SINAMICS G130 / G150 / S120 Chassis / S120 Cabinet Modules / S150
Safety Integrated

Manual · 05/2010

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G130, G150, S120 Chassis, S120 Cabinet Modules, S150 Safety Integrated

Function Manual

Firmware Version 4.3 SP2

05/2010

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Ⓟ 10/2010

Preface

Technical Support

In case of questions, please contact us through the following hotline:

Time zone Europe / Africa	
Phone	+49 (0) 911 895 7222
Fax	+49 (0) 911 895 7223
Internet	http://www.siemens.com/automation/support-request

Time zone Americas	
Phone	+1 423 262 2522
Fax	+1 423 262 2200
E-mail	techsupport.sea@siemens.com

Time zone Asia/Pacific	
Phone	+86 1064 757 575
Fax	+86 1064 747 474
E-mail	support.asia.automation@siemens.com

Note

Country-specific telephone numbers for technical support are provided under the following Internet address:

http://www.automation.siemens.com/partners

Spare parts

You will find spare parts on the Internet at:
http://support.automation.siemens.com/WW/view/en/16612315.

Internet address for SINAMICS

http://www.siemens.com/sinamics.

Internet address for Safety Integrated

http://www.siemens.com/safety

This address contains detailed application examples for Safety Integrated.

Notation

The following notation and abbreviations are used in this documentation:

Notation for parameters (examples):

- p0918 Adjustable parameter 918
- r1024 Display parameter 1024
- p1070[1] Adjustable parameter 1070, index 1
- p2098[1].3 Adjustable parameter 2098, index 1, bit 3
- p0099[0...3] Adjustable parameter 99 indices 0 to 3
- r0945[2](3) Display parameter 945 index 2 of drive object 3
- p0795.4 Adjustable parameter 795 bit 4

Notation for faults and alarms (examples):

- F12345 Fault 12345
- A67890 Alarm 67890

ESD information

⚠ CAUTION

Electrostatic sensitive devices (ESD) are single components, integrated circuits or devices that can be damaged by electrostatic fields or electrostatic discharges.

Regulations for the ESD handling:

During the handling of electronic components, pay attention to the grounding of the person, workplace and packaging!

Electronic components may be touched by persons only when

- these persons are grounded using an ESD wristband, or
- these persons in ESD areas with a conducting floor wear ESD shoes or ESD grounding straps.

Electronic components should be touched only when this is unavoidable. The touching is permitted only on the front panel or on the circuit board edge.

Electronic components must not be brought into contact with plastics or clothing made of artificial fibers.

Electronic components may only be placed on conducting surfaces (table with ESD coating, conducting ESD foamed material, ESD packing bag, ESD transport container).

Electronic components may not be placed near display units, monitors or televisions (minimum distance from the screen > 10 cm).

Measurements must only be taken on boards when the measuring instrument is grounded (via protective conductors, for example) or the measuring probe is briefly discharged before measurements are taken with an isolated measuring device (for example, touching a bare metal housing).

Safety notices

⚠ DANGER
SINAMICS devices and AC motors must only be commissioned by suitably qualified personnel. The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and follow the specified danger and warning notices. When electrical equipment and motors are operated, the electrical circuits automatically conduct a dangerous voltage. When the machine or system is operated, hazardous axis movements can occur. All of the work carried-out on the electrical machine or system must be carried-out with it in a no-voltage condition.

Note

Machinery Directive (2006/42/EC)

When the European common market was launched, a decision was made that the domestic Typicals and regulations of all of the EU Member States relating to the technical implementation of machines would be harmonized. This meant that, as an internal market directive, the content of the Machinery Directive had to be implemented by the individual member states as national legislation. For the Machinery Directive, this was realized with the objective to achieve standard protective goals thus removing trade barriers resulting from technical differences. In accordance with the definition of a machine ("an assembly of linked parts or components, at least one of which moves"), this directive has a very broad scope. The revised version from 2006, which shall be binding as of Dec. 29, 2009, without transitional period, has expanded its area of application and now includes "Logic units to ensure safety functions".

The Machinery Directive involves the implementation of machines. It has 28 Articles and 12 Annexes. The basic safety and health requirements specified in Annex I of the Directive must be fulfilled for the safety of machines.

The protective goals must be implemented responsibly to ensure compliance with the Directive.

Manufacturers of a machine must verify that their machine complies with the basic requirements. This proof is made more simple by applying harmonized Typicals.

DANGER

Five safety rules

When carrying out any kind of work on electrical devices, the "five safety rules" according to EN 50110 must always be complied with:

1. Disconnect the system.
2. Protect against reconnection.
3. Make sure that the equipment is de-energized.
4. Ground and short-circuit.
5. Cover or enclose adjacent components that are still live.

WARNING

Correct and safe operation of SINAMICS units assumes correct transportation in the transport packaging, correct long-term storage in the transport packaging, setup and installation, as well as careful operation and maintenance.

For special versions of the drive units and motors, information and data in the Catalogs and quotations additionally apply.

In addition to the danger and warning information provided in the technical customer documentation, the applicable national, local, and plant-specific regulations and requirements must be taken into account.

According to EN 61800-5-1 and UL 508, only safely isolated protective extra-low voltages on the electronic modules may be connected to any of the terminals on the electronic modules.

CAUTION

The motors can have surface temperatures of over +80 °C.

This is the reason that temperature-sensitive components, e.g. cables or electronic components may neither be in contact nor be attached to the motor.

When attaching the connecting cables, you must ensure that:

- they may not be damaged,
- they may not be stressed,
- they may not be able to come into contact with any rotating parts

Note

In the configuration specified in the corresponding EC Declaration of Conformity regarding EMC requirements and when the EMC installation guideline (order no. 6FC5297-0AD30-0*P2) is complied with, SINAMICS devices fulfill the EMC Directive 2004/108/EC requirements.
(*A: German; *B: English)

Note

When operated in dry operating areas, SINAMICS equipment with AC motors conforms to Low-Voltage Directive 2006/95/EC.

CAUTION

Operating the equipment in the immediate vicinity (< 1.5 m) of mobile telephones with a transmitting power of > 1 W may cause the devices to malfunction.

Safety notes on Safety Integrated

DANGER

High voltages

The drive is not disconnected from the mains by the "Safe Torque Off" function. Dangerous voltages may be present on the motor and converter. This can result in death, serious personal injury or severe material damage. Work on the electrical connections is not allowed.

DANGER

Unexpected start up of the drive

If the function "Safe Torque Off" is not checked for proper function after service work, then the drive can also start up unexpectedly after activating the "Safe Torque Off" function. This can result in death, serious personal injury or severe material damage. Upon conclusion of service work on all components with safety function (e.g., replacement of components), you must verify and document proper function through a test activation.

DANGER

Restart

Drive systems, in which power supply to the motor is also possible via the load (e.g., ship's drives, conveyors, fans, etc.) cannot be protected against restart using the "Safe Torque Off" function. This can result in death, serious personal injury or severe material damage. Take appropriate countermeasures such as mechanical braking.

WARNING

Only circuits that have been manufactured by I DT LD or by certified factories or that have been installed by I DT LD Service for option K82 possess an approval. Possible plant-side reproductions by non-certified manufacturers do not possess this approval!

An up-to-date list of authorized factories is available on request from your local Siemens office.

WARNING

Unexpected start up of the drive

If the function "Safe Torque Off" is deactivated, the drive can start up unexpectedly. This can result in death, serious personal injury or severe material damage.

To demonstrate that the function "Safe Torque Off" is deactivated, the specified switches (e.g., "Safe Torque Off" mushroom-head pushbutton on the system) must be removed.

Note

The components must be protected against conductive pollution (e.g., using a cabinet with IP54 protection).

Provided that conducted interference can be prevented at the installation site, the degree of protection for the cabinet can be decreased accordingly.

Table of contents

1 Typicals and regulations

1.1 General information

1.1.1 Aims

Manufacturers and operating companies of equipment, machines, and products are responsible for ensuring the required level of safety. This means that plants, machines, and other equipment must be designed to be as safe as possible in accordance with the current state of the art. To ensure this, companies describe in the various Typicals the current state of the art covering all aspects relevant to safety. When the relevant Typicals are observed, this ensures that state-of-the-art technology has been utilized and, in turn, the erector/builder of a plant or a manufacturer of a machine or a piece of equipment has fulfilled his appropriate responsibility.

Safety systems are designed to minimize potential hazards for both people and the environment by means of suitable technical equipment, without restricting industrial production and the use of machines more than is necessary. The protection of man and environment must be assigned equal importance in all countries, which is it is important that rules and regulations that have been internationally harmonized are applied. This is also designed to avoid distortions in the competition due to different safety requirements in different countries.

There are different concepts and requirements in the various regions and countries of the world when it comes to ensuring the appropriate degree of safety. The legislation and the requirements of how and when proof is to be given and whether there is an adequate level of safety are just as different as the assignment of responsibilities.

The most important thing for manufacturers of machines and companies that set up plants and systems is that the legislation and regulations in the country where the machine or plant is being operated apply. For example, the control system for a machine that is to be used in the US must fulfill local US requirements even if the machine manufacturer (OEM) is based in the European Economic Area (EEA).

1.1.2 Functional safety

Safety, from the perspective of the object to be protected, cannot be split-up. The causes of hazards and, in turn, the technical measures to avoid them can vary significantly. This is why a differentiation is made between different types of safety (e.g. by specifying the cause of possible hazards). "Functional safety" is involved if safety depends on the correct function.

To ensure the functional safety of a machine or plant, the safety-related parts of the protection and control devices must function correctly. In addition, the systems must behave in such a way that either the plant remains in a safe state or it is brought into a safe state if a fault occurs. In this case, it is necessary to use specially qualified technology that fulfills the requirements described in the associated Typicals. The requirements to achieve functional safety are based on the following basic goals:

- Avoiding systematic faults
- Controlling systematic faults
- Controlling random faults or failures

Benchmarks for establishing whether or not a sufficient level of functional safety has been achieved include the probability of hazardous failures, the fault tolerance, and the quality that is to be ensured by minimizing systematic faults. This is expressed in the Typicals using different terms. In IEC/EN 61508, IEC/EN 62061, IEC/EN 61800-5-2 "Safety Integrity Level" (SIL) and EN ISO 13849-1 "Categories" and "Performance Level" (PL).

1.2 Safety of machinery in Europe

The EU Directives that apply to the implementation of products are based on Article 95 of the EU contract, which regulates the free exchange of goods. These are based on a new global concept ("new approach", "global approach"):

- EU Directives only specify general safety goals and define basic safety requirements.
- Technical details can be defined by means of standards by Standards Associations that have the appropriate mandate from the commission of the European Parliament and Council (CEN, CENELEC). These standards are harmonized in line with a specific directive and listed in the official journal of the commission of the European Parliament and Council. Legislation does not specify that certain standards have to be observed. When the harmonized Standards are observed, it can be assumed that the safety requirements and specifications of the Directives involved have been fulfilled.
- EU Directives specify that the Member States must mutually recognize domestic regulations.

The EU Directives are equal. This means that if several Directives apply for a specific piece of equipment or device, the requirements of all of the relevant Directives apply (e.g. for a machine with electrical equipment, the Machinery Directive and the Low-Voltage Directive apply).

1.2.1 Machinery Directive

The basic safety and health requirements specified in Annex I of the Directive must be fulfilled for the safety of machines.

The protective goals must be implemented responsibly to ensure compliance with the Directive.

Manufacturers of a machine must verify that their machine complies with the basic requirements. This verification is facilitated by means of harmonized standards.

1.2.2 Harmonized European Standards

The two Typicals Organizations CEN (Comité Européen de Normalisation) and CENELEC (Comité Européen de Normalisation Électrotechnique), mandated by the EU Commission, drew-up harmonized European Typicals in order to precisely specify the requirements of the EC directives for a specific product. These Typicals (EN Typicals) are published in the official journal of the commission of the European Parliament and Council and must be included without revision in domestic Typicals. They are designed to fulfill basic health and safety requirements as well as the protective goals specified in Annex I of the Machinery Directive.

When the harmonized Typicals are observed, it is "automatically assumed" that the Directive is fulfilled. As such, manufacturers can assume that they have observed the safety aspects of the Directive under the assumption that these are also covered in this Typical. However, not every European standardis harmonized in this sense. Key here is the listing in the official journal of the commission of the European Parliament and Council.

The European Typicals regarding the safety of machines are structured in a hierarchical manner as follows:

- A Typicals (basic Typicals)
- B Typicals (group Typicals)
- C Typicals (product Typicals)

Type A Typicals/basic Typicals

A Typicals include basic terminology and definitions relating to all types of machine. This includes EN ISO 12100-1 (previously EN 292) "Safety of Machines, Basic Terminology, General Design Principles."

A Typicals are aimed primarily at the bodies responsible for setting the B and C Typicals. The measures specified here for minimizing risk, however, may also be useful for manufacturers if no applicable C Typicals have been defined.

Type B Typicals/group Typicals

B Typicals cover all safety-related Typicals for various different machine types. B Typicals are aimed primarily at the bodies responsible for setting C Typicals. They can also be useful for manufacturers during the machine design and construction phases, however, if no applicable C Typicals have been defined.

A further sub-division has been made for B Typicals:

- Type B1 Typicals for higher-level safety aspects (e.g. ergonomic principles, safety clearances from sources of danger, minimum clearances to prevent parts of the body from being crushed).
- Type B2 Typicals for protective safety devices are defined for different machine types (e.g. EMERGENCY STOP devices, two-hand operating circuits, interlocking elements, contactless protective devices, safety-related parts of controls).

Type C Typicals/product Typicals

C Typicals are product-specific Typicals (e.g. for machine tools, woodworking machines, elevators, packaging machines, printing machines, etc.). Product Typicals contain machine-specific requirements. The requirements can, under certain circumstances, deviate from the basic and group Typicals. Type C/product Typicals have the highest priority for machine manufacturers who can assume that it fulfills the basic requirements of Annex I of the Machinery Directive (automatic presumption of compliance). If no product standard has been defined for a particular machine, type B Typicals can be applied when the machine is constructed.

A complete list of the Typicals specified and the mandated draft Typicals are available on the Internet at the following address:

http://www.newapproach.org/

Recommendation: Due to the rapid pace of technical development and the associated changes in machine concepts, the Typicals (and C Typicals in particular) should be checked to ensure that they are up to date. Please note that the application of a particular standard may not be mandatory provided that all the safety requirements of the applicable EU directives are fulfilled.

1.2.3 Standards for implementing safety-related controllers

If the functional safety of a machine depends on various control functions, the controller must be implemented in such a way that the probability of the safety functions failing is sufficiently minimized. EN ISO 13849-1 (formerly EN 954-1) and EN 62061 define principles for implementing safety-related machine controllers which, when properly applied, ensure that all the safety requirements of the EC Machinery Directive are fulfilled. These Typicals ensure that the relevant safety requirements of the Machinery Directive are fulfilled.

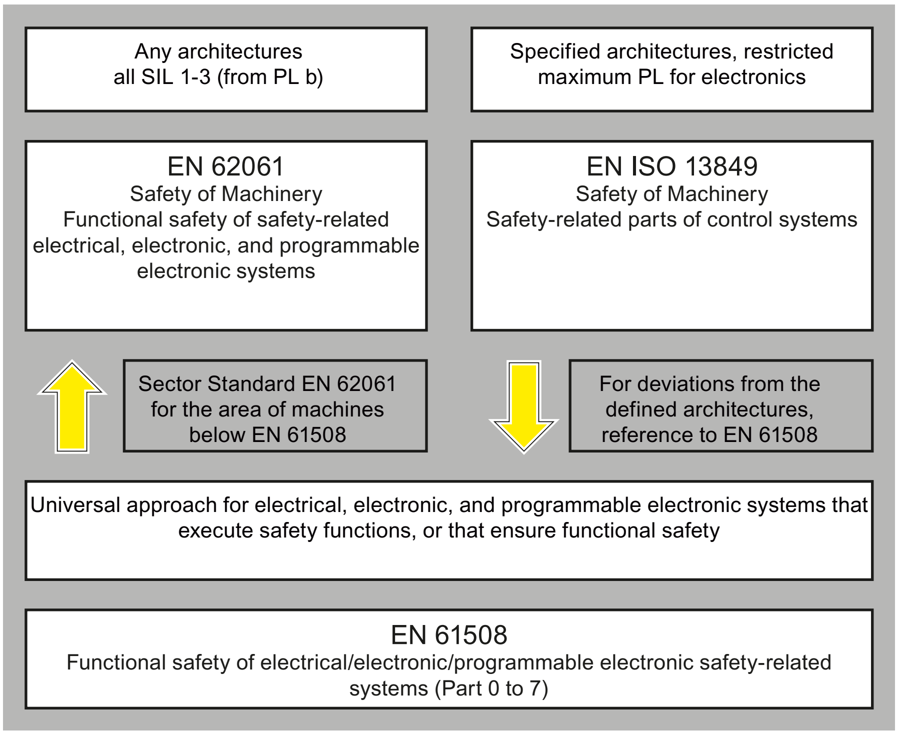

Figure 1-1 Typicals for implementing safety-related controllers

The application areas of EN ISO 13849-1, EN 62061, and EN 61508 are very similar. To help users make an appropriate decision, the IEC and ISO associations have specified the application areas of both Typicals in a joint table in the introduction to the Typicals.
EN ISO 13849-1 or EN 62061 should be applied depending on the technology (mechanics, hydraulics, pneumatics, electrics, electronics, programmable electronics), risk classification and architecture.

	Systems for executing safety-related control functions	EN ISO 13849-1	EN 62061
A	Non-electrical (e.g. hydraulic, pneumatic)	X	Not covered
B	Electromechanical (e.g. relay and/or basic electronics)	Restricted to the designated architectures (see comment 1) and max. up to PL = e	All architectures and max. up to SIL 3
C	Complex electronics (e.g. programmable electronics)	Restricted to the designated architectures (see comment 1) and max. up to PL = d	All architectures and max. up to SIL 3
D	A Typicals combined with B Typicals	Restricted to the designated architectures (see comment 1) and max. up to PL = e	X See comment 3
E	C Typicals combined with B Typicals	Restricted to the designated architectures (see comment 1) and max. up to PL = d	All architectures and max. up to SIL 3
F	C Typicals combined with A Typicals or C Typicals combined with A Typicals and B Typicals	X See comment 2	X See comment 3

"X" indicates that the point is covered by this Typical.

Comment 1:
Designated architectures are described in Annex B of EN ISO 13849-1 and provide a simplified basis for the quantification.

Comment 2:
For complex electronics: Using designated architectures in compliance with EN ISO 13849-1 up to PL = d or every architecture in compliance with EN 62061.

Comment 3:
For non-electrical systems: Use components that comply with EN ISO 13849-1 as sub-systems.

1.2.4 EN ISO 13849-1 (previously EN 954-1)

A qualitative analysis (to EN 954-1) is not sufficient for modern controllers due to their technology. Among other things, EN 954-1 does not take into account time behavior (e.g. test interval and/or cyclic test, lifetime). This results in the probabilistic basis in EN ISO 13849-1 (probability of failure per unit time).

EN ISO 13849-1 is based on the known categories of EN 954-1. It now also takes into account complete safety functions and all the devices required to execute these. With EN ISO 13849-1, safety functions are investigated from a quantitative perspective going beyond the qualitative basis of EN 954-1. Performance levels (PL), which are based on the categories, are used. The following safety-related characteristic quantities are required for devices/equipment:

- Category (structural requirement)
- PL: Performance level
- $MTTF_d$: Mean time to dangerous failure
- DC: Diagnostic coverage
- CCF:
  Common cause failure

The standard describes how the performance level (PL) is calculated for safety-related components of the controller on the basis of designated architectures. For deviations from this, EN ISO 13849-1 refers to EN 61508.

When combining several safety-related parts to form a complete system, the standard explains how to determine the resulting PL.

Note

Since December 2008, EN ISO 13849-1 has been harmonized as part of the Machinery Directive. EN 954-1 will continue to apply until 30.12.2011.

1.2.5 EN 62061

EN 62061 (identical to IEC 62061) is a sector-specific standard subordinate to IEC/EN 61508. It describes the implementation of safety-related electrical machine control systems and considers the complete lifecycle, from the conceptual phase to decommissioning. The standard is based on the quantitative and qualitative analyses of safety functions,

whereby it systematically applies a top-down approach to implementing complex control systems (known as "functional decomposition"). The safety functions derived from the risk analysis are sub-divided into sub-safety functions, which are then assigned to real devices, sub-systems, and sub-system elements. Both the hardware and software are covered. EN 62061 also describes requirements regarding the implementation of application programs.

A safety-related control systems comprises different sub-systems. From a safety perspective, the sub-systems are described in terms of the SIL claim limit and PFH_D characteristic quantities.

Programmable electronic devices (e.g. PLCs or variable-speed drives) must fulfill EN 61508. They can then be integrated in the controller as sub-systems. The following safety-related characteristic quantities must be specified by the manufacturers of these devices.

Safety-related characteristic quantities for subsystems:

- SIL CL: SIL claim limit
- PFH_D:
  Probability of dangerous failures per hour
- T1:
  Lifetime

Simple sub-systems (e.g. sensors and actuators) in electromechanical components can, in turn, comprise sub-system elements (devices) interconnected in different ways with the characteristic quantities required for determining the relevant PFH_D value of the sub-system.

Safety-related characteristic quantities for subsystem elements (devices):

- λ: Ausfallrate
  failure rate
- B10 value: For elements that are subject to wear
- T1: Lebensdauer
  lifetime

For electromechanical devices, a manufacturer specifies a failure rate λ with reference to the number of operating cycles. The failure rate per unit time and the lifetime must be determined using the switching frequency for the particular application.

Parameters for the sub-system, which comprises sub-system elements, that must be defined during the design phase:

- T2: Diagnose-Testintervall
  diagnostic test interval
- β: Empfindlichkeit für Fehler gemeinsamer Ursache
  susceptibility to common cause failure
- DC: Diagnosedeckungsgrad
  diagnostic coverage

The PFH_D value of the safety-related controller is determined by adding the individual PFH_D values for subsystems.

The user has the following options when setting up a safety-related controller:

- Use devices and sub-systems that already comply with EN ISO 13849-1, IEC/EN 61508, or IEC/EN 62061. The standard provides information specifying how qualified devices can be integrated when safety functions are implemented.
- Develop own subsystems:
  - Programmable, electronic systems and complex systems: Application of EN 61508 or EN 61800-5-2.
  - Simple devices and subsystems: Application of EN 62061.

EN 62061 does not include information about non-electric systems. The standard provides detailed information on implementing safety-related electrical, electronic, and programmable electronic control systems. EN ISO 13849-1 must be applied for non-electric systems.

Note

Details of simple sub-systems that have been implemented and integrated are now available as "functional examples".

Note

IEC 62061 has been ratified as EN 62061 in Europe and harmonized as part of the Machinery Directive.

1.2.6 Series of standards EN 61508 (VDE 0803)

This series of Typicals describes the current state of the art.

EN 61508 is not harmonized in line with any EU directive. which means that an automatic presumption of conformity for fulfilling the protective requirements of a directive is not implied. The manufacturer of a safety-related product, however, can also use EN 61508 to fulfill basic requirements of European directives in accordance with the latest conceptual design, for example, in the following cases:

- If no harmonized standard exists for the application in question. In this case, the manufacturer can use EN 61508. although no presumption of conformity exists here.
- A harmonized European standard (e.g. EN 62061, EN ISO 13849, EN 60204-1) references EN 61508. This ensures that the appropriate requirements of the directives are fulfilled ("standard that is also applicable"). When manufacturers apply EN 61508 properly and responsibly in accordance with this reference, they can use the presumption of conformity of the referencing Typical.

