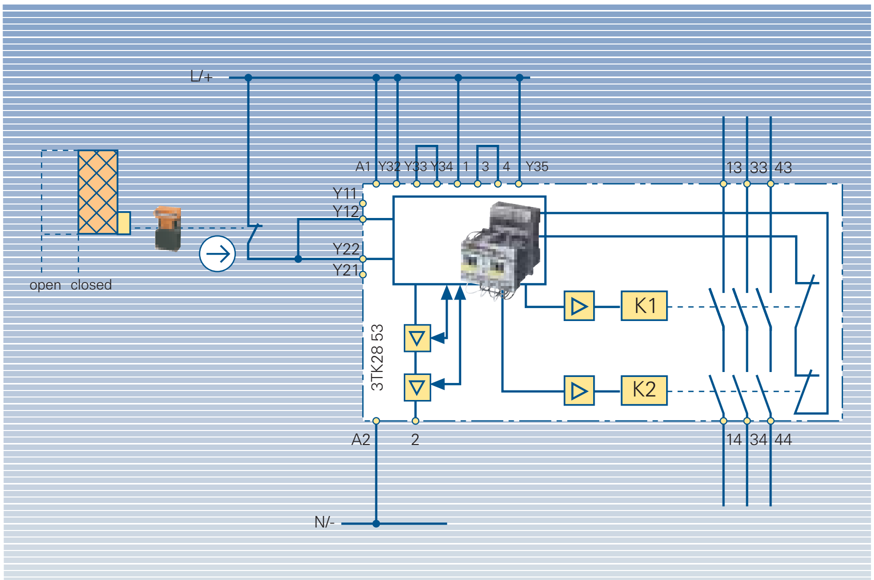


Fig. 7/70
The electronic basic 3TK2853 device with auxiliary contactors, protective door monitoring, 1-channel, autostart, Category 2 acc. to EN 954-1, SIL 3

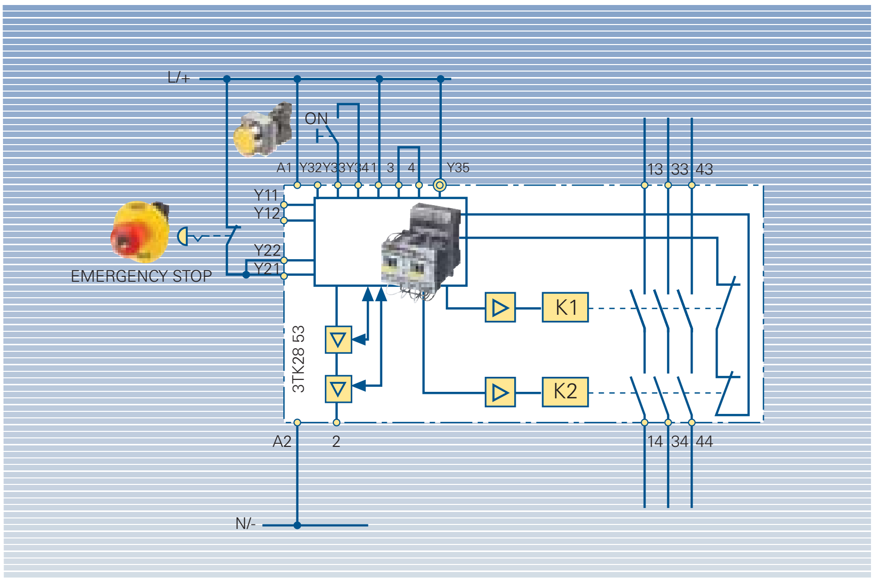


Fig. 7/71
The electronic basic 3TK2853 device with auxiliary contactors, EMERGENCY STOP, 1-channel, with additional EN button, Cat. 2 acc. to EN 954-1, SIL 3

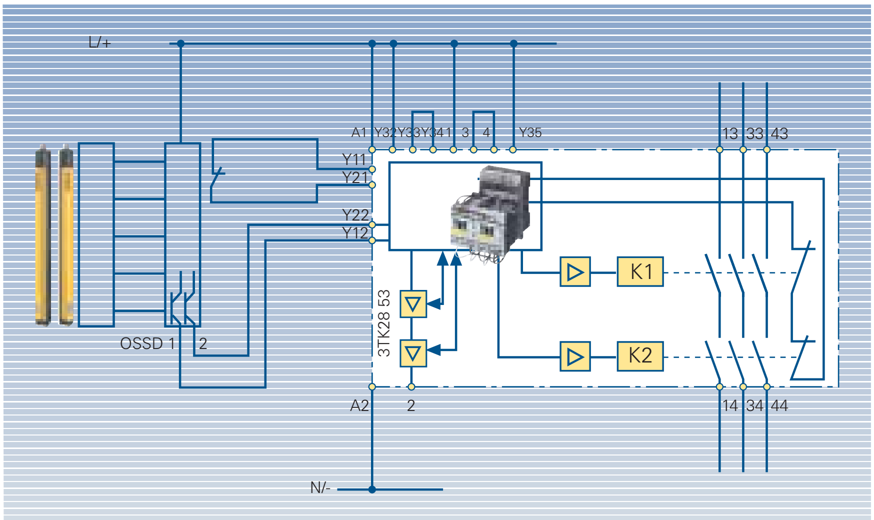
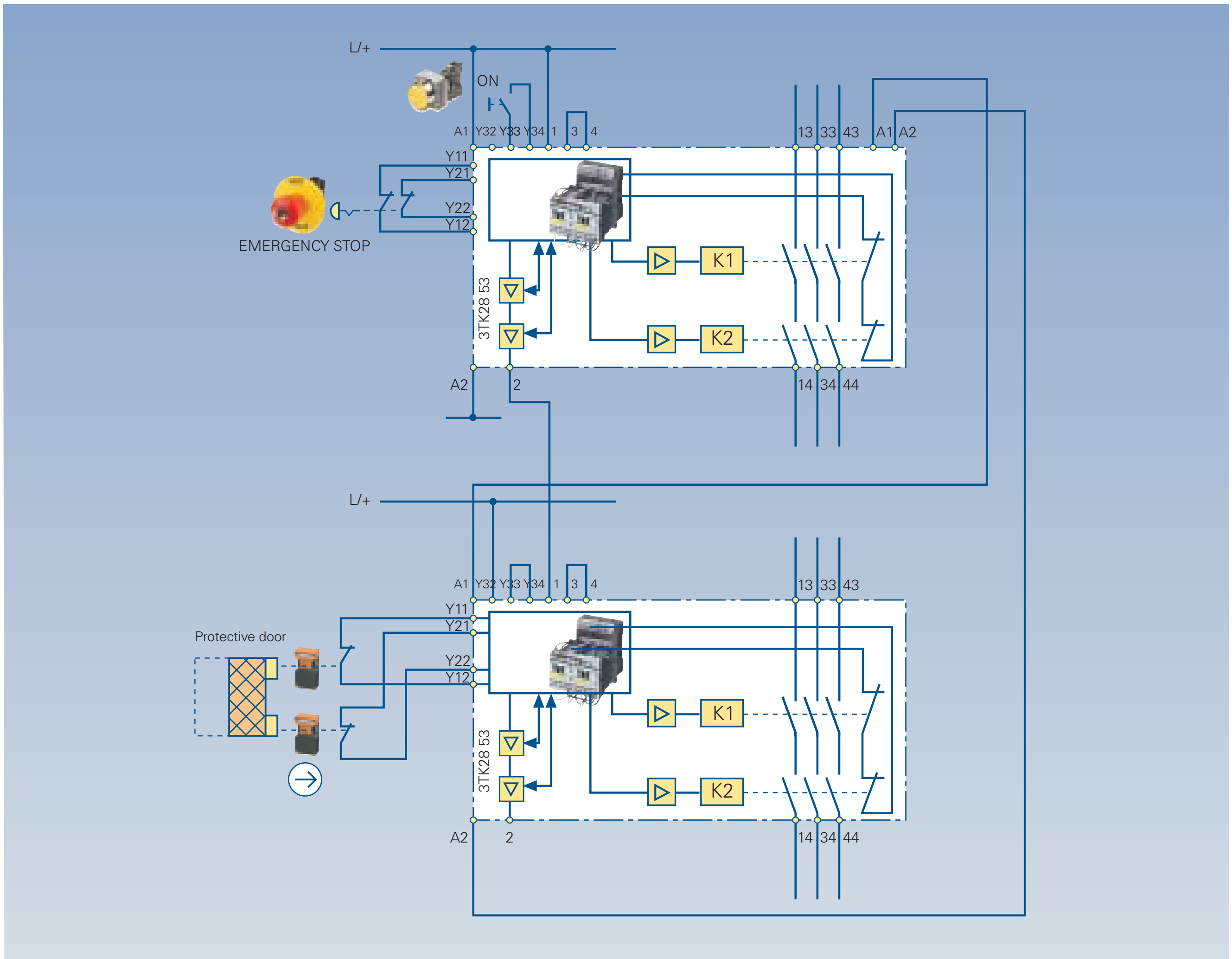
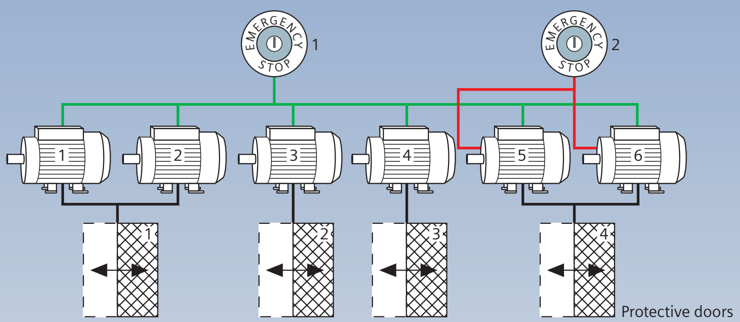


Fig. 7/72
The electronic basic 3TK2853 device with auxiliary contactors, light curtain/grid, 2-channel, autostart, Category 4 acc. to EN 954-1

Fig. 7/73
The electronic basic 3TK2853 device with auxiliary contactors, cascading EMERGENCY STOP and protective door monitoring, 2-channel, Cat. 4 acc. to EN 954-1, SIL 3

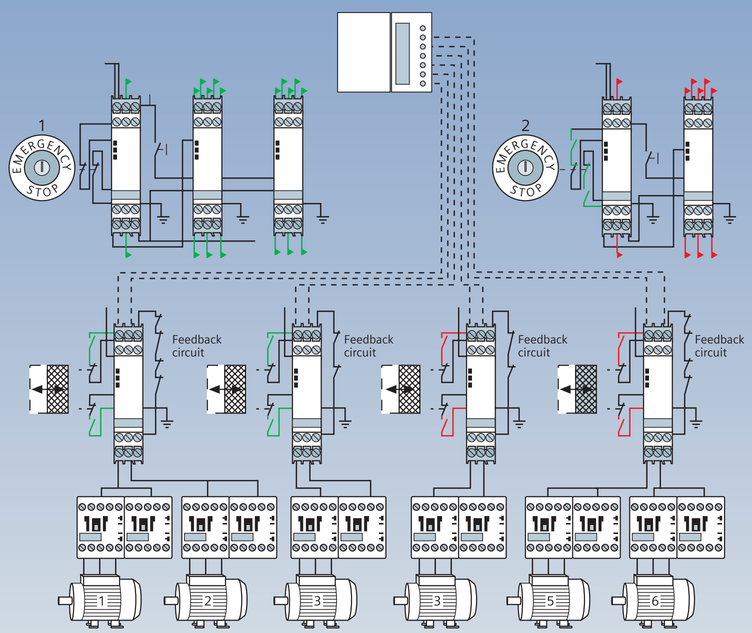


Load feeders with Integrated Safety Technology



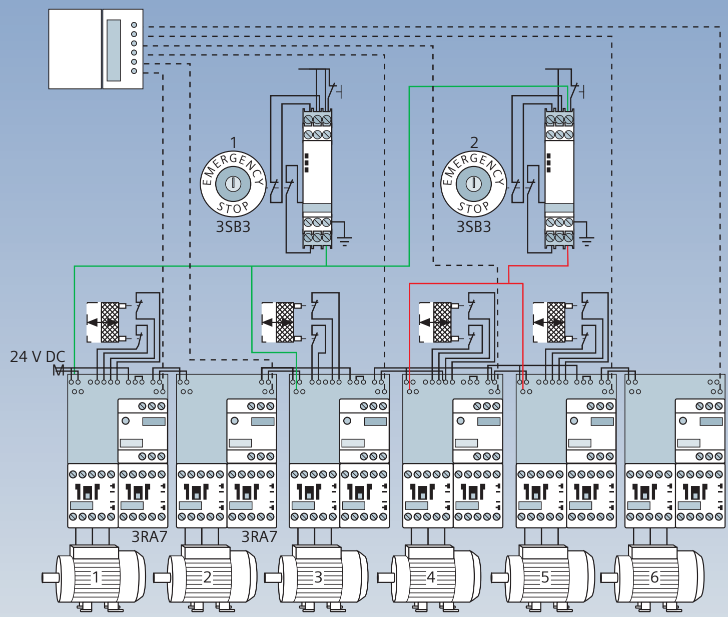
Typical application for load feeder outgoing cables

- Six actuation units are monitored by two EMERGENCY STOP switches
- The actuation equipment can either be individual de-activated or in groups using the protective doors
- During operation, the equipment is switched-over using a PLC or a pushbutton.



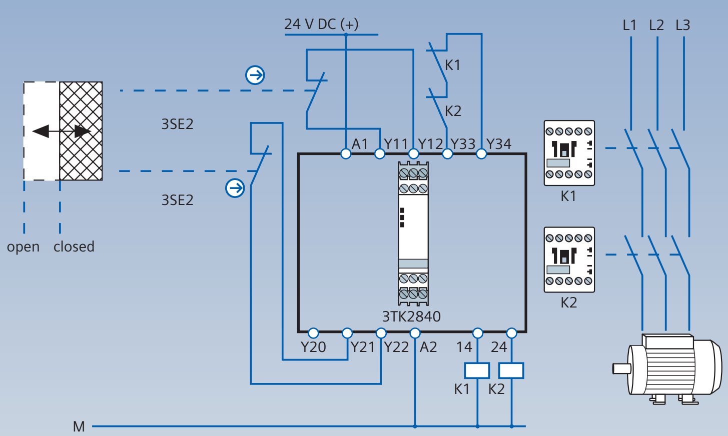
Conventional solution

- Conventional wiring => approx. 160 different solutions
- Complex installation => high costs => increased space requirement
- Frequent faults
- No overload or short-circuit protection



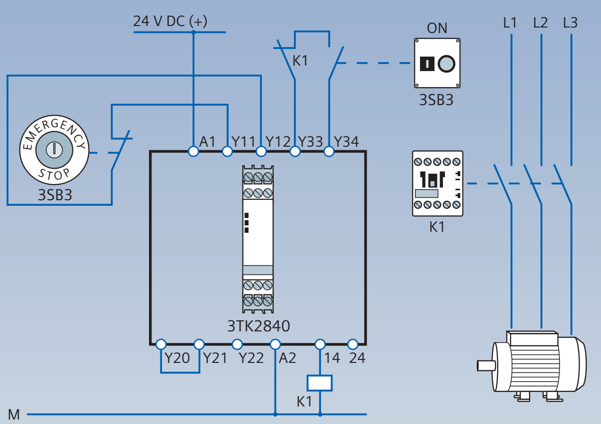
Solution with 3RA7

- Combination of 3RA7 and 3TK28 (cascading)
- Approx. 80 connections
- Simpler installation => lower costs => compact design
- Few faults due to the "single wire connection"
- Motor protection using a protection circuit-breaker

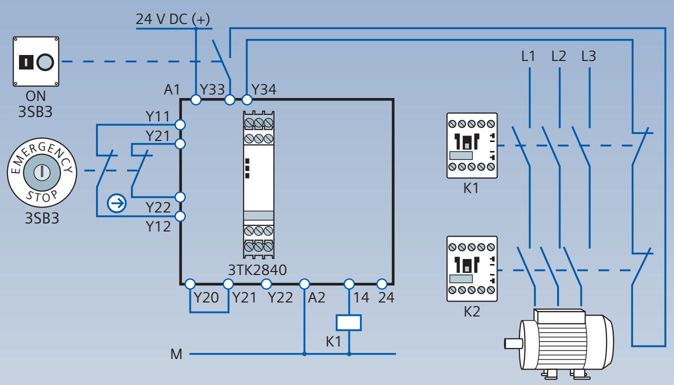


Typical applications for safe combinations

- 3TK2840 electronic basic device
- Protective door monitoring
- Category 3 acc. to EN 954-1
- 2 channels with feedback circuit



- 3TK2840 electronic basic device
- EMERGENCY STOP
- Category 2 acc. to EN 954-1
- 1 channel with feedback circuit



- 3TK2840 electronic basic device
- EMERGENCY STOP
- Category 3 acc. to EN 954-1
- 2 channels with feedback circuit

7.1.3 Contactless Protective Devices

Circuit examples for SIGUARD light curtains

Connection example, light curtain Category 4 connected to a standard evaluation unit 3RG7847-4BB

Light curtain or light grid 3RG7842 connected through 2 channels to the evaluation unit 3RG7847-4BB:

- Category 4 acc. to EN 954-1
- Manual start with monitored start button
- Contactor monitoring

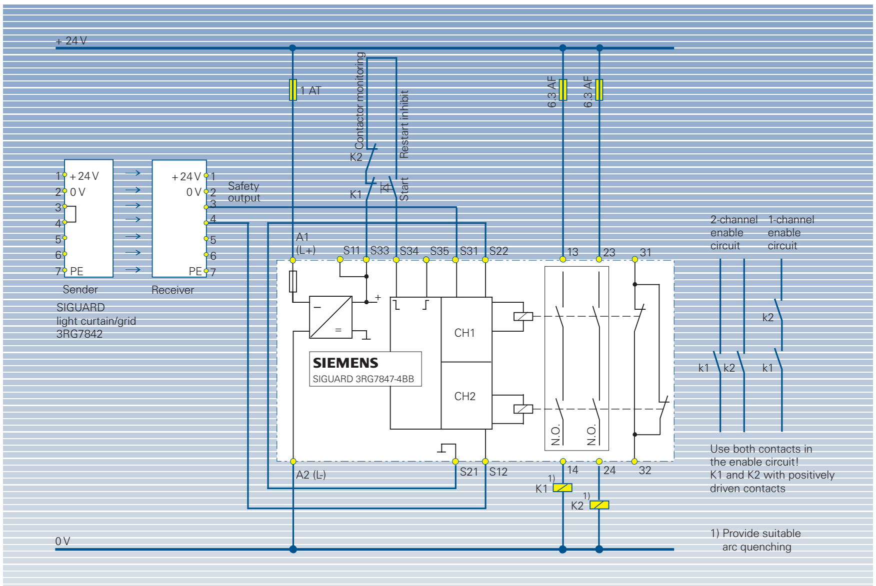


Fig. 7/74
Connection example, light curtain Category 4 connected to a standard evaluation unit 3RG7847-4BB

Connection example, light curtain Category 4 connected to an evaluation unit with muting function

A light curtain or light grid 3RG7842 connected to the evaluation unit with muting function 3RG7847-4BF:

- Category 4 acc. to EN 954-1
- Integrated muting function (e.g. with light barriers as muting sensors)
- Manual start with dynamically monitored start button
- Dynamic contactor monitoring

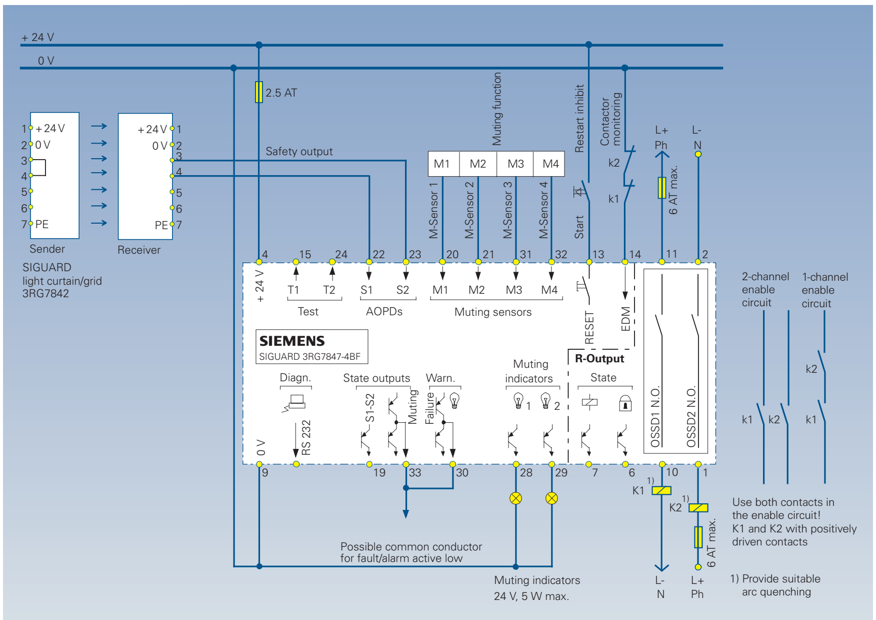


Fig. 7/75
Connection example, light curtain Category 4 connected to an evaluation unit with muting function