EN 61508 covers all the aspects that must be taken into account when E/E/PES systems (**e**lectrical, **e**lectronic, and **p**rogrammable **e**lectronic **S**ystem) are used in order to execute safety functions and/or to ensure the appropriate level of functional safety. Other hazards (e.g. electric shock) are, as in EN ISO 13849, not part of the Typical.

EN 61508 has recently been declared the "International Basic Safety Publication", which makes it a framework for other sector-specific Typicals (e.g. EN 62061). As a result, this standard is now accepted worldwide, particularly in North America and in the automotive industry. Today, many regulatory bodies already stipulate it (e.g. as a basis for NRTL listing).

Another recent development with respect to EN 61508 is its system approach, which extends the technical requirements to include the entire safety installation from the sensor to the actuator, the quantification of the probability of hazardous failure due to random hardware failures, and the creation of documentation covering all phases of the safety-related lifecycle of the E/E/PES.

1.2.7 Risk analysis/assessment

Risks are intrinsic in machines due to their design and functionality. For this reason, the Machinery Directive requires that a risk assessment be performed for each machine and, if necessary, the level of risk reduced until the residual risk is less than the tolerable risk. To assess these risks, the following Typicals must be applied:

- EN ISO 12100-1 "Safety of Machinery - basic terminology, general principles for design"
- EN ISO 13849-1 (successor to EN 954-1) "Safety-related parts of control systems"
- EN ISO 14121-1 (previously EN 1050, Paragraph 5) "Safety of machinery - risk assessment"

EN ISO 12100-1 focuses on the risks to be analyzed and the design principles for minimizing risk. EN ISO 14121-1 describes the iterative process for assessing and minimizing risk to achieve the required level of safety.

The risk assessment is a procedure that allows hazards resulting from machines to be systematically investigated. Where necessary, the risk assessment is followed by a risk reduction procedure. When the procedure is repeated, this is known as an iterative process. This can help eliminate hazards (as far as this is possible) and can act as a basis for implementing suitable protective measures.

The risk assessment involves the following:

- Risk analysis
  - Determining the limits of the machine (EN ISO 12100-1, EN ISO 14121-1 Paragraph 5)
  - Identifying the hazards (EN ISO 12100-1, EN ISO 14121-1 Paragraph 6)
  - Estimating the level of risk (EN 1050 Paragraph 7)
- Risk assessment (EN ISO 14121-1 Paragraph 8)

As part of the iterative process to achieve the required level of safety, a risk assessment is carried out after the risk estimation. A decision must be made here as to whether the residual risk needs to be reduced. If the risk is to be further reduced, suitable protective measures must be selected and applied. The risk assessment must then be repeated.

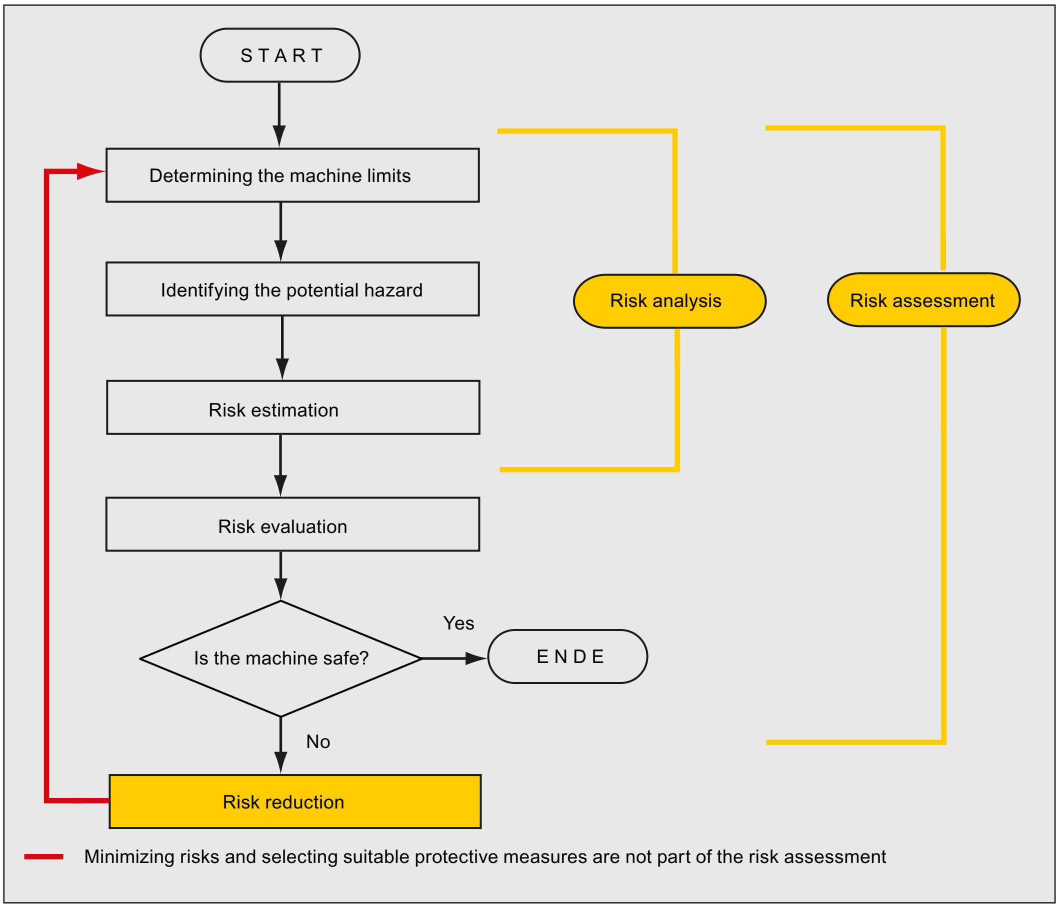

Figure 1-2 Iterative process to achieve the required level of safety to ISO 14121-1

Risks must be reduced by designing and implementing the machine accordingly (e.g. by means of controllers or protective measures suitable for the safety-related functions).

If the protective measures involve the use of interlocking or control functions, these must be designed in accordance with EN ISO 13849-1. For electrical and electronic controllers, EN 62061 can be used as an alternative to EN ISO 13849-1. Electronic controls and bus systems must also comply with IEC/EN 61508.

1.2.8 Risk reduction

Risk reduction measures for a machine can be implemented by means of safety-related control functions in addition to structural measures. To implement these control functions, special requirements, graded according to the magnitude of the risk, must be taken into account. These are described in EN ISO 13849-1 or, in the case of electrical controllers (particularly programmable electronics), in EN 61508 or EN 62061. The requirements regarding safety-related controller components are graded according to the magnitude of the risk and the level to which the risk needs to be reduced.

EN ISO 13849-1 defines a risk graph, which can be used instead of the categories to create hierarchical performance levels (PL).

IEC/EN 62061 uses "Safety Integrity Level" (SIL) for classification purposes. This is a quantified measure of the safety-related performance of a controller. The required SIL is also determined in accordance with the risk assessment principle as specified in ISO 14121 (EN 1050). Annex A of the standard describes a method for determining the required Safety Integrity Level (SIL).

Regardless of which standard is applied, steps must be taken to ensure that all the machine controller components required for executing the safety-related functions fulfill these requirements.

1.2.9 Residual risk

In today's technologically advanced world, the concept of safety is relative. In practice, the ability to ensure safety to the extent that risk is permanently excluded – "zero-risk guarantee" – is impossible. The residual risk is the risk that remains once all the relevant protective measures have been implemented in accordance with the latest state of the art.

Residual risks must be clearly referred to in the machine/plant documentation (user information according to EN ISO 12100-2).

1.3 Machine safety in the USA

A key difference between the USA and Europe in the legal requirements regarding safety at work is, that in the USA, no legislation exists regarding machinery safety that is applicable in all of the states and that defines the responsibility of the manufacturer/supplier. A general requirement exists stating that employers must ensure a safe workplace.

1.3.1 Minimum requirements of the OSHA

The Occupational Safety and Health Act (OSHA) from 1970 regulates the requirement that employers must offer a safe place of work. The core requirements of OSHA are specified in Section 5 "Duties".

The requirements of the OSH Act are managed by the "Occupational Safety and Health Administration" (also known as OSHA). OSHA employs regional inspectors who check whether or not workplaces comply with the applicable regulations.

The OSHA regulations are described in OSHA 29 CFR 1910.xxx ("OSHA Regulations (29 CFR) PART 1910 Occupational Safety and Health"). (CFR: Code of Federal Regulations.)

http://www.osha.gov

The application of standards is regulated in 29 CFR 1910.5 "Applicability of standards". The concept is similar to that used in Europe. Product-specific standards have priority over general standards insofar as they cover the relevant aspects. Once the standards are fulfilled, employers can assume that they have fulfilled the core requirements of the OSH Act with respect to the aspects covered by the standards.

In conjunction with certain applications, OSHA requires that all electrical equipment and devices that are used to protect workers be authorized by an OSHA-certified, "Nationally Recognized Testing Laboratory" (NRTL) for the specific application.

In addition to the OSHA regulations, the current standards defined by organizations such as NFPA and ANSI must be carefully observed and the extensive product liability legislation that exists in the US taken into account. Due to the product liability legislation, it is in the interests of manufacturing and operating companies that they carefully maintain the applicable regulations and are "forced" to fulfill the requirement to use state-of-the-art technology.

Third-party insurance companies generally demand that their customers fulfill the applicable standards of the standards organizations. Self-insured companies are not initially subject to this requirement but, in the event of an accident, they must provide verification that they have applied generally-recognized safety principles.

1.3.2 NRTL listing

To protect employees, all electrical equipment used in the USA must be certified for the planned application by a "Nationally Recognized Testing Laboratory" (NRTL) certified by the OSHA. NRTLs are authorized to certify equipment and material by means of listing, labeling, or similar. Domestic Typicals (e.g. NFPA 79) and international Typicals (e.g. IEC/EN 61508 for E/E/PES systems) are the basis for testing.

1.3.3 NFPA 79

Standard NFPA 79 (Electrical standard for Industrial Machinery) applies to electrical equipment on industrial machines with rated voltages of less than 600 V. A group of machines that operate together in a coordinated fashion is also considered to be one machine.

For programmable electronics and communication buses, NFPA 79 states as a basic requirement that these must be listed if they are to be used to implement and execute safety-related functions. If this requirement is fulfilled, then electronic controls and communication buses can also be used for Emergency Stop functions, Stop Categories 0 and 1 (refer to NFPA 79 9.2.5.4.1.4). Like EN 60204-1, NFPA 79 no longer specifies that the electrical energy must be disconnected by electromechanical means for emergency stop functions.

The core requirements regarding programmable electronics and communication buses are: system requirements (see NFPA 79 9.4.3)

1. Control systems that contain software-based controllers must:
   - In the event of a single fault
     (a) cause the system to switch to a safe shutdown mode
     (b) prevent the system from restarting until the fault has been rectified
     (c) prevent an unexpected restart
   - Offer the same level of protection as hard-wired controllers
   - Be implemented in accordance with a recognized standard that defines the requirements for such systems.
2. IEC 61508, IEC 62061, ISO 13849-1, ISO 13849-2 and IEC 61800-5-2 are specified as suitable Typicals in a note.

Underwriter Laboratories Inc. (UL) has defined a special category for "Programmable Safety Controllers" for implementing this requirement (code NRGF). This category covers control devices that contain software and are designed for use in safety-related functions.

A precise description of the category and a list of devices that fulfill this requirement can be found on the Internet at the following address:

http://www.ul.com → certifications directory → UL Category code/ Guide information → search for category "NRGF"

TUV Rheinland of North America, Inc. is also an NRTL for these applications.

1.3.4 ANSI B11

ANSI B11 Typicals are joint Typicals developed by associations such as the Association for Manufacturing Technology (AMT) and the Robotic Industries Association (RIA).

The hazards of a machine are evaluated by means of a risk analysis/assessment. Risk analysis is an important requirement in accordance with NFPA 79, ANSI/RIA 15.06, ANSI B11.TR-3 and SEMI S10 (semiconductors). The documented findings of a risk analysis can be used to select a suitable safety system based on the safety class of the application in question.

1.4 Machine safety in Japan

The situation in Japan is different from that in Europe and the US. Legislation such as that prescribed in Europe does not exist. Similarly, product liability does not play such an important role as it does in the US.

Instead of legal requirements to apply Typicals have been defined, an administrative recommendation to apply JIS (Japanese Industrial Typical) is in place: Japan bases its approach on the European concept and uses basic Typicals as national Typicals (see table).

Table 1- 1 Japanese Typicals

ISO/IEC number	JIS number	Comments
ISO 12100-1	JIS B 9700-1	Earlier designation TR B 0008
ISO 12100-2	JIS B 9700-2	Earlier designation TR B 0009
ISO 14121- 1 / EN 1050	JIS B 9702	
ISO 13849-1	JIS B 9705-1	
ISO 13849-2	JIS B 9705-1	
IEC 60204-1	JIS B 9960-1	Without annex F or route map of the European foreword
IEC 61508-0 to -7	JIS C 0508	
IEC 62061		JIS number not yet assigned

1.5 Equipment regulations

In addition to the requirements of the guidelines and Typicals, company-specific requirements must be taken into account. Large corporations in particular (e.g. automobile manufacturers) have stringent demands regarding automation components, which are often listed in their own equipment specifications.

Safety-related issues (e.g. operating modes, operator actions with access to hazardous areas, EMERGENCY STOP concepts, etc.) should be clarified with customers early on so that they can be integrated in the risk assessment/risk reduction process.

1.6 Other safety-related issues

1.6.1 Information sheets issued by the Employer's Liability Insurance Association

Safety-related measures to be implemented cannot always be derived from directives, standards, or regulations. In this case, supplementary information and explanations are required.

Some regulatory bodies issue publications on an extremely wide range of subjects.

Information sheets covering the following areas are available, for example:

- Process monitoring in production environments
- Axes subject to gravitational force
- Roller pressing machines
- Lathes and turning centers - purchasing/selling

These information sheets issued by specialist committees can be obtained by all interested parties (e.g. to provide support in factories, or when regulations or safety-related measures for plants and machines are defined). These information sheets provide support for the fields of machinery construction, production systems, and steel construction.

You can download the information sheets from the following Internet address (website is in German, although some of the sheets are available in English):

http://www.bg-metall.de/

Click the "Downloads" quick link and select the category "Informationblätter der Fachausschüsse".

1.6.2 Additional references

- Safety Integrated: The Safety System for Industry (5th Edition and supplement), order no. 6ZB5 000-0AA01-0BA1
- Safety Integrated - Terms and Standards - Machine Safety Terminology (Edition 04/2007), order no. E86060-T1813-A101-A1

2 General information about SINAMICS Safety Integrated

2.1 Safety Integrated Functions

All of the Safety Integrated functions available under SINAMICS are listed in this chapter. SINAMICS makes a distinction between Safety Integrated Basic Functions and Safety Integrated Extended Functions.

The safety functions listed conform to Safety Integrity Level (SIL) 2 to DIN EN 61508, to Category 3 to DIN EN ISO 13849-1 and to Performance Level (PL) d to DIN EN ISO 13849-1.
The safety functions correspond to the functions STO, SS1 and SBC to DIN EN 61800-5-2.

The following Safety Integrated functions (SI functions) are available:

- **Safety Integrated basic functions**

  These functions are part of the standard scope of the drive and can be used without requiring an additional license:

  – Safe Torque Off (STO)

    STO is a safety function that prevents the drive from restarting unexpectedly, in accordance with EN 60204-1, Section 5.4.

  – Safe Stop 1 (SS1, time controlled)

    Safe Stop 1 is based on the "Safe Torque Off" function. This means that a Category 1 stop in accordance with EN 60204-1 can be implemented.

  – Safe Brake Control (SBC)

    The SBC function permits the safe control of a holding brake.

- Safety Integrated Extended Functions

  These functions require an additional safety license:

  – Safe Torque Off (STO)

    STO is a safety function that prevents the drive from restarting unexpectedly, in accordance with EN 60204-1, Section 5.4.

  – Safe Stop 1 (SS1, time and acceleration controlled)

    The SS1 function is based on the “Safe Torque Off” function. This means that a Category 1 stop in accordance with EN 60204-1 can be implemented.

  – Safe Stop 2 (SS2)

    The SS2 function brakes the motor safely with a subsequent transition to "Safe Operating Stop" (SOS). This means that a Category 2 stop in accordance with EN 60204-1 can be implemented.

  – Safe Operating Stop (SOS)

    SOS protects against unintentional movement. The drive is in closed-loop control mode and is not disconnected from the power supply.

  – Safely-Limited Speed (SLS)

    The SLS function ensures that the drive does not exceed a preset speed limit.

  – Safe Speed Monitor (SSM)

    The SSM function safely monitors the speed limit and issues a safe output signal, but without initiating a response function.

  – Safe Acceleration Monitor (SBR)

    The function monitors the safe braking of the drive during the ramp down. An unintentional "reacceleration" is reliably prevented.
    This is part of the SS1 and SS2 functions.

  – Safe Brake Ramp (SBR)

    The Safe Brake Ramp function safely monitors a braking ramp.
    This is part of the SS1 functions without encoder and SLS without encoder.

2.2 Preconditions for Safety Integrated Basic Functions

The following prerequisites apply for operation of the Safety Integrated Basic Functions:

- For G150, S120 Cabinet Modules and S150: Option K82 (terminal module for activation of the safety functions "Safe Torque Off" and "Safe Stop 1"), at activation signals of 230 V and/or cable lengths of more than 30 m
- An activated speed controller in the drive

2.3 Preconditions for Safety Integrated Extended Functions

The following prerequisites apply for operation of the Safety Integrated Extended Functions:

- A license is required to use the Safety Integrated Extended Functions. If the options (F01 to F05 or K01 to K05) are ordered, the license is already enabled on the memory card. If a license is purchased subsequently, the respective license key must be entered in parameter p9920 in ASCII code. The license key is activated using parameter p9921 = 1. For information on how to generate the license key for the product "SINAMICS Safety Integrated Extended Functions", read the section "Licensing" in the SINAMICS S120 Function Manual. An insufficient license is indicated via the following alarm and LED:
  - A13000 --> License not sufficient
  - LED RDY --> Flashes greed/red at 0.5 Hz
- Control via PROFIsafe or TM54F
- An activated speed controller in the drive
- No parallel connection of motor/power modules
- Overview of hardware components that support the Extended Functions:
  - Control Unit CU320-2
  - Motor Modules Booksize where the order number ends as follows: -xxx3 or higher
  - Motor Modules Chassis where the order number ends as follows: -xxx3 or higher (For this design, Extended Functions are permitted only **with** sin/cos encoders.)
  - Motor Modules Cabinet where the order number ends as follows: -xxx2 or higher
  - Sensor Module SMC20, SME20/25/120/125, SMI20
- Motors with integrated encoder and encoder evaluation with DRIVE-CLiQ interface

2.4 Controlling the Safety Integrated functions

The activation of Safety Integrated Functions can be performed via terminals (on the control unit and on the motor/power module), via PROFIsafe on the basis of PROFIBUS or PROFINET or, for the Extended Functions, via the terminal module TM54F. In this case, control via terminals and TM54F or terminals and PROFIsafe can be simultaneously selected.

NOTICE
Safety Integrated functions with SIMOTION
PROFISafe via PROFINET is not permitted with SIMOTION.

NOTICE
PROFIsafe or TM54F
Using a Control Unit, control is possible either via PROFIsafe or TM54F. Mixed operation is not permissible.

When asynchronous motors or synchronous motors without encoders are used, not all Safety Integrated Extended Functions can be used.
When operating without encoders, the actual speed values are calculated from the measured electrical actual values. As a consequence, speed monitoring down to n = 0 rpm is also possible for operation without an encoder.

Table 2- 1 Overview of Safety Integrated functions

	Functions	Abbreviation	With encoder	Without encoder	Short description
Basic Functions	Safe Torque Off	STO	Yes	Yes	Safe Torque Off
	Safe Stop 1	SS1	Yes	Yes	Safe stopping according to stop category 1
	Safe Brake Control	SBC	Yes	Yes	Safe Brake Control
Extended Functions	Safe Torque Off	STO	Yes	Yes 1)	Safe Torque Off
	Safe Stop 1	SS1	Yes	Yes 1)	Safe stop according to stop category 1
	Safe Stop 2	SS2	Yes	No	Safe stop according to stop category 2
	Safe Operating Stop	SOS	Yes	No	Safe monitoring of the standstill position
	Safely Limited Speed	SLS	Yes	Yes 1)	Safe monitoring of the maximum speed
	Safe Speed Monitor	SSM	Yes	No	Safe monitoring of the minimum speed
	Safe Acceleration Monitor	SBR	Yes	No	Safe monitoring of the drive acceleration
	Safe Brake Ramp	SBR	No	Yes 1)	Safe Brake Ramp

1) The use of the safety function without an encoder is possible only for asynchronous motors.

The Safety Integrated functions are selected and activated and the monitoring with or without encoder is selected in the Safety screen forms of the STARTER or SCOUT tools.

2.5 Parameter, Checksum, Version, Password

Properties of Safety Integrated parameters

The following applies to Safety Integrated parameters:

- The safety parameters are kept separate for each monitoring channel.
- During startup, checksum calculations (Cyclic Redundancy Check, CRC) are performed on the safety parameter data and checked. The display parameters are not contained in the CRC.
- Data storage: The parameters are stored on the non-volatile memory card.
- Factory settings for safety parameters

  A reset of the safety parameters to the factory setting on a drive-specific basis using p0970 or p3900 and p0010 = 30 is only possible when the safety functions are not enabled (p9301 = p9501 = p9601 = p9801 = p10010 = 0).

  A complete reset of all parameters to the factory settings (p0976 = 1 and p0009 = 30 on the Control Unit) is possible even when the safety functions are enabled (p9301 = p9501 = p9601 = p9801 = p10010 ≠ 0).
- They are password-protected against accidental or unauthorized changes.

NOTICE
The following safety parameters are not protected by the safety password: • p9370 SI Motion acceptance test mode (Motor Module) • p9570 SI Motion acceptance test mode (Control Unit) • p9533 SI Motion SLS setpoint speed limitation

Checking the checksum

For each monitoring channel, the safety parameters include one parameter for the actual checksum for the safety parameters that have undergone a checksum check.

During commissioning, the actual checksum must be transferred to the corresponding parameter for the setpoint checksum. This can be done for all checksums of a drive object at the same time with parameter p9701.

Basic functions

- r9798 SI actual checksum SI parameters (Control Unit)
- p9799 SI setpoint checksum SI parameters (Control Unit)
- r9898 SI actual checksum SI parameters (Motor Module)
- p9899 SI setpoint checksum SI parameters (Motor Module)

Extended functions

- r9398[0...1] SI Motion actual checksum SI parameters (Motor Module)
- r9399[0...1] SI Motion setpoint checksum SI parameters (Motor Module)
- r9728[0...2] SI Motion actual checksum SI parameters
- p9729[0...2] SI Motion setpoint checksum SI parameters

During each ramp-up procedure, the actual checksum is calculated via the safety parameters and then compared with the setpoint checksum.

If the actual and setpoint checksums are different, fault F01650/F30650 or F01680/F30680 is output and an acceptance test requested.

Safety Integrated versions

The safety firmware has a separate version ID for the Motor/Power Module.

For the basic functions:

- r9770 SI version, drive-autonomous safety functions (Control Unit)
- r9870 SI version (Motor Module)

For the Extended Functions:

- r9590 SI Motion version safe movement monitoring (Control Unit)
- r9390 SI Motion version safe movement monitoring (Motor Module)
- r9890 SI version (Sensor Module)
- r10090 SI version TM54F

Note

For detailed requirements regarding Safety Integrated firmware, see "Safety Integrated firmware versions".

Password

The safety password protects the safety parameters against unintentional or unauthorized access.

In commissioning mode for Safety Integrated (p0010 = 95), you cannot change safety parameters until you have entered the valid safety password in p9761 for the drives or p10061 for the TM54F.

- When Safety Integrated is commissioned for the first time, the following applies:
  - Safety passwords = 0
  - Default setting for p10061 = 0
  - Default setting for p9761 = 0

  In other words:
  The safety password does not need to be set during first commissioning.
- In the case of a series commissioning of Safety or in the case of spare part installation, the following applies:
  - The safety password is retained on the memory card and in the STARTER project.
  - No safety password is required in the case of spare part installation.
- Change password for the drives
  - p0010 = 95 Commissioning mode
  - p9761 = Enter "old safety password".
  - p9762 = Enter "new password".
  - p9763 = Confirm "new password".
  - The new and confirmed safety password is valid immediately.
- Change password for the TM54F
  - p0010 = 95 Commissioning mode
  - p10061 = Enter "Old TM54F Safety Password" (factory setting "0")
  - p10062 = Enter "new password"
  - p10063 = Acknowledge "new password"
  - The new and acknowledged safety password is valid immediately.

If you need to change safety parameters but you do not know the safety password, proceed as follows:

1. Set the entire drive unit (Control Unit with all connected drives/components) to the factory setting.
2. Recommission the drive unit and drives.
3. Recommission Safety Integrated.

Or contact your regional Siemens office and ask for the password to be deleted (complete drive project must be made available).

Overview of important parameters for "Password" (see SINAMICS List Manual)

- p9761 SI password input
- p9762 SI password new
- p9763 SI password acknowledgement
- p10061 SI password input TM54F
- p10062 SI password new TM54F
- p10063 SI password acknowledgement TM54F

2.6 DRIVE-CLiQ rules for Safety Integrated Functions

Note

For the Safety Integrated Functions (Basic and Extended Functions) the general DRIVE-CLiQ rules apply as a basic principle. These rules are provided in the chapter "Rules for wiring with DRIVE-CLiQ" in the SINAMICS S120 Drive Functions Function Manual.

The following rules are also valid particularly for the Safety Integrated functions:

- Maximum of 6 servo axes for default cycle time settings (monitoring cycle: 12 ms; current controller cycle: = 125 µs).
- Of which, a maximum of 4 servo axes in a DRIVE-CLiQ line.
- Max. 6 vector axes for standard settings of cycle times (monitoring cycle: 12 ms; current controller cycle: = 500 µs).
- The TM54F must be directly connected to a Control Unit via DRIVE-CLiQ. Motor/Power Modules or infeed must not be connected to a TM54F.
- A Double Motor Module, a DMC20 or DME20 and a TM54F each correspond to two DRIVE-CLiQ nodes.

3 System Features

3.1 Latest information

Important note for maintaining the operational safety of your system:

⚠ WARNING
Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operating company. The supplier is also obliged to maintain certain measures regarding his product. For this reason, we publish a special newsletter containing information on product developments and features that are (or could be) relevant when operating safety-related systems. You should subscribe to the corresponding newsletter in order to obtain the latest information and to allow you to modify your equipment accordingly.

Go into the Internet under:

http://automation.siemens.com

To subscribe to the newsletter, please proceed as follows:

1. Select the desired language for the webpage.
2. Click on the menu item "Support".
3. Click on the menu item "Newsletter".

Note

You have to register and log in if you want to subscribe to any newsletters. You will be led automatically through the registration process.

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4. Click on "Login" and log in with your access data. If you do not yet have a login and password, select "Yes, I would like to register now".

   You can subscribe to the individual newsletters in the following window.
5. Select the document type you wish to be informed about under "Select document type for topic and product newsletters".
6. Under the "Product Support" heading on this page, you can see which newsletter is currently available.

7. Open the subject area "Safety Engineering - Safety Integrated".

   You will now be shown which newsletter is available for this particular subject area or topic. You can subscribe to the corresponding newsletter by clicking on the box. If you require more detailed information on the newsletters then please click on this box. A small supplementary window is opened from which you can take the appropriate information.

8. At the very least, register for the newsletters for the following product areas:

   – Safety Integrated for SIMOTION

   – Drives

3.2 Certification

The safety functions of the SINAMICS drive system meet the following requirements:

- Category 3 to EN ISO 13849-1.
- Performance Level (PL) d to EN ISO 13849-1.
- Safety integrity level 2 (SIL 2) to IEC 61508.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

3.3 Safety instructions

Note

Additional safety information and residual risks not specified in this section are included in the relevant sections of this Function Manual.

DANGER

Safety Integrated can be used to minimize the level of risk associated with machines and plants.
Machines and plants can only be operated safely in conjunction with Safety Integrated, however, when the machine manufacturer

- precisely knows and complies with this technical user documentation - including the documented limitations, safety information, and residual risks.
- Carefully constructs and configures the machine/plant. A careful and thorough acceptance test must then be performed by qualified personnel and the results documented.
- Implements and validates all the measures required in accordance with the machine/plant risk analysis by means of the programmed and configured Safety Integrated functions or by other means.

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the EC Machinery Directive.
In addition to using the Safety Integrated functions, further risk reduction measures must be implemented.

WARNING

The Safety Integrated functions cannot be activated until the system has been completely powered up. System startup is a critical operating state with increased risk. No personnel may be present in the immediate danger zone in this phase.

The drives of vertical axes must be in torque state.

A complete forced dormant error detection is necessary after switching on (→see chapter, "forced dormant error detection").

WARNING

EN 60204-1
The Emergency Stop function must bring the machine to a standstill in accordance with stop category 0 or 1 (STO or SS1).
The machine must not restart automatically after EMERGENCY STOP.
When the safety functions (Basic or Extended Functions) are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is permitted when a protective door is closed, for example.

⚠ WARNING

After hardware and/or software components have been modified or replaced, all protective equipment must be closed prior to system startup and drive activation. Personnel shall not be present within the danger zone.

It may be necessary to carry out a partial or complete acceptance test or a simplified functional test (see chapter "Acceptance test") after having made certain changes or replacements.

Before allowing anybody to re-enter the danger zone, you should test steady control response by briefly moving the drives in forward and reverse direction (+/–).

To observe during power on:

The Safety Integrated functions are only available and can only be selected after the system has completely powered up.

⚠ WARNING

- For a 1-encoder system, encoder faults are detected using different hardware and software monitoring functions. It is not permissible to disable these monitoring functions and parameters must be assigned carefully. Depending on the fault type and responding monitoring function, stop function category 0 or 1 in accordance with EN 60204-1 (fault response functions STOP A or STOP B in accordance with Safety Integrated) is selected.
- The category 0 stop function to EN 60204-1 (STO or STOP A to Safety Integrated) means that the drives are not decelerated but instead coast to standstill (the time required to coast to standstill depends on the kinetic energy). This must be included in the logic of the protective door lock, for example, by means of logic operation of SSM (n<nx).
- Safety Integrated Functions cannot detect parameter assignment errors made by the machine manufacturer. The required safety level can only be reached by by means of an elaborate acceptance test.
- Motor Modules or the motor must be replaced with a device of the same type, as the parameter settings will otherwise lead to an incorrect response of the Safety Integrated Functions. The corresponding drive must be re-calibrated after an encoder is replaced.

⚠ WARNING

If an internal or external fault occurs, none or only some of the parameter-assigned safety functions are available during the STOP-F response triggered by the fault. This must be taken into account when parameters are assigned for a delay time between STOP F and STOP B. This applies in particular to vertical axes.

NOTICE
Changing the EDS with safe motion monitoring An encoder that is used for Safety Functions should not be switched over when a data set is switched over. The Safety Functions check the safety-relevant encoder data for changes when data sets are switched over. If a change is detected, fault F01670 is displayed with a fault value of 10, which results in a non-acknowledgeable STOP A. The safety-relevant encoder data in the various data sets must therefore be identical.

3.4 Probability of failure of the safety functions (PFH value)

Probabilities of failure

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) in accordance with IEC 61508, IEC 62061, and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive unit and its hardware configuration, as well as on the PFH values of other components used for this safety function.

For SINAMICS drives and cabinets G130, G150, S120 Chassis, S120 Cabinet Modules and S150, PFH values are available depending on the hardware configuration (number of drives, type of control, number of encoders used). The various integrated safety functions are not differentiated.

The PHF values can be requested from your local sales office.

3.5 Response times

3.5.1 Response times Safety Integrated Basic Functions

The Basic Functions are executed in the monitoring clock cycle (p9780). PROFIsafe telegrams are evaluated in the PROFIsafe scan cycle, which corresponds to twice the monitoring clock cycle (PROFIsafe scan cycle = 2 × r9780).

Controlling Basic Functions via terminals on the Control Unit and Motor/Power Module

The following table lists the response times from the control via terminals until the response actually occurs.

Table 3- 1 Response times for control via terminals on the Control Unit and the Motor/Power Module.

Function	Typical	Worst case
STO	2 x r9780 + p0799	4 x r9780 + p0799
SBC 5)	4 x r9780 + p0799	8 x r9780 + p0799
SS1 (time controlled) Selection until braking is initiated	2 x r9780 + p0799 + 2 ms	4 x r9780 + p0799 + 2 ms

Controlling Basic Functions via Profisafe

The following table lists the response times from receiving the PROFIsafe telegram on the Control Unit up to initiating the response.

Table 3- 2 Response times when controlling via PROFIsafe

Function	Typical	Worst case
STO	5 x r9780	5 x r9780
SBC 5)	4 x r9780	10 x r9780
SS1 (time controlled) Selection until STO is initiated	5 x r9780 + p9652	5 x r9780 + p9652
SS1 (time controlled) Selection until SBC is initiated	6 x r9780 + p9652	10 x r9780 + p9652
SS1 (time controlled) Selection until braking is initiated	2 x r9780 + p0799 + 2 ms	4 x r9780 + p0799 + 2 ms

3.5.2 Response times, Safety Integrated Extended Functions with encoder

Activation of Extended Functions with encoder via PROFIsafe

The following table lists the response times from receiving the PROFIsafe telegram on the Control Unit up to initiating the response.

Table 3- 3 Response times when controlling via PROFIsafe

Function	Typical	Worst case
STO	4 x p9500 + r9780	4 x p9500 + 3 x r9780
SBC [5]	4 x p9500 + 2 x r9780	4 x p9500 + 6 x r9780
SS1 (time and acceleration controlled), SS2: Call	4 x p9500 + 2 ms	5 x p9500 + 2 ms
SBR, safe acceleration monitoring responds	2 x p9500 + 2 ms	2.5 x p9500 + r9780 + t_DP [1]
SOS standstill tolerance window violated	1.5 x p9500 + 2 ms	3 x p9500 + t_DP [1] + 2 ms
SLS speed limit violated [2]	2 x p9500 + 2 ms	3.5 x p9500 + t_DP [1] + 2 ms
SSM [3]	4 x p9500	4.5 x p9500 + t_DP [1]

The specified response times involve internal SINAMICS response times. Program run times in the F host and the transmission time via PROFIBUS or PROFINET are not taken into account.

Activation of Extended Functions with encoder via TM54F

The following table lists the response times between a signal occurring at the terminals up to the initiation of the response.

Table 3- 4 Response times with control via TM54F

Function	typical	Worst case
STO	2.5 x p9500 + r9780 + 1.5 ms	3 x p9500 + 3 x r9780 + 2 ms
SBC [5]	2.5 x p9500 + 2 x r9780 + 1 ms	3 x p9500 + 6 x r9780 + 2 ms
SS1 (time and acceleration controlled), SS2: Call	2.5 x p9500 + 3 ms	4 x p9500 + 4 ms
SBR, safe acceleration monitoring responds	2 x p9500 + 2 ms	2.5 x p9500 + r9780 + t_DP [1]
SOS standstill tolerance window violated	1.5 x p9500 + 2 ms	3 x p9500 + t_DP [1] + 2 ms
SLS speed limit violated [2]	2 x p9500 + 2 ms	3.5 x p9500 + t_DP [1] + 2 ms
SSM [4]	3 x p9500	3.5 x p9500 + t_DP [1]

3.5.3 Response times for Safety Integrated Extended Functions without encoder

Control of Extended Functions without encoder via PROFIsafe

The following table lists the response times from receiving the PROFIsafe telegram on the Control Unit up to initiating the response.

Table 3- 5 Response times when controlling via PROFIsafe

Function	Typical	Worst case
STO	4 x p9500 + r9780	4 x p9500 + 3 x r9780
SBC [5)]	4 x p9500 + 2 x r9780	4 x p9500 + 6 x r9780
SS1 (time and acceleration controlled)	4 x p9500 + 2 ms	5 x p9500 + 2 ms
SBR, safe acceleration monitoring responds	3 x p9500 + 31 ms	3.5 x p9500 + r9780 + 57 ms
SLS speed limit violated [2)]	3 x p9500 + 31 ms	4.5 x p9500 + r9780 + 57 ms

The specified response times involve internal SINAMICS response times. Program run times in the F host and the transmission time via PROFIBUS or PROFINET are not taken into account.

Activation of Extended Functions without encoder via TM54F

The following table lists the response times between a signal occurring at the terminals up to the initiation of the response.

Table 3- 6 Response times with control via TM54F

Function	typical	Worst case
STO	2.5 x p9500 + r9780 + 1.5 ms	3 x p9500 + 3 x r9780 + 2 ms
SBC [5)]	2.5 x p9500 + 2 x r9780 + 1 ms	3 x p9500 + 6 x r9780 + 2 ms
SS1 (time and acceleration controlled)	2.5 x p9500 + 3 ms	4 x p9500 + 4 ms
SBR, safe acceleration monitoring responds	3 x p9500 + 31 ms	3.5 x p9500 + r9780 + 57 ms
SLS speed limit violated [2)]	3 x p9500 + 31 ms	4.5 x p9500 + r9780 + 57 ms

Information on the tables:

[1)] t_DP = PROFIBUS cycle with isochronous PROFIBUS master, otherwise 1 ms

[2)] SLS: Specification of the response time required for initiation of a braking reaction in the drive, or for the output of the "SOS selected" message to the motion control system.

[3)] SSM: The data corresponds to the times between the limit value being undershot up to sending the information via PROFIsafe.

[4)] SSM: The data corresponds to the times between the limit value being undershot up to output of the information via the TM54F terminals.

[5)] SBC:The data correspond to the times for brake activation without additional hardware (Safe Brake Adapter).

3.6 Residual risk

The fault analysis enables the machine manufacturer to determine the residual risk at his machine with regard to the drive unit. The following residual risks are known:

⚠ WARNING

Due to the intrinsic potential of hardware faults, electrical systems are subject to additional residual risk, which can be expressed by means of the PFH value.

⚠ WARNING

- Faults in the absolute track (C-D track), cyclicly swapped phases of the motor connections (V-W-U instead of U-V-W) and reversal of the control direction may cause acceleration of the drive. Due to the fault, however, Category 1 and 2 stop functions to EN 60204-1 (fault response functions STOP B to D in accordance with Safety Integrated) are not activated.
  Stop function Category 0 to EN 60204-1 (fault response function STOP A in accordance with Safety Integrated) is not triggered until after the transition or delay time set in the parameter has elapsed. These faults are detected when SBR is selected (fault reaction functions STOP B/C) and stop function category 0 to EN 60204-1 (fault reaction function STOP A in accordance with Safety Integrated) is triggered as early as possible regardless of this delay. Electrical faults (defective components or similar) can also cause the response cited above.
- Simultaneous failure of two power transistors (one in the upper and the other offset in the lower inverter bridge) in the inverter may cause brief movement of the drive, depending on the number of poles of the motor.
  Maximum value of this movement:

  Synchronous rotary motors: Max. movement = 180 ° / no. of pole pairs

  Synchronous linear motors: max. movement = pole width

⚠ WARNING

- Upper limit violations may briefly lead to a rotational speed higher than the speed setpoint, or the axis may overtravel the defined position to a certain extent, depending on the dynamic response of the drive and on parameter settings.
- Mechanical forces greater than the maximum drive torque may force a drive currently operated in position control mode out of the Safe Operating Stop state (SOS) and trigger stop function category 1 to EN 60204-1 (fault reaction function STOP B).

WARNING

Within a single-encoder system:

a) a single electrical fault in the encoder

b) encoder shaft break, (or detachment of the encoder shaft coupling), or a loose encoder housing will cause a static state of the encoder signals (i.e. they no longer follow the movement while still returning a correct level), and thus do not detect this fault while the drive is in stop state (for example, drive in SOS state).

Generally, the drive is held by the active closed-loop control. With closed loop control, it is conceivable that vertical (suspended) drives in particular can move without their motion being detected.

The risk of an electrical fault in the encoder as described under a) is only present for few encoder types with specific function principle (for example, encoders with microprocessor controlled signal generation such as the Heidenheim EQI, Hübner HEAG 159/160, or AMO measuring systems with sin/cos signals).
The risk analysis of the machine manufacturer must include all of the faults described above. Additional safety measures have to be taken for drives with suspended/vertical or dragging loads in order to exclude the faults described in a), for example:

- Use of an encoder with analog signal generation or
- Use of a two-encoder system

and in order to exclude the fault described in b):

- Execution of an FMEA regarding encoder shaft breakage (or detachment of the encoder shaft coupling), and a solution to prevent loose encoder housings, integration of a fault exclusion process, e.g. in accordance with CDV IEC 61800-5-2, or
- implementation of a two-encoder system (the encoders should not be mounted on the same shaft).

4 Supported functions

4.1 Content of this chapter

In this chapter all Safety Integrated Functions for SINAMICS G130, G150, S120 Chassis, S120 Cabinet Modules and S150 are explained. See the overviews for the preconditions, the supported functions, and the control possibilities per converter

The safety functions listed conform to Safety Integrity Level (SIL) 2 to DIN EN 61508, to Category 3 to DIN EN ISO 13849-1 and to Performance Level (PL) d to DIN EN ISO 13849-1.
The safety functions correspond to the functions STO, SS1 and SBC to DIN EN 61800-5-2.

4.2 SINAMICS G130

4.2.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	No

Activation possibilities

Activation	STO	SS1	SBC
Control unit & terminal (power unit)	Yes	Yes	No
PROFIsafe & terminal (power unit)	Yes	Yes	No

4.2.2 Extended Functions

Use of the Safety Integrated Extended Functions is not possible with SINAMICS G130.

4.3 SINAMICS G150

4.3.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	No

Activation possibilities

Activation	STO	SS1	SBC
With option K82: Terminal module for activation of the safety functions "STO" & "SS1"	Yes	Yes	No
Control unit & terminal (power unit)	Yes	Yes	No
PROFIsafe & terminal (power unit)	Yes	Yes	No

4.3.2 Extended Functions

Use of the Safety Integrated Extended Functions is not possible with SINAMICS G150.

4.4 SINAMICS S120 Chassis

4.4.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	No

Activation possibilities

Activation	STO	SS1	SBC
Control unit & terminal (power unit)	Yes	Yes	No
PROFIsafe & terminal (power unit)	Yes	Yes	No

4.4.2 Extended Functions

Preconditions

- Option **F01 to F05**: Safety license for one axis to five axes
- sin/cos sensor evaluation (Sensor Module SMC20, SME20/25/120/125, SMI20)

Supported Safety Integrated Extended Functions

Safety Function	Abbreviation	With encoder [1)	Without encoder
Safe Torque Off	STO	Yes	No
Safe Stop 1	SS1	Yes	No
Safe Stop 2	SS2	Yes	No
Safe Operating Stop	SOS	Yes	No
Safely-Limited Speed	SLS	Yes	No
Safe Speed Monitor	SSM	Yes	No
Safe Acceleration Monitor	SBR	Yes	No
Safe Brake Ramp	SBR	No	No

[1)] sin/cos sensor evaluation

Activation possibilities

- Terminal (TM54F)
- PROFIsafe

Restrictions

Use of the Safety Integrated Extended Functions is not possible with SINAMICS G120 Chassis in parallel switching.

4.5 SINAMICS S120 Cabinet Modules

4.5.1 Booksize format Motor Module

4.5.1.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	Yes

Activation possibilities

Activation	STO	SS1	SBC
With option K82: Terminal module for activation of the safety functions "STO" & "SS1"	Yes	Yes	No
Control unit & terminal (power unit)	Yes	Yes	Yes
PROFIsafe & terminal (power unit)	Yes	Yes	Yes

4.5.1.2 Extended Functions

Preconditions

- Option **K01 to K05**: Safety license for one axis to five axes
- Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

Supported Safety Integrated Extended Functions

Safety Function	Abbreviation	With encoder [1]	Without encoder
Safe Torque Off	STO	Yes	Yes [2]
Safe Stop 1	SS1	Yes	Yes [2]
Safe Stop 2	SS2	Yes	No
Safe Operating Stop	SOS	Yes	No
Safely-Limited Speed	SLS	Yes	Yes [2]
Safe Speed Monitor	SSM	Yes	No
Safe Acceleration Monitor	SBR	Yes	No
Safe Brake Ramp	SBR	No	Yes [2]

[1] Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

[2] Only possible with asynchronous motors

Activation possibilities

- Option **K87**: Terminal Module TM54F
- PROFIsafe

Restrictions

Use of the Safety Integrated Extended Functions is not possible with SINAMICS S120 Cabinet Modules in parallel switching.

4.5.2 Motor Module in chassis format

4.5.2.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	No

Activation possibilities

Activation	STO	SS1	SBC
With option **K82**: Terminal module for activation of the safety functions "STO" & "SS1"	Yes	Yes	No
Control unit & terminal (power unit)	Yes	Yes	No
PROFIsafe & terminal (power unit)	Yes	Yes	No

4.5.2.2 Extended Functions

Preconditions

- Option **K01 to K05**: Safety license for one axis to five axes
- Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

Supported Safety Integrated Extended Functions

Safety Function	Abbreviation	With encoder [1]	Without encoder
Safe Torque Off	STO	Yes	No
Safe Stop 1	SS1	Yes	No
Safe Stop 2	SS2	Yes	No
Safe Operating Stop	SOS	Yes	No
Safely-Limited Speed	SLS	Yes	No
Safe Speed Monitor	SSM	Yes	No
Safe Acceleration Monitor	SBR	Yes	No
Safe Brake Ramp	SBR	No	No

[1] Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

Activation possibilities

- Option **K87**: Terminal Module TM54F
- PROFIsafe

Restrictions

Use of the Safety Integrated Extended Functions is not possible with SINAMICS S120 Cabinet Modules in parallel switching.

4.6 SINAMICS S150

4.6.1 Basic functions

Preconditions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license.

Supported Safety Integrated Basic Functions

Safety Function	Abbreviation	
Safe Torque Off	STO	Yes
Safe Stop 1	SS1	Yes
Safe Brake Control	SBC	No

Activation possibilities

Activation	STO	SS1	SBC
With option **K82**: Terminal module for activation of the safety functions "STO" & "SS1"	Yes	Yes	No
Control unit & terminal (power unit)	Yes	Yes	No
PROFIsafe & terminal (power unit)	Yes	Yes	No

4.6.2 Extended Functions

Preconditions

- Option **K01**: Safety license for one axis
- Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

Supported Safety Integrated Extended Functions

Safety Function	Abbreviation	With encoder [1)]	Without encoder
Safe Torque Off	STO	Yes	No
Safe Stop 1	SS1	Yes	No
Safe Stop 2	SS2	Yes	No
Safe Operating Stop	SOS	Yes	No
Safely-Limited Speed	SLS	Yes	No
Safe Speed Monitor	SSM	Yes	No
Safe Acceleration Monitor	SBR	Yes	No
Safe Brake Ramp	SBR	No	No

[1)] Option **K48**: Sensor Module Cabinet-Mounted SMC20 (sin/cos encoder)

Activation possibilities

- Option **K87**: Terminal Module TM54F
- PROFIsafe

Safety Integrated Basic Functions 5

5.1 Safe Torque Off (STO)

General description

In conjunction with a machine function or in the event of a fault, the "Safe Torque Off" (STO) function is used to safely disconnect the torque-generating energy feed to the motor.