Connection example, light curtain Category 2 connected to a standard evaluation unit 3RG7847-4BD

A light curtain 3RG7841 connected to the evaluation unit 3RG7847-4BD:

- Category 2 acc. to EN 954-1
- Cyclic testing of the light curtain
- Manual start with dynamically monitored start button
- Dynamic contactor monitoring

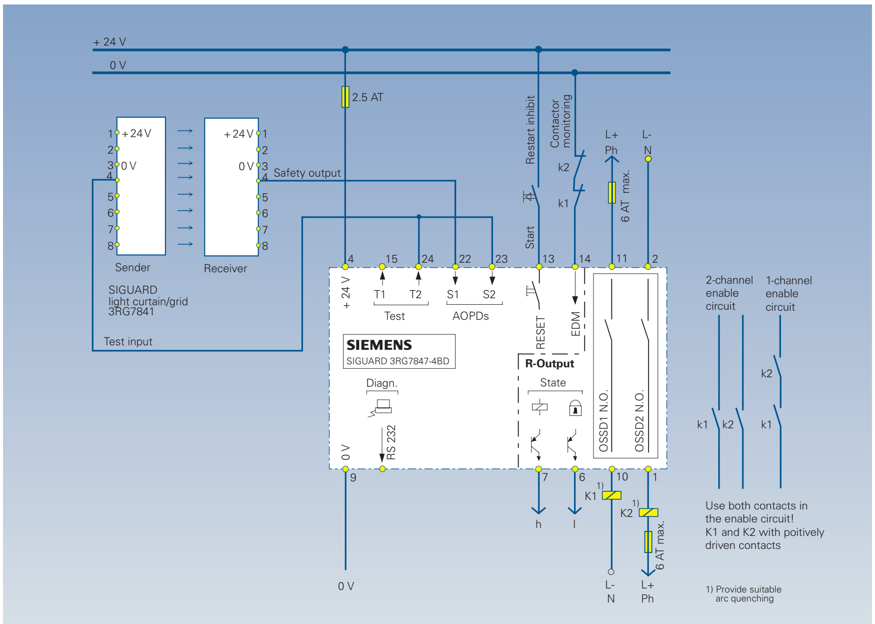


Fig. 7/76
Connection example, light curtain Category 2 connected to a standard evaluation unit 3RG7847-4BD

Connection example, light curtain Category 4 connected to an evaluation unit with cycle control

A light curtain or grid 3RG7842/44 connected through 2 channels to the evaluation unit 3RG7847-4BH:

- Category 4 acc. to EN 954-1
- Automatic single or two-cycle control
- Manual start with dynamically monitored start button
- Dynamic contactor monitoring

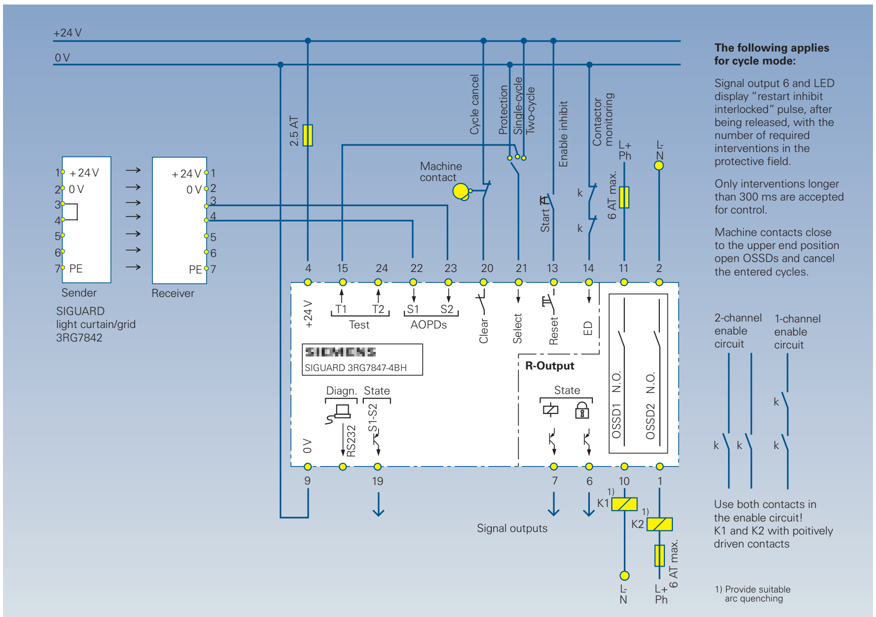


Fig. 7/77
Connection example, light curtain Category 4 connected to an evaluation unit with cycle control

Circuit examples for SIGUARD light barriers

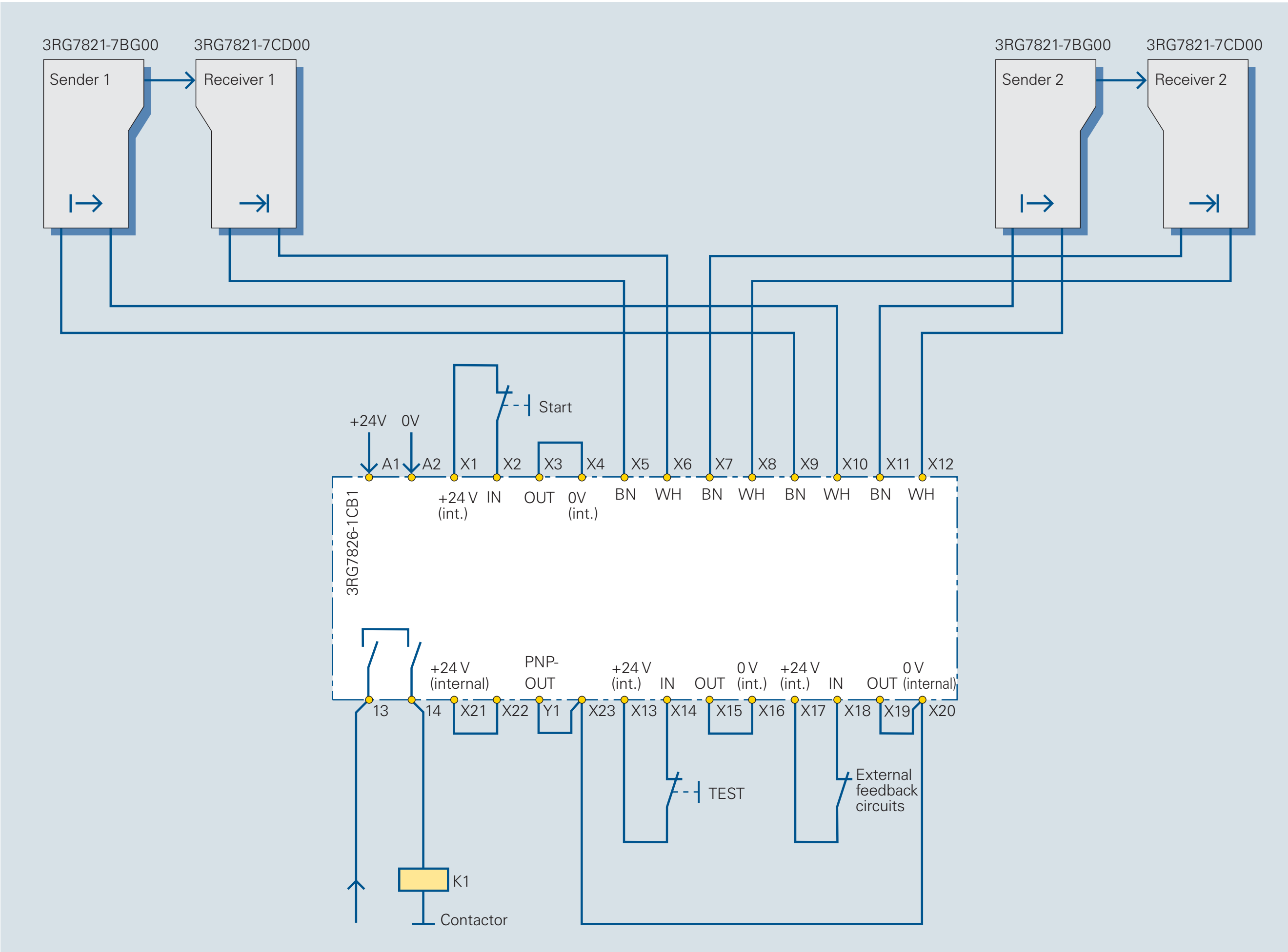


Fig. 7/78

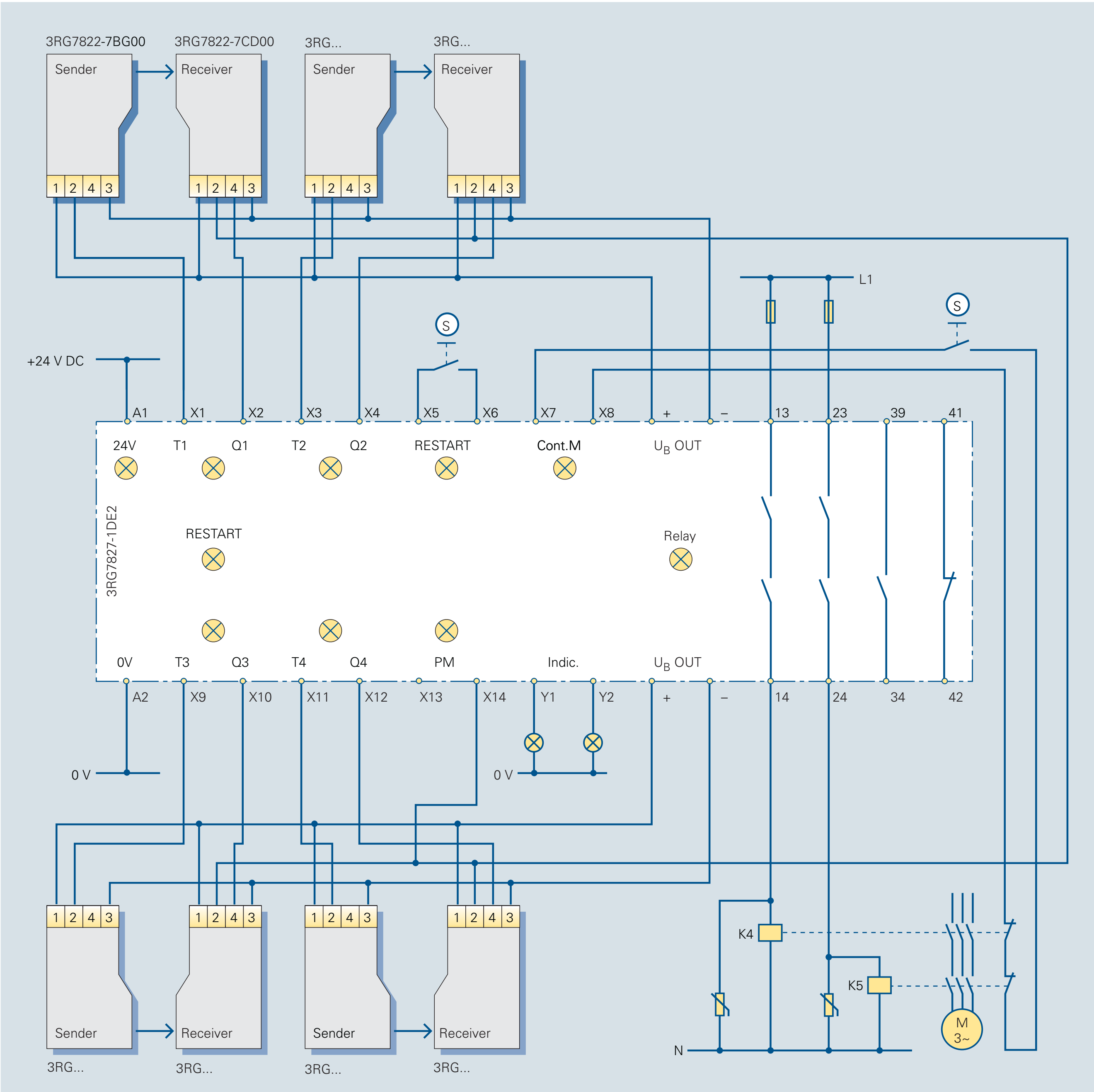
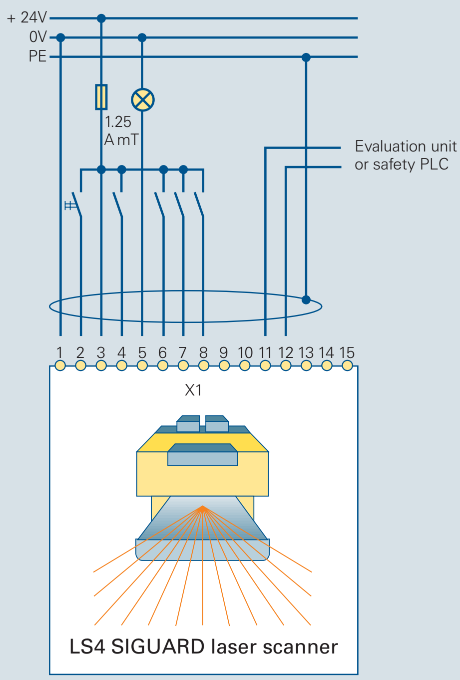

3RG7822-7BG00
3RG7822-7CD00
3RG...
3RG...
Sender
Receiver
Sender
Receiver
1 2 4 3
L1
S
+24 V DC
A1
X1
X2
X3
X4
X5
X6
X7
X8
+
–
13
23
39
41
24V
T1
Q1
T2
Q2
RESTART
Cont.M
U_B OUT
3RG7827-1DE2
RESTART
Relay
0V
T3
Q3
T4
Q4
PM
Indic.
U_B OUT
A2
X9
X10
X11
X12
X13
X14
Y1
Y2
+
–
14
24
34
42
0 V
0 V
K4
K5
M
3~
N
Sender
Receiver
Sender
Receiver
3RG...
3RG...
3RG...
3RG...

Fig. 7/79

LS4 laser scanner application

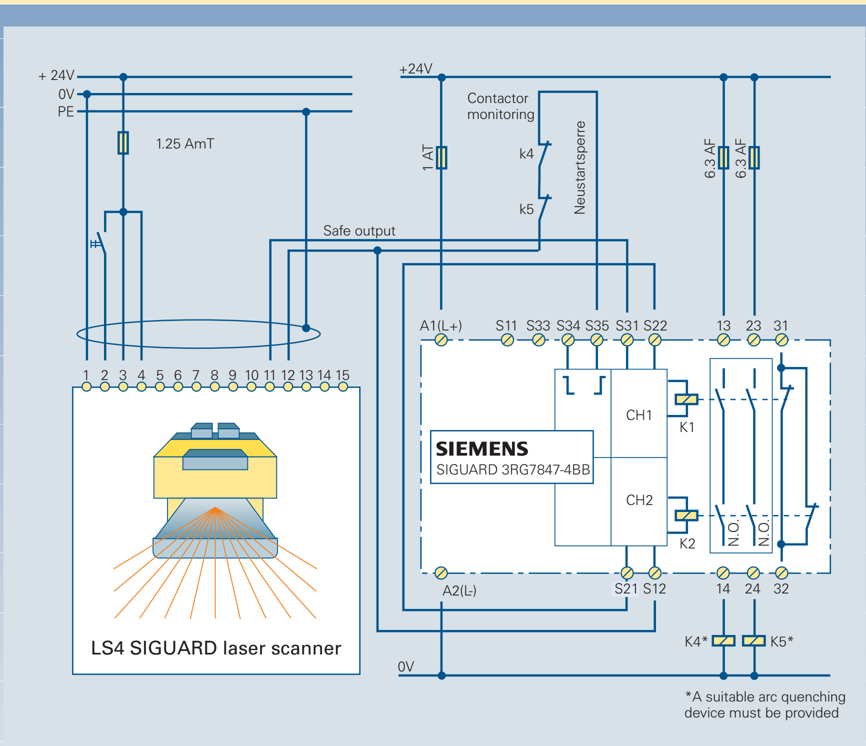
Connection example, LS4 SIGUARD laser scanner
Changing-over the protective field, start button

- Start button for a manual restart directly at the scanner (connection 2)
- Alarm output at connection 5 (e.g. alarm lamp)
- The protective field is changed-over at connections 4, 6, 7 and 8
- The safe outputs are safely processed (connections 11 and 12) when using an evaluation unit or fail-safe PLC



Connection example, LS4 SIGUARD laser scanner
Connected to a standard 3RG7847-4BB evaluation unit

- Start button for a manual restart directly at the scanner (connection 2)
- Fixed protective field pair 1 (24 V always present at connection 4)



7.1.4 SIGUARD Switching Strips

Circuit examples with evaluation unit

SIGUARD switching strips, together with the 3RG78 57-1BD evaluation unit, can be used as a safety system up to Category 4 acc. to EN 954-1. The evaluation electronics in the 22.5 mm enclosure is used to evaluate the transmitter/receiver signal and to monitor the complete system for faults and errors.

The power supply voltage of the evaluation unit is 24 V DC.
Two relay outputs are available as safety-related outputs. A semiconductor output can be used to issue a signal to a PLC. After the switching strip has been actuated, the device must be enabled using a manual start button, so that the system can restart.

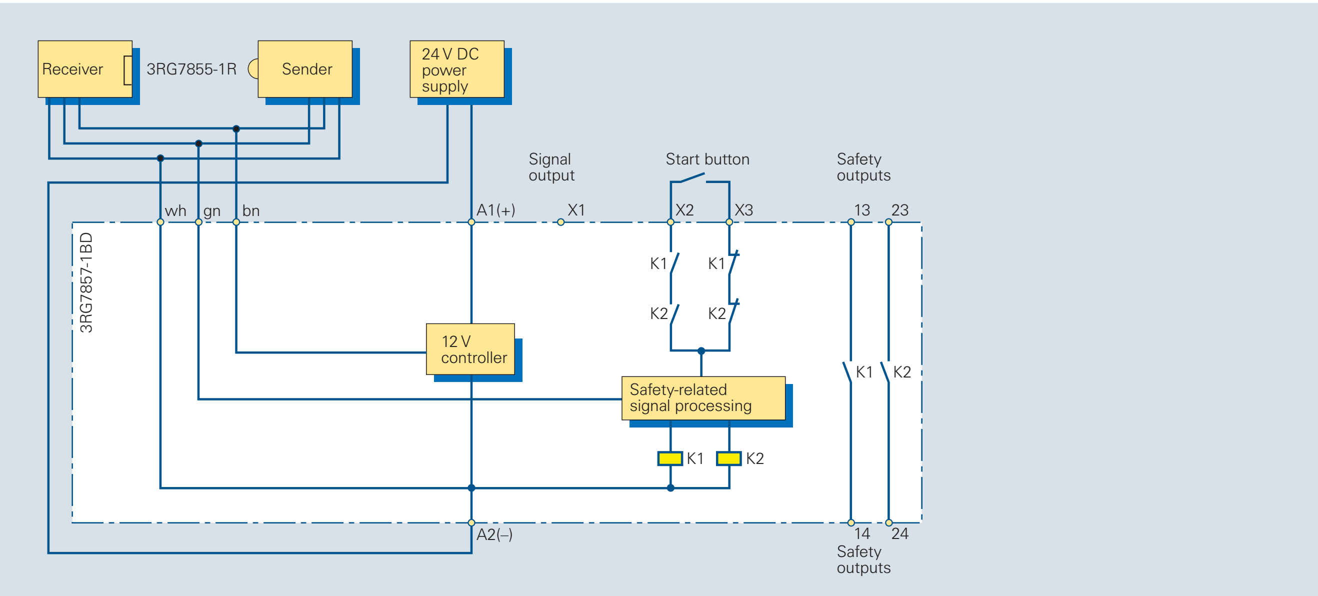


Fig. 7/80

7.1.5 Circuit examples, ET 200S SIGUARD

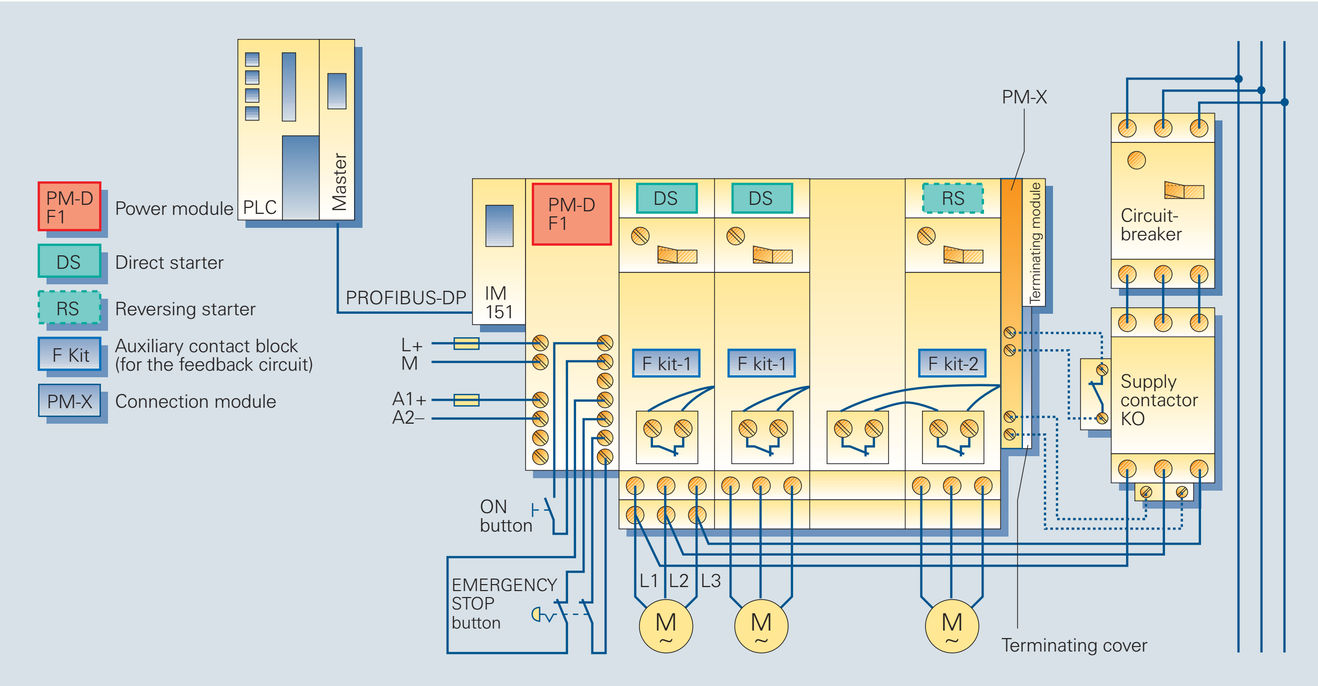


Fig. 7/81
EMERGENCY STOP circuit with monitored start, Category 4 acc. to EN 954-1