When the function is selected, the drive unit is in a "safe status". The switching on inhibited function prevents the drive unit from being restarted.

The two-channel pulse suppression integrated in the Motor/Power Modules is the basis for this function.

Functional features of "Safe Torque Off"

- This function is integrated in the drive; this means that a higher-level controller is not required.
- The function is drive-specific, i.e. it is available for each drive and must be individually commissioned.
- The function must be enabled using parameters.
- When the "Safe Torque Off" function is selected, the following applies:
  - The motor cannot be started accidentally.
  - The pulse suppression safely disconnects the torque-generating energy feed to the motor.
  - The power unit and motor are not electrically isolated.
- Extended acknowledgment:

  If STO is selected/deselected (and p9307.0/p9507.0 = 1 are set), safety messages, in addition to fault messages, are also canceled automatically.
- A debounce function can be applied to the terminals of the Control Unit and the Motor/Power Module in order to prevent incorrect trips due to signal disturbances. The filter times are set using parameters p9651 and p9851.

⚠ WARNING
Appropriate measures must be taken to ensure that the motor does not undesirably move once the energy feed has been disconnected, e.g. against coasting down or for a hanging/suspended axis, the "Safe Brake Control" (SBC) function should be enabled, also refer to Chapter "Safe Brake Control".

⚠ CAUTION
If two power transistors simultaneously fail in the power unit (one in the upper and one in the lower bridge), then this can cause brief momentary movement. The maximum movement can be: Synchronous rotary motors: Max. movement = 180 ° / No. of pole pairs Synchronous linear motors: Max. movement = pole width

- The status of the "Safe Torque Off" function is displayed using parameters.

Enabling the "Safe Torque Off" function

The "Safe Torque Off" function is enabled via the following parameters:

- STO via terminals on the Control Unit and the power unit
  p9601.0 = 1, p9801.0 = 1
- STO via PROFIsafe:
  - p9601.0 = 0, p9801.0 = 0
  - Basic Functions: p9601.2 = 0, p9801.2 = 0
    Extended Functions: p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 1, p9801.3 = 1
- STO via PROFIsafe and terminals:
  - p9601.0 = 1, p9801.0 = 1
  - Basic Functions: p9601.2 = 0, p9801.2 = 0
    Extended Functions: p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 1, p9801.3 = 1
- STO via TM54F (only with "Extended Functions" option):
  - p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 0, p9801.3 = 0

Selecting/deselecting "Safe Torque Off"

The following occurs when "Safe Torque Off" is selected:

- Each monitoring channel triggers safe pulse suppression via its switch-off signal path.
- A motor holding brake is applied (if connected and configured).

If "Safe Torque Off" is deselected, this is treated as an internal safe acknowledgment. The following processes occur:

- Each monitoring channel cancels safe pulse suppression via its switch-off signal path.
- The safety prompt "Apply motor holding brake" is canceled.
- Any pending STOP F or STOP A commands are canceled (see r9772 / r9872).
- The cause of the fault must be remedied.
- The messages in the fault memory also need to be reset using the general acknowledgment mechanism.

Note

If "Safe Torque Off" is selected and de-selected through one channel within the time in p9650/p9850, the pulses are suppressed without a message being output.

If you want a message to be displayed in this case, however, you have to reconfigure N01620/N30620 via p2118 and p2119 as an alarm or fault.

Restart after the "Safe Torque Off" function has been selected

1. Deselect the function in each monitoring channel via the input terminals.
2. Set drive enables.
3. Revoke "closing lockout" and switch the drive back on.
   – 1/0 pulse edge at input signal "ON/OFF1" (revoke "closing lockout")
   – 0/1pulse edge at input signal "ON/OFF1" (switch on drive)
4. Run the drives again.

Status for "Safe Torque Off"

The status of the "Safe Torque Off" (STO) function is displayed via parameters r9772, r9872, r9773, and r9774.

As an alternative, the status of the function can be displayed using the configurable messages N01620 and N30620 (configured using p2118 and p2119).

Response time with the "Safe Torque Off" function

For the response times when the function is selected/deselected via input terminals, see the table in chapter "System features", subchapter, "Response times".

Example - chassis example

Assumption:

Safety monitoring clock cycle CU (r9780) = 16 ms and
inputs/outputs sampling time (p0799) = 4 ms

t_{R_type} = 2 x r9780 (16 ms) + p0799 (4 ms) = 36 ms

t_{R_max} = 4 x r9780 (16 ms) + p0799 (4 ms) = 68 ms

Example - booksize design

Assumption:

Safety monitoring clock cycle CU (r9780) = 4 ms and
inputs/outputs sampling time (p0799) = 4 ms

t_{R_type} = 2 x r9780 (4 ms) + p0799 (4 ms) = 12 ms

t_{R_max} = 4 x r9780 (4 ms) + p0799 (4 ms) = 20 ms

Internal armature short-circuit with the "Safe Torque Off" function

The function "internal armature short-circuit" can be configured together with the "STO" function. However, only one of the two functions can be selected, as an OFF2 is also always triggered when STO is selected. This OFF2 disables the function "Internal armature short-circuit".

The "STO" safety function has the higher priority when simultaneously selected. If the "STO" function is initiated, then an activated "internal armature short-circuit" is disabled.

Overview of important parameters

- p9601 SI enable, functions integrated in the drive (Control Unit)
- r9720.0...10 CO/BO: SI Motion control signals integrated in the drive
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals
- r9772 CO/BO: SI Status (Control Unit)
- r9872 CO/BO: SI Status (Motor Module)
- r9773 CO/BO: SI Status (Control Unit + Motor Module)
- r9774 CO/BO: SI Status (group STO)
- p0799 CU inputs/outputs sampling time
- r9780 SI monitoring clock cycle (Control Unit)
- p9801 SI enable, functions integrated in the drive (Motor Module)
- r9880 SI monitoring clock cycle (Motor Module)

5.2 Safe Stop 1 (SS1, time controlled)

General description

The "Safe Stop 1" (SS1, time controlled) function allows the drive to be stopped in accordance with EN 60204-1, stop category 1. The drive brakes with the OFF3 ramp (p1135) once "Safe Stop 1" is selected and switches to "Safe Torque Off" status once the delay time set in p9652/p9852 has elapsed.

CAUTION
If the "Safe Stop 1" function (time-controlled) function has been selected by parameterizing a delay in p9652/p9852, STO can no longer be selected directly via terminals.

Functional features of "Safe Stop 1"

SS1 is enabled when p9652 and p9852 (delay time) are not equal to "0".

- The precondition is the Basic Functions or STO are enabled via terminals.
  - p9601.0/p9801.0 = 1
- Setting parameter p9652/p9852 has the following effect:
  - p9652/p9852 = 0: STO active
  - p9652/p9852 > 0: SS1 active
- When SS1 is selected, the drive is braked along the OFF3 ramp (p1135) and STO/SBC is automatically initiated after the delay time has expired (p9652/p9852).

  After the function has been selected, the delay timer runs down - even if the function is deselected during this time. In this case, after the delay time has expired, the STO/SBC function is selected and then again de-selected immediately.
- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.
- A debounce function can be applied to the terminals of the Control Unit and the Motor Module in order to prevent incorrect trips due to signal disturbances. The filter times are set using parameters p9651 and p9851.

Enabling the "Safe Stop 1" function

The "Safe Stop 1" (SS1) function is enabled via the following parameters:

- SS1 via terminals or PROFIsafe:
  - By entering the delay time in p9652 and p9852,

Prerequisite

The "Safe Torque Off" function must be enabled.

In order that the drive can brake down to a standstill even when selected through one channel, the time in p9652/p9852 must be shorter than the sum of the parameters for the data cross-check (p9650/p9850 and p9658/p9858).

The time in p9652/p9852 must be dimensioned so that after selection, the drive brakes to a standstill.

Status for "Safe Stop 1"

The status of the "Safe Stop 1" (SS1) function is displayed using the parameters r9772, r9872, r9773 and r9774.

Alternatively, the status of the functions can be displayed using the configurable messages N01621 and N30621 (configured using p2118 and p2119).

Overview of important parameters

- p1135[0...n] OFF3 ramp-down time
- p9652 SI Safe Stop 1 delay time (Control Unit)
- r9720.0...10 CO/BO: SI Motion control signals integrated in the drive
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals
- r9772 CO/BO: SI Status (Control Unit)
- r9773 CO/BO: SI Status (Control Unit + Motor Module)
- r9774 CO/BO: SI Status (group STO)
- r9872 CO/BO: SI Status (Motor Module)
- p9852 SI Safe Stop 1 delay time (Motor Module)

5.3 Safe Brake Control (SBC)

General description

The "Safe Brake Control" function (SBC) is used to control holding brakes that function according to the quiescent current principle (e.g. motor holding brake).

The command for releasing or applying the brake is transmitted to the Motor/Power Module via DRIVE-CLiQ. The Motor/Power Module then carries out the action and activates the outputs for the brake.

Brake activation via the brake connection on the Motor/Power Module is carried out using a safe, two-channel method.

> ⚠ **WARNING**
>
> The "Safe Brake Control" function does not detect electrical faults or mechanical defects.
> The system does not detect whether a brake is worn, for example, or has a mechanical defect, or whether it opens or closes.
> A cable break or a short-circuit in the brake winding is only detected when the state changes, i.e. when the brake either opens or closes.

Functional features of "Safe Brake Control"

- When "Safe Torque Off" (STO) is selected or when safety monitoring functions respond, SBC is executed with safe pulse suppression.
- Unlike conventional brake control, SBC is executed via p1215 through two channels.
- SBC is executed regardless of the brake control or mode set in p1215. SBC is not recommended, however, when 1215 = 0 or 3.
- The function must be enabled using parameters.
- If SBC is enabled, each time "Safe Torque Off" is selected, the holding brake is closed immediately with forced dormant error detection.
- When the state changes, electrical faults, such as e.g. a short-circuit in the brake winding or wire breakage can be detected.
- A debounce function can be applied to the terminals of the Control Unit and the Motor/Power Module in order to prevent incorrect trips due to signal disturbances. The filter times are set using parameters p9651 and p9851.

Enabling the "Safe Brake Control" function

The "Safe Brake Control" function is enabled via the following parameters:

- p9602 SI enable safe brake control (Control Unit)
- p9802 SI enable safe brake control (Motor Module)

The "Safe Brake Control" function is not triggered until at least one safety monitoring function is enabled (i. e. p9601 = p9801 ≠ 0).

Two-channel brake control

Note

Connecting the brake

The brake cannot be directly applied at the motor module of the chassis design. The connection terminals are designed only for 24 V DC with 100 mA; additional hardware is necessary for higher currents and voltages.

The brake is essentially controlled from the Control Unit. Two signal paths are available for applying the brake.

For the "Safe Brake Control" function, the Motor/Power Module assumes a monitoring function to ensure that when the Control Unit fails or malfunctions the brake current is interrupted therefore closing the brake.

The brake diagnosis can only reliably detect a malfunction in either of the switches (TB+, TB-) when the status changes (when the brake is released or applied).

If the Motor/Power Module or the Control Unit detects a fault, the brake current is switched off and the safe condition is thereby achieved.

Response time with the "Safe Brake Control" function

For the response times when the function is selected/deselected via input terminals, see the table in chapter "System features", subchapter, "Response times".

Example - booksize design

Safety Integrated Basic Functions via terminals:

Safety monitoring clock cycle CU (r9780) = 4 ms and
inputs/outputs sampling time (p0799) = 4 ms

t_{R_type} = 4 x r9780 (4 ms) + p0799 (4 ms) = 20 ms

t_{R_max} = 8 x r9780 (4 ms) + p0799 (4 ms) = 36 ms

Overview of important parameters

- p0799 CU inputs/outputs sampling time
- p9602 SI enable, functions integrated in the drive (Control Unit)
- r9780 SI Monitoring clock cycle (Control Unit)
- p9802 SI enable safe brake control (Motor Module)
- r9880 SI monitoring clock cycle (Motor Module)

5.4 Safety faults

The fault messages of the Safety Integrated Basic Functions are saved in the standard message buffer and can be read out from there.

When faults associated with Safety Integrated Basic Functions occur, the following stop responses can be initiated:

Table 5- 1 Stop responses for Safety Integrated Basic Functions

<table>
<tr><th>Stop response</th><th>Triggered ...</th><th>Action</th><th>Effect</th></tr>
<tr><td>STOP A cannot be acknowledged</td><td>For all non-acknowledgeable Safety faults with pulse suppression.</td><td rowspan="2">Trigger safe pulse suppression via the switch-off signal path for the relevant monitoring channel. During operation with SBC:
apply motor holding brake.</td><td rowspan="2">The motor coasts to a standstill or is braked by the holding brake.</td></tr>
<tr><td>STOP A</td><td>For all acknowledgeable Safety faults
As a follow-up reaction of STOP F.</td></tr>
<tr><td></td><td colspan="3">STOP A corresponds to Stop Category 0 to EN 60204-1.
With STOP A, the motor is switched directly to zero torque via the "Safe Torque Off (STO)" function.
A motor at standstill cannot be started again accidentally.
A moving motor coasts to standstill. This can be prevented by using external braking mechanisms, e.g. holding or operating brake.
When STOP A is present, "Safe Torque Off" (STO) is active.</td></tr>
<tr><td>STOP F</td><td>If an error occurs in the data cross-check.</td><td>Transition to STOP A.</td><td>Follow-up response STOP A with adjustable delay (default setting without delay) if one of the Safety functions is selected</td></tr>
<tr><td></td><td colspan="3">STOP F is permanently assigned to the data cross-check (DCC). In this way, errors are detected in the monitoring channels.
After STOP F, STOP A is triggered.
When STOP A is present, "Safe Torque Off" (STO) is active.</td></tr>
</table>

⚠ WARNING

With a vertical axis or pulling load, there is a risk of uncontrolled axis movements when STOP A/F is triggered. This can be prevented by using "Safe Brake Control (SBC)" and a holding brake (not a safety brake!) with sufficient holding force.

Acknowledging the Safety faults

Faults associated with Safety Integrated Basic Functions must be acknowledged as follows:

1. Remove the cause of the fault.
2. Deselect "Safe Torque Off" (STO).
3. Acknowledge the fault.

If the Safety commissioning mode is exited when the Safety functions are switched off (p0010 = value not equal to 95 when p9601 = p9801 = 0), then all the Safety faults can be acknowledged.

Once Safety commissioning mode has been selected again (p0010 = 95), all the faults that were previously present reappear.

NOTICE
Safety faults can also be acknowledged (as is the case for all other faults) by switching the drive unit off and then on again (POWER ON). If this action has not eliminated the fault cause, the fault is displayed again immediately after power up.

Description of faults and alarms

Note

The faults and alarms for SINAMICS Safety Integrated functions are described in SINAMICS Parameter Manual

5.5 Forced checking procedure

Forced dormant error detection or test of the switch-off signal paths for Safety Integrated Basic Functions

The forced dormant error detection function at the switch-off signal paths is used to detect software/hardware faults at both monitoring channels in time and is automated by means of activation/deactivation of the "Safe Torque Off" function.

To fulfill the requirements of ISO 13849-1 regarding timely error detection, the two switch-off signal paths must be tested at least once within a defined time to ensure that they are functioning properly. This functionality must be implemented by means of forced dormant error detection function, triggered either in manual mode or by the automated process.

A timer ensures that forced dormant error detection is carried out as quickly as possible.

- p9659 SI timer for the forced dormant error detection.

Forced dormant error detection must be carried out at least once during the time set in this parameter.

Once this time has elapsed, an alarm is output and remains present until forced dormant error detection is carried out.

The timer returns to the set value each time the STO function is deactivated.

When the appropriate safety devices are implemented (e.g. protective doors), it can be assumed that running machinery will not pose any risk to personnel. For this reason, only an alarm is output to inform the user that a forced dormant error detection run is due and to request that this be carried out at the next available opportunity. This alarm does not affect machine operation.

The user must set the time interval for carrying out forced dormant error detection to between 0.00 and 9000.00 hours depending on the application (factory setting: 8.00 hours).

Examples of when to carry out forced dormant error detection:

- When the drives are at a standstill after the system has been switched on (POWER ON).
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent)

NOTICE
The timer of the Basic Functions will be reset if the associated forced dormant error detection is executed and the Extended Functions are used simultaneously. Discrepancy is not checked at the terminals used to select the Basic Functions as long as STO is set by the Extended Functions. This means that the forced dormant error detection procedure of the Basic Functions always has to be executed without simultaneous selection of STO or SS1 by the Extended Functions. It is otherwise not possible to verify the correct control through the terminals.

6 Safety Integrated Extended Functions

6.1 Safety functions "with encoder" / "without encoder"

For activation of the Safety Integrated Functions "with encoder" and "without encoder", set the parameters p9306 and p9506 (factory setting = 0). You can also make this setting by selecting "with encoder" or "without encoder" on the Safety Integrated STARTER screen. This STARTER screen can be found for each drive under "Functions" → "Safety Integrated".

- Operation with encoder
  p9306 = p9506 = 0
- Operation without encoder
  p9306 = p9506 = 1

Restrictions for Safety Integrated Extended Functions "without encoder"

The following restrictions apply for the Extended Functions "without encoder":

	Cannot be used in conjunction with
1	SINAMICS chassis format
2	Synchronous motors
3	Torque control
4	Software gating unit

	Cannot be used in conjunction with the following functions
1	Motor identification [1)]
2	Rotating measurement [1)]
3	Flying restart
4	Pole position identification
5	Vdc control
6	DC braking (DC brake)
7	Measurement functions (frequency response measurement)
8	Current limitation (I_{Lim})

[1)] Note: Carry out these functions before commissioning the Safety Functions.

> ⚠ **CAUTION**
>
> Safety Integrated Extended Functions "without encoder" must not be used if the motor, after it has been switched off, can still be accelerated by the mechanical elements of the connected machine component.
>
> Whether or not a mechanical brake is installed is irrelevant here.

Examples:

1. For the hoisting gear of a crane, the suspended load can accelerate the motor as soon as the motor is switched off. In this case, safety functions SS1 and SLS are not permitted.

   Even if the mechanical brake of the hoisting gear is generally applied after the motor has been switched off, the use of safety functions SS1 and SLS in this application is still prohibited.
2. A horizontal conveyor is always braked to a standstill due to friction as soon as the motor is switched off. In this case, safety functions SS1 and SLS can be used without any restriction.

6.2 Safety licenses for 1 to 5 axes

6.2.1 Safety licenses for S120 Chassis

6.2.1.1 Option F01 to F05 (safety licenses for 1 to 5 axes)

The Safety Integrated basic functions are unlicensed. A license is, however, required for each axis with safety functions in the case of Safety Integrated Extended Functions. In this regard it is irrelevant which safety functions are used and how many.

The option F01 stands for 1 axis, option F02 stands for 2 axes, etc. to option F05 for 5 axes.

- F01: Safety license for 1 axis
- F02: Safety license for 2 axes
- F03: Safety license for 3 axes
- F04: Safety license for 4 axes
- F05: Safety license for 5 axes

Note

Currently on a Control Unit CU320-2, a max. of 5 safety axes with Safety Integrated Extended Functions are possible.

Licenses

The required licenses can optionally be ordered with the CompactFlash Card.

Retroactive licensing is executed on the Internet via the "WEB License Manager" by generating a license key:
http://www.siemens.com/automation/license

Note

The process for generating a license key is described in detail in the SINAMICS S120 Function Manual, chapter, "Fundamentals of the drive system" under, "Licensing.

Activation

The associated license key is entered in parameter p9920 in ASCII code. The license key is activated using parameter p9921 = 1.

Diagnosis

An insufficient license is indicated via the following alarm and LED:

- Warning A13000 → License not sufficient
- LED READY → Flashes green/red at 0.5 Hz

6.2.2 Safety licenses for S120 Cabinet Modules and S150

6.2.2.1 Option K01 to K05 (safety licenses for 1 to 5 axes)

The Safety Integrated basic functions are unlicensed. A license is, however, required for each axis with safety functions in the case of Safety Integrated Extended Functions. In this regard it is irrelevant which safety functions are used and how many.

The option K01 stands for 1 axis, option K02 stands for 2 axes, etc. to option K05 for 5 axes.

- K01: Safety license for 1 axis
- K02: Safety license for 2 axes
- K03: Safety license for 3 axes
- K04: Safety license for 4 axes
- K05: Safety license for 5 axes

Note

Currently on a Control Unit CU320-2, a max. of 5 safety axes with Safety Integrated Extended Functions are possible.

Licenses

The required licenses can optionally be ordered with the converter cabinet.

Retroactive licensing is executed on the Internet via the "WEB License Manager" by generating a license key:
http://www.siemens.com/automation/license

Note

The process for generating a license key is described in detail in the SINAMICS S120 Function Manual, chapter, "Fundamentals of the drive system" under, "Licensing.

Activation

The associated license key is entered in parameter p9920 in ASCII code. The license key is activated using parameter p9921 = 1.

Diagnosis

An insufficient license is indicated via the following alarm and LED:

- Warning A13000 → License not sufficient
- LED READY → Flashes green/red at 0.5 Hz

6.3 Safe Torque Off (STO)

In addition to the control options specified under Safety Integrated Basic Functions, "Safe Torque Off (STO) under Safety Integrated Extended Functions can also be activated via TM54F or PROFIsafe.

Note

Use of the "Safe Torque Off" (STO) safety function without encoder is only possible with asynchronous motors.

Functional features of "Safe Torque Off"

The functionality of "Safe Torque Off (STO) is described in the section, "Safety Integrated Basic Functions".

6.4 Safe Stop 1 (SS1)

6.4.1 Safe Stop 1 with encoder (time and acceleration controlled)

General description

The "Safe Stop 1" (SS1) function with encoder monitors whether motor acceleration reaches impermissible levels during the SS1 time.

The "Safe Stop 1" (SS1) function allows the drive to be stopped to EN 60204-1, Stop Category 1. The drive brakes with the OFF3 ramp (p1135) once "Safe Stop 1" is selected and switches to "Safe Torque Off" (STO) once the delay time has elapsed (p9356/p9556) or when the shutdown speed is reached (p9360/p9560).

If the drive complies with acceleration monitoring limits, STO is triggered when the shutdown speed is reached. If acceleration monitoring limits are violated, messages C01706 and C30706 are output and the drive is stopped with STOP A. If the motor does not reach the shutdown speed within the set braking time, STO is still triggered and the drive coasts to a standstill. No message is issued.

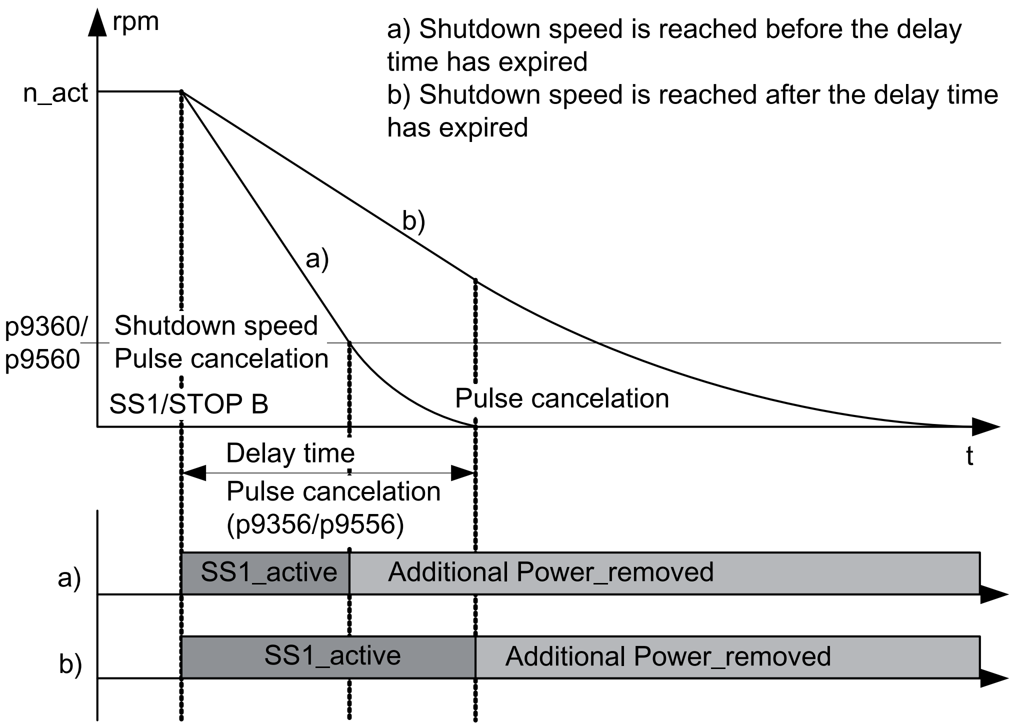

Figure 6-1 Sequence for "Safe Stop 1" with encoder

Functional features of "Safe Stop 1" with encoder

- The delay time starts after the function is selected. If SS1 is deselected again within this time, after the delay time has expired or after the shutdown speed has been undershot, the STO function is selected and then immediately deselected again.
- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.
- The "Safe Acceleration Monitor" (SBR) function is activated when braking (see "Safe Acceleration Monitor").

Note

Activating SS1 can mean that the device (PLC, motion controller) which issues the speed setpoint interrupts the ramp function with OFF2.
The reason is a fault response of this device, which is initiated due to the activation of OFF3. The fault response can be prevented using suitable parameterization or wiring, which then signals the initiation of SS1 to this device.

Note

If you use SS1 under EPOS, then an OFF2 is not permitted as fault response to a following error.

Commissioning

Note

When "Safe Stop 1" (SS1) is installed, the function "Safe Acceleration Monitor" (SBR) is active. For assigning parameters to the "Safe Acceleration Monitor" (SBR) function
→ see section " Safe Acceleration Monitor" (SBR).

The delay time is set by entering parameters p9356 and p9556. The delay time until the pulses are suppressed can be shortened by defining a shutdown speed in p9360 and p9560.

To enable the drive to decelerate to standstill, the time set in p9356/p9556 must be sufficient to allow the drive to decelerate to below the shutdown speed in p9360/p9560 with the OFF3 ramp (p1135).

The shutdown speed defined in p9360/p9560 must be set in such a way that personal safety or the safety of the machine is not compromised as of this speed and as a result of subsequent coasting due to the pulses being suppressed.

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

System errors:

1. STOP F with subsequent STOP B, followed by STOP A
2. Safety message C01711/C30711

Status for "Safe Stop 1"

The status of the "Safe Stop 1" function is displayed using the following parameters:

- r9722.1 CO/BO: SI Motion status signals, SS1 active
- r9722.0 CO/BO: SI Motion status signals, STO active (power removed)

6.4.2 Safe Stop 1 without encoder (time and speed controlled)

Note

Use of "Safe Stop 1" (SS1) without encoder s only possible for asynchronous motors.

Functional features of "Safe Stop 1" without encoder

The motor is immediately braked with the OFF3 ramp as soon as "Safe Stop 1" is triggered. Monitoring is activated once the delay time in p9582/p9382 has elapsed. Monitoring ensures that the motor does not exceed the set braking ramp during the braking process. As soon as the speed drops below the breaking speed (p9560/p9360), safe monitoring of the brake ramp is deactivated and safe pulse suppression (STO) is activated. If the set brake ramp is violated (exceeded), messages C01706 and C30706 are output and the drive is stopped with STO (STOP A).

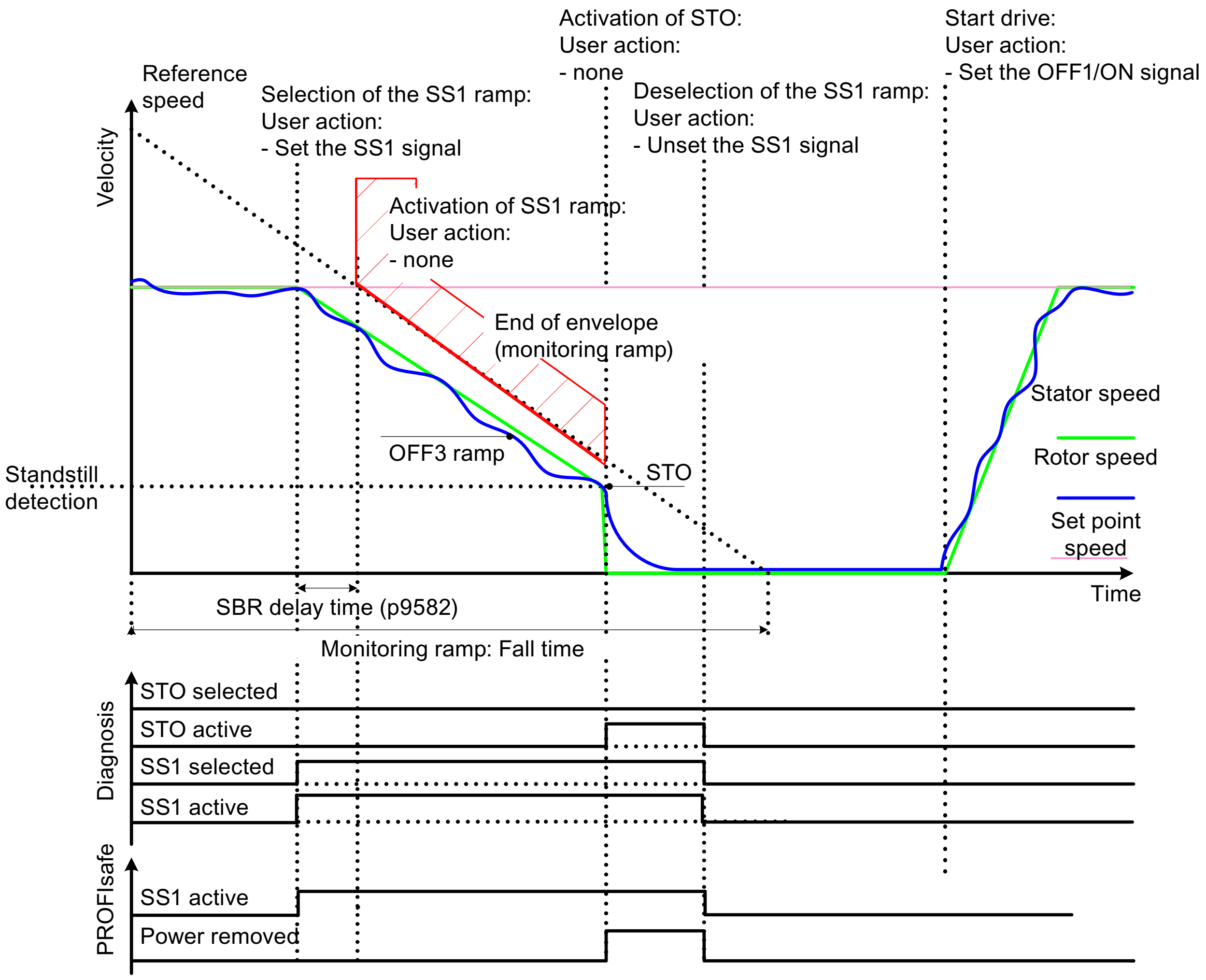

Figure 6-2 Sequence for "Safe Stop 1" without encoder

Braking ramp for "Safe Stop 1" without encoder

p9581/p9381 and p9583/p9383 are used to set the steepness of the brake ramp. Parameters p9581/p9381 determine the reference speed and parameters p9583/p9383 define the monitoring period. Parameters p9582/p9382 are used to set the time between the triggering of Safe Stop 1 and the start of brake ramp monitoring.

Restrictions

For the restrictions on "Safe Stop 1" without encoder, see section
→ "Safety Integrated Extended Functions" / Safety Functions "with encoder"/"without encoder"

6.4.3 Overview of important parameters

- p1135[0...n] OFF3 ramp-down time
- p9301 SI Motion enable safety functions (Motor Module)
- p9501 SI Motion enable safety functions (Control Unit)
- p9306 SI Motion function specification (Motor Module)
- p9506 SI Motion function specification (Control Unit)
- p9360 SI Motion pulse cancelation shutdown speed (Motor Module)
- p9560 SI Motion pulse cancelation shutdown speed (Control Unit)
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals

Only for SS1 with encoder:

- p9348 SI Motion SBR actual velocity tolerance (Motor Module)
- p9548 SI Motion SBR actual velocity tolerance (Control Unit)
- p9356 SI Motion pulse cancelation delay time (Motor Module)
- p9556 SI Motion pulse cancelation delay time (Control Unit)

Only for SS1 without encoder:

- p9381 SI Motion braking ramp reference value (Motor Module)
- p9581 SI Motion braking ramp reference value (Control Unit)
- p9382 SI Motion brake ramp delay time (Motor Module)
- p9582 SI Motion brake ramp delay time (Control Unit)
- p9383 SI Motion brake ramp monitoring time (Motor Module)
- p9583 SI Motion brake ramp monitoring time (Control Unit)

6.5 Safe Stop 2 (SS2)

6.5.1 General description

Note

The safety function "Safe Stop 2" (SS2) can only be used with an encoder.

The "Safe Stop 2" (SS2) function is used to brake the motor safely along the OFF3 deceleration ramp (p1135) with subsequent transition to the SOS state (see "Safe Operating Stop") after the delay time expires (p9352/p9552). The delay time set must allow for the drive to brake down to a standstill within this time. The standstill tolerance (p9330/p9530) may not be violated after this time.

After the braking operation is completed, the drives remain in the speed control mode with the speed setpoint n = 0.

⚠ WARNING
The motor is supplied with current during SS2.

The default setpoint (e.g from the setpoint channel, or from a higher-level control system) remains locked as long as SS2 is selected. The "Safe Acceleration Monitor" (SBR) function is selected during braking.

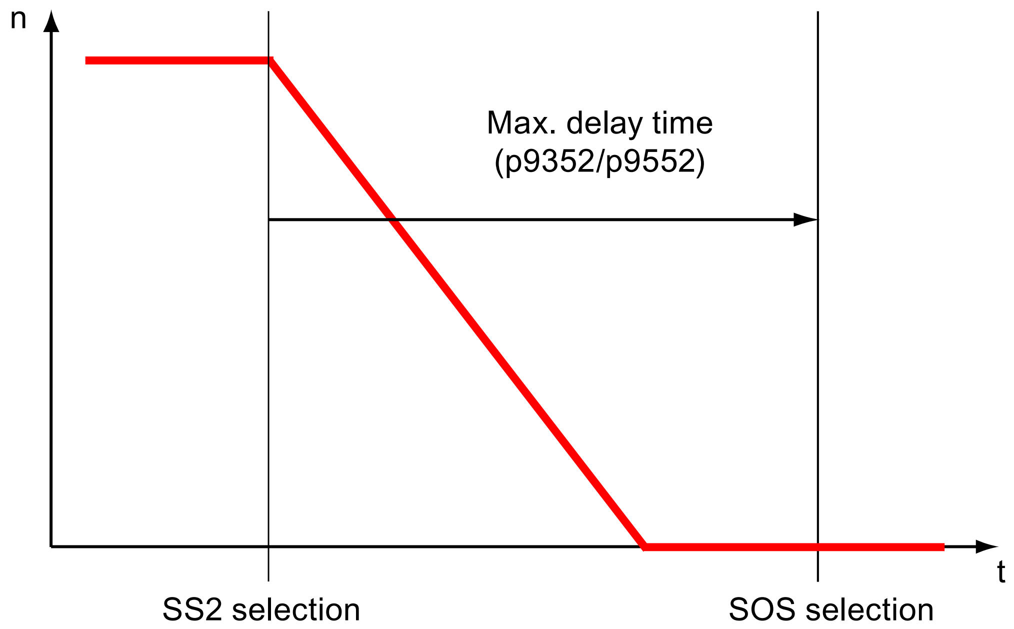

Figure 6-3 Sequence with SS2 selection

Note

Activating SS2 may cause the device (PLC, motion controller) that governs the speed setpoint to interrupt the ramp function (by triggering OFF2).
The device behaves in this way as a result of a fault reaction triggered by OFF3 activation. This fault reaction can be avoided by assigning appropriate parameters or appropriate wiring.

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

Standstill tolerance violated in p9330/p9530 (SOS):

- STOP B with subsequent STOP A
- Safety message C01707/C30707

System errors:

- STOP F with subsequent STOP A
- Safety message C01711/C30711

Overview of important parameters

- p1135[0...n] OFF3 ramp-down time
- p9301 SI Motion enable safety functions (Motor Module)
- p9501 SI Motion enable safety functions (Control Unit)
- p9330 SI Motion standstill tolerance (Motor Module)
- p9530 SI Motion standstill tolerance (Control Unit)
- p9348 SI Motion SBR actual velocity tolerance (Motor Module)
- p9548 SI Motion SBR actual velocity tolerance (Control Unit)
- p9352 SI Motion transition time STOP C to SOS (Motor Module)
- p9552 SI Motion transition time STOP C to SOS (Control Unit)
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals

6.5.2 EPOS and Safe Stop 2

Since the function SS2 – with its setpoint-independent braking – is not suitable for use with EPOS, the Safe Operating Stop (SOS) function can be used with delay.

On selection of SOS, the EPOS function "intermediate stop" (p2640 = 0) ensures that EPOS is able to stop the drive in its tracks and then keep it under control in this state before the SOS becomes active. The maximum necessary braking time (from p2573 and p2645 from EPOS) must then be entered in the delay time for SLS/SOS (p9551/p9351) with a small safety addition: This ensures that the drive is stationary before SOS becomes active.

Proceed as follows:

1. Connect the EPOS function "intermediate stop" (p2640) with the SOS selection (p9720.3).
2. Enter the maximum necessary braking time from EPOS (depending on the values set in p2573 and p2645) with a safety addition (+1 to +5%) in the SOS delay time (p9551/p9351).

Overview of important parameters

- p2573 EPOS maximum deceleration
- p2594 CI: EPOS maximum speed externally limited
- p2640 BI: EPOS intermediate stop (0 signal)
- p2645 CI: EPOS direct setpoint input/MDI, deceleration override
- p9351 SI Motion SLS changeover delay time (Motor Module)
- p9551 SI Motion SLS(SG) changeover delay time (Control Unit)
- r9720.0...10 CO/BO: SI Motion control signals integrated in the drive
- r9733[0...1] CO: SI Motion speed setpoint limit active

6.6 Safe Operating Stop (SOS)

General description

Note

The "Safe Operating Stop" function is only available for operation with an encoder.

This function serves for fail-safe monitoring of the standstill position of a drive.

Personnel can enter the protected machine areas without having to shut down the machine as long as SOS is active.

Drive standstill is monitored by means of an SOS tolerance window (p9330 and p9530). The function SOS comes into effect in the following cases:

- After SOS has been selected and after the delay time set in p9351/p9551 has elapsed. The drive must be braked to standstill within this delay time (e.g. by the controller).
- As a consequence of SS2.
- As a consequence of STOP C.
- As a consequence of STOP D.

When this function is activated, the current actual position is saved as a comparative position, until SOS is deselected again. There is no delay time after SOS has been deselected; the drive can be operated immediately and also again accelerates immediately to the setpoint set at that time.

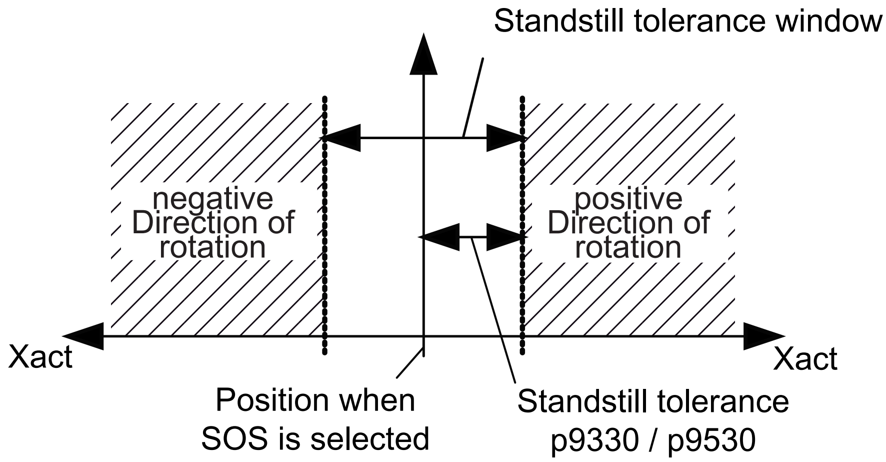

Figure 6-4 Standstill tolerance

Functional features of "Safe Operating Stop" with encoder

- The drive remains in the closed-loop control mode.
- A programmable standstill tolerance window is available.
- STOP B is the stop response if the standstill tolerance window is violated

---

Note

The size of the tolerance window should be slightly above the standard standstill monitoring limit, otherwise the standard monitoring functions will no longer be effective.

Parameter r9731 displays the safe position accuracy (load side) that can be achieved as a maximum due to the acquisition of the actual value for the safe motion monitoring functions.

Responses

Standstill tolerance violated in p9330/p9530:

- STOP B with subsequent STOP A
- Safety message C01707/C30707

System errors:

- STOP F
- Safety message C01711/C30711

Overview of important parameters

- p9301 SI Motion enable safety functions (Motor Module)
- p9501 SI Motion enable safety functions (Control Unit)
- p9330 SI Motion standstill tolerance (Motor Module)
- p9530 SI Motion standstill tolerance (Control Unit)
- p9351 SI Motion SLS changeover delay time (Motor Module)
- p9551 SI Motion SLS(SG) changeover delay time (Control Unit)
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals
- r9731 SI Motion safe position accuracy

6.7 Safely-Limited Speed (SLS)

6.7.1 General description

The Safely-Limited Speed (SLS) function is used to protect a drive against unintentionally high speeds in both directions of rotation. This is achieved by monitoring the current drive speed up to a speed limit.

Safely-Limited Speed prevents a parameter-assigned speed limit from being exceeded. Limits must be specified based on results of the risk analysis. Up to 4 different SLS speed limits can be assigned via parameter p9331[0 to 3]/p9531[0 to 3].

Changeover of speed limits

The switchover is executed binary-coded via two F-DIs or two PROFIsafe control bits. The speed selection status can be checked using parameters r9720.9/r9720.10. Parameters r9722.9 and r9722.10 indicate the actual speed limit, bit r9722.4 must carry a "1" signal.

Table 6- 1 Changeover of speed limits:

F-DI for bit 1 (r9720.10)	F-DI for bit 0 (r9720.9)	Speed limit	SLS level
0	0	p9331[0]/p9531[0]	1
0	1	p9331[1]/p9531[1]	2
1	0	p9331[2]/p9531[2]	3
1	1	p9331[3]/p9531[3]	4

The changeover from a lower to a higher speed limit takes effect without any delay.

The changeover from a higher to a lower limit triggers a delay time which can be set at the corresponding parameter (p9351 and p9551).

⚠ CAUTION

SLS level 1 must be defined as the lowest speed limit value.

SLS level 1 is activated after two unacknowledged discrepancy errors; in other words, 0 is the fail-safe value for the 2 F-DIs for speed level selection. The SLS levels to be switched between should, therefore, always be assigned via parameter in ascending order, i.e. with SLS level 1 as the lowest speed and SLS level 4 as the highest.

6.7.2 Parking note

Note

When a drive object for which the "Safely Limited Speed" function with encoder is enabled is switched to "Park" mode, the Safety Integrated software responds by selecting STO without generating a separate message. This internal STO selection is displayed in parameter r9772.19.

6.7.3 Safely-Limited Speed with encoder

Functional features of "Safely Limited Speed" with encoder

To ensure that the drive reaches the reduced speed below the new speed limit value once the delay time has elapsed, it must be braked accordingly within the delay time by means of the higher-level motion control/setpoint channel. The previous SLS limit value is still active during the delay time.

- A selected speed limit is activated once SLS has been selected and after the delay time (p9351/p9551) has elapsed. When switching over to a lower speed limit value, the speed must be braked to below the new maximum limit value within this delay time.
- However, if the ACTUAL speed is higher than the new speed limit value after the delay time has expired, an appropriate signal is generated with the parameterized stop response.
- The stop responses are parameterized using p9363/p9563.
- The delay time is not active when switching over to a higher speed limit value.
- 4 parameterizable speed limit values p9331[0...3] and p9531[0...3]

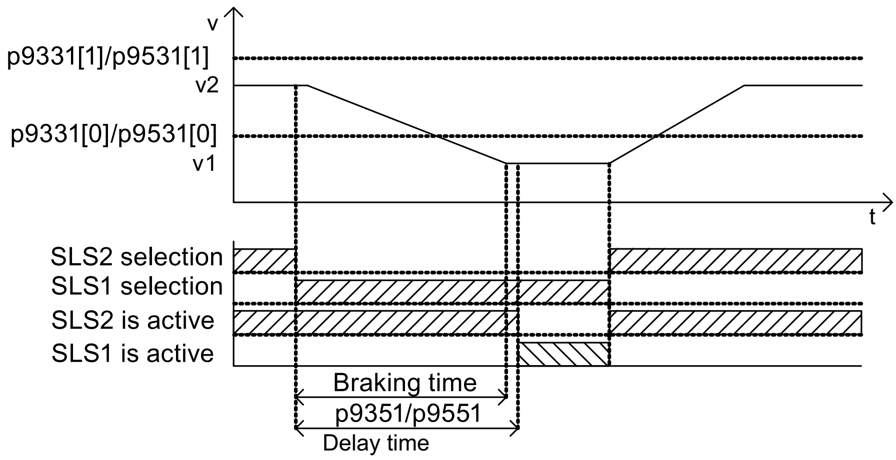

Figure 6-5 Delay time SLS speed limit value

A speed setpoint limit can be set as percentage in p9533. This value is used to calculate a speed setpoint limit r9733, depending on the selected speed limit p9531[x].

As opposed to SLS limit parameters, this parameter specifies limits on the motor side instead of limits on the load side.

- r9733[0] = p9531[x] * p9533; x = selected SLS stage
- r9733[1] = - p9531[x] * p9533; x = selected SLS stage

Responses

Speed limit value exceeded:

- Configured subsequent stop STOP A / B / C / D by means of p9363/p9563
- Safety message C01714/C30714

System errors:

- STOP F
- Safety messages C01711/C30711

6.7.4 Safely-Limited Speed without encoder

Functional features of "Safely Limited Speed" without encoder

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Note

The use of the safety function, "Safely-Limited Speed" (SLS) without encoder is only possible for asynchronous motors.

If you are using a speed setpoint limit, after activating SLS the motor will immediately be braked with the OFF3-ramp from the current speed under the selected SLS [1 to 4] speed limit; otherwise the motor will continue to run and violate the Safe Brake Ramp. Monitoring is activated after delay time p9582/p9382 (SI Motion brake ramp delay time Control Unit/Motor Module) has elapsed. Monitoring ensures that the motor does not exceed the safe brake ramp (SBR) during braking. If the brake ramp is violated, messages C01706 and C30706 are output and the drive is stopped with STOP A.