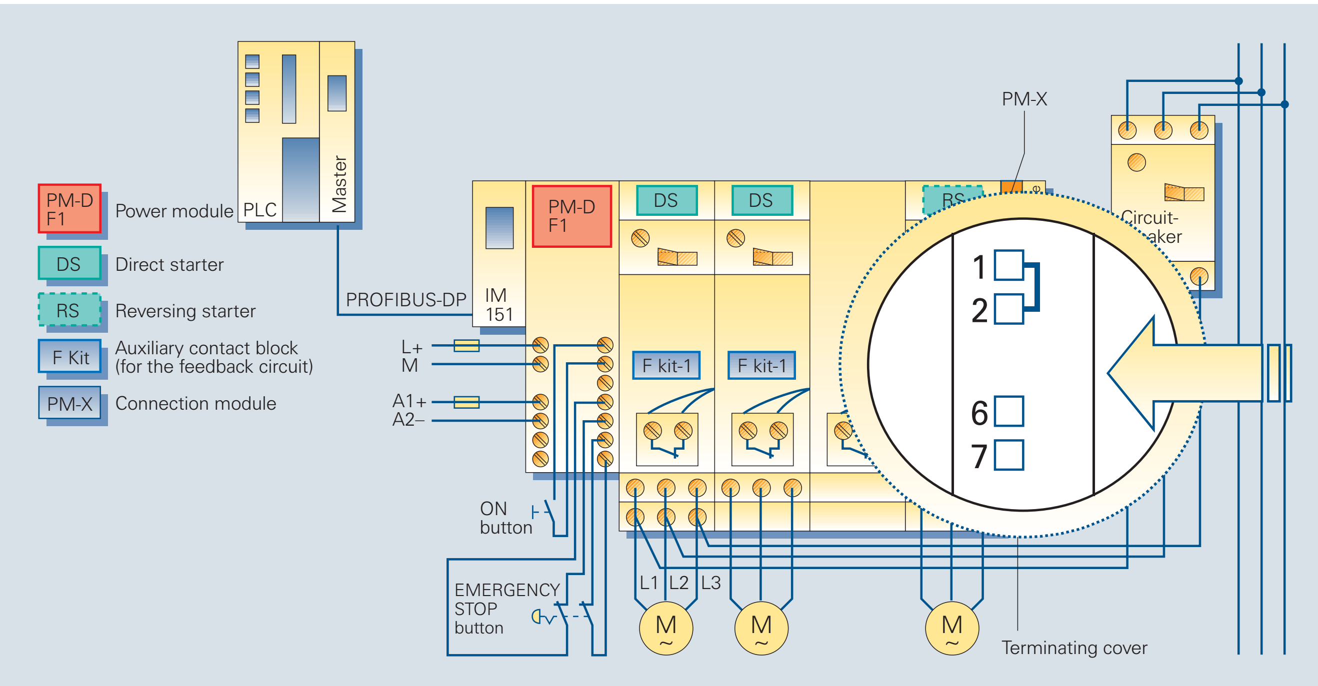


Fig. 7/82
EMERGENCY STOP circuit with monitored start, Category 2 acc. to EN 954-1

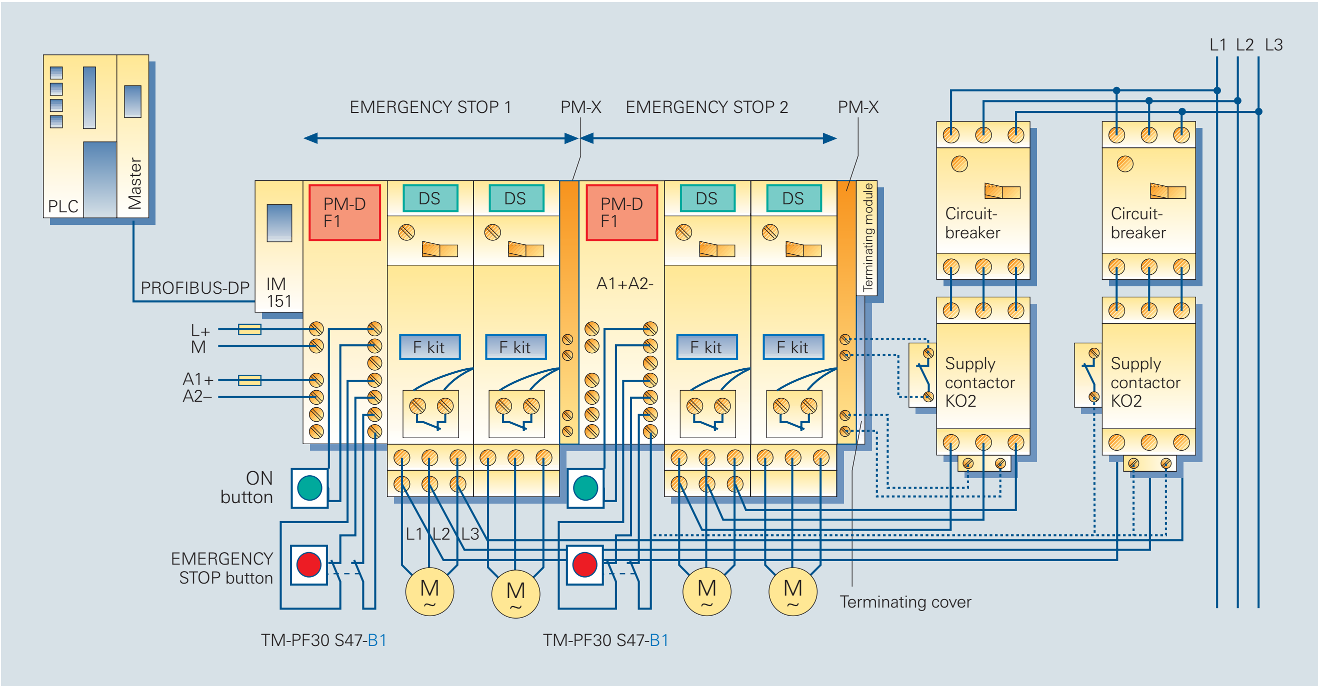


Fig. 7/83
EMERGENCY STOP circuit in two groups

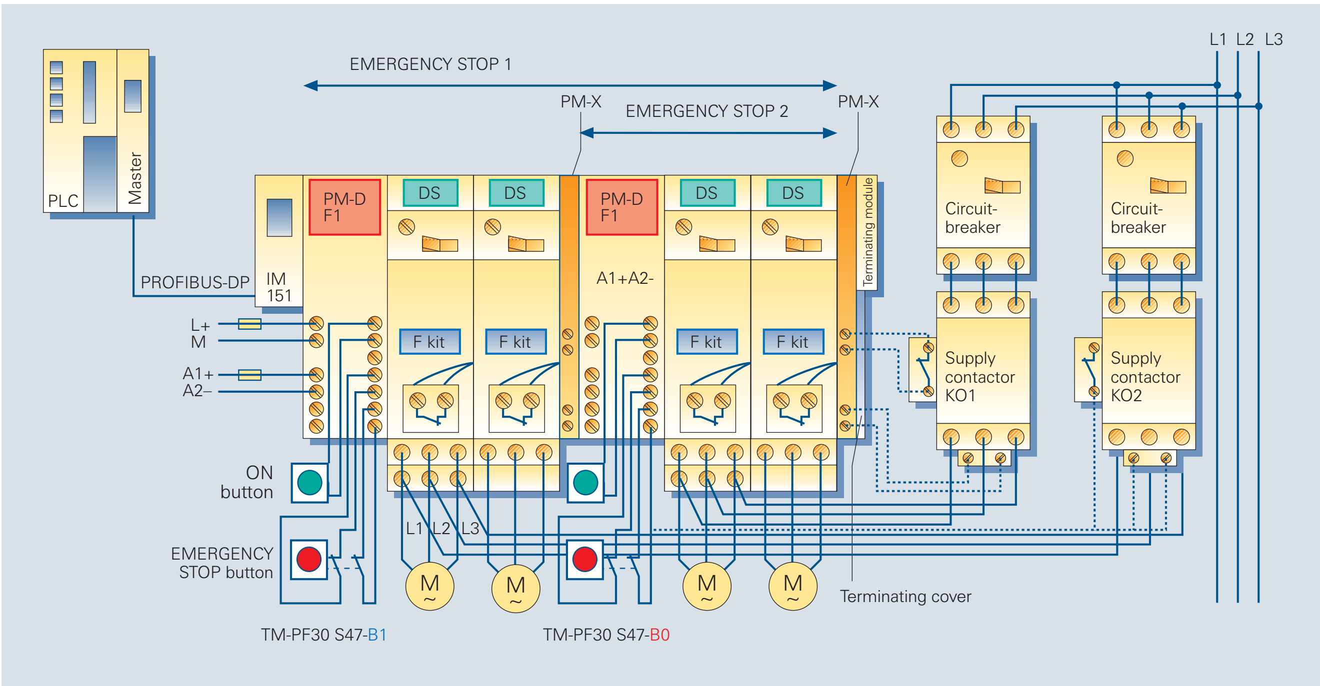


Fig. 7/84
EMERGENCY STOP circuit arranged in a cascade

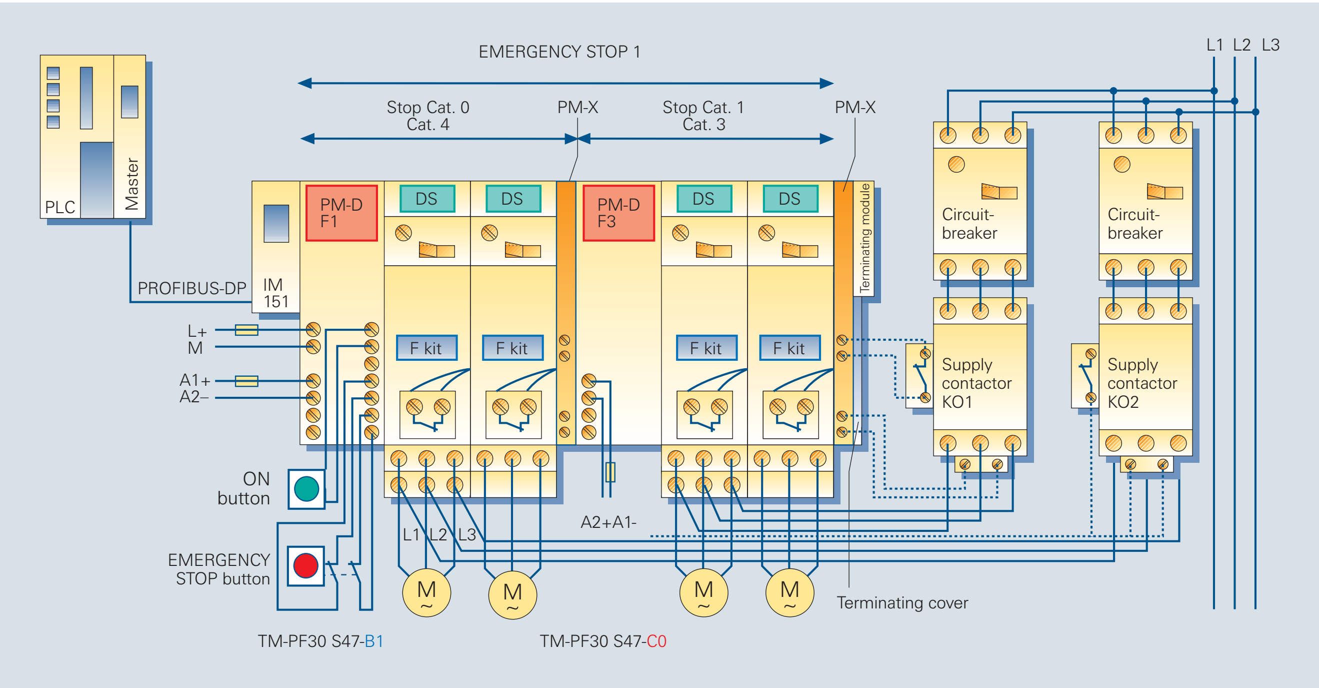


Fig. 7/85
EMERGENCY STOP circuit arranged in a cascade with delayed shutdown (Stop Category 1)

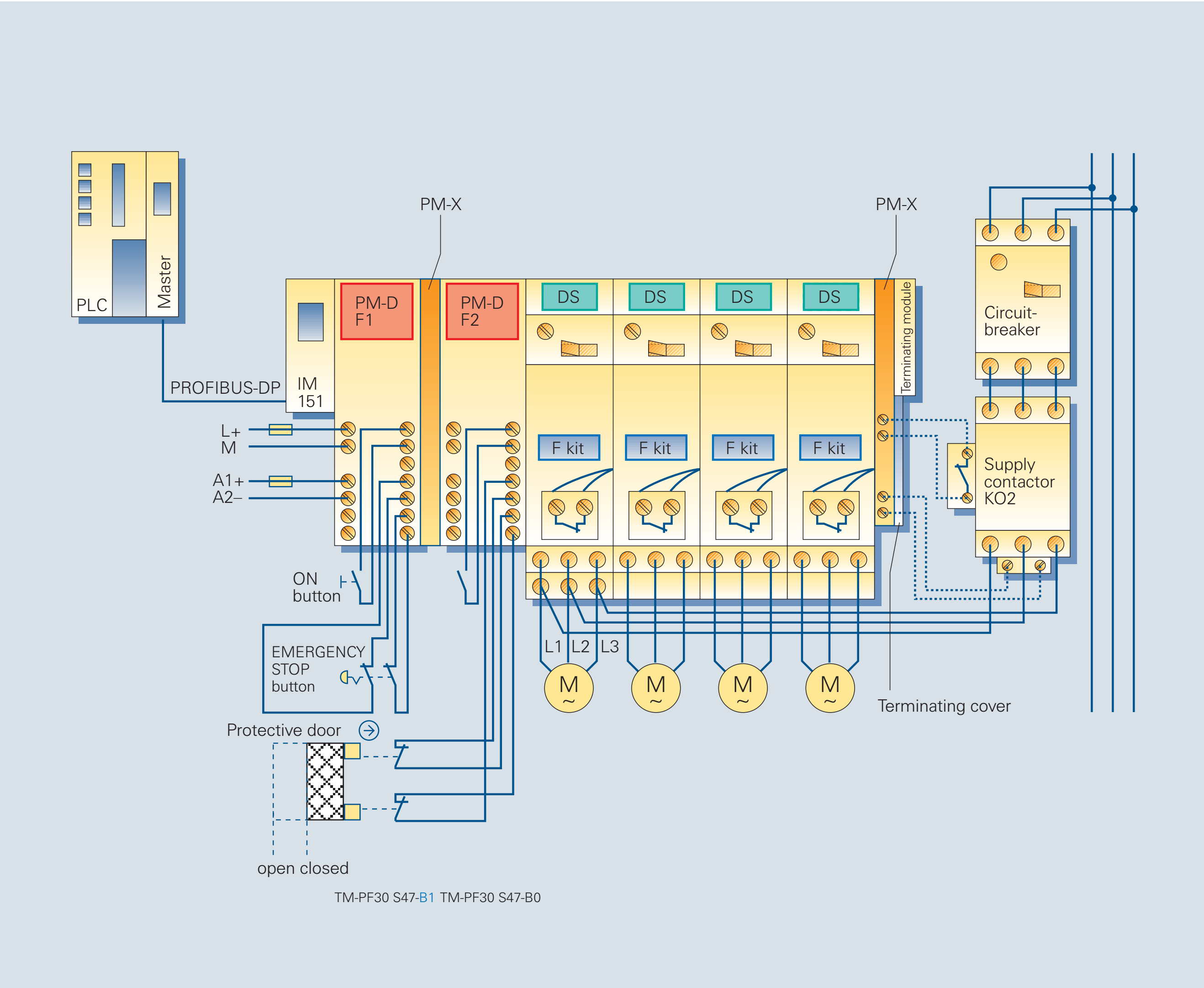


Fig. 7/86
EMERGENCY STOP combined with protective door

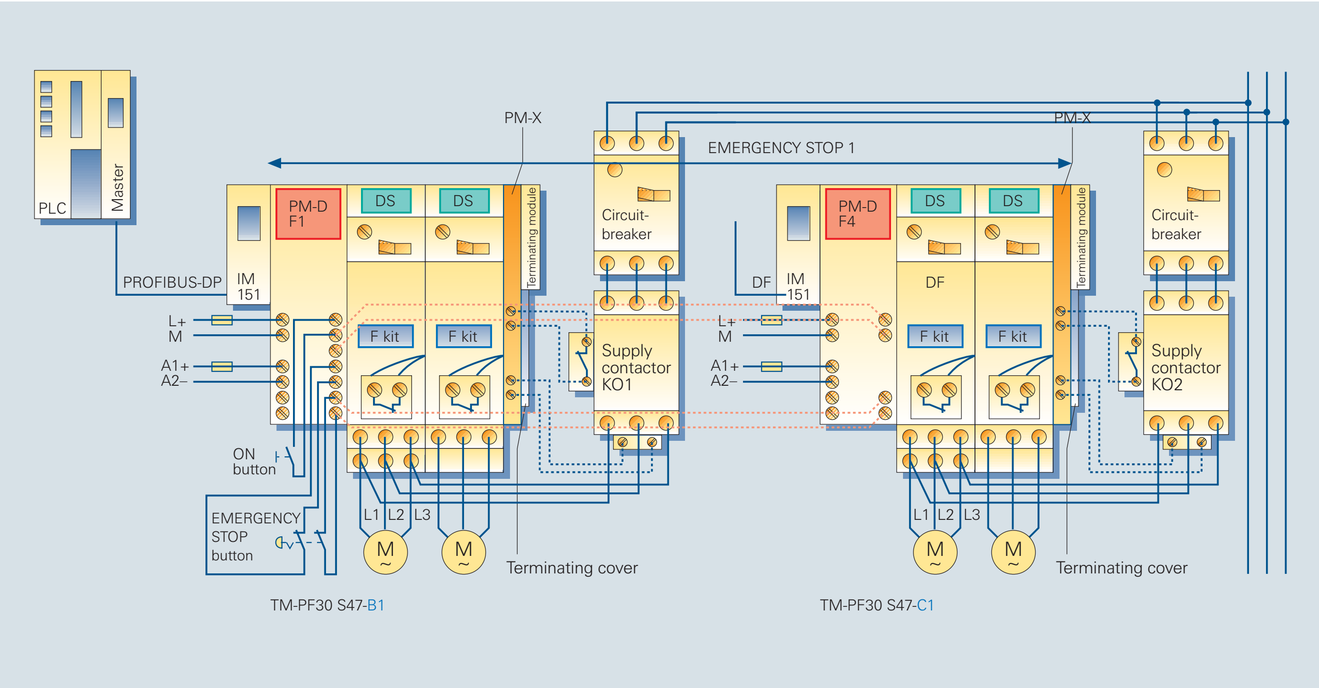


Fig. 7/87
One EMERGENCY STOP circuit for several ET 200S rails

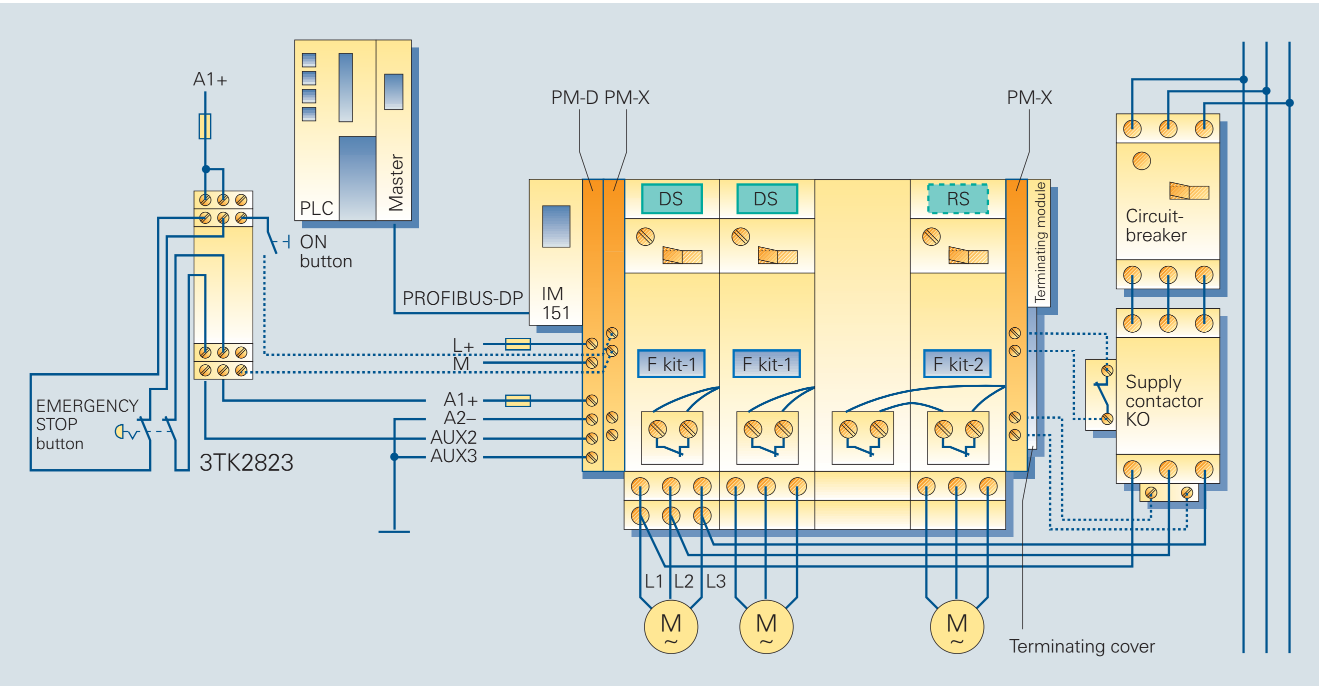


Fig. 7/88
Integrated in an external EMERGENCY STOP circuit, Category 4 acc. to EN 954-1