The new SLS speed limit is accepted as the new limit speed if either the brake ramp has reached the new SLS speed limit or the actual speed of the drive was below the new SLS speed limit for at least as long as p9582 (SI Motion brake ramp delay time Control Unit).

The SLS function then monitors whether the new actual speed remains below the selected SLS speed limit. The parameter-assigned stop response is triggered if the limit speed is exceeded (p9563[x]).

Configuring the limits

- Speed limits for SLS without encoder are configured in exactly the same way as described for SLS with an encoder.
- Only STOP A and STOP B may be configured as stop responses for "Safely-Limited Speed" (SLS) without encoder.

Signal profile for SLS without encoder

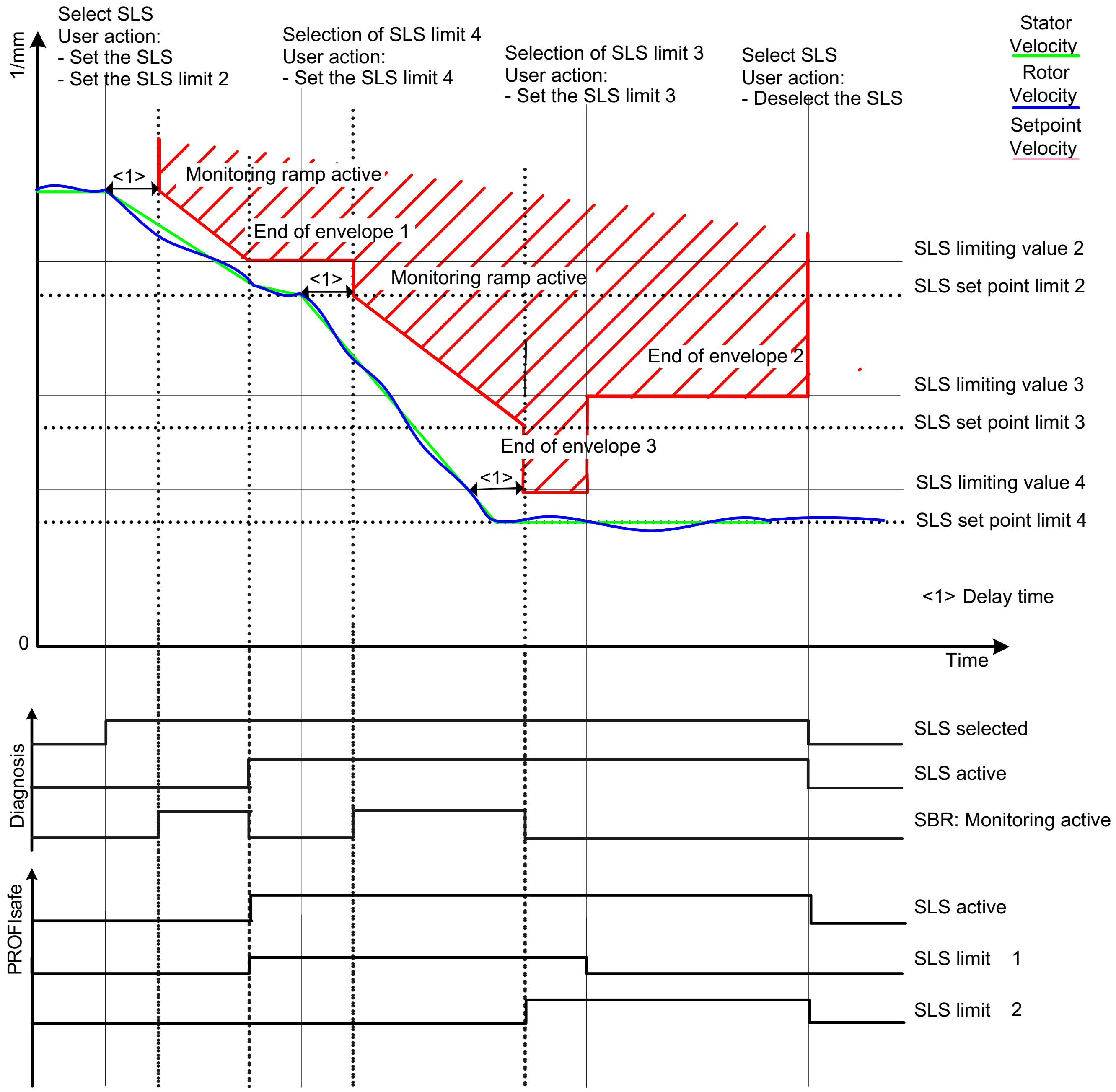


Figure 6-6 Signal profile for SLS without encoder

Restart after OFF2

If the drive has been switched off via OFF2/STO, the following steps must be carried out before a restart can be performed:

1. scenario:

- State after switching on: SLS selected, STO selected, OFF2 active
- Deselect STO
- The drive enable must be given within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.

2. scenario

- Situation: Run until standstill with SLS selected, then OFF2 activated
- Select STO
- Deselect STO

  STO activated internally via OFF2: This activation must be undone by selection/deselection.
- The drive enable must be given within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.

3. scenario

- Situation: Run until standstill with SLS selected, then OFF2 activated
- Deselect SLS
- Select SLS

  STO activated internally via OFF2: This activation must be undone by selecting/deselecting SLS.
- After this the drive enable must be given by a positive edge at OFF1.

4. scenario

- Situation: All Safety Integrated Functions are deselected
- After this the drive enable must be given by a positive edge at OFF1.

Note

In the 4th case the motor is not reliably started.

Brake rampe for "Safely-Limited Speed"

p9581/p9381 and p9583/p9383 are used to set the steepness of the brake ramp. Parameters p9581/p9381 determine the reference speed and parameters p9583/p9383 define the monitoring period. Parameters p9582/p9382 are used to set the time which elapses between the switchover to a lower SLS speed level and the start of brake ramp monitoring.

6.7.5 Overview of important parameters

- p9301.0 SI Motion enable safety functions (CPU 2)
- p9501.0 SI Motion enable safety functions (CPU 1)
- p9306 SI Motion function specification (Motor Module)
- p9506 SI Motion function specification (Control Unit)
- p9331[0 to 3] SI Motion SLS limits (Motor Module)
- p9531[0 to 3] SI Motion SLS (SG) limits (Control Unit)
- p9351 SI Motion SLS changeover delay time (Motor Module)
- p9551 SI Motion SLS(SG) switchover delay time (Control Unit)
- p9381 SI Motion braking ramp reference value (Motor Module)
- p9581 SI Motion braking ramp reference value (Control Unit)
- p9382 SI Motion brake ramp delay time (Motor Module)
- p9582 SI Motion brake ramp delay time (Control Unit)
- p9383 SI Motion brake ramp monitoring time (Motor Module)
- p9583 SI Motion brake ramp monitoring time (Control Unit)
- p9601 SI enable, functions integrated in the drive (processor 1)
- p9801 SI enable, functions integrated in the drive (processor 2)
- r9714[0...1] SI Motion diagnostics speed
- r9720.0...10 CO/BO: SI Motion control signals integrated in the drive
- r9721.0 to 15 CO/BO: SI motion, status signals
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals

6.7.6 EPOS and Safely-Limited Speed

If safe speed monitoring (SLS) will also be used at the same time as the EPOS positioning function, EPOS must be informed of the activated speed monitoring limit. Otherwise the speed monitoring limit can be violated by the EPOS setpoint input. Through the SLS monitoring, this infringement results in the drive being stopped and thus abandoning the planned movement sequences. Here the relevant safety faults are output first, and only then are the subsequent faults created by EPOS output.

With its parameter r9733, the SLS function provides a setpoint limiting value which when complied with prevents the SLS limiting value from being infringed.

This means that the setpoint limiting value in r9733 must therefore be transferred to the input for the maximum setpoint speed/velocity of EPOS (p2594), to prevent an SLS limiting value infringement as a result of the EPOS setpoint input. In this regard you must set the delay time for SLS/SOS (p9551/p9351) so that the SLS only becomes active after the maximum required time for the speed to be reduced below the SLS limit. This required braking time is determined by the current speed, the jerk limit in p2574 and the maximum delay in p2573.

Overview of important parameters

- p2573 EPOS maximum deceleration
- p2574 EPOS jerk limit
- p2593 CI: EPOS LU/revolution LU/mm
- p2594 CI: EPOS maximum speed externally limited
- p9351 SI Motion SLS changeover delay time (Motor Module)
- p9551 SI Motion SLS(SG) changeover delay time (Control Unit)
- r9733(0.1) CO: SI Motion speed setpoint limit active

6.8 Safe Speed Monitor (SSM)

General description

Note

The "Safe Speed Monitor" function is only available for operation with an encoder.

The "Safe Speed Monitor" function is used for reliably detecting when a velocity limit value has been undershot (p9346/p9546) (e.g. for standstill detection) in both directions. A fail-safe output signal is available for further processing.

The function is activated automatically as soon as the Extended Functions are enabled with p9301.0 = p9501.0 = 1.

NOTICE

If 0 is entered for p9368/p9568, the speed limit of the SSM function (p9346/p9546) is also used as shutdown limit for the SBR function (safe braking ramp).

In this case, the effects of safe acceleration monitoring are therefore restricted if a relatively high SSM/SBR velocity limit is set when using the SS1 and SS2 stop functions.

WARNING

STOP F (indicated by safety message C01711/C30711) only results in a follow-up response (STOP B / STOP A) if one of the safety functions (SOS or SLS) is active or has been selected. If only the SSM function is active, a STOP F crosswise comparison error does not result in a follow-up response STOP B / STOP A.

If SSM is to be used as a safety function, at least one of the SOS or SLS functions must be active/selected (e.g. by selecting a high SLS level).

Functional features of "Safe Speed Monitor with encoder"

The parameter p9346/p9546 "SI Motion SSM (SGA n < nx) velocity limit n_x (CU)" is used to set the velocity limit. The abbreviation "SGA n < nx" indicates the safety function required for determining an output signal when a parameterizable velocity limit has been undershot.

If the velocity limit for the "Safe Speed Monitor" feedback signal (n < n_x) is undershot, the "SSM feedback signal active" signal (SGA n < n_x) is set. When the set threshold value has been undershot, the "Safe Acceleration Monitor" (SBR) function is also deactivated (see p9368/p9568). If p9368 = p9568 = 0, then p9346/p9546 (SSM feedback signal) is also used as a trip threshold for the SBR monitoring.

The hysteresis for the SSM output signal is set in parameter p9347/p9547 "SI motion SSM speed hysteresis n_x". In other words the SSM output signal can take on either state "1" or state "0" - depending on the direction from the belt is reached.

If the maximum permissible velocity tolerance is overshot (i.e. one channel displays a velocity less than p9546 - p9547, while the other channel displays a velocity greater than p9546), a STOP F is issued. As an additional function, parameters p9347/p9547 are used to define the maximum tolerance of the velocity actual values between the two channels.

In addition, the output signal for SSM can be smoothed by means of a PT1 filter by setting a filter time p9345/9545.

During safe motion monitoring, the hysteresis and filtering functions can be activated or deactivated jointly using the enable bit p9301.16 (Motor Modules) and p9501.16 (CU). In the default setting, the functions are deactivated (p9301.16/p9501.16 = 0).

NOTICE
Exception The activated "hysteresis and filtering" function is evaluated as activated monitoring function and, after a STOP F, also results in a subsequent STOP B/STOP A response.

The following diagram shows the characteristic of the safe output signal SSM when the hysteresis is active:

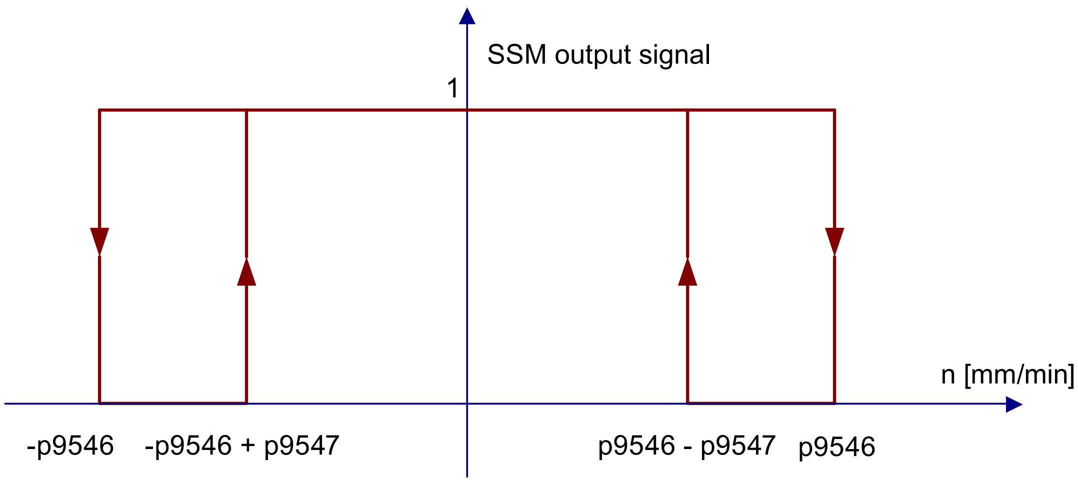


Figure 6-7 Safe output signal for SSM with hysteresis

Note

When the hysteresis and filtering are activated with output signal SSM, the axes behave in a time-delayed manner. This is a characteristic of the filter.

Features

- Safe monitoring of the speed limit specified in p9346 and p9546
- Parameterizable hysteresis via p9347 and p9547
- Variable PT1 filter via p9345 and p9545
- Fail-safe output signal
- No stop response

Overview of important parameters

- p9345 SI Motion SSM (SGA n < nx) filter time (Motor Module)
- p9545 SI Motion SSM (SGA n < nx) filter time (Control Unit)
- p9346 SI Motion SSM velocity limit (Motor Module)
- p9546 SI Motion SSM (SGA n < nx) velocity limit n_x (CU)
- p9347 SI Motion velocity hysteresis (crosswise) (Motor Module)
- p9547 SI Motion velocity hysteresis (crosswise) (Control Unit)
- p9368 SI Motion SBR velocity limit (Motor Module)
- p9568 SI Motion SBR velocity limit (CU)
- r9722.0...15 CO/BO: SI Motion drive-integrated status signals

6.9 Safe Acceleration Monitor (SBR)

General description

Note

The "Safe Acceleration Monitor" function is only available for operation with an encoder.

The "Safe Acceleration Monitor" (SBR) function with encoder is used to safely monitor drive acceleration. This function is part of the SS1 (time and acceleration-controlled) and SS2 (or STOP B and STOP C) safety functions.

Functional features of "Safe Acceleration Monitor" with encoder

A STOP A is generated if any drive acceleration within the ramp-down phase exceeds the tolerance defined in p9348/p9548. The monitoring function is activated for SS1 (or STOP B) and SS2 (or STOP C) and is deactivated after the speed drops below the value set in p9368/p9568.

NOTICE

If 0 is entered for p9368/p9568, the speed limit of the SSM function (p9346/p9546) is also used as shutdown limit for the SBR function (safe braking ramp). The SBR is deactivated if the speed is below this limit.

In this case, the effects of safe acceleration monitoring are therefore greatly restricted if a relatively high SSM/SBR velocity limit is set when using the SS1 and SS2 stop functions.

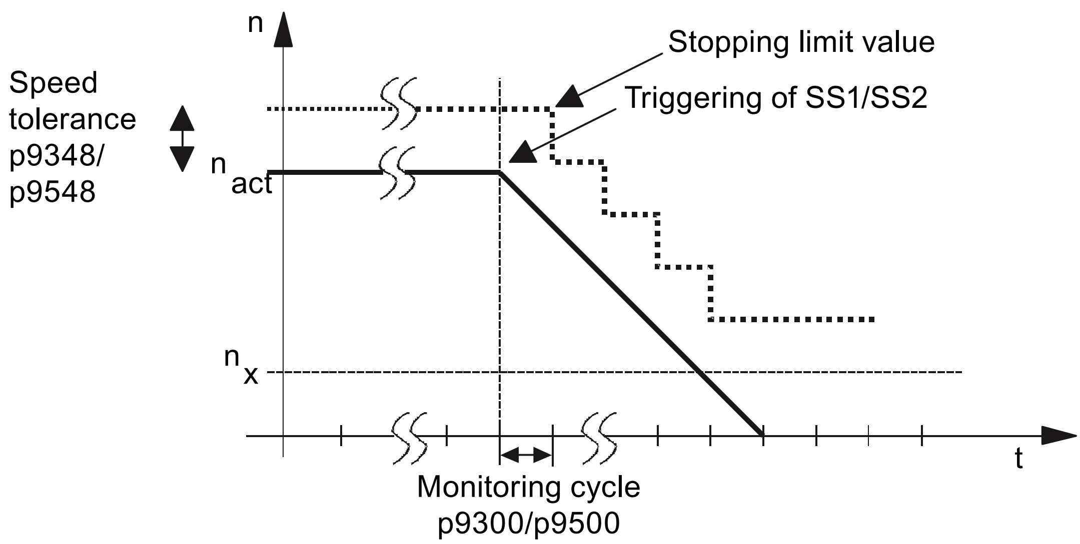


Figure 6-8 Characteristics of the shutdown limit for SBR

Calculating the SBR tolerance of the ACTUAL speed:

- The following applies when parameterizing the SBR tolerance:
  - The maximum speed increase after SS1 / SS2 is triggered is derived from the effective acceleration (a) and the duration of the acceleration phase.
  - The duration of the acceleration phase is equivalent to one monitoring clock cycle (p9300/p9500) MC (delay from detecting an SS1 / SS2 until n_{set} = 0):
- SBR tolerance:

  Actual speed SBR = acceleration * acceleration duration

  The following setup rule is derived thereof:
  - At linear axes:
    SBR tolerance [mm/min] = a [m/s^2] * MC [s] * 1000 [mm/m] * 60 [s/min]
  - At rotary axes:
    SBR tolerance [rev/min] = a [rev/s^2] * MC [s] * 60 [s/min]
- Recommendation:
  The SBR tolerance value entered should be approx. 20 % higher than the calculated value.

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

System errors:

- STOP F with subsequent STOP A
- Safety message C01711/C30711

Features

- Element of the SS1 (time and acceleration controlled) and SS2 functions
- Parameterizable, minimum shutdown speed to be monitored

Overview of important parameters

- p9346 SI Motion SSM velocity limit (Motor Module)
- p9546 SI Motion SSM (SGA n < nx) velocity limit n_x (CU)
- p9348 SI Motion SBR actual velocity tolerance (Motor Module)
- p9548 SI Motion SBR actual velocity tolerance (Control Unit)
- p9368 SI Motion SBR velocity limit (Motor Module)
- p9568 SI Motion SBR velocity limit (CU)

6.10 Safe Brake Ramp (SBR)

General description

Note

The "Safe Brake Ramp" (SBR) safety function can only be used without an encoder and should be used only with asynchronous motors.

The Safe Brake Ramp (SBR) function provides a safe method for monitoring the brake ramp. The Safe Brake Ramp function is used to monitor braking when using the "SS1 without encoder" and "SLS without encoder" functions.

Functional features of "Safe Brake Ramp" without encoder

The motor is immediately decelerated with the OFF3 ramp as soon as SS1 or SLS is triggered (if setpoint speed limitation is used). Monitoring of the brake ramp is activated once the delay time in p9582/p9382 has elapsed. Monitoring ensures that the motor does not exceed the set brake ramp (SBR) when braking. Deactivation of the safe monitoring of the brake ramp occurs according to the following basic conditions:

- for SS1:

  as soon as the speed drops below the shutdown speed (p9560/p9360).
- for SLS:
  - as soon as the set brake ramp has reached the new SLS level

    or
  - as soon as the actual speed has fallen below the newly selected SLS level and has remained there for the time parameterized in p9582/p9382.

Additional specific functions (e.g. STO, new SLS speed limit, etc.) are activated at this point, depending on the Safety Integrated Function used.

Signal profile for "Safe Brake Ramp" without encoder

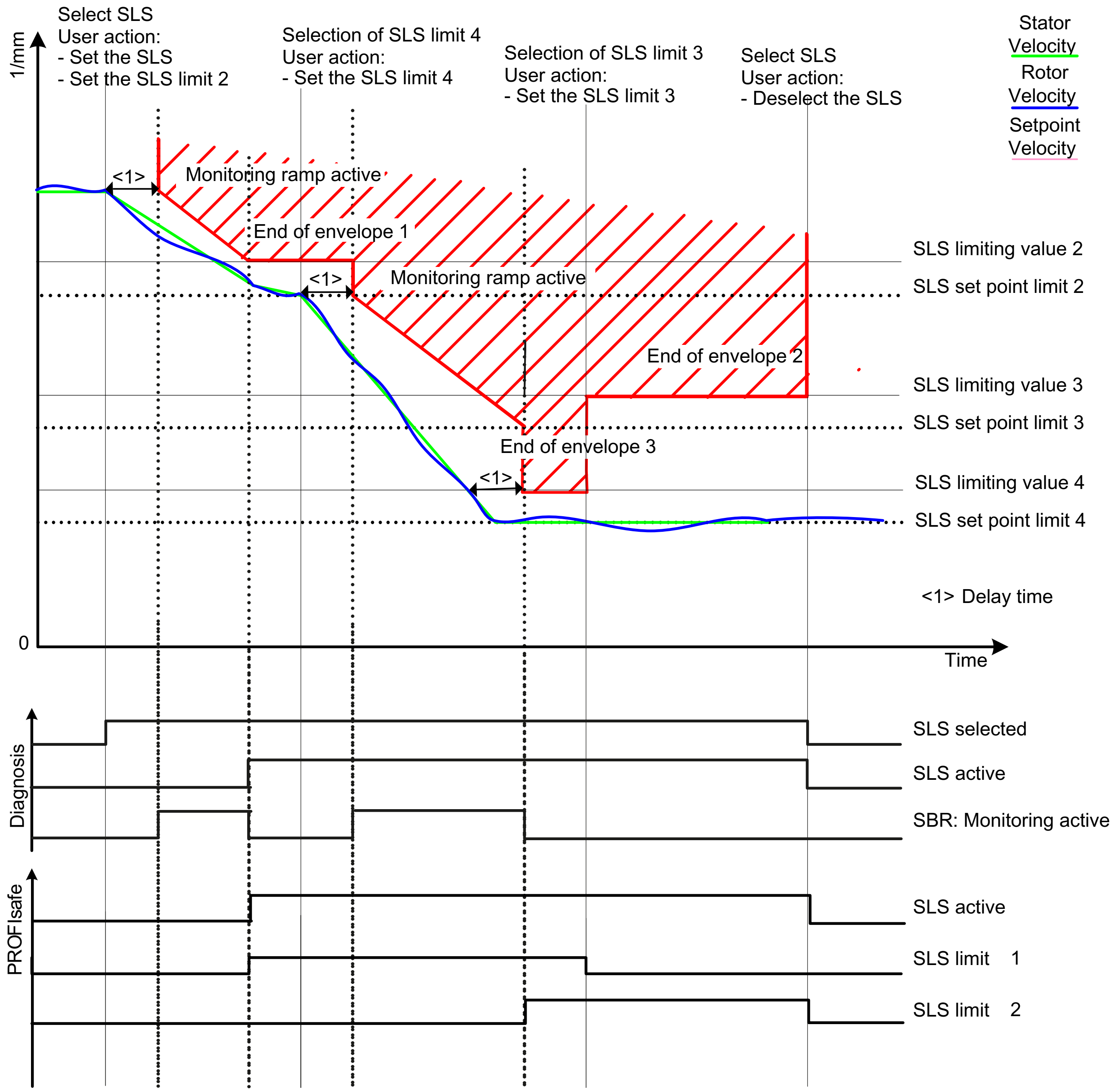


Figure 6-9 Safe Brake Ramp without encoder

Brake ramp for "Safe Brake Ramp" without encoder

p9581/p9381 (SI Motion braking ramp reference value, Control Unit/Motor Module) and p9583/p9383 (SI Motion brake ramp monitoring time, Control Unit/Motor Module) are used to set the steepness of the brake ramp. Parameters p9581/p9381 determine the reference speed and parameters p9583/p9383 define the monitoring period. Parameters p9582/p9382 are used to set the time which passes after the triggering of Safe Stop 1, selection of SLS or SLS level changeover and the start of brake ramp monitoring.

Responses to brake ramp violations (SBR)

- Safety messages C01706 (SI Motion CU: SBR limit exceeded) and C30706 (SI Motion MM: SBR limit exceeded)
- Drive stopped with STOP A

Features

- Part of the "SS1 without encoder" and "SLS without encoder" functions.
- Parameterizable safe brake ramp

Overview of important parameters

- p9360 SI Motion pulse cancelation shutdown speed (Motor Module)
- p9560 SI Motion pulse cancelation shutdown speed (Control Unit)
- p9381 SI Motion braking ramp reference value (Motor Module)
- p9581 SI Motion braking ramp reference value (Control Unit)
- p9382 SI Motion brake ramp delay time (Motor Module)
- p9582 SI Motion brake ramp delay time (Control Unit)
- p9383 SI Motion brake ramp monitoring time (Motor Module)
- p9583 SI Motion brake ramp monitoring time (Control Unit)

6.11 Safety faults

Stop responses

Faults with Safety Integrated Extended Functions and violation of limits can trigger the following stop responses:

Table 6- 2 Overview, stop responses

Stop response	Triggered ...	Action	Effect
STOP A	For all acknowledgeable safety faults with pulse disable.	Immediate pulse cancelation	Drive coasts down
STOP B	Examples: - standstill tolerance violated in p9330/p9530 (SOS). - Configured subsequent stop p9363/p9563 for SLS. - Subsequent response of STOP F.	Immediate input of speed setpoint = 0 and start of timer t_B . Once t_B or n_{act} < $n_{shutdown}$, STOP A is triggered.	STOP B with subsequent STOP A. The drive is braked along the OFF3 ramp and then switches to STOP A.
STOP C	Configurable subsequent stop p9363/p9563 with SLS.	Immediate input of speed setpoint = 0 and start of timer t_C. Once t_C has elapsed, SOS is selected.	The drive decelerates along the OFF3 ramp; SOS is then selected.
STOP D	Configurable subsequent stop p9363/p9563 with SLS.	Timer t_D starts. No drive-integrated response. SOS is activated on expiration of t_D.	The drive must be decelerated by the higher-level control (within the drive group)! Once t_D has elapsed, SOS is selected. An automatic response is only triggered if the standstill tolerance window is violated in SOS.
STOP F	If a fault occurs in the crosswise data comparison. Follow-up response STOP B.	Timer t_{F1} (Basic Functions) or t_{F2} (Extended Functions) No drive response	If a safety function (SOS, SLS) has been selected or if SSM with hysteresis has been enabled, transition to STOP A after t_{F1} (Basic Functions) has elapsed or STOP B after t_{F2} (Extended Functions) has elapsed.

Note

A delay time between STOP F and STOP B should only be set if an additional response is initiated during this time when the "Internal Event" (r9722.7) message signal is evaluated.

Further, when using the delay time, a monitoring function should always be selected (e.g. SLS with a high limit speed) or the hysteresis of SSM should be configured.

When hysteresis is activated for SSM, then this should be considered to be an activated monitoring function.

On delays at the transition of the stop responses

- t_B: p9356/p9556
- t_C: p9352/p9552
- $t_{D:}$ p9353/p9553
- t_{F1}: p9658/p9858
- t_{F2}: p9355/p9555
- $n_{shutdown}$: p9360/p9560

Priorities of the stop responses

Table 6- 3 Priorities of the stop responses

Priority classes	Stop response
Highest priority	STOP A
.....	STOP B
...	STOP C
..	STOP D
Lowest priority	STOP F

Priorities of stop responses and Extended Functions

Table 6- 4 Priorities of stop responses and Extended Functions

Stop response / Extended Function		Highest priority	...	...	...	Lowest priority
		STOP A	STOP B	STOP C	STOP D	STOP F
Highest priority	STO	STOP A / STO	STO	STO	STO	STO
.....	SS1	STOP A	STOP B / SS1	SS1	SS1	SS1
...	SS2	STOP A	STOP B	STOP C / SS2	SS2	SS2 / STOP B[2)]
..	SOS	STOP A[1)]	STOP B[1)]	SOS	SOS	STOP B[2)]
Lowest priority	SLS	STOP A[3)]	STOP B[3)]	STOP C[4)]	STOP D[4)]	STOP B[2)]

1) The SOS monitoring function remains active, although the fault response in the event of a fault can no longer be triggered because it is already present.

2) STOP B is the subsequent stop of STOP F, which is activated after a parameterizable time. STOP F alone does not have any effect; the active safety function is still present.

3) The SLS monitoring function remains active, although the fault response in the event of a fault can no longer be triggered because it is already present.

4) SLS remains active during the braking phase, after which the system switches to SOS.

The table above specifies which stop response or safety function is set when a STOP is triggered when a safety function is active. The STOPs are arranged here from left to right in descending order of priority (STOP A-F).

No overall priority is assigned in the individual safety functions. SOS remains active, for example, even if STO is requested. The safety functions that cause the drive to decelerate (STO, SS1, SS2) are specified from top to bottom in descending order of priority.

If a field contains two entries, the stop responses and safety functions have the same priority. Explanation:

- STOP A corresponds to STO
- STOP B corresponds to SS1
- STOP C corresponds to SS2
- When the SS2 function is active, STOP F results in subsequent stop B. SS2 remains active.

Examples for illustrating the information in the table

1. Safety function SS1 has just been selected. STOP A remains active; a STOP B operation that is currently in progress is not interrupted by this. Any remaining STOP C-F would be replaced by SS1.
2. The SLS safety function is selected. This selection does not modify the function of STOP A-D. A STOP F now triggers a STOP B because a safety function has been activated.
3. Stop response, STOP C is selected. If the STO or SS1 safety functions are active, this does not have any effect. If SS2 is active, this braking ramp is retained. If SOS is active, SOS remains effective, which is also the end status of STOP C. When SLS is selected, the drive is decelerated with STOP C.

Acknowledging the safety faults

General

NOTICE
Safety faults can also be acknowledged (as is the case for all other faults) by switching the drive unit off and then on again (POWER ON). If this action has not eliminated the fault cause, the fault is displayed again immediately after power up

Acknowledgement via TM54F

Parameter p10006 "SI acknowledgement internal event input terminal" allows faults to be acknowledged in the safety drives and in TM54F itself.

The **"safe fault acknowledgement"** mechanism functions as follows:
The safe input F-DI on the TM54F parameterized with the function p10006 "Safety Integrated acknowledgement internal event input terminal" is energized. This allows faults that occurred in the firmware installed in the Control Unit or Motor Module to be acknowledged by means of a safe input signal. The falling edge at this input resets the status "Internal Event" in the drives and, if used, in the TM54F.

To prevent safety faults from being acknowledged unintentionally or incorrectly, the signal at the TM54F F DI terminal, which was parameterized for acknowledgement purposes, must be at level "0" in the idle state. To trigger the acknowledgement (falling edge at F DI), the signal must first be set to "1" and then back to "0". If the required idle state is not reached, an alarm is output.

After "safe fault acknowledgement", an acknowledgement must be issued on the Control Unit in order to:

- Delete the TM54F faults from the fault buffer
- Reset the queued, red Ready LED on the TM54F.

Acknowledgement via PROFIsafe

The higher-level controller sets the signal "Internal Event ACK" via the PROFIsafe telegram (STW bit 7) separately for each drive object. A falling edge in this signal sets the status "Internal Event" in the relevant drive, which acknowledges the fault.
Faults in the drive objects (DOs) cannot be acknowledged by the higher-level controller in the line-up but must instead be acknowledged separately for each individual drive object.

Extended acknowledgment

If STO is selected/deselected and p9307.0/p9507.0 = 1 are set, safety messages, in addition to fault messages, are also canceled automatically.

Description of faults and alarms

Note

The faults and alarms for SINAMICS Safety Integrated functions are described in SINAMICS Parameter Manual

6.12 Message buffer

In addition to the fault buffer for F... faults and the alarm buffer for A... alarms, (see SINAMICS S120 Commissioning Manual) a special message buffer for C... safety messages is available for Safety Integrated Extended Functions...

The fault messages for the Safety Integrated Basic Functions are stored in the standard fault buffer (see chapter "Buffer for faults and alarms" in the SINAMICS Commissioning Manual).

Note

Set parameter p3117 = 1 if you need to save both the Basic Functions messages and the Extended Functions messages in the standard fault buffer.

The message buffer for safety messages is similar to the fault buffer for fault messages. The message buffer comprises the message code, message value, and message time (received, resolved), the component number for identifying the affected SINAMICS component and diagnostics attributes. The following diagram shows how the message buffer is structured:

		Message code	Message time "received" in ms	Message value	Message value for float values	Message time "received" in days	Message time "resolved" in ms	Message time "resolved" in days	SI Kom-ponenten-nummer	SI Diagnose-attribute
Current message case	Message 1	r9747[0]	r9748[0]	r9749[0]	r9753[0]	r9754[0]	r9755[0]	r9756[0]	r9745[0]	r9750[0]
	Message 2	r9747[1]	r9748[1]	r9749[1]	r9753[1]	r9754[1]	r9755[1]	r9756[1]	r9745[1]	r9750[1]
	•			•						
	Message 8	r9747[7]	r9748[7]	r9749[7]	r9753[7]	r9754[7]	r9755[7]	r9756[7]	r9745[7]	r9750[7]
1st acknow-ledged message case	Message 1	r9747[8]	r9748[8]	r9749[8]	r9753[8]	r9754[8]	r9755[8]	r9756[8]	r9745[8]	r9750[8]
	Message 2	r9747[9]	r9748[9]	r9749[9]	r9753[9]	r9754[9]	r9755[9]	r9756[9]	r9745[9]	r9750[9]
	•			•						
	Message 8	r9747[15]	r9748[15]	r9749[15]	r9753[15]	r9754[15]	r9755[15]	r9756[15]	r9745[15]	r9750[15]
•										
7th acknow-ledged message case [oldest]	Message 1	r9747[56]	r9748[56]	r9749[56]	r9753[56]	r9754[56]	r9755[56]	r9756[56]	r9745[56]	r9750[56]
	Message 2	r9747[57]	r9748[57]	r9749[57]	r9753[57]	r9754[57]	r9755[57]	r9756[57]	r9745[57]	r9750[57]
	•			•						
	Message 8	r9747[63]	r9748[63]	r9749[63]	r9753[63]	r9754[63]	r9755[63]	r9756[63]	r9745[63]	r9750[63]

Figure 6-10 Structure of the message buffer

When a safety message is present, the bit 2139.5 = 1 ("Safety message present") is set. The entry in the message buffer is delayed. For this reason, the message buffer should not be read until a change in the buffer (r9744) has been detected after "Safety message present" is output.

The messages must be acknowledged via the fail-safe inputs F-DI of the TM54F or via PROFIsafe.

Properties of the safety message buffer:

- The entries appear in the buffer according to the time at which they occurred.
- If the cause of at least one message in "Current message case" is rectified and acknowledged, the message buffer is reorganized accordingly. Messages that have not been rectified remain in "Current message case".
- A maximum of 8 messages can be saved in the message buffer of the "Current message case". If 8 messages are entered in the "Current message case" and a new message occurs then this message can no longer be saved.
- If a fault is rectified and the message is acknowledged, the message buffer will be reorganized. The history is recorded in the "Acknowledged message case" 1 to 7.
- r9744 is incremented each time the message buffer changes.
- A message value (r9749, r9753) can be output for a message. The message value is used to diagnose the message more accurately (refer to the message description for more details).

Deleting the message buffer

The message buffer is deleted with p9752 = 0. The parameter p9752 (SI message cases, counter) is also reset to 0 at POWER ON. This also clears the fault memory.

Overview of important parameters

- r2139.0...12 CO/BO: Status word, faults/alarms 1
- r9744 SI message buffer changes, counter
- r9745[0...63] SI component number
- r9747[0...63] SI message code
- r9748[0...63] SI message time received in milliseconds
- r9749[0...63] SI message value
- r9750[0...63] SI diagnostic attributes
- p9752 SI message cases, counter
- r9753[0...63] SI message value for float values
- r9754[0...63] SI message time received in days
- r9755[0...63] SI message time removed in milliseconds
- r9756[0...63] SI message time removed in days

6.13 Reliable actual value acquisition with the encoder system

Supported encoder systems

The Safety Functions used to monitor motion (e.g. SS1, SS2, SOS, SLS and SSM) require reliable actual value acquisition.

The following encoder systems should primarily be used for reliable speed/position acquisition:

- Single-encoder systems or
- Two-encoder systems

Single-encoder system

In a single-encoder system, only the motor encoder is used to safely acquire the drive actual values. This motor encoder must be appropriately qualified (see encoder types). The safety-relevant actual values are generated either directly in the encoder or in the Sensor Module and are transferred to the Control Unit by way of fail-safe communication via DRIVE-CLiQ.

For motors without a DRIVE-CLiQ interface, the connection is established by means of additional Sensor Modules (SMC or SME).

Even if the drive is operating in the closed-loop torque controlled mode, motion monitoring functions may be selected as long as it is guaranteed that the encoder signals can be evaluated.

Special feature in the case of linear motors

The motor encoder (linear scale) of linear motors also acts as load measuring system. Only one measuring system is required for this reason. The system is connected by means of a Sensor Module or directly via DRIVE-CLiQ.

NOTICE
When specifying the standstill tolerance window, you must remember that fail-safe position monitoring takes place with a maximum of the precision displayed in r9731.

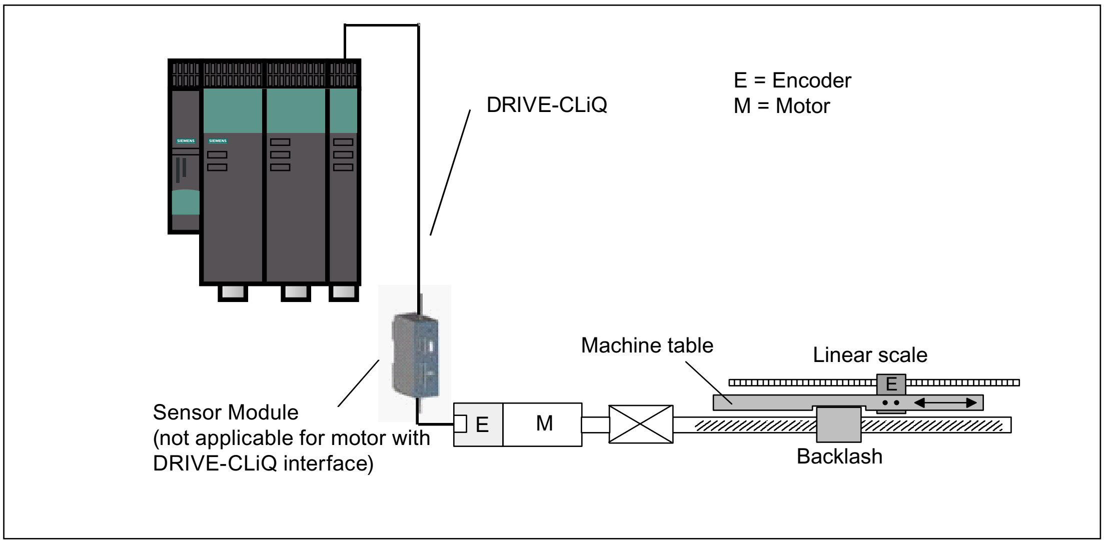


Figure 6-11 Example for a single-encoder system

Two-encoder system

For a two-encoder system the safe actual values for a drive are provided by two separate encoders. The actual values are transferred to the Control Unit by means of fail-safe communication via DRIVE-CLiQ.

For motors without a DRIVE-CLiQ interface, the connection is established by means of additional Sensor Modules (SMC or SME).

Each measuring system requires a separate connection or a separate Sensor Module.

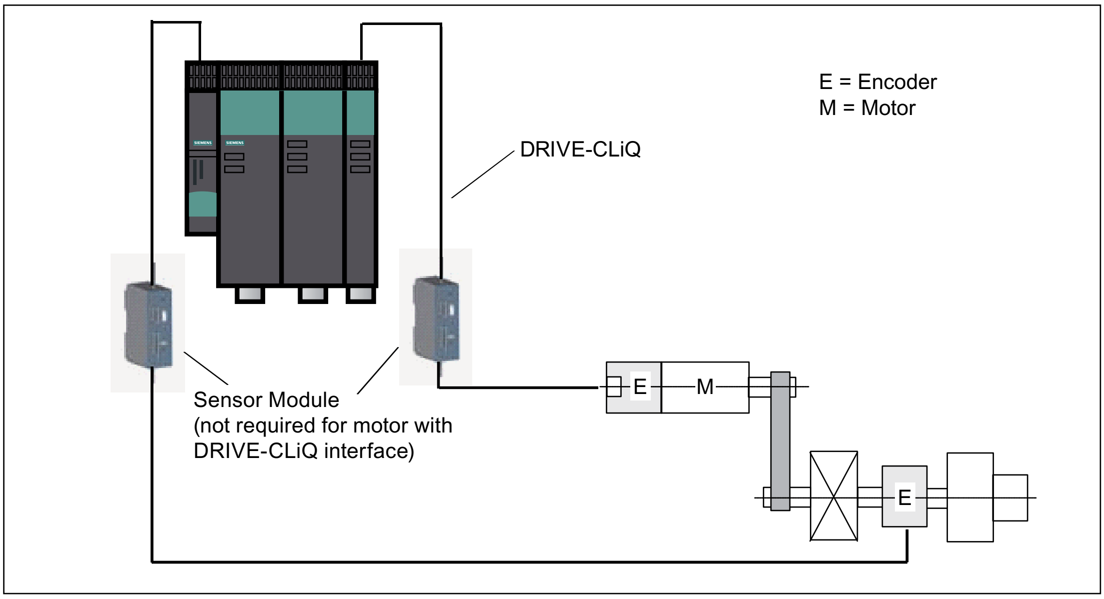


Figure 6-12 Example for a two-encoder system

Encoder types

Incremental encoders or absolute encoders can be used for safe acquisition of the position values on a drive.

Safe actual value acquisition relies on redundant evaluation of the incremental channels A/B that supply sin/cos signals of 1 Vpp.

The absolute position values can be transferred via the serial EnDat interface or an SSI interface to the controller.

Encoder types for 1 and 2 encoder systems

In systems with encoders with SINAMICS Safety Integrated (1 and 2 encoder systems), for safe actual value acquisition only encoders with sin/cos 1 Vss signals to the SINAMICS Sensor Modules SME20/25, SME120/125 and SMC20 are permitted which fulfill the following conditions:

1. The encoders must contain purely analog signal processing and creation. This is necessary to be able to prevent the A/B track signals with valid levels from becoming static ("freezing").
2. A failure mode and effects analysis (FMEA) must be carried out for the fixation of the encoder onto the motor shaft or the linear drive. The result should incorporate exclusion of the failure "Loosening of encoder fixation so that encoder no longer reports movement correctly" (see IEC 61800-5-2, table D.16).

It should be noted that the machine manufacturer has sole responsibility for the fulfillment of the above-described requirements. Information on the internal realization of the encoder must come from the encoder manufacturer. The FMEA must be created by the machine manufacturer.

Also certain motors with and without DRIVE-CLiQ connection can be used for Safety Integrated functions; see http://support.automation.siemens.com/WW/view/de/33512621

NOTICE
Basic absolute encoders (e.g. ECI, EQI), which offer an EnDat interface with additional sin/cos tracks but operate according to an inductive measuring principle internally, are not permitted until their suitability for SINAMICS Safety Integrated has been determined.

Actual value synchronization

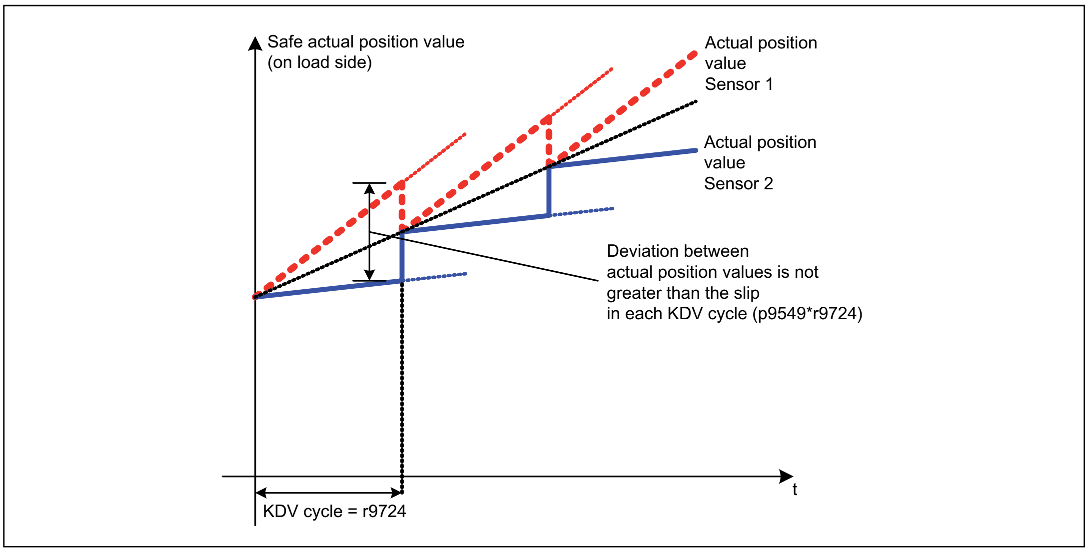


Figure 6-13 Example diagram of actual value synchronization

The mean value of the actual values of both encoders is calculated cyclically after actual value synchronization (p9301.3 = p9501.3 = 1) was activated. The maximum slip defined in p9349/p9549 is monitored within the crosswise comparison clock cycle (r9724). If "actual value synchronization" is not enabled, the value parameterized in p9342/p9542 is used as tolerance value for the crosswise comparison.

Two read parameters are available for safe motion monitoring:

r9730: SI Motion safe maximum velocity

Displays the maximum speed (load side) permissible due to the acquisition of actual values for safe motion monitoring functions. The maximum velocity for actual value acquisition depends on the actual value update clock cycle (p9311/p9511). Parameters p9311/p9511 are used to set the clock cycle time of the actual value acquisition for safe motion monitoring.

A slower clock cycle reduces the maximum permissible velocity, but also reduces the load on the Control Unit for safe actual value acquisition.

The maximum permissible velocity which, if overshot, can trigger faults in safe actual value acquisition, is displayed in parameter r9730.

With a default value of p9311/p9511 (0 ms), the isochronous PROFIBUS clock cycle is used (or 1 ms in non-isochronous mode).

r9731: SI Motion safe position accuracy

Displays the greatest position accuracy (load side) that can be ensured due to the acquisition of the actual value for the safe motion monitoring functions.

Both parameters (r9730/r9731) depend on the relevant encoder type.