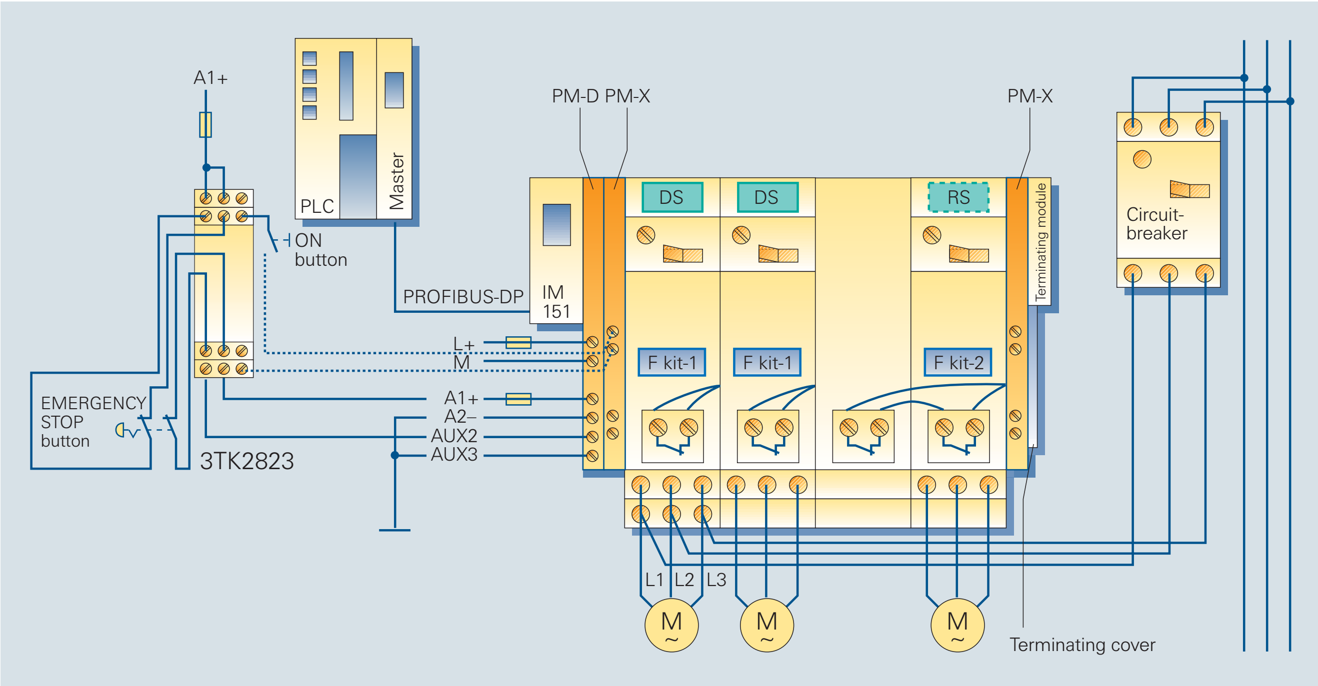


Fig. 7/89
Integrated in an external EMERGENCY STOP circuit, Category 2 acc. to EN 954-1

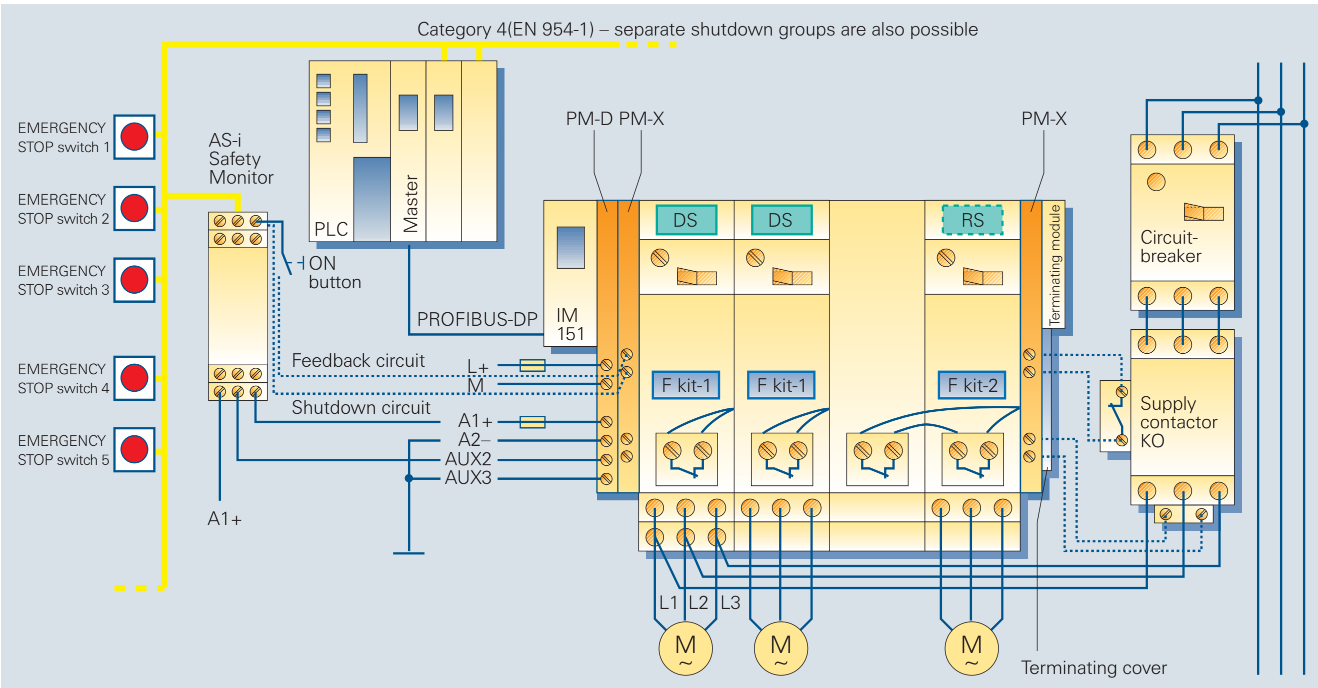


Fig. 7/90
SIMATIC ET 200S SIGUARD and AS-i Safety at Work

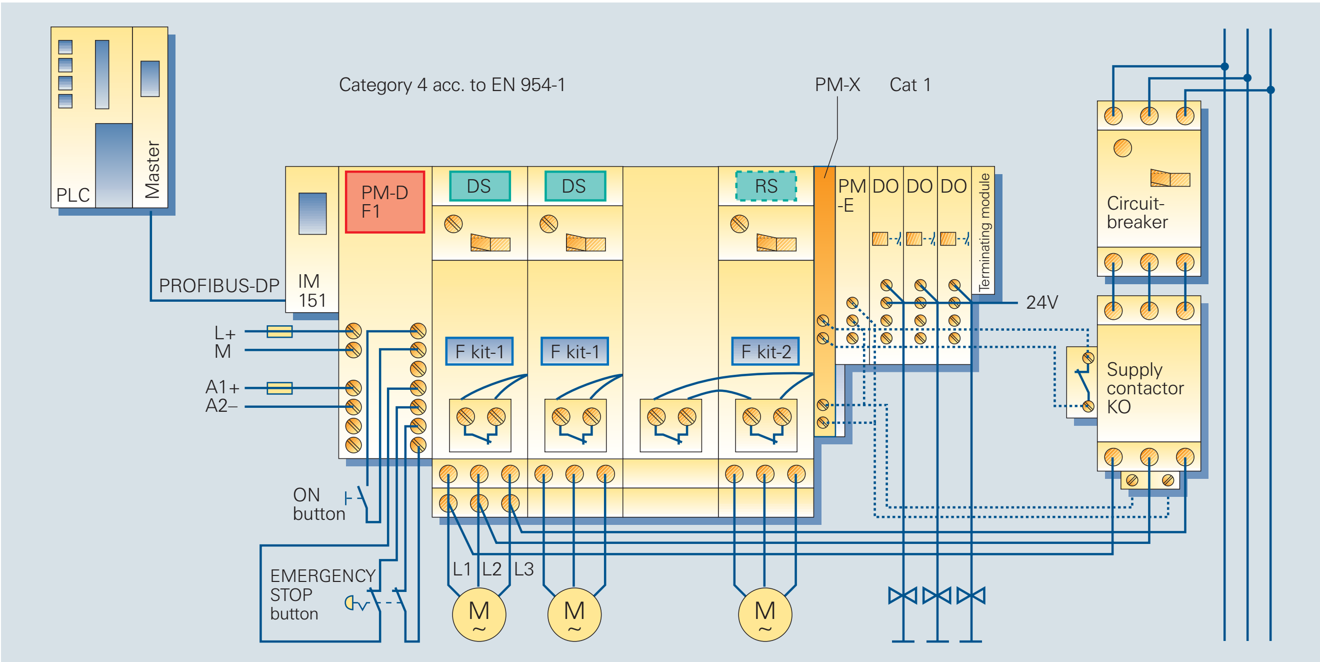


Fig. 7/91
EMERGENCY STOP circuit with integrated pneumatic valves

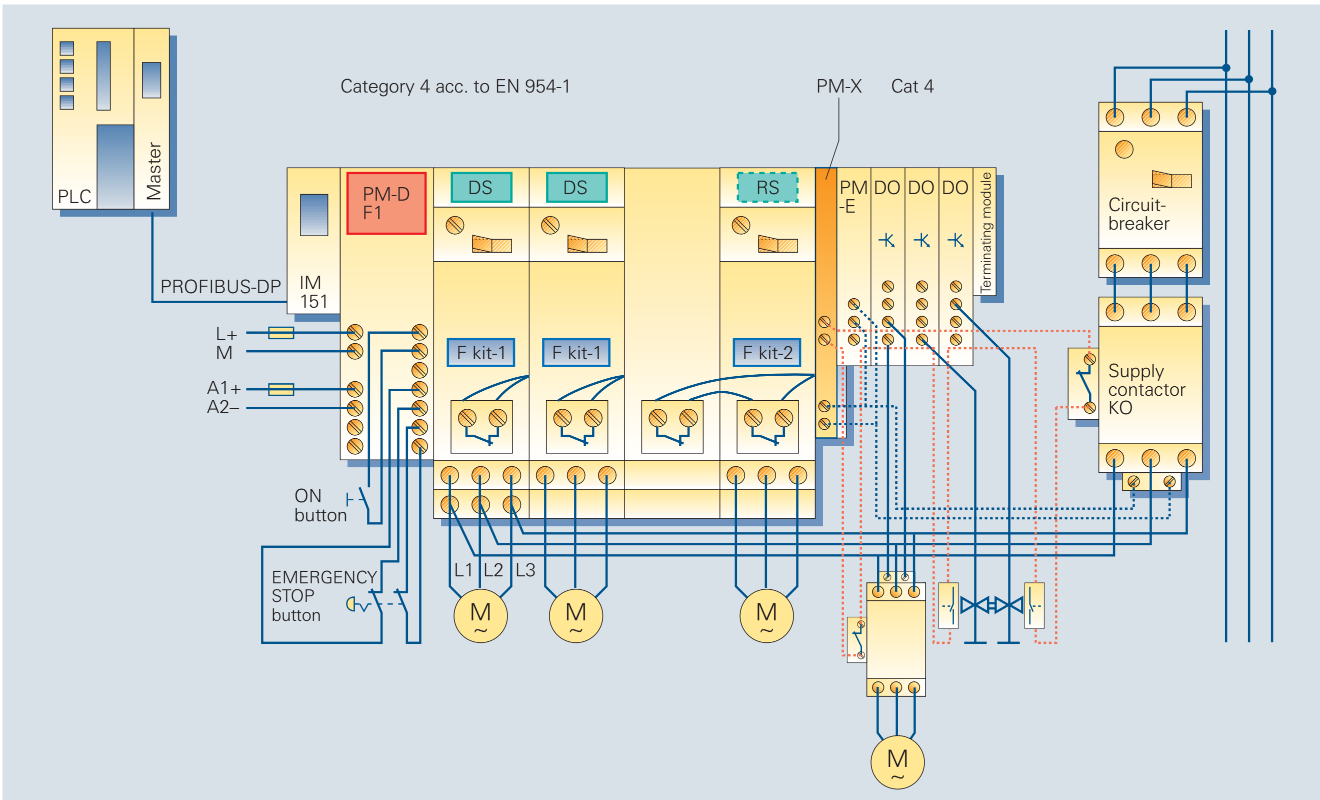


Fig. 7/92
EMERGENCY STOP circuit with integrated external actuators

7.2.1 Circuit examples for S7-300F

This section shows you the possibilities of achieving Safety Classes AK4/SIL2/Cat.3 and AK6/SIL3/Cat.4 using the F I/O in S7-300F and S7-400F/FH. This information refers to the F I/O of the SIMATIC S7 range - this means F-SMs S7-300 and F modules ET 200S.

How is the safety class achieved for F inputs?

For F inputs, the required Safety Class is achieved by the type of transmitter evaluation. This means that **Safety Class** AK4/SIL2/Cat.3 or AK6/SIL3/Cat.4. is defined by how the transmitter is connected-up.

How is the Safety Class achieved with F outputs?

For F outputs, the required Safety Class is achieved by the way in which the **test signals are connected to the F I/O**.

Evaluating transmitters for F digital inputs

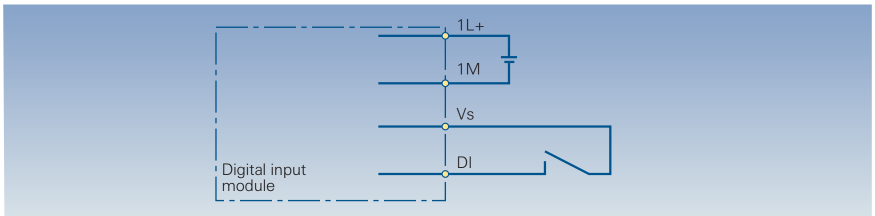
For F **digital inputs**, the required Safety Class is achieved by the type of transmitter evaluation.

Safety Classes			Achieved by
Acc. to IEC 61508	Acc. to DIN V 19250	Acc. to EN 954-1	Transmitter evaluation
SIL2	AK4	Cat. 3	1-from-1 evaluation
SIL3	AK5,6	Cat. 4	2-from-2 evaluation

Table: Safety Classes which can be achieved for F digital inputs

Example: A transmitter connected to an F-DI through 1 channel (AK4/SIL2/Cat.3)

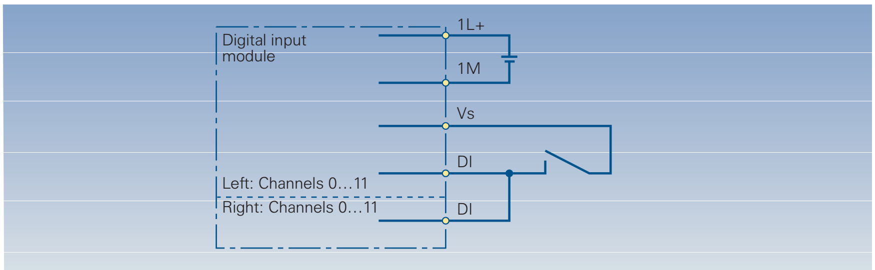
The connection schematic for an SM 326, DI 24 x 24V DC for a 1-from-1 evaluation of the transmitter is shown in the following diagram. The transmitter is supplied from the F I/O. AK4/SIL2/Cat.3 can be achieved using this connection.



Example: Wiring schematic for a transmitter connected to an F-DI (1-from-1) through 1 channel

Example: A transmitter connected to an F-DI through 1 channel (AK6/SIL3/Cat.4)

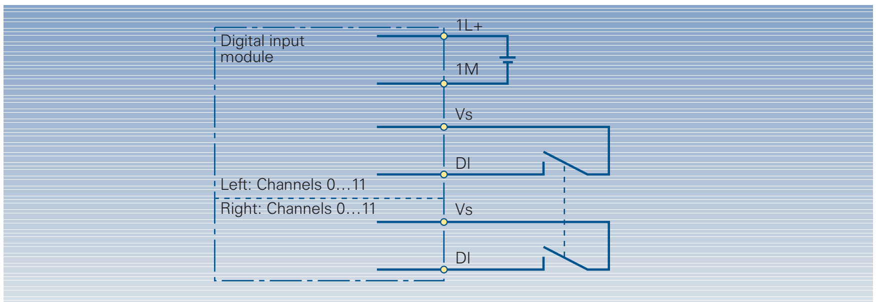
The connection schematic for an SM 326, DI 24 x 24V DC for a 2-from-2 evaluation of the transmitter is shown in the following diagram. The transmitter is supplied from the F I/O. AK6/SIL3/Cat.4 can be achieved using this connection as long as a suitably qualified transmitter is used.



Example: Wiring schematic for a transmitter connected to an F-DI (2-from-2) through 1 channel)

Example: A transmitter connected to an F-DI through 2 channels (AK6/SIL3/Cat.4)

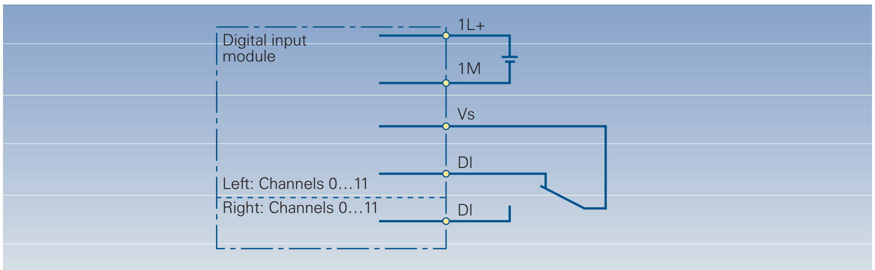
The connection schematic for an SM 326, DI 24 x 24V DC for a 2-from-2 evaluation of the transmitter is shown in the following diagram. AK6/SIL3/Cat.4 can be achieved using this connection.



Example: Wiring schematic for a transmitter connected to an F-DI (2-from-2) through 2 channels)

Example: An antivalent transmitter (2-channel) connected to an F-DI (AK6/SIL3/Cat.4)

The connection schematic for an SM 326, DI 24 x 24V DC with antivalent transmitter (2-from-2 evaluation) is shown in the following diagram. AK6/SIL3/Cat.4 can be achieved with this connection.



Example: Connection schematic for an anti-valent transmitter connected to an F-DI (2-from-2) through 2 channels

7.2.2 Function block for the S7-300F muting function

Mode of operation

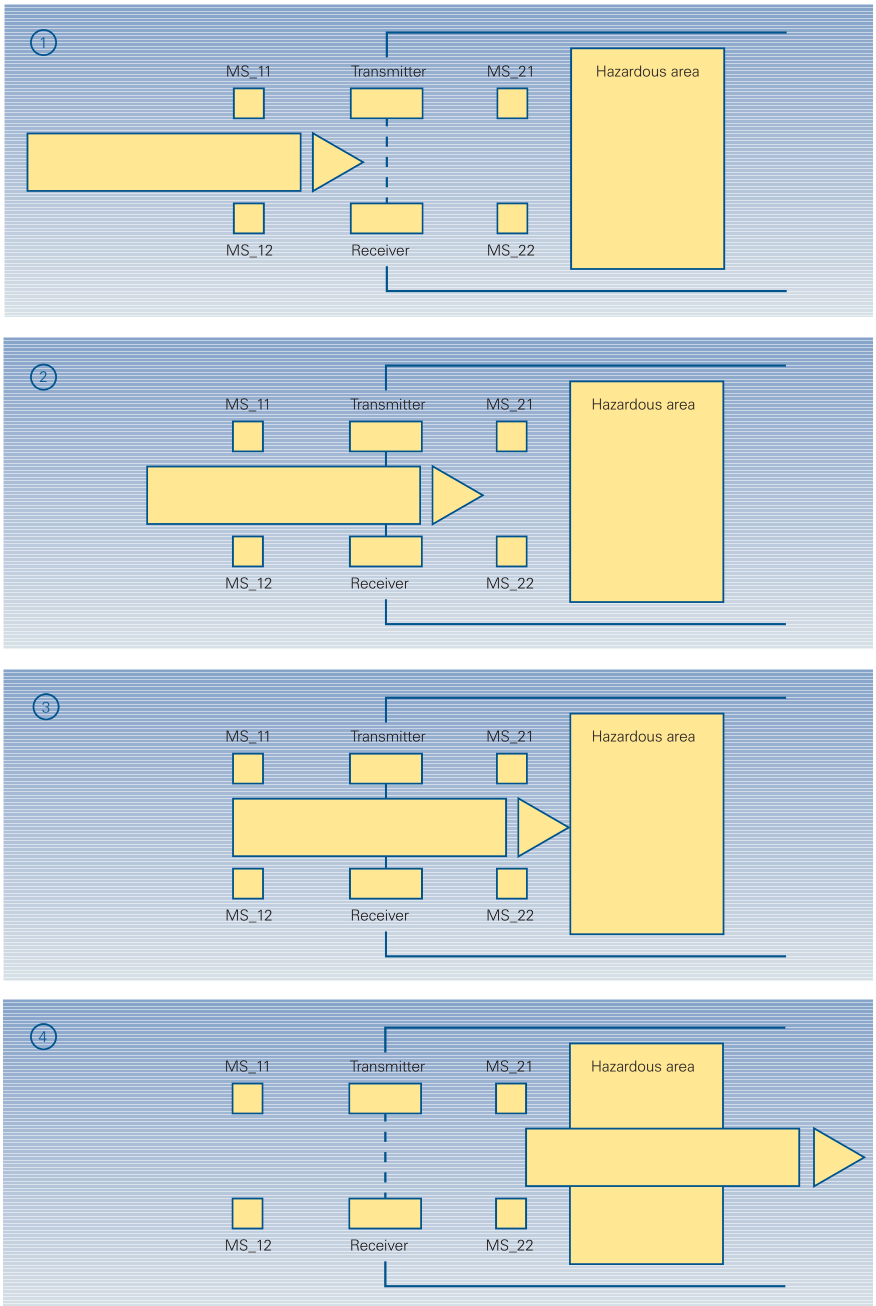
Light curtains can be operated in the muting mode so that products or objects can be brought into the hazardous area, monitored by the light curtain, without stopping the machine. It must be ensured that personnel cannot enter the hazardous area while the light curtain is bypassed by using two or four muting sensors as well as the correct integration into the production sequence.
It is extremely important to note that the interval in which the safety program is called (e.g. OB 35) must be less than the selected discrepancy time.

Schematic sequence of an error-free muting operation using 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

1. If the inputs for the muting sensors MS_11 and MS_12 are activated by the product within DISCTIM1, then the F application block switches to MUTING. The enable signal Q remains at 1, also if the input FREE = 0 (the product interrupts the light curtain). The output MUTING goes to 1 to control the muting lamp.

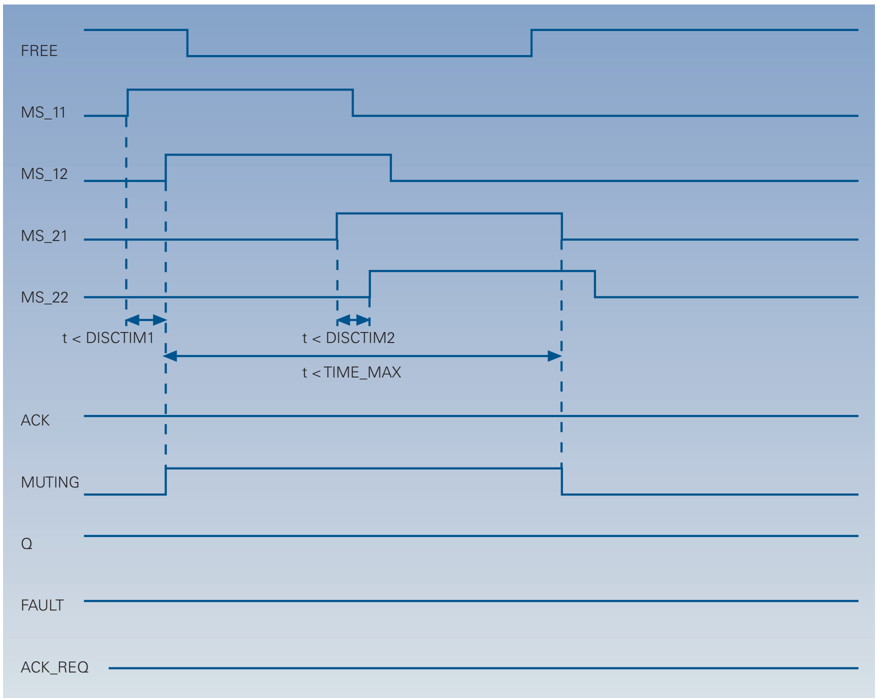
2. As long as the two inputs MS_11 and MS_12 are still activated by the product, Q remains at 1 and MUTING remains at 1 as a result of the MUTING function of the F application block (so that the product may pass through the light curtain without the machine stopping).

3. The inputs for the muting sensors MS_21 and MS_22 must have been activated within DISCTIM2 and before the inputs for the muting sensors MS_11 and MS_12 are switched into an inactive state. This means that the F application block maintains the MUTING. (Q = 1, MUTING = 1).



4. After one of the inputs for the muting sensors MS_21 and MS_22 = 0 (the product enables the sensors), the MUTING function is exited (Q = 1, MUTING = 0). The MUTING function may be active for a maximum time parameterized at the input TIME_MAX.

Timing diagram for error-free muting using 4 muting sensors



DISCTIM1 and DISCTIM2 are discrepancy times for sensor pairs 1 and 2.

This section describes the circuit examples using the drive systems SIMOVERT MASTERDRIVES and SIMODRIVE 611 universal for applications involving variable-speed drives with AC motors.

These examples show possibilities of implementing the various solutions. The solution required for the machine must be aligned to the particular machine function. This results in individual parameter assignments or control commands for applications associated with stop Category 1.

Using the "safe standstill" function, the drive pulses are cancelled thus preventing the drive from undesirably starting.

The solutions which are shown can, from the actual principle, also be implemented using other drive systems. However, the appropriate information/instructions in the documentation describing the various products must be carefully observed (also refer to the Certificate in Section 8.6.3)

SIMOVERT MASTERDRIVES
Vector Control Catalog DA 65.10

SIMOVERT MASTERDRIVES
Motion Control Catalog DA 65.11

SIMODRIVE 611
Catalog NC 60.1 and NC 60.2

7.3.1 Application examples for EMERGENCY STOP Category 0

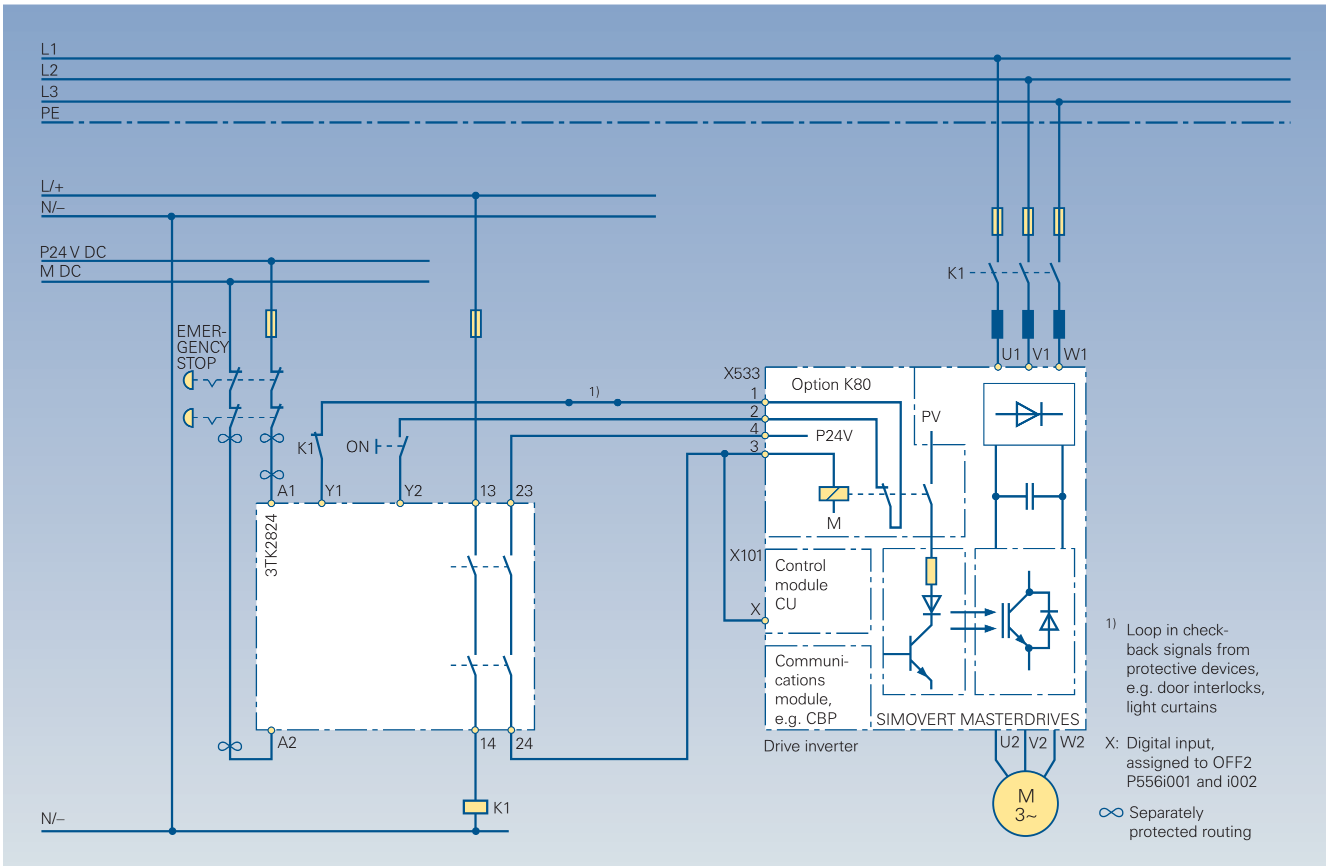


Fig. 7/93
Stop Category 0, 2-channel, with feedback circuit; Category 3 acc. to EN 954-1; Function with a motor coasting down

7.3.2 Application examples for EMERGENCY STOP Category 1

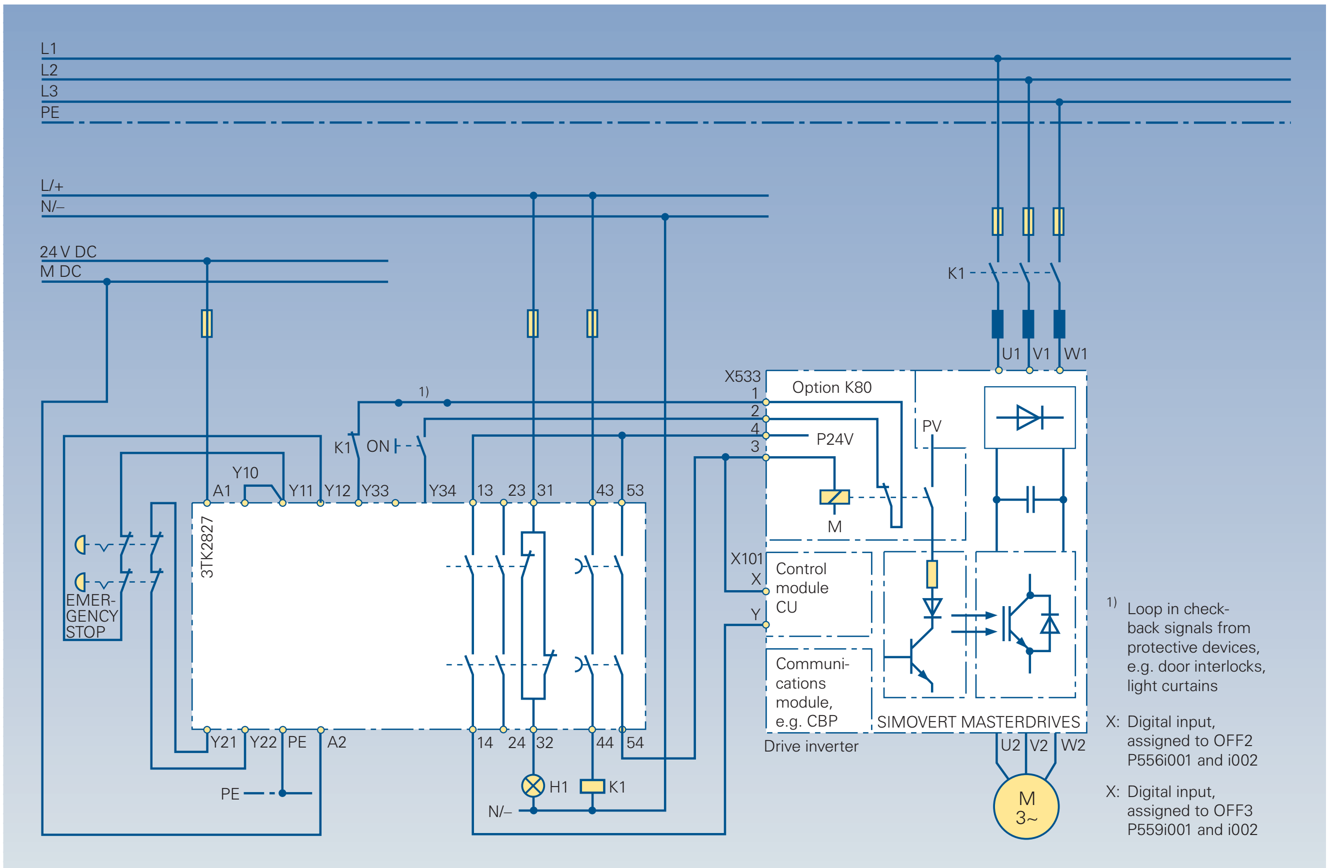


Fig. 7/94
Stop Category 1, 2-channel, with feedback circuit, Category 3 acc. to EN 954-1;
Function where the motor is shut down along the torque limit in a controlled fashion.

7.3.3 Application examples for EMERGENCY SWITCHING-OFF and EMERGENCY STOP Category 1

Structure acc. to EN 954-1 control category 3 and EN1037

The drive is shut down according to the stop function, Category 1 acc. to EN 60204-1.

By implementing as a higher-level circuit using contacts, the "Safe standstill" function is even guaranteed for erroneous behavior or if the PLC fails.
For an EMERGENCY SWITCHING-OFF, the drive is electrically isolated from the line supply.
For this type of connection, the internal line contactor of the supply unit only drops-out if the internal safety relay functions erroneously.

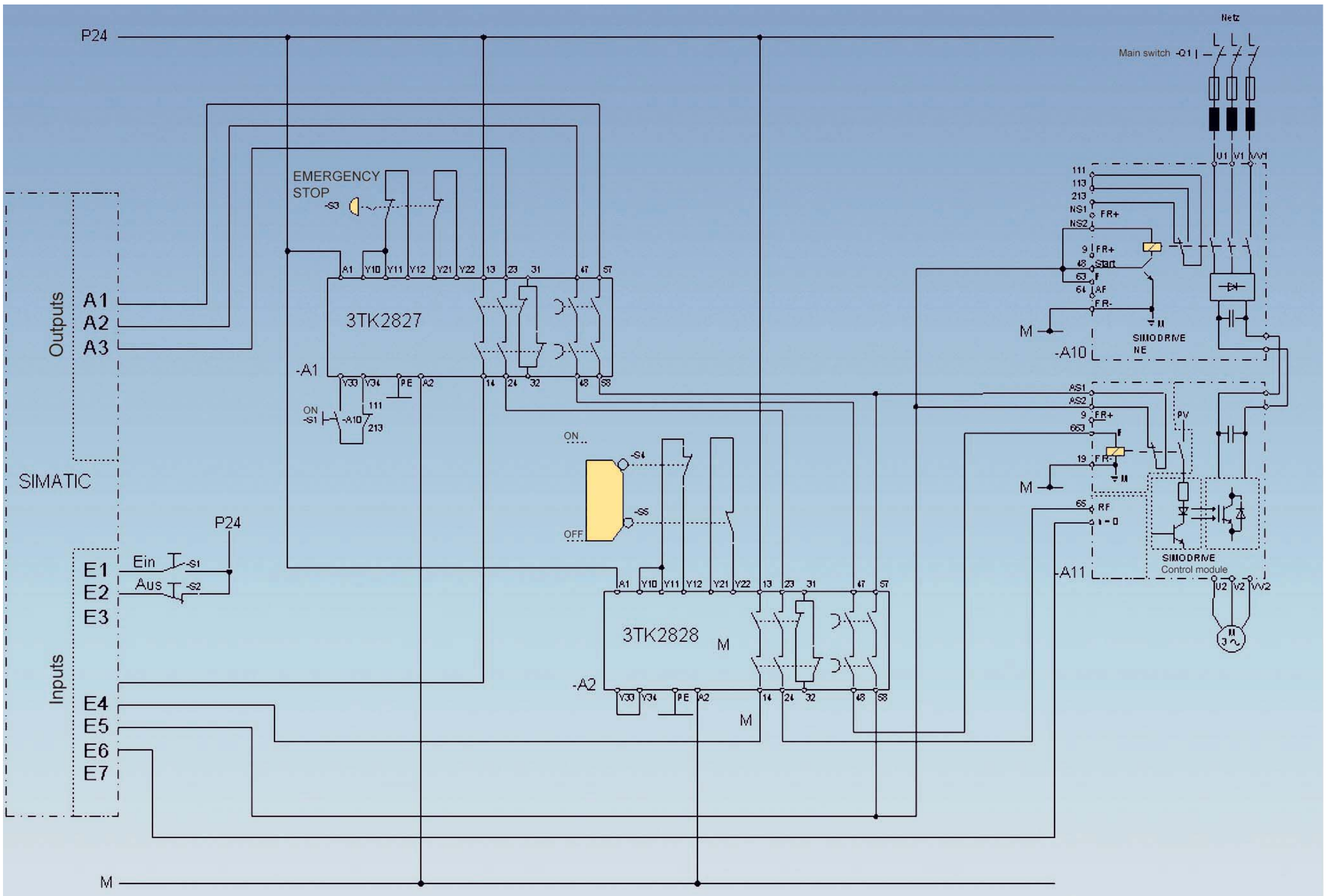


Fig. 7/95
EMERGENCY SWITCHING-OFF and EMERGENCY STOP, Stop Category 1 acc. to EN 60204, 2-channel with feedback circuit, control Category 3 acc. to EN 954-1

7.3.4 Application example for EMERGENCY STOP, Category 1 for several drives

Structure/design in accordance with EN 954-1 control Category 3 and EN1037

The drive is shut down in accordance with stop function Category 1 acc. to EN 60204-1.

With this particular circuit principle, the internal line contactor of the supply unit only drops-out if one of the two internal safety relays has an erroneous function.

This circuit principle is suitable if individual drive groups must be selectively shut down.

The circuit principle can be expanded to several drive groups.

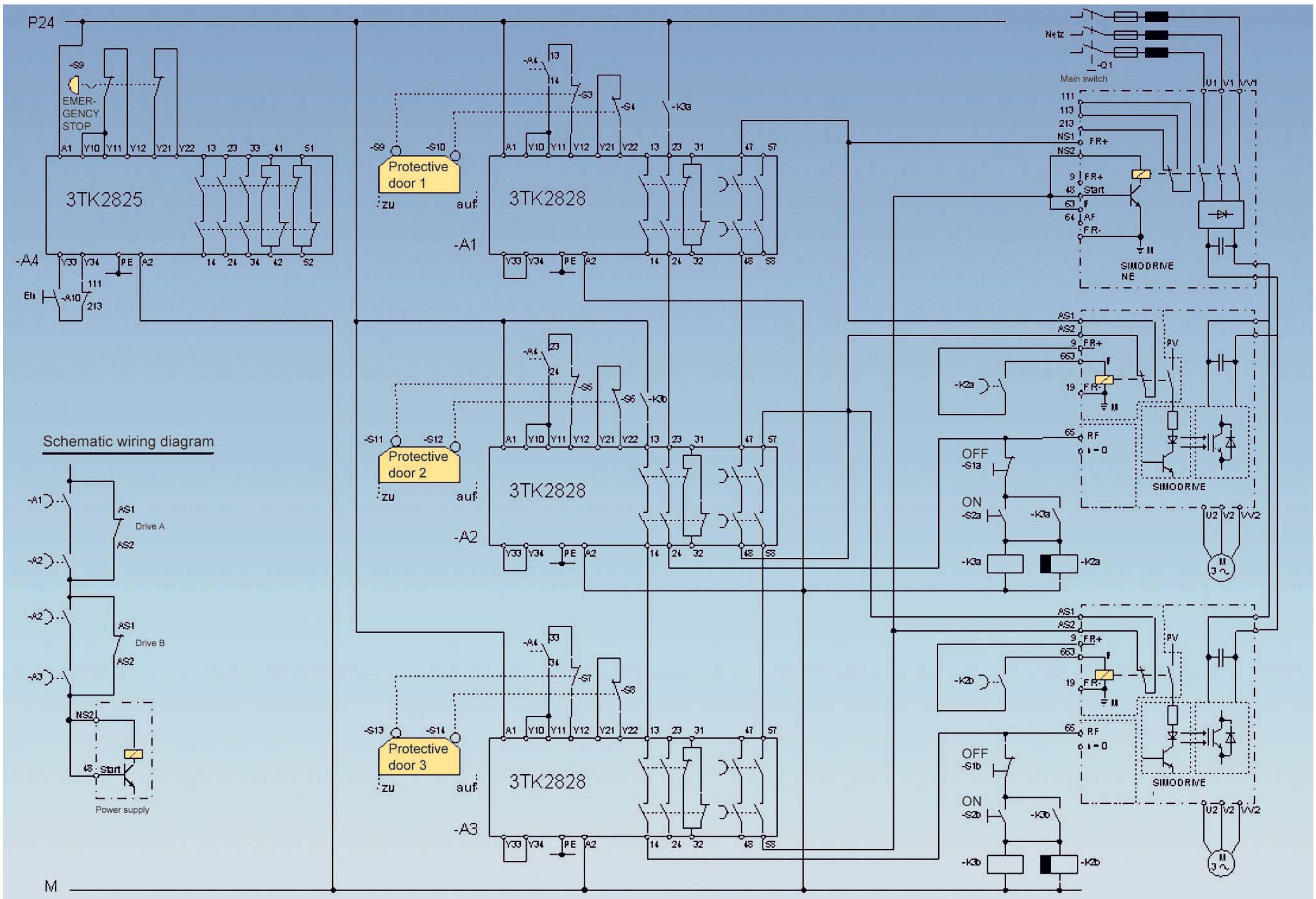
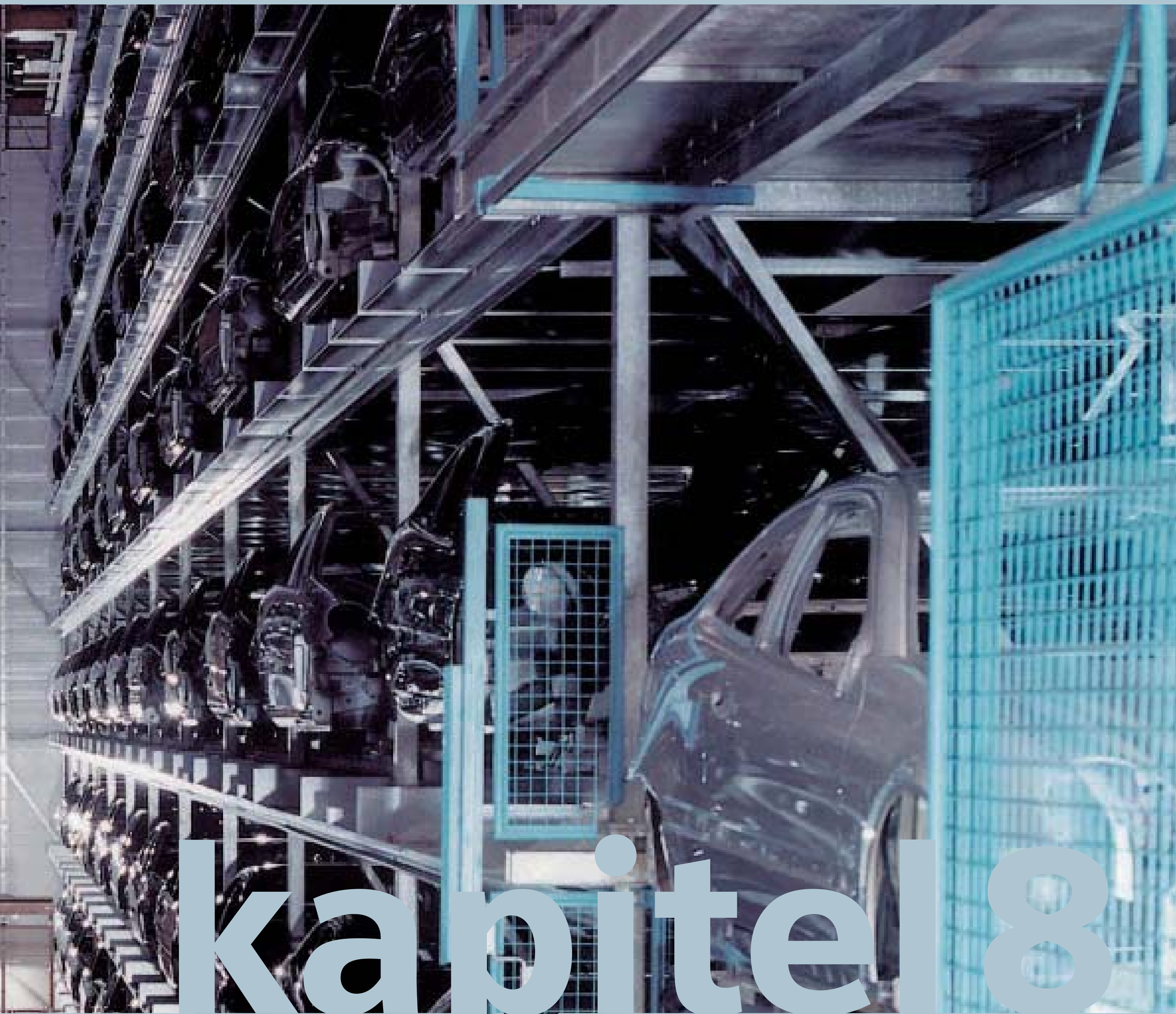
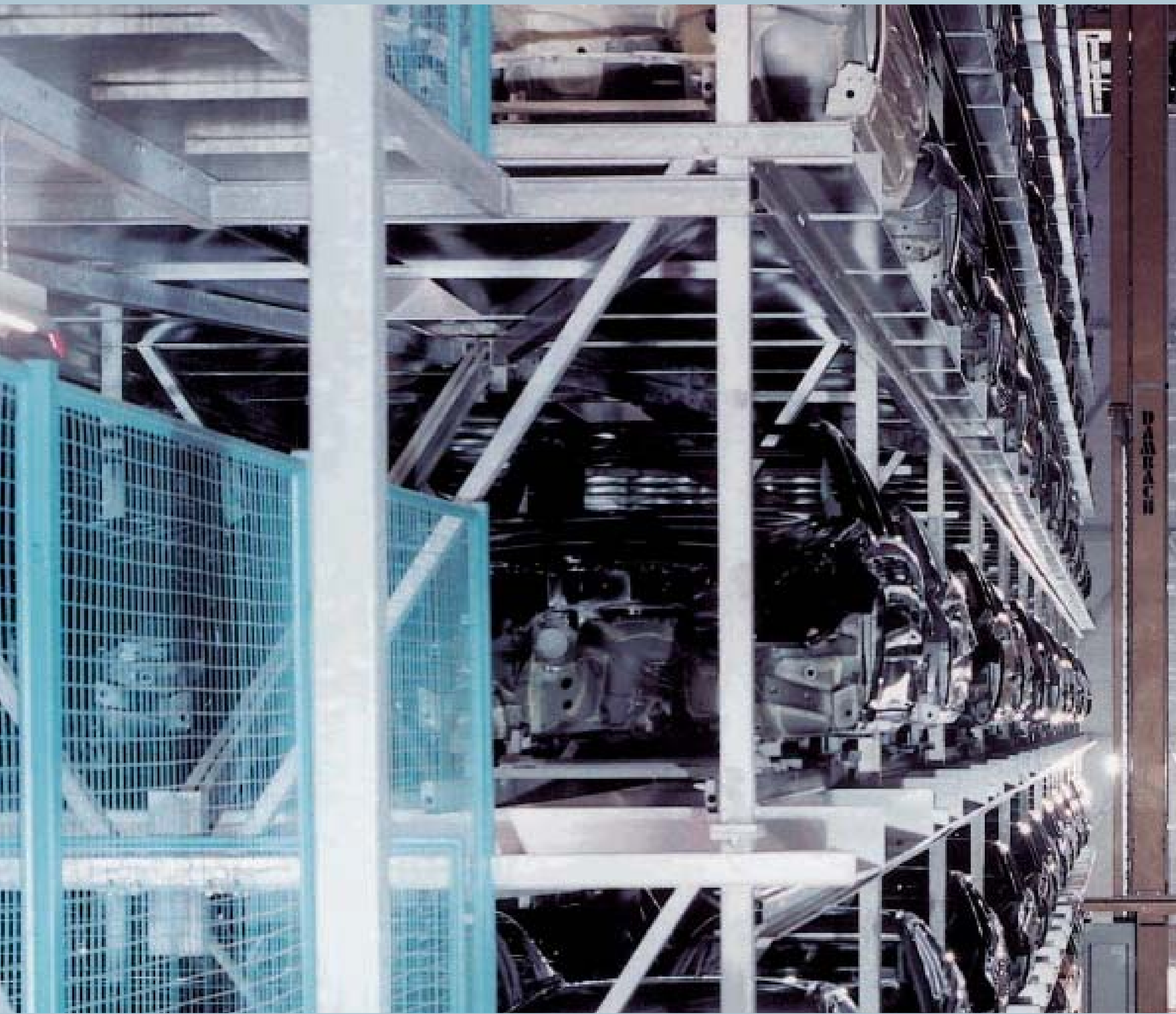


Fig. 7/96
Emergency Stop, Stop Category 1 acc. to EN 60204, 2-channel with feedback circuit, control Category 3 acc. to EN 954-1

Appendix



kapitel 8


DAMBACH

8.1 Overview, Important Basic Safety, Group and Specialist Standards* under the Machinery Directive

The hierarchic European Standards for the safety of machinery is structured so that the Safety Product Standards (Type C Standards), regarding general safety aspects and general safety equipment for machinery construction, refer to the Basic Standard (Type A Standard) and to specific Group Standards (Type B Standard). They also refer to specific definitions or categories as long as these are applicable for the machines defined in the validity area of the product Standard and if the responsible design engineer or the competent Standards committee considers these as solution.

A European Standard can be applied after it has been ratified as EN (in some cases, even as prEN). However, these Standards (those identified in the table as "ratified") only have the so-called "presumption effect" if they were published in a Council Journal EEC Archive. .../C...). Example: EN 418, Safety of Machinery - EMERGENCY STOP equipment, functional aspects, design principles, council document 93/C229/03, published 10-1992.

Note: The following list of Standards does not claim to be complete. It only provides a selection of Standards for engineers designing machines and plants and also for authors of Product Standards (Type C Standards) as decision-making support for Standards which are already available, partially already implemented in "DIN EN" (EN) and Drafts (prEN or IEC. Sec). Additional Standards and the actual status are available from the following web site: http://www.NewApproach.org/directiveList.asp

Type A Standards (Basic Standards) and Type B Standards (Group Standards)

Standard	Title
EN 292-1	Safety of Machinery – Basic concepts, general principles for design Part 1: Basic terminology, methodology
EN 292-1	Safety of Machinery – Basic concepts, general principles for design Part 2: Technical principles and specifications
EN 292-2/A1	Safety of Machinery – Basic concepts, general principles for design Part 2: Technical principles and specifications
EN 294	Safety of Machinery – Safety distances to prevent danger zones being reached by the upper limbs
EN 294	Safety of Machinery – Minimum gaps to avoid crushing of parts of the human body
EN 418	Safety of Machinery – EMERGENCY STOP equipment, functional aspects – Principles for design
EN 457	Safety of Machinery – Auditory danger signals – General requirements, design and testing (ISO 7731:1986 modified)
EN 457-1	Safety of Machinery – Human body measurements – Part 1: principles for determining the dimensions required for openings for whole body access into machinery
EN 574	Safety of Machinery – Two-hand control devices – Functional aspects– Principles for design
EN 614-1	Safety of Machinery – Ergonomic design principles Part 1: Terminology and general principles
EN 626-1	Safety of Machinery – reduction of risks to health from hazardous substances emitted by the machinery – Part 1: Principles and specifications for machinery manufacturers
EN 692	Mechanical presses – Safety 7 Reference: 89/392/EEC <M>

* The above mentioned standards are only an excerpt of the valid A, B and C Standards.
We do not claim that these standards are complete.

Type A Standards (Basic Standards) and Type B Standards (Group Standards)

Standard	Title
EN 811	Safety of Machinery – Safety distances to prevent danger zones being reached by the lower limbs
EN 953	Safety of Machinery – Guards – General requirements for the design and construction of fixed and movable guards
EN 954-1	Safety of Machinery – Safety-related parts of control systems – Part 1: General principles for design
EN 60204-1	Safety of Machinery – Electrical equipment of machines – Part 1: General requirements (IEC 60204-1:1997) Publication in the Official Journal 20.05.2000

Type C Standards (Specialist or Product Standards)

Lifts	
• Revision 1994-02 Safety rules for the construction and installation of lifts – Part 1: Electric lifts	EN 81-1
• Revision 1994-02 Part 2: Hydraulic lifts	EN 81-2
• 1995-06 Part 3: Electric and hydraulic lifts	EN 81-3
• Safety rules for the construction and installation of escalators and passenger conveyors	EN 115
Lifting platforms	
• rev: 1994-11 Mobile elevating work platforms – Design calculations – Stability criteria, construction	prEN 280
• 1995-01 Suspended access equipment	EN 1908
Safety of woodworking machines	
• 1992-04 Woodworking machinery	prEN 691
• 1997-07 Planing machines	EN 859 since 13.3.98
• 1995-01 Band sawing machines	EN 1807
• 1995-03 Circular sawing machines - Part 1: Circular saw benches (with and without sliding table) and dimension saws	EN 1870-1
• 1997-◊ One-side molding machines with rotating tool – Part 1: Single-spindle vertical molding machines	EN 848-1
• 1997-05 Combined woodworking machines	EN 940
Machine tools – Safety	
• 1996-06 Mechanical presses – Safety	EN 692
• 1992-03 Hydraulic presses – Safety	prEN 693

Type C Standards (Specialist or Product Standards)	
Machine tools – Safety	
• 1996-10 Hydraulic bending presses	EN 12622
• 1996-06 Safety requirements for bonded abrasive products	EN 12413
• 1996-05 Small numerically controlled turning machines and turning centers	EN 12415
• Large numerically controlled turning machines and turning centers	EN 12478
• 1996-05 – Machining centers	EN 12417
• 1996-12 – Drilling machines	EN 12717
• Manually controlled turning machines	EN 12840
• Spark erosion machines	EN 12957
• Permanently installed grinding machines	prEN 13218
• Horizontal (single and) multi-spindle turning machines	prEN 13788
• Dimensioning separating protective equipment (Annex A of EN 12415)	prEN 12415
• Transfer and single-purpose or special-purpose machines	prEN 14070
Agriculture and forestry machine safety	
• rev: 1994-11 Mobile lifting platforms	prEN 280
• 1995-01 Suspended working platforms	EN 1808
Woodworking machines – Safety	
• 1994-06 Guards for power take-off (PTO) drive shafts – wear and strength tests (**DIN** EN 1152 : 1994-12)	EN 1152
• 1997-07 Power take-off drive shafts and their guards	prEN 12965
Rubber and plastics machinery – Safety	
• 1997-02 Injection molding machines	EN 201
• 1993-10 Compression and transfer molding presses for rubber and plastic	EN 289
• 1996-10 Extruders and extrusion lines - Part 1: Extruders	EN 1114-1
• 1995-06 Size reduction machines - Part 1: Blade granulators	EN 12012-1
• 1996-02 Internal mixer	prEN 12103
• 1997-08 Metering and mixing units	EN 1612-1
Packaging machines – Safety	
• 1996-07 Packaging machines safety – Part 1: Terminology and classification of packaging machines and associated equipment	prEN 415-1
• 1995-09 -, Part 2: Pre-formed rigid container packaging machines	EN 415-2
• 1997-03 Part 4: Palletizers and depalletizers	EN 415-4
Cranes - Safety	
• Part 2 Limiting and indicating devices	EN 12077-2

Type C Standards (Specialist or Product Standards)	
Rail-dependent storage and retrieval equipment – Safety	
• 1996-08 Rail-dependent storage and retrieval equipment – Safety	EN 528
Industrial trucks – Safety	
• 1988-12 Self-propelled industrial truck sit-down rider-controlled; Rules for the construction and layout of pedals	EN 281
Industrial trucks – Safety	
• 1993-08 -, Part 1: Electrical requirements for battery-powered industrial trucks	EN 1175-1
• 1993-08 -, Part 3: Electrical requirements for the electric power transmission systems of internal combustion engine powered trucks	EN 1175-3
• 1994-11 Safety of industrial trucks	EN 1726-1
Building and machines – Safety	
• 1994-09 Earth moving machinery – Safety – Part 1: General requirements	EN 474-1
Pile driving equipment	
• 1995-01 Piling equipment – Safety requirements	EN 996
• 1995-06 Drill rigs – Safety	EN 791
Tunnel boring machines	
• 1996-06 Safety of unshielded tunnel boring machines and rodless shaft boring machines for rock	EN 815
• 1995-08 Air locks – Safety requirements	prEN 12110
• 1995-08 Road headers, continuous miners and impact rippers – Safety requirements	prEN 12111
• 1996-02 Shield machines, horizontal thrust-boring machines, lining erection equipment – Safety requirements	prEN 12336
Road construction machinery	
• 1995-09 Mobile construction machinery – Safety Part 1: Common requirements	EN 500-1
Processing machines and equipment for building materials	
• 1997-08 Portable, handheld, internal combustion cutting-off machines – Safety	EN 1454
• 1996-03 Core drilling machines on stands – Safety	EN 12348
• 1996-05 Masonry and stone cutting-off machines for job site – Safety	EN 12418
• 1996-10 Floor sawing, grooving and milling machines – Safety	prEN 12638
• Wood saws – Safety	WI 151054
• Stone splitting equipment – Safety	WI 151055

Type C Standards (Specialist or Product Standards)	
Machines and systems to produce and transport concrete	
• 1995-06 Conveying, spraying and distributing machines for concrete and mortar – Safety requirements	prEN 12001
• 1996-09 Truck mixer – Safety requirements	prEN 12609
• 1996-19 Concrete compactors and floating machines – Safety requirements	prEN 12649
Machines and systems to produce cement, line, plaster	
• 1997-07 Feeding, crushing, milling, sizing, and sorting machines for mechanical processing or minerals and similar solid materials – Safety – Part 1: General	prEN 1009-1
• 1997-07 Thermal installations for the cement, line and gypsum industry – Safety requirements	prEN 12950
Machines for the manufacturer of concrete and calcium silicate	
• 1996-10 Machines for the manufacture of constructional products from concrete and calcium-silicate - Part 1: Common requirements	EN 12629-1
• 1997-04 Safety requirements for diamond wire saws	prEN 12866
• 1997-04 Safety requirements for chain and belt slotting machines	prEN 12867
Machines and systems to produce ceramics	
• 1996-11 Ceramic machines – Safety – Sorting and glazing of fine clay tiles	prEN 12651
• 1996-12 Ceramic machines – Safety – Presses	prEN 12692
Food processing machinery - Safety and hygiene requirements	
• 1994-12 Food processing machinery – Safety and hygiene requirements – Basic concepts – Part 1: Safety requirements	EN 1672-12
Thermo-processing technique – Safety	
• 1997-03 Industrial thermo-processing equipment – Part 1: General safety requirements for industrial thermo-processing equipment	EN 746-1
• 1997-03-, Part 2: Safety requirements for combustion and fuel handling systems	EN 746-2
• Part 3: Safety requirements for the generation and use of protective gases	pEN 746-3
Machines for underground mines – Safety	
• 1996-02 Safety requirements for armored scraper conveyors	prEN 12321
Pumps	
• 1992-09 Pumps and pump units for liquids - Common safety requirements	EN 809

Type C Standards (Specialist or Product Standards)	
Printing and paper machines – Safety	
Printing and paper finishing machines	
• 1993-02 Technical safety requirements for the design and construction of printing and paper converting machines	prEN 1010
Paper producing machines	
• 1993-03 Safety requirements for the design and construction of paper making and finishing machines	EN 1034
Leather and imitation leather goods and footwear manufacturing machinery – Safety	
• 1995-07 Cutting and punching	prEN 12044
• 1997-08 Roughing, scouring, polishing and trimming machines	EN 930
• 1995-02 Footwear molding machines	EN 1845
Foundry machinery	
• 1997-◊ Safety requirements for high-pressure metal die casting units	EN 869
• 1997-◊ Safety requirements for foundry molding and core-making machinery and plant-associated equipment	EN 710
• 1993-11 Safety requirements for ladles, pouring equipment, centrifugal casting machines, continuous and semi-continuous casting machines	prEN 1247
• Safety requirements for abrasive blasting equipment	prEN 1248
Textile and associated machines	
• 1995-09 Safety requirements for textile machinery	EN 11111
• 1995-03 Safety requirements for dry-cleaning machines using perchloroethylene	EN ISO 8230
• 1994-12 Safety requirements for industrial laundry machinery – Part 1: Common requirements	EN ISO 10472
Compressors – Safety	
• 1996-04 Compressors and vacuum pumps – Safety requirements Part 1: Compressors	EN 1012-1
Aircraft ground support equipment	
• 1995-05 Aircraft ground support equipment – General requirements – Part 1: Basic safety requirements	prEN 1915-05
• 1996-08 Centrifuges – Common safety requirements	prEN 12547
Industrial robots	
• 1992-+AC: 1993-05 Industrial robots – Safety	EN 775
Sewing machines	
• 1990-+08 Electrical equipment – Part 3: Particular requirements for sewing machines, units and systems	EN 60204-3-1
• 1990-+10 Part 2: Particular requirements for sewing machines	prEN 60335-2-28

8.2 Important Addresses

1. CEN Members = sources for the national editions of EN + prEN

AENOR

Asociación Española de Normalización
y Certificación (AENOR)
Génova, 6
E-28004 Madrid

Phone: + 34 91 432 60 00
Fax: + 34 91 310 40 32
e-mail: info@aenor.es

AFNOR

Association Française de Normalisation
11, Avenue Francis de Pressensé
F-93571 Saint-Denis La Plaine Cédex

Phone: + 33 14 162 80 00
Fax: + 33 14 917 90 00

BSI

British Standards Institution
389 Chiswick High Road
GB-London W4 4AL

Phone: + 44 208 996 90 00
Fax: + 44 208 996 74 00
e-mail : info@bsi-global.com

COSMIT

Czech Standards Institute
Biskupsky dvùr 5
CZ-110 02 Praha 1

Phone: + 42 02 218 02 100
Fax: + 42 02 218 02 311
e-mail : info@csni.cz

DIN

Deutsches Institut für Normung e. V.
D-10772 Berlin

Phone: + 49 30 26 01 0
Fax: + 49 30 26 01 12 31
e-mail: postmaster@din.de

DS

Dansk Standard
Kollegievej 6
DK-2920 Charlottenlund

Phone: + 45 39 96 61 01
Fax: + 45 39 96 61 02
e-mail: dansk.standard@ds.dk

ELLOT

Hellenic Organization for
Standardization
313, Acharnon Street
GR-11145 Athens

Phone: + 30 1 212 01 00
TX : (0601) 219670 elot gr
Fax: + 30 1 228 62 19
e-mail: info@elot.gr

IBN/BIN

Institut Belge de Normalisation/
Belgisch Instituut voor Normalisatie
Avenue de la Brabançonne 29/
Brabançonnelaan 29
B-1000 Bruxelles/Brussel

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e-mail: info@ibn.be

IPQ

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Rua António Gião, 2
P-2829-513 Caparica

Phone: + 351 21 294 81 00
Fax: + 351 21 294 81 01
e-mail: ipq@mail.ipq.pt

NEN

Nederlands Normalisatie-Instituut
Kalfjeslaan
Postbus 5059
NL-2600 GB Delft

Phone: + 3115690390
Fax: + 3115690190
e-mail: (firstname.lastname)@nen.nl

NSAI

The National Standards Authority
of Ireland
Glasnevin
IRL-Dublin 9

Phone: + 353 1 807 38 00
Fax: + 353 1 807 38 38
e-mail: nsai@nsai.ie

NSF

Norges Standardiseringsforbund
PO Box 353 Skøyen
N-0213 Oslo

Phone: + 47 22 04 92 00
Fax: + 47 22 04 92 11
e-mail: info@standard.no

ON

Österreichisches Normungsinstitut
Postfach 130
Heinestraße 38
A-1021 Vienna

Phone: + 43 1 213 00
Fax: + 43 1 213 00 650
e-mail : infostelle@on-norm.at

SEE

Service de L'Energie de l'Etat
Organisme Luxembourgeois
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B.P. 10
L-2010 Luxembourg

Phone: + 352 46 97 46 1
Fax: + 352 46 97 46 39
e-mail: see.normalisation@eg.etat.lu

SFS

Suomen Standardisoinisliitto
PO Box 116
FIN-00241 Helsinki
Finland

Phone: + 358 9 149 93 31
Fax: + 358 9 146 49 25
e-mail: sfs@sfs.fi

SIS

Standardiseringen i Sverige
Box 6455
S-113 81 Stockholm

Phone: + 46 8 610 30 00
Fax: + 46 8 30 77 57
e-mail: info@sis.se

SNV

Schweizerische Normen-Vereinigung
Bürglistraße 29
CH-8400 Winterthur

Phone: + 41 1 254 54 54
TX : (045) 755931 snv ch
Fax: + 41 1 254 54 74
e-mail: info@snv.ch

STRI

Icelandic Council for Standardization
Laugavegur 178
IS-105 Reykjavik

Phone: + 354 520 71 50
Fax: + 354 520 71 71
e-mail: stri@stri.is

UNI
Ente Nazionale Italiano di Unificazione
Via Battistotti Sassi, 11b
I-20133 Milano MI

Phone: + 39 02 70 02 41
Fax: + 39 02 70 10 61 06
e-mail: uni@uni.com

CEN
European Committee for Standardization
Rue de Stassrt 36
B-1050 Bruxelles

Phone: + 32 25 50 08 11
Fax: + 32 25 50 08 19

CENELEC
European Committee for Electrotechnical Standardization
Rue de Stassrt 36
B-1050 Bruxelles

Phone: + 32 25 19 68 71
Fax: + 32 25 19 69 19

2. DIN – Deutsches Institut für Normung e.V., important Standards committees with reference to machines

NAM
Normenausschuss Maschinenbau
(NAM)im DIN
Postfach 71 08 64
60498 Frankfurt/M.

Phone: 0 69/66 03-13 41
Fax: 0 69/66 03-15 57

NWM
Normenausschuss Werkzeugmaschinen
Corneliusstraße 4
60325 Frankfurt

Phone: 0 69/75 60 81 25
Fax: 0 69/75 60 81 11

AGSA, FNErg, FNFW, FNL, NAL, NALS, NAS, Nasg, NI, NKT, NMP, Textilnorm
DIN Deutsches Institut für Normung e.V.
10772 Berlin

Phone: 0 30/26 01-0
Fax: 0 30/26 01-12 31

FNCA, FNKä, FWS, Naa, NAD, NL, NÖG, NRK, NÜA
DIN Deutsches Institut für Normung e.V.
Zweigstelle Köln
Kamekestraße 8
50672 Köln

Phone: 02 21/57 13-0
Fax: 02 21/57 13-4 14

NA EBM
Normenausschuss Eisen-, Blech- und Metallwaren
Kaiserwerther Str. 137
40474 Düsseldorf

Phone: 02 11/45 64 274/276
Fax: 02 11/45 64 277

NA FuO
Normenausschuss Feinmechanik und Optik
Turnplatz 2
75172 Pforzheim

Phone: 0 72 31/91 88 22
Fax: 0 72 31/91 88 33

FAKAU
Normenausschuss Kautschuktechnik
Postfach 90 03 60
60443 Frankfurt/M.

Phone: 0 69/79 36-0/117
Fax: 0 69/79 36 165

DKE
Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE
Stresemannallee 15
60596 Frankfurt/M.

Phone: 0 69/63 08 26 0
Fax: 0 69/96 31 52 22

3. Sources for technical regulations in Germany

For EC Directives as well as legislation and regulations
Bundesanzeiger-Verlags GmbH
Amsterdamer Straße 192
50667 Cologne

Phone: (02 21) 97668-0
Fax: (02 21)

For DIN Standards and VDM Sheets
Beuth Verlag GmbH
Burggrafenstraße 6
10787 Berlin

Phone: (0 30) 26 01-0
Fax: (0 30) 26 01-12 60

For VDE Regulations as well as DKE and IEC Standards
VDE-Verlag GmbH
Bismarckstraße 33
10625 Berlin

Phone: (0 30) 34 80 01-16
Fax: (0 30) 34 17 09 3

For accident prevention regulations and ZH-1 documents from the Trade Associations
Carl Heynemanns Verlag KG
Luxemburger Straße 449
50939 Cologne

Phone: (02 21) 94 373-0
Fax: (02 21) 94 373-901

Information about Standards, Regulations, Directives
Deutsches Institut für technische Regeln (DITR) im DIN (Deutsches Institut für Normung)
Burggrafenstraße 6
10787 Berlin

Phone: (0 30) 26 01-0
Fax: (0 30) 26 28 125

8.3 Terminology and Abbreviations

8.3.1 Terminology

Actuator

An actuator converts electrical signals into mechanical or other non-electrical quantities.

Blanking

Using blanking, a specified section or area is suppressed from a protective field, e.g. a light curtain or light grid, i.e. it is disabled. There are two types of blanking: Fixed and floating blanking.

Fixed blanking

For fixed blanking, the selected area or range is fixed. This function is used, for example, if fixed objects protrude into the protective field.

Floating blanking

Floating blanking permits that normally one or two light beams in a protective field are interrupted without a stop signal being output from a light curtain. This function is required if the "permissible" interruption of the light beams does not refer to a fixed position in the protective field, e.g. if a moving cable enters the protective field.

Category

In EN 954-1, this is used to "classify the safety-related parts of a control with reference to their immunity to faults and their behavior under fault conditions which is achieved as a result of the structural arrangement of the parts and/or their reliability."

Channel

Element or group of elements which executes a function independently.

2-channel structure

Structure which is used to achieve fault tolerance.

For example, a 2-channel contactor control can be achieved if at least two enable circuits are available and the main current can be redundantly switched off or a sensor (e.g. EMERGENCY OFF switch) is interrogated using two contacts which are separately connected to an evaluation unit.

Danger

Potential source of damage. (taken from EN 292-1)

e.g. danger due to electric shock, danger due to crushing, ...

EMERGENCY STOP

An operation in an emergency which is designed to stop a process or movement which is potentially dangerous (from EN 60204-1 Annex D).

EMERGENCY SWITCHING-OFF

EMERGENCY SWITCHING-OFF equipment

Arrangement of components which are intended to implement an EMERGENCY SWITCHING-OFF function (EN 418-1992). (Note: Today, a differentiation is made between "Stopping in an emergency" and "Power off in an emergency".

Stopping in an emergency

A function which either avoids or minimizes approaching or existing danger for persons, damage to the machine or when carrying out work;
– initiated by the single action of a person.
(prEN 292-1 2000)

Power off in an emergency

Power off in an emergency is achieved by disconnecting the machine from the supply subsequent to a Category 0 stop (EN 60204 1997). Power off in an emergency should be provided, in compliance with EN 60204-1 1997, where there is possibility of danger due to electricity (i.e. electric shock).

Enabling device

Additional manually actuated control device which permits a specific function of a machine if it is continually actuated.

Fail-safe

The capability of a control to maintain a safe condition of the controlled equipment (e.g. machine, process), or to bring this into a safe condition when faults occur (failures).

Failure / Fault

Failure

When a piece of equipment or a device is no longer capable of executing a specified function.

Fault

Unintentional status of a piece of equipment or device which is characterized by the fact that it is not capable of executing a specified function.

Note: "Failure" is an event and "Fault" is a condition.

Feedback circuit

Circuit to monitor controlled contactors.

The function of contactors can be monitored by reading back the positively driven auxiliary contacts by an evaluation unit. If the contactor contacts are welded, the evaluation unit prevents a restart.

Fault

Refer to "Failure / Fault".

Fault tolerance

Fault tolerance N means that a piece of equipment or device can still execute the specified task even when N faults/errors are present. For N+1 faults, the piece of equipment or device fails when executing the specified function.

Load group

A group of motor starters which is supplied through a power bus. A load group can be located within a potential group or can include parts of two potential groups.

Motor starter (MS)

Motor starters include direct and reversing starters. Starting and direction of rotation are determined using a motor starter.

Direct starter

A direct starter is a motor starter for one direction of rotation, which directly powers up or powers down a motor. It comprises a power switch and a contactor.

Reversing starter

A reversing starter is a motor starter for two directions of rotation. It comprises a circuit-breaker and two contactors.

Muting

Muting disables one or several safety functions for a limited time in-line with specifications

Partial potential group

A partial potential group exists if within a potential group, the auxiliary voltage can be partially switched out.

Potential group

A group of motor starter and/or electronic modules which is supplied from a power module.

Redundancy

Availability of resources or equipment more than is actually required for its execution.

Requirement Class (AK)

Measure of the safety-related performance of control equipment. Defined in DIN V 19250 and DIN V VDE 0801.

Risk

Combination of the probability of the occurrence of damage and the extent of the damage.

Safety

Freedom from unacceptable risk.

Functional safety

Part of the safety of a piece of equipment or device (e.g. machine, plant) which depends on the correct function.

Safety function

Function (e.g. of a machine or a control) whose failure (or breakdown) can increase the risk(s).

Safety functions of controls (EN 954)

"A function, initiated by an input signal and processed by safety-related parts of controls which allows the machine to achieve a safe condition (as system)."

Safety goal

To keep the potential hazards for man and the environment as low as possible without restricting industrial production, the use of machines or the production of chemicals as far as is absolutely necessary.

Safety Integrity Level (SIL)

In IEC 61508, this is defined as the measure for the safety performance of electrical or electronic control equipment. (-> Section 1)

Safety-relevant control function

Slightly differing definitions are provided in the various Standards.

Safety-relevant control function (draft IEC 62061)

Control function which is executed by a safety-relevant control system in order that a system goes into a safe condition (e.g. machine) or to avoid hazardous conditions occurring.

Stop Category

A term which is used in EN 60204-1 to designate three different stopping functions.

Stopping

This is a function which is intended to avoid or minimize hazards to personnel, damage to the machine or the execution of operational processes. It has priority over every other operating mode.

Two-hand circuit

Control device which requires that it is simultaneously actuated by both hands in order to activate hazardous machine functions and also maintain them.

8.3.2 Abbreviations

ANSI	American National Standards Institute
BAG	Operating mode group
BIA	German Statutory Industrial Accident Insurance Association
HHU	Handheld unit
BWS	Contactless device
CNC	Computerized Numerical Control
CPU	Central Processing Unit
DMS	Direct measuring system
FTS	Driverless transportation system
HMI	Human Machine Interface
IBS	Start-up
IMS	Indirect Measuring System
KDV	Cross-checking
MRPD	Machine readable product designation: Order No. of Siemens components
NC	Numerical Control
NCK	Numerical Control Kernel
NCU	Numerical Control Unit
NFPA	National Fire Protection Association
OP	Operator Panel
OSHA	Occupational Safety and Health Administration
PLC	Programmable Logic Control
PG	Positive-ground switching
PP	Positive-positive switching
S5	SIMATIC S5
S7	SIMATIC S7

8

8.4 Contact – Internet & Hotlines

Internet address:

General information

http://www.siemens.de/safety
http://www.siemens.de/automation/mall

AS-Interface

http://www.siemens.de/as-interface

SIGUARD

http://www.siemens.de/siguard

SIMATIC

http://www.siemens.de/simatic-controller
http://www.siemens.de/simatic-dp

SIMODRIVE 611, SIMODRIVE POSMO, SIMOVERT MASTERDRIVES

http://www.siemens.de/simodrive

SINUMERIK

http://www.siemens.de/sinumerik

Hotlines:

SIMATIC
++ 49 (0) 91 1-8 95-70 00

SIGUARD
++ 49 (0) 91 31-7- 4 38 33

SINUMERIK
++ 49 (0)1 80-5 25 80 08

8.5 Seminars on Safety Technology, Standards and Directives

The Training Center of the Automation and Drives Group can train and qualify your personnel so that they can handle innovative technology. Well-trained employees are motivated and play their role in creating optimum automation solutions.

The training courses are held using training equipment which has been especially developed for this purpose and is optimally equipped. The actual racks can be separately ordered.

The courses are modular and are aligned to the various target groups as well as individual customer requirements. We offer courses for decision-makers and managers as well as for operating personnel, programmers, configuring engineers, service specialists and maintenance personnel.

In addition to standard courses, we also offer individual courses tailored to the special requirements and demands of our customers. When requested, these courses can also be held at the customer's facility.

Please refer to the SITRAIN catalog for more information on the courses.

SIGUARD Safety Integrated – basic course
Safety for man and machine

How can safety be optimized for production/manufacturing cells and islands? You get to know important aspects such as: Machinery Directive and risk analysis; reliable system solutions using sensors, safety combinations, actuators and drives – with the configuration for a customized safety control system.

Contents

- Standards according to EEC legislation (CE marking)
- Harmonized machine standards (Group and Specialist Standards)
- Product liability legislation
- Risk analysis
- Risks related to the electrical design
- Overview of Siemens safety technology
- Overview of Siemens devices, equipment and system solutions
- Practical exercises

Participants/ type of training

Engineers responsible for safety, design engineers, commissioning and maintenance personnel; training course

Prerequisites

Knowledge about electronic and electrical engineering

Duration
1 day

Course fee
On request

Location and time
On request

More info and course registration
e-mail: Safety_Integrated@siemens.com

SIMATIC S7-400F system course

This course is aimed at everybody who wants to learn how to handle, engineer and commission the fail-safe SIMATIC S7-400F automation system as well as the philosophy of fail-safe controllers, diagnostics and troubleshooting.

Contents

- Overview of the various redundancy techniques (H/F difference, availability, redundant systems, regulations)
- AS S7-400F (principle, system configuration and I/O)
- Configuring using the STEP7/F tool (system parameterization, system handling, fault diagnostics, documentation, acceptance)
- Fail-safe communications
- Exercises in configuring I/O, communications, troubleshooting, examples of programming, programming features

Prerequisites

SIMATIC STEP7 knowhow

Duration
3 days

Course fee
EUR 1,140 (plus Value Added Tax)

Location and time
On request

More info and course registration
www.sitrain.com

Fail-safe automation system SIMATIC S7-300F

This course is aimed at everybody who wants to learn how to handle, engineer and commission the fail-safe SIMATIC S7-300F automation system as well as the philosophy of fail-safe controllers, diagnostics and troubleshooting.

Contents

- AS S7-300F (principle, system configuration and I/O)
- Configuring with STEP7/F tool (system parameterization, system handling, fault diagnostics, documentation, acceptance)
- Fail-safe I/O ET200S F, ET200M F
- Generating programs with F-FBD/ F-LAD, software prerequisites
- Fail-safe communications S7-300F
- Exercises in configuring I/O, communications, troubleshooting, examples of programming, programming features.

Prerequisites

SIMATIC STEP7 knowhow

Duration
2 days

Course fee
On request

Location and time
On request

More info and course registration
www.sitrain.com

Safety Integrated NC-84D SIW

This course addresses configuring engineers, service-specialists and commissioning engineers who configure, engineer and commission machines with SINUMERIK 840D and Safety Integrated functionality. This course builds on the knowhow which you require to commission an 840D system. This knowhow can be obtained by participating in the NC-84D SIP Service Course.

Contents

- General information on safety technology
- System prerequisites
- Description of the following safety-related functions:
  - Safety-related inputs and outputs
  - Safe standstill
  - Safe operating stop
  - Safely reduced speed
  - Safe software limit switch
  - Safe software cam
  - Safe stopping process
  - Safe programmable logic
- Integrating sensors/actuators
- Safe communications
- Safe brake management
- Description of machine data and interface signals
- Commissioning and troubleshooting procedures
- Evaluating diagnostics and alarm displays
- Circuit examples for Safety Integrated
- Practical exercises relating to commissioning and service

Duration
5 days

Course fee
On request

Location and time
The current dates are available through the Internet under:
http://www.sitrain.com

More info and course registration
www.sitrain.com

Safety Integrated NC-84D SIS

This course targets maintenance personnel who service/maintain machines equipped with SINUMERIK 840D and Safety Integrated. This course builds on the knowhow which you require to service/maintain a SINUMERIK 840D. This knowhow can be obtained by participating in the NC-84D SK Service Course.

Contents

- General information on safety technology
- System prerequisites
- Description of the following safety-related functions:
  - Safety-related inputs and outputs
  - Safe standstill
  - Safe operating stop
  - Safely reduced speed
  - Safe software limit switch
  - Safe software cam
  - Safe stopping process
  - Safe programmable logic
- Integrating sensors/actuators
- Description of machine data and interface signals
- Fault finding procedures
- Evaluating diagnostics and alarm displays
- Circuit examples for Safety Integrated
- Practical service exercises

Duration
On request

Course fee
On request

Location and time
The current dates are available through the Internet under:
http://www.sitrain.com

More info and course registration
www.sitrain.com

National and International Standards: Low-voltage switchgear according to DIN EN 60947 (VDE 0660, IEC 60947)

As markets grow together and merge – in addition to the domestic standards – international standards are also becoming increasingly more important for product quality. For low-voltage switchgear, IEC 60947 defines the standard for the basic requirements. Our training course explains exactly what is regulated and what this involves for the product groups.

Contents

- Series of standards:
  - Structure and general definitions
  - Product standards
  - Actual status and a look to the future
- VDE 0660 – Part 100:
  - Terminology, contents, new aspects
  - Test requirements and testing
- Product standards for low-voltage devices
- EC Directives, testing and certification:
  - EMC Directive
  - Low-Voltage Directive
  - ALPHA/LOVAG

Participants/ type of training

Training course for customers and Siemens employees

Prerequisites

Knowledge about electronic and electrical engineering

Duration
1 day

Course fee
On request

Location and time
On request

More info and course registration
e-mail: Safety_Integrated@siemens.com

Switchgear combinations for machines according to DIN EN 60439-1 (VDE 0660 Part 500) and DIN EN 60204-1 (VDE 0113 Part 1)

You are involved with switchgear and switching devices for industry or other machines and you have to know the important standards? What is valid for the electrical equipment taking into account the Machinery and EMC Directive? This course helps - it explains DIN EN 60439-1 (VDE 0660 Part 500) for low-voltage switchgear combinations and DIN EN 60204-1 (VDE 0113 Part 1) for Safety of Machinery.

Contents

- An overview of the important standards
- DIN EN 60204-1 (VDE 0113 Part 1)
- DIN EN 60439-1 (VDE 0660 Part 500) – proof and tests
- Dimensioning insulated and bare conductors
- Protection of actuating elements according to DIN VDE 0106-100 (VDE 0106 Part 100)
- Procedures according to DIN VDE 0100-729 (VDE 0100 Part 729)
- CE marking and certification
- Retrofitting old equipment

Participants/ type of training

Training course for customers and Siemens employees

Prerequisites

Knowledge about electronic and electrical engineering

Duration
1 day

Course fee
On request

Location and time
On request

More info and course registration
e-mail: Safety_Integrated@siemens.com

Training course for contactless SIGUARD protective devices

Do you want to bring yourself or your personnel up-to-speed about the application and use of contactless protective devices, then this is the optimum workshop for you.

Contents

- European Directives
- Safety-related parts of controls acc. to EN 945-1
- SIGUARD safety light curtain
- Calculating safety clearances acc. to EN 999
- Evaluation units
- Checking contactless protective devices
- Diagnostics

Participants/ type of training

Training course

Prerequisites

Knowledge about basic electrical and electronic engineering

Duration

2 days

Course fee

EURO 400.– plus Value Added Tax.

Location and time

After prior discussion (min. 6 participants)

More info and course registration

e-mail: Safety_Integrated@siemens.com

8.6 Type Test Certificates

8.6.1 Certificates for SIMATIC Safety Integrated

ZERTIFIKAT ◆ CERTIFICATE ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Zertifikat

Nr.: Z2 99 12 38282 001

TÜV PRODUCT SERVICE

Siemens AG
A&D AS
Werner-von-Siemens-Str. 50
92224 Amberg

mit der Fertigungsstätte
38282

Sicherheit geprüft
Produktion überwacht
TÜV PRODUCT SERVICE
Funktionale Sicherheit

ist berechtigt, nachfolgend genanntes Produkt mit dem Zeichen TÜV **Mark** gemäß Anlage zu kennzeichnen. Umseitige Hinweise sind zu beachten.

Produkt: **Sicherheitsgerichtetes programmierbares elektronisches System**

Modell: **SIMATIC - S7-400F und S7-400FH**

Kenndaten:	Zentralbaugruppe:	S7-400F:	1oo1 mit diversitärer Struktur der Applikations-software, Selbsttests, Programm- und Datenflusskontrolle und Vergleich durch sicherheitsrelevante Ausgangsbaugruppen
		S7-400FH:	2oo2 Konfiguration von 1oo1 S7-400F
	Feldbus:		1oo1 oder 2oo2 ProfiSafe
	Signalbaugruppen (F-SMs):		1oo2 mit Ruhestromprinzip oder 2oo2 Konfiguration von 1oo2 Signalbaugruppen

Anmerkung: Text im Prüfzeichen: **"Funktionale Sicherheit"**

Das Produkt entspricht den zutreffenden sicherheitsrelevanten Anforderungen und bezeichneten Eigenschaften und wurde geprüft nach:

- 93/68/EWG Niederspannungsrichtlinie
- IEC 61508:1999, Teile 1 bis 7, SIL 1-3 (soweit anwendbar für PES)
- DIN V 19250:1994
- DIN V VDE 0801:1990 mit Änderung A1:1994, AK 1-6
- prEN 50159-1:1996 (soweit anwendbar)
- VDI/VDE 2180:1998, Teil 3
- DIN VDE 0116:1989, Kapitel 8.7
- EN 298:1993, Kapitel 9.10
- EN 954-1:1997 Sicherheitskategorie 2-4
- EN 61131-2:1995
- EN 60204-1:1997 (soweit anwendbar)

Der Bericht Nr. 10042360, Autor J. Neumann, ist notwendiger Bestandteil dieses Zertifikats. Das Produkt erfüllt die Sicherheitsanforderungen nur, wenn die Maßgaben der jeweils gültigen Revision dieses Berichts eingehalten werden.

Freigegeben mit der obigen Zertifikatsnummer durch die Zertifizierstelle von TÜV PRODUCT SERVICE GMBH.

Abteilung: ASE-IQSE / Velten-Philipp
Datum: 2. Dezember 1999

TÜV PRODUCT SERVICE GMBH · Zertifizierstelle · Ridlerstrasse 31 · D-80339 München

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Certificate

No.: Z2 02 03 20411 009

TÜV PRODUCT SERVICE

Siemens AG
A & D AS
Gleiwitzer Straße 555
90475 Nürnberg

with production facilities
20411

is authorized to label the following products with the certification mark

as shown in the certification mark list. See also notes overleaf.

Product:	**Safety-Related Programmable System**
Model:	**SIMATIC S7 Distributed Safety**
Parameters:	Logic solver: 1oo1D with coded processing and comparison by safety-related output modules Fieldbus: 1oo1 PROFIsafe I/O modules: 1oo2 with normally energized outputs
Remarks:	For the certification mark the following text is assigned: **"Functional Safety"**

The product meets the relevant safety requirements and above mentioned properties and was tested according to:

- 93/68/EEC Low Voltage Directive
- IEC 61508:2000, parts 1 to 4, SIL 1-3 (to the extend applicable)
- DIN V 19250:1994
- DIN V VDE 0801:1990 with Amendment A1:1994, AK 1-6
- EN 50159:2001 (to the extend applicable)
- VDI/VDE 2180: 2000, part 2
- DIN VDE 0116:1989, Chapter 8.7
- EN 298:1993, Chapters 9,10
- EN 954-1:1997, pr EN 954-2 Safety Categories 2-4 (to the extend applicable)
- EN 61131-2:1995
- EN 60204-1:1997 (to the extend applicable)

The report no. 70013560, is a mandatory part of this certificate. The product complies with the above listed safety requirements only, if the specifications documented in the currently valid revision of this report are met.

Released with No. of Certificate by the Certification Body of TÜV PRODUCT SERVICE GmbH.

Organization unit: TA-ES/MUC / Müller
Date: 26th March 2002

TÜV PRODUCT SERVICE GMBH · Zertifizierstelle · Ridlerstrasse 65 · D-80339 München

8.6.2 Certificates for SINUMERIK Safety Integrated

Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BIA
Berufsgenossenschaftliches
Institut für
Arbeitssicherheit

Hauptverband der gewerblichen
Berufsgenossenschaften

Baumusterprüfbescheinigung

963043
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Firma Siemens AG, AUT E 2 Frauenauracher Straße 80 D-91056 Erlangen
Name und Anschrift des Herstellers:	Firma Siemens AG, AUT E 2 Frauenauracher Straße 80 D-91056 Erlangen

Zeichen des Auftraggebers: AUT 2 QM/Schl/Mi
Zeichen der Prüf- und Zertifizierungsstelle: 9507364 Rt/Sch/Sz
Ausstellungsdatum: 24.07.1996

Produktbezeichnung:	Sicherheits-Antriebssteuerung für Maschinen
Typ:	SINUMERIK 840 C safety integrated mit SIMODRIVE 611D safety integrated Nähere Angaben zur Hard- und Softwareständen siehe Anlage.
Bestimmungsgemäße Verwendung:	Realisierung sicherer Maschinenfunktionen wie sicherer Halt, sicherer Betriebshalt, sicher reduzierte Geschwindigkeit, sicher begrenzte Absolutlage und sichere Ein/Ausgangssignale.
Prüfgrundlage:	[1] DIN V VDE 0801 mit Änderung A1; (10/94) [2] ISO 11161: 1994 (E) [3] prEN 954-1: 11.94 [4] EN 60204-1: 1992 [5] IEC Arbeitspapier 22G/21/CDV, Date of circulation: 1995-04-14 EMC product standard including specific test methods for power drive systems.
Bemerkungen:	Gültig für Steuerungen mit den in der Anlage näher bezeichneten Versionsständen entspricht Anforderungsklasse 4 nach DIN V VDE 0801 und Kategorie 3 nach prEN 954-1; 11.94. Siehe auch Prüfzeugnis Nr. 9507364.

Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 89/392/EWG (**Maschinen**), geändert durch die Richtlinien 91/368/EWG und 93/44/EWG.

Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Januar 1993

Leiter der Zertifizierungsstelle

Dr.-Ing. J. Lambert

Fachzertifizierer

Dr. D. Reinert

Postadresse:
53754 Sankt Augustin

Hausadresse:
Alte Heerstraße 111
53757 Sankt Augustin

Tel: 0 22 41/2 31-02
Fax: 0 22 41/23 12 34

Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BIA
Berufsgenossenschaftliches
Institut für
Arbeitssicherheit

Hauptverband der gewerblichen
Berufsgenossenschaften

Baumusterprüfbescheinigung

20003012
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Siemens AG A&D MC Frauenauracher Str. 80, D-91056 Erlangen
Name und Anschrift des Herstellers:	Siemens AG A&D MC Frauenauracher Str. 80, D-91056 Erlangen

Zeichen des Auftraggebers:	Zeichen der Prüf- und Zertifizierungsstelle:	Ausstellungsdatum:
A&D MC E12	2000 23147 Apl/Scha/Zö	13.11.2000

Produktbezeichnung:	Sicherheits-Antriebssteuerung für Maschinen
Typ:	SINUMERIK 840 D und 840 DE safety integrated mit SIMODRIVE 611 D safety integrated Nähere Angaben zu Hard- und Softwareständen siehe Anlage.
Bestimmungsgemäße Verwendung:	Realisierung sicherer Maschinenfunktionen: Halt, Betriebshalt, reduzierte Geschwindigkeit, begrenzte Absolutlage, Ein-/Ausgangssignale, programmierbare Logik, Bremsrampe, Stillsetzen über sicherheitsgerichtete Eingänge
Prüfgrundlage:	[1] DIN V VDE 0801 mit Änderung A1: (10/94) [2] ISO 11161: 1994 (E) [3] EN 954-1: 1996 [4] EN 60204-1: 1992 [5] IEC Arbeitspapier 22G/21/CDV, Date of circulation: 1995-04-14 EMC product standard including specific test methods for power drive systems
Bemerkungen:	Gültig für Steuerungen mit den in der Anlage näher bezeichneten Versionsständen entspricht Anforderungsklasse 4 nach DIN V VDE 0801 und Kategorie 3 nach EN 954-1: 1996. Siehe auch Prüfzeugnis Nr.: 2000 23147

Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 98/37/EG (Maschinen).

Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Oktober 1997

Leiter der Zertifizierungsstelle
i.A. (Dr. rer. nat. Dietmar Reinert)

Fachzertifizierer
(Dipl.-Ing. Ralf Apfeld)

Postadresse:
53754 Sankt Augustin

Hausadresse:
Alte Heerstraße 111
53757 Sankt Augustin

Tel: 0 22 41/2 31-02
Fax: 0 22 41/2 31-22 34

PZ810
10.98

The Czech Machine Testing Institute, effective 22.06.2000, recognised the current BIA certificate of SINUMERIK Safety Integrated.

Strojírenský zkušební ústav, s.p., autorizovaná osoba 202, Hudcova 56b, 621 00 Brno
Česká republika
Rozhodnutí o autorizaci č. 20/1999 ze dne 12. srpna 1999

CERTIFIKÁT TYPU

číslo: B - 30 - 00725 / 00

vydaný dovozci, firmě

Siemens s. r. o.
Evropská 33a, 160 00 Praha 6
identifikační číslo organizace: 00268577

na výrobky

Řídicí systémy
SINUMERIC 840D Safety Integrated
s pohonem SIMODRIVE 611D Safety Integrated
specifikace variant je uvedena na 2. straně

výrobce

Siemens AG, AUT E 2
Erlangen, Německo

U těchto výrobků byla provedena certifikace podle ustanovení §10 zákona č. 22/1997 Sb. ve znění zákona č. 71/2000 Sb., o technických požadavcích na výrobky a o změně a doplnění některých zákonů. Výše uvedená autorizovaná osoba tímto osvědčuje, že u vzorku předmětných výrobků zjistila shodu jeho vlastností se základními požadavky nařízení vlády č. 170/1997 Sb. ve znění nařízení vlády č. 15/1999 Sb.

Při posuzování shody použila autorizovaná osoba normativní dokumenty, jejichž seznam je na druhé straně certifikátu. Nedílnou součástí tohoto certifikátu je závěrečný protokol č. 30-0036 ze dne 15. června 2000.

Tento certifikát se vydává pro účely vydání prohlášení o shodě výrobků s požadavky uvedených nařízení vlády.

Pravidla pro nakládání s certifikátem jsou uvedena na druhé straně.

AUTORIZOVANÁ OSOBA 202
ÚNMZ
1

V Brně 22. června 2000

Ing. Josef Bartl
ředitel

8.6.3 Certificate for SIMOVERT Masterdrive

Fachausschuß Eisen und Metall II
Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

Hauptverband der gewerblichen
Berufsgenossenschaften

Übereinstimmungsbescheinigung

(Aufbewahrung von technischen Unterlagen nach EG-Maschinenrichtlinie)

00009
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber) Siemens AG A & D MC GWE
Frauenauracher Str. 80, D-91050 Erlangen

Name und Anschrift des Herstellers: siehe oben

Zeichen des Auftraggebers:

Zeichen der Prüf- und Zertifizierungsstelle: 612.17-EM II

Ausstellungsdatum: 05.12.2000

Produktbezeichnung: Technische Dokumentation Anlaufsperre für Antriebsregelgeräte SIMOVERT Masterdrives
Funktion "Sicherer Halt" Version V 1.1 vom 02.11.2000

Typ:
- Einbau- und Schrankgerät nur der Baugruppe SSB
- Kompakt
- Kompakt Plus

Prüfgrundlage: DIN EN 60204-1; "Elektrische Ausrüstung von Maschinen-Teil 1: Allgemeine Anforderungen"; 11.98
DIN EN 1037; "Sicherheit von Maschinen - Vermeiden von unerwartetem Anlauf"; 04.96
DIN EN 954-1; Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen Teil 1- Allgemeine Gestaltungsleitsätze; Kategorie 3; 03.97

Bemerkungen: Prüfbericht Nr.: 2977-2/00
Die Funktion "sicherer Halt" der o. g. Antriebsregelgeräte genügt den Anforderungen von DIN EN 954-1 Kat. 3 und kann in Verbindung mit Maschinensteuerungen entsprechend Kat. 3 eingesetzt werden.

Die eingereichten technischen Unterlagen zu oben aufgeführten Produkt entsprechen den einschlägigen Vorschriften der Richtlinie 98/37/EG (Maschinen).

Die geprüften Unterlagen werden aufbewahrt bis zum: 31.12.2005

und anschließend gemäß Wunsch des Auftraggebers weiter aufbewahrt, zurückgeschickt oder vernichtet.
Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Oktober 1997.

Unterschrift (Körner)

Postadresse:
Postfach 37 80
55027 Mainz

Hausadresse:
Wilh.-Theodor-Römheld-Str. 15
55130 Mainz

Tel: 06131/802-0
Fax: 06131/802-220

PZ/IIHH
11.98

8.6.4 Certificate for SIMODRIVE 611 U

Fachausschuß Eisen und Metall II
Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

Hauptverband der gewerblichen Berufsgenossenschaften

BG-Prüfbescheinigung

01007
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Siemens AG Automatisierungs- und Antriebstechnik Frauenauracher Str. 80, D-91056 Erlangen
Name und Anschrift des Herstellers:	siehe oben

Zeichen des Auftraggebers:	Zeichen der Prüf- und Zertifizierungsstelle:	Ausstellungsdatum:
	612.17-EM II	28.09.2001

Produktbezeichnung:	Anlaufsperre für Antriebsregelgeräte		
Typ:	SIMODRIVE 611 U		
Bestimmungsgemäße Verwendung:	Verhinderung von unerwartetem Anlauf. Kraftlos schalten des Antriebs		
Prüfgrundlage:	DIN EN 60204-1	"Elektrische Ausrüstung von Maschinen-Teil 1: Allgemeine Anforderungen"	11.98
	DIN EN 954-1	Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen Teil 1 - Allgemeine Gestaltungsleitsätze	03.97
	Nr. I	Grundsätze für die Prüfung und Zertifizierung von Be- und Verarbeitungsmaschinen	05.01
Bemerkungen:	Prüfbericht Nr.: 3012-4/01 Die Anlaufsperre für Antriebsregelgeräte genügt den Anforderungen von DIN EN 954-1, Kat. 3 und kann in Verbindung mit Maschinensteuerungen, die Kat. 3 genügen, eingesetzt werden.		

Das geprüfte Baumuster entspricht der oben angegebenen Prüfgrundlage.
Der Bescheinigungsinhaber ist berechtigt, das umseitig abgebildete BG-PRÜFZERT-Zeichen an den mit dem geprüften Baumuster übereinstimmenden Produkten anzubringen, und zwar mit dem unter "Bemerkungen" genannten Hinweis.
Diese Bescheinigung wird spätestens ungültig am:

30.09.2006

Weiteres über die Gültigkeit, eine Gültigkeitsverlängerung und andere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Oktober 1997.

Unterschrift (Körner)

Postadresse:
Postfach 37 80
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Hausadresse:
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P2008
12.99

8.7 List of contents

Impressum:

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Application Manual Safety Technology, 4th Edition

Published by:
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Automation and Drives Group
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Important note:
The products described here have been developed to realize safety-related functions as part of a complete plant or machine. Generally, a complete safety-related system includes sensors, evaluation units, signalling devices and concepts for safe shutdown and stopping. The manufacturer of a plant or machine is responsible for ensuring the correct overall function. Siemens AG, its local offices and affiliated companies (in the following "known as Siemens") is not in a position to guarantee all of the properties and features of a complete plant or machine which Siemens did not design.

Siemens does not accept any liability for recommendations which are given or implied in this Manual. It is important that all of the associated product documentation is carefully observed in order to correctly use the products. This Manual shall neither become a part of nor modify any prior or existing agreement, commitment or relationship. The sales contract contains the entire obligation of Siemens. The warranty contained in the contract between the parties is the sole warranty of Siemens. Any statements contained in this Manual neither create new warranties nor modify the existing warranty.

Subject to change without prior notice

Siemens Aktiengesellschaft

Automation and Drives
Low Voltage Controls and Distribution
P.O. Box 3240, D-91050 Erlangen

Automation and Drives
Industrial Automation Systems
P.O. Box 4848, D-90327 Nürnberg

Automation and Drives
Motion Control Systems
P.O. Box 3180, D-91050 Erlangen

www.siemens.de/safety

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