Overview of important parameters

- p9301.3 SI Motion enable safety functions (Motor Module), enable actual value synchronization
- p9501.3 SI Motion enable safety functions (Control Unit), enable actual value synchronization
- p9302 SI Motion axis type (Motor Module)
- p9502 SI Motion axis type (Control Unit)
- p9311 SI Motion actual value sensing clock cycle (Motor Module)
- p9511 SI Motion actual value sensing clock cycle (Control Unit)
- p9315 SI Motion encoder coarse position value configuration (Motor Module)
- p9515 SI Motion encoder coarse position value configuration (Control Unit)
- p9316 SI Motion motor encoder configuration safety functions (Motor Module)
- p9516 SI Motion motor encoder configuration safety functions (Control Unit)
- p9317 SI Motion linear scale grid division (Motor Module)
- p9517 SI Motion linear scale grid division (Control Unit)
- p9318 SI Motion encoder pulses per revolution (Motor Module)
- p9518 SI Motion encoder pulses per revolution (Control Unit)
- p9319 SI Motion fine resolution Gn_XIST1 (Motor Module)
- p9519 SI Motion fine resolution G1_XIST1 (Control Unit)
- p9320 SI Motion spindle pitch (Motor Module)
- p9520 SI Motion spindle pitch (Control Unit)
- p9321[0...7] SI Motion gearbox encoder/load denominator (Motor Module)
- p9521[0...7] SI Motion gearbox encoder/load denominator (Control Unit)
- p9322[0...7] SI Motion gearbox encoder/load numerator (Motor Module)
- p9522[0...7] SI Motion gearbox encoder/load numerator (Control Unit)
- p9323 SI Motion redundant coarse position value valid bits (Motor Module)
- p9324 SI Motion redundant coarse position value fine resolution (Motor Module)
- p9325 SI Motion redundant coarse position value relevant bits (Motor Module)
- p9523 SI Motion redundant coarse position value valid bits (Control Unit)
- p9524 SI Motion redundant coarse position value fine resolution (Control Unit)
- p9525 SI Motion redundant coarse position value relevant bits (Control Unit)
- p9326 SI Motion encoder assignment (Motor Module)
- p9526 SI Motion encoder assignment second channel
- p9342 SI Motion actual value comparison tolerance (crosswise) (Motor Module)
- p9542 SI Motion actual value comparison tolerance (crosswise) (Control Unit)
- p9349 SI Motion slip velocity tolerance (Motor Module)
- p9549 SI Motion slip velocity tolerance (Control Unit)

- r9713[0...3] SI Motion diagnostics position action value load side
- r9714[0...1] SI Motion diagnostics speed
- r9724 SI Motion crosswise comparison clock cycle
- r9730 SI Motion safe maximum velocity
- r9731 SI Motion safe position accuracy

6.14 Forced dormant error detection

Forced dormant error detection and function test through test stop

The functions and switch-off signal paths must be tested at least once within a defined period to establish whether they are working properly in order to meet the requirements of EN ISO 13849-1 and IEC 61508 in terms of timely error detection.

The maximum permissible interval for forced dormant error detection with the Basic Functions and Extended Functions is 9000 hours or once a year.

This functionality must be implemented by means of test stop triggering either in cyclic manual mode or by the automated process.

The test stop cycle is monitored. On expiration of the parameterized timer (also after POWER ON / warm restart), the alarm A01697: "SI Motion: Test of motion monitoring required" is generated and a status bit is set which can be transferred to an output or to a PZD bit via BICO. This alarm does not affect machine operation.

The test stop must be initiated application-specific and be executed at a time which suits application requirements. This functionality is implemented by means of a single-channel parameter p9705 which can be wired via BICO either to an input terminal on the drive unit (CU), or to an IO-PZD in the drive telegram.

- p9559 SI Motion Forced dormant error detection timer (Control Unit)
- p9705 BI: SI Motion Test stop signal source
- r9723.0 CO/BO: SI Motion diagnostics signals integrated in the drive

A test stop does not require POWER ON. The acknowledgment is set by canceling the test stop request.

When the appropriate safety devices are implemented (e.g. protective doors), it can be assumed that running machinery will not pose any risk to personnel. For this reason, only an alarm is output to inform the user that a forced dormant error detection run is due and to request that this be carried out at the next available opportunity.

Examples of when to carry out forced dormant error detection:

- When the drives are at a standstill after the system has been switched on (POWER ON).
- Before the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent)

Note

STO is triggered when a test stop is carried out for the Safety functions. STO should not be selected prior to selecting the test stop, and the axis should not be in operation.

Forced dormant error detection F-DI/F-DO of TM54F through test stop

An automatic test stop function is available for forced dormant error detection within the F-DIs/DOs test.

To ensure that the test stop function of the TM54F can be used, the F-DIs that are used must be interconnected in accordance with the following wiring example. The digital inputs of F-DI0 to F-DI4 must be connected to the "L1+" power supply. The digital inputs of F-DI5 to F-DI9 must be connected to the "L2+" power supply.

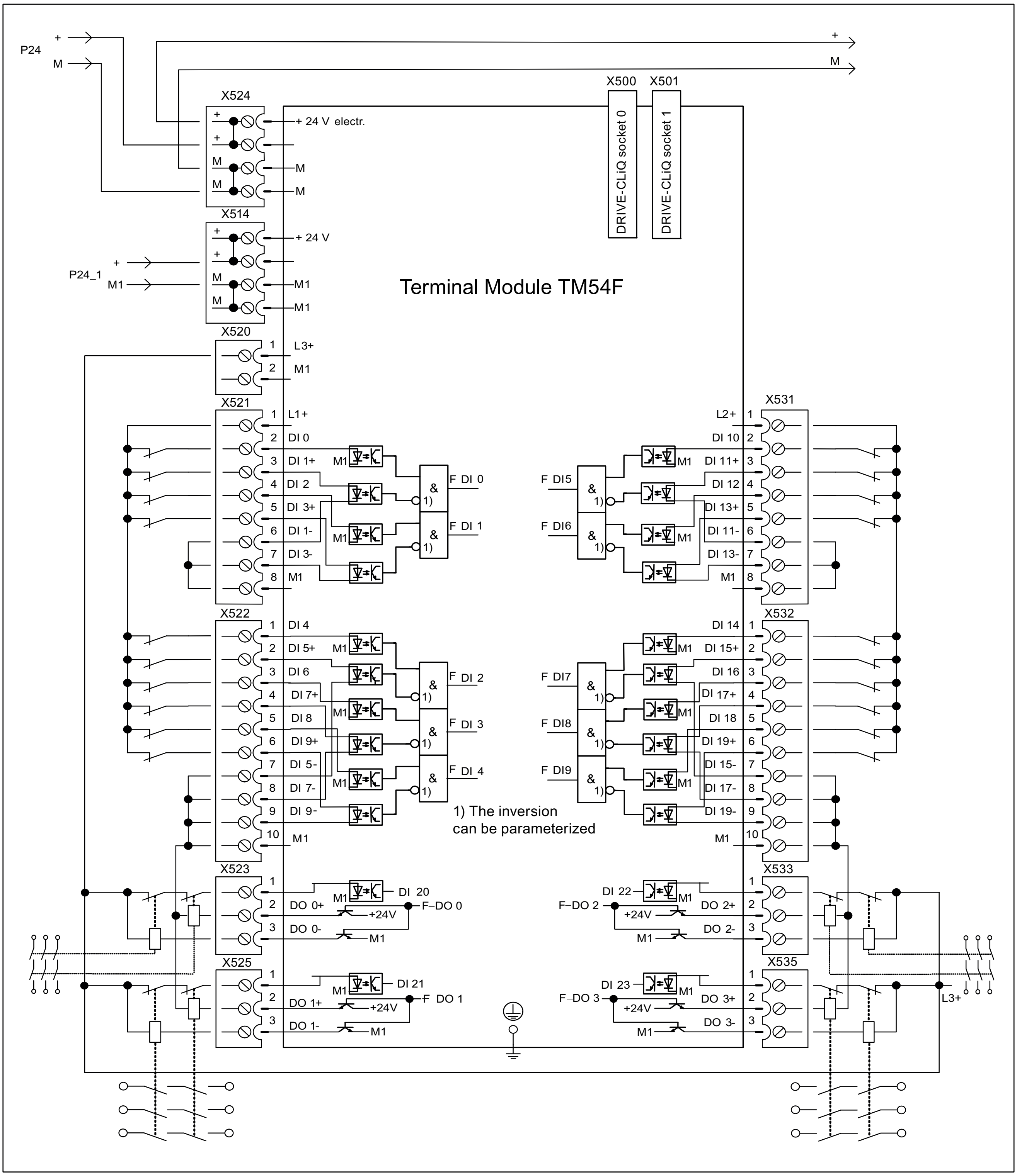


Figure 6-14 Example of the TM54F wiring

The F-DIs must be registered for the test stop by means of p10041.

CAUTION
The F-DI states are frozen for the duration of the test (approx. 100 ms)!

In order to be able to use the test stop function, the F-DOs being used must be interconnected in accordance with the connection example shown above and the forced feedback signals of the two relays must be connected to the corresponding digital input (DI 20 to DI 23).

The corresponding F-DOs must be registered for the test stop by means of p10046.

NOTICE

F-DOs which are not registered for evaluation by means of p10046 are set to "0" for the duration of the test stop ("fail-safe values").

Maximum test stop period: $T_{Teststop} = T_{FDIs} + T_{FDOs}$

- Test of the FDIs: 3 * p10000 + 3 * X ms
  (X = 20 ms or p10000 or p10017 - the greatest time value of the 3 values determines the waiting time X)
- Test of the FDOs: 8 * p10000 + 6 * Y ms
  (Y = p10001 or p10000 or p10017 - the greatest time value of the 3 values determines the waiting time Y)

⚠ WARNING

If the connected devices do not support the test stop function for specific F-DIs or F-DOs, the relevant F-DIs/F-DOs must be operated dynamically, e.g. by means of switch operation, or through specific machine functions.

The test stop must be executed at a suitable time. That is, it must be initiated application-specific. This functionality is implemented by means of a parameter p10007 which can be wired via BICO either to an input terminal on the drive unit (CU), or to an IO-PZD in the drive telegram.

The test stop cycle is monitored. On expiration of the parameterized timer (also after POWER ON / warm restart), the alarm A35014: "TM54F: Test stop required" is output.

- p10001 SI delay time for test stop at F-DO 0 ... 3
- p10003 SI forced dormant error detection timer
- p10007 BI: SI input terminal forced dormant error detection F-DO 0 ... 3
- p10041 SI F-DI test enable
- p10046 SI test sensor feedback input DI 20 ... 23

A test stop does not require POWER ON. The acknowledgment is set by canceling the test stop request.

Additional instructions for performing the test stops are provided in the chapter "Commissioning TM54F using STARTER/Scout → Test stop of the TM54F".

7 Controlling the safety functions

7.1 Overview of F-DI/F-DOs and of their structure

The safety-oriented input and output terminals (F-DI and F-DO) act as an interface between the internal Safety Integrated functionality and the process.

A dual-channel signal applied to an F-DI (Fail-safe Digital Input, safety-oriented digital input = safe input terminal pair) controls the active monitoring of the activation/deactivation of safety functions. This function also depends on the status of sensors (e.g. switches).

An F-DO (Failsafe Digital Output, safety-oriented digital output = safe output terminal pair) delivers a dual-channel signal representing feedback from the safety functions. It is suitable, for example, for the safety-oriented control of actuators (e.g. line contactor). See also the figures "F-DI 0 ... 4 overview", "F-DI 5 ... 9 overview" and "F-DO overview (without showing the main contacts on the contactors)".

Dual-channel processing of I/O signals

A dual-channel structure is implemented for data input/output and for processing safety-oriented I/O signals. All requests and feedback signals for safety-oriented functions should be entered or tapped using both channels.

The following options are available for controlling Safety Integrated functions:

- Control by way of terminals on the Control Unit and Motor Module (only STO, SS1(time controlled) and SBC).
- Control by way of PROFIsafe
- Control by way of TM54F terminals

Control by way of terminals on the Control Unit and Motor Module can be activated alongside with one of the other two options. Only one of the two control modes can be selected for each drive object; either PROFIsafe or TM54F.

NOTICE
Per single Control Unit, either control via PROFIsafe or TM54F is permitted. Mixed operation is not permitted.

7.2 Control of "STO" and "SS1" via terminal module for option K82

7.2.1 Terminal module for control of "STO" and "SS1" for SINAMICS G150

Description

The K82 option (terminal module for activating "Safe Torque Off" and "Safe Stop 1" is used for optically isolated activation via a variable control voltage range of the safety functions already present in the standard, which can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

Option K82 is used to activate the following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2):

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In combination with the option K82, the requirements specified in EN 61800-5-2, EN 60204-1, as well as in DIN EN ISO 13849-1 category 3 (formerly EN954-1) are satisfied for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This option is used when:

- Activation will be executed optically isolated in a voltage range of 24 V – 230 V DC/AC.
- You will be working with non-shielded control lines with lengths greater than 30 m.
- The devices will be used in plants with greater spatial elongation (ideal PA not present).

Functional principle

Two independent channels of the integrated safety function are activated via the relays (K41, K42).

The relay K41 activates the signal to the control unit that is necessary for the safety function and the relay K42 on the Power Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The circuit is structured so that it is protected against wire break, i.e. if the relay's control voltage fails then the safety function is active.

A checkback signal can be derived for information, diagnostics, or troubleshooting from the normally-closed contact switched in series of the relay. Wiring of the checkback signal can be executed optionally and is not part of the safety concept.

Note

The checkback signal is not necessary for compliance with the standard DIN EN ISO 13849-1 (formerly EN954-1) cat. 3 PL d and DIN EN 61508 SIL2.

The selection of the safety function must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER
Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

Customer interface –X41

Table 7- 1 Terminal strip -X41

Terminal	Meaning	Technical data
-X41:1	Activation –K41: A1	Connection for activation element at channel 1 "+"
-X41:2	Connected to -X41:1	
-X41:3	Activation –K41:A2, -K42:A2 , N conductor or ground	Connection of reference potential for activation elements at channel 1 and channel 2
-X41:4	Connected to -X41:3	
-X41:5	Checkback signal, status –K41, -K42	Connection of supply voltage for optional checkback signal
-X41:6	Checkback signal, status –K41, -K42	Connection of optional checkback signal
-X41:7	Activation –K42: A1	Connection for activation element at channel 2 "+"
-X41:8	Connected to -X41:7	
-X41:9	Not assigned	
-X41:10	Output -K41: Permanently wired with CU320-2: -X132:4 (DI7)	

Control circuit:

Rated voltage: DC/AC 24 to 230 V (0.85 to 1.1 x Us)

Max. line length (applies to total of current and return conductors):

- AC (line capacity: 300 pF/m):
  - 24 V: 5000 m
  - 110 V: 800 m
  - 230 V: 200 m

  The values apply for 50 Hz, at 60 Hz the line lengths must be reduced by 20%.

  > **WARNING**
  >
  > If the permissible cable lengths and/or the permissible cable capacity is exceeded, then due to the couple capacity of the cable and the associated residual current it may be the case that the relay remains energized in spite of opened activation element.

- DC (min. cross-section 0.75 mm²): 1500 m

Max. connectable cross-section: 2.5 mm²

Fuse: max. 4 A

Load side:

Operational voltage: max. 250 V DC/AC

Rated operating currents:

- AC-15 (in accordance with IEC 60947-5-1): 24 - 230 V = 3 A
- DC-13 (in accordance with IEC 60947-5-1):
  - 24 V = 1 A
  - 10 V = 0.2 A
  - 230 V = 0.1 A

Min. contact load: 5 V DC, 1 mA at 1 ppm error

Fuse: max. 4 A (fuse weld-free, duty category gL/gG with Ik ≥ 1 kA)

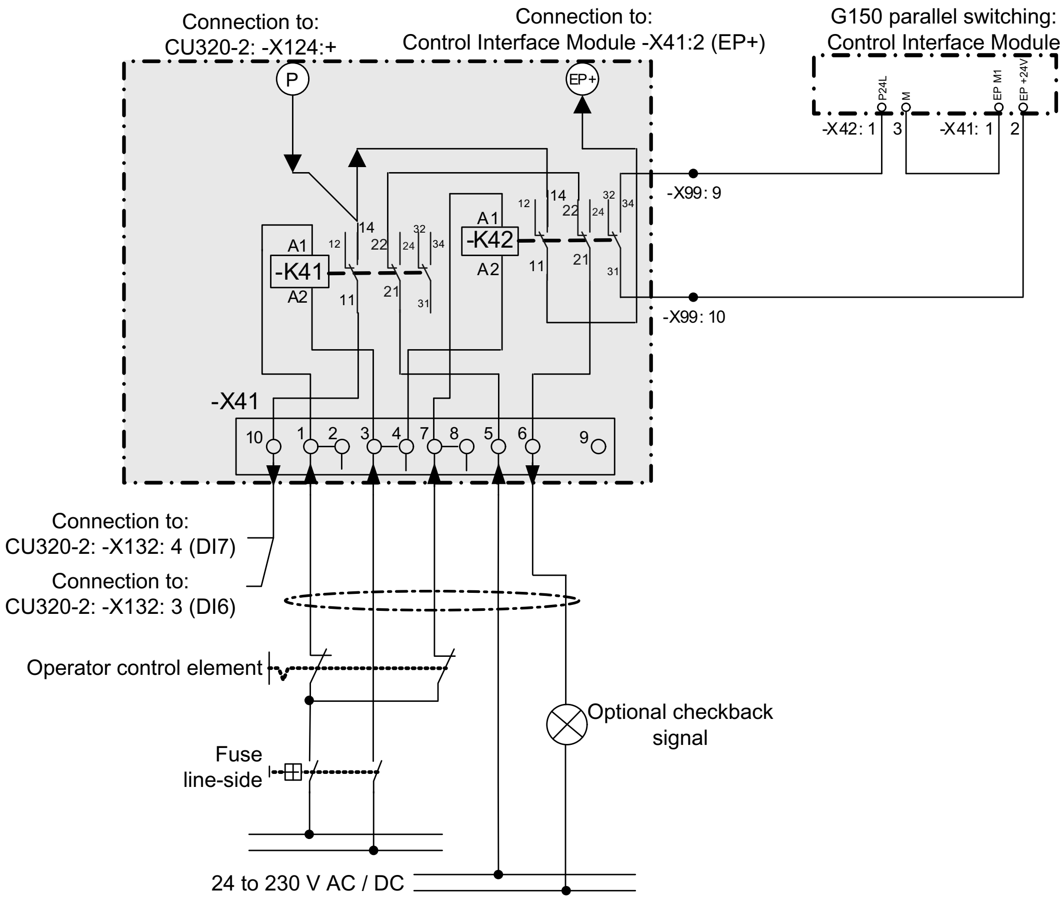


Figure 7-1 Circuit terminal module for option K82

A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

Note

The terminal -X41:10 is permanently connected to the digital input DI7 of the Control Unit.

Note

For the following cabinet units (automatic synchronizers), the digital input DI6 of the Control Unit is also used:

- For 3 AC 380 to 480 V:
  6SL3710-2GE41-1AAx, 6SL3710-2GE41-4AAx, 6SL3710-2GE41-6AAx
- For 3 AC 500 to 600 V:
  6SL3710-2GF38-6AAx, 6SL3710-2GF41-1AAx, 6SL3710-2GF41-4AAx
- For 3 AC 660 to 690 V:
  6SL3710-2GH41-1AAx, 6SL3710-2GH41-4AAx, 6SL3710-2GH41-5AAx

Interconnection in groups

When using a single activation element for multiple cabinet units, the following terminals have to be used on terminal strip -X41:

- -X41:2: Interconnection to the next cabinet unit, terminal -X41:1
- -X41:4: Interconnection to the next cabinet unit, terminal -X41:3
- -X41:6: Interconnection to the next cabinet unit, terminal -X41:5
- -X41:8: Interconnection to the next cabinet unit, terminal -X41:7
- -X41:9: Interconnection to the next cabinet unit, terminal -X41:6
- Connection of the optional checkback signal to terminal -X41:9

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g. as specified in IEC 60204-1).

7.2.2 Terminal module for control of "STO" and "SS1" for SINAMICS S120 Cabinet Modules

7.2.2.1 General information

Availability of option

This option is available for the following S120 cabinet modules:

- Motor Module in chassis format
- Booksize Cabinet Kit

Description

The K82 option (terminal module for activating "Safe Torque Off" and "Safe Stop 1" is used for optically isolated activation via a variable control voltage range of the safety functions already present in the standard, which can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

Option K82 is used to activate the following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2):

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In combination with the option K82, the requirements specified in EN 61800-5-2, EN 60204-1, as well as in DIN EN ISO 13849-1 category 3 (formerly EN954-1) are satisfied for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This option is used when:

- Activation will be executed optically isolated in a voltage range of 24 V – 230 V DC/AC.
- You will be working with non-shielded control lines with lengths greater than 30 m.
- The devices will be used in plants with greater spatial elongation (ideal PA not present).

Functional principle

Two independent channels of the integrated safety function are activated via the relays (K41, K42).

Relay K41 activates the signal to the control unit that is necessary for the safety function and the relay K42 on the Motor Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The circuit is structured so that it is protected against wire break, i.e. if the relay's control voltage fails then the safety function is active.

A checkback signal can be derived for information, diagnostics, or troubleshooting from the normally-closed contact switched in series of the relay.

Wiring of the checkback signal can be executed optionally and is not part of the safety concept.

Note

The checkback signal is not necessary for compliance with the standard DIN EN ISO 13849-1 (formerly EN954-1) cat. 3 PL d and DIN EN 61508 SIL2.

The selection of the safety function must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER
Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

Customer interface –X41

Table 7- 2 Terminal strip -X41

Terminal	Meaning	Technical data
-X41:1	Activation –K41: A1	Connection for activation element at channel 1 "+"
-X41:2	Connected to -X41:1	Connection for activation element at channel 1 "+", for interconnecting motor modules in groups
-X41:3	Activation –K41:A2, -K42:A2 , N conductor or ground	Connection of reference potential for activation elements at channel 1 and channel 2
-X41:4	Connected to -X41:3	Connection of reference potential for activation elements at channel 1 and channel 2, for interconnecting motor modules in groups
-X41:5	Checkback signal, status –K41, -K42	Connection of supply voltage for optional checkback signal
-X41:6	Checkback signal, status –K41, -K42	Connection for optional checkback signal, for interconnecting motor modules in groups
-X41:7	Activation –K42: A1	Connection for activation element at channel 2 "+"
-X41:8	Connected to -X41:7	Connection for activation element at channel 2 "+", for interconnecting motor modules in groups
-X41:9	Connection of optional checkback	For the option of connecting other checkback signals in series when motor modules are grouped
-X41:10	Output -K41: Permanently wired with CU320-2: -X132:4 (DI7)	Output -K41: For connecting to a digital input in accordance with the Safety settings on the CU320-2 (already wired in option K90)

Control circuit:

Rated voltage: DC/AC 24 to 230 V (0.85 to 1.1 x Us)

Max. line length (applies to total of current and return conductors):

- AC (line capacity: 300 pF/m):
  - 24 V: 5000 m
  - 110 V: 800 m
  - 230 V: 200 m

  The values apply for 50 Hz, at 60 Hz the line lengths must be reduced by 20%.

  > ⚠ WARNING
  >
  > If the permissible cable lengths and/or the permissible cable capacity is exceeded, then due to the couple capacity of the cable and the associated residual current it may be the case that the relay remains energized in spite of opened activation element.

- DC (min. cross-section 0.75 mm²): 1500 m

Max. connectable cross-section: 2.5 mm²

Fuse: max. 4 A

Load side:

Operational voltage: max. 250 V DC/AC

Rated operating currents:

- AC-15 (in accordance with IEC 60947-5-1): 24 - 230 V = 3 A
- DC-13 (in accordance with IEC 60947-5-1):
  - 24 V = 1 A
  - 10 V = 0.2 A
  - 230 V = 0.1 A

Min. contact load: 5 V DC, 1 mA at 1 ppm error

Fuse: max. 4 A (fuse weld-free, duty category gL/gG with Ik ≥ 1 kA)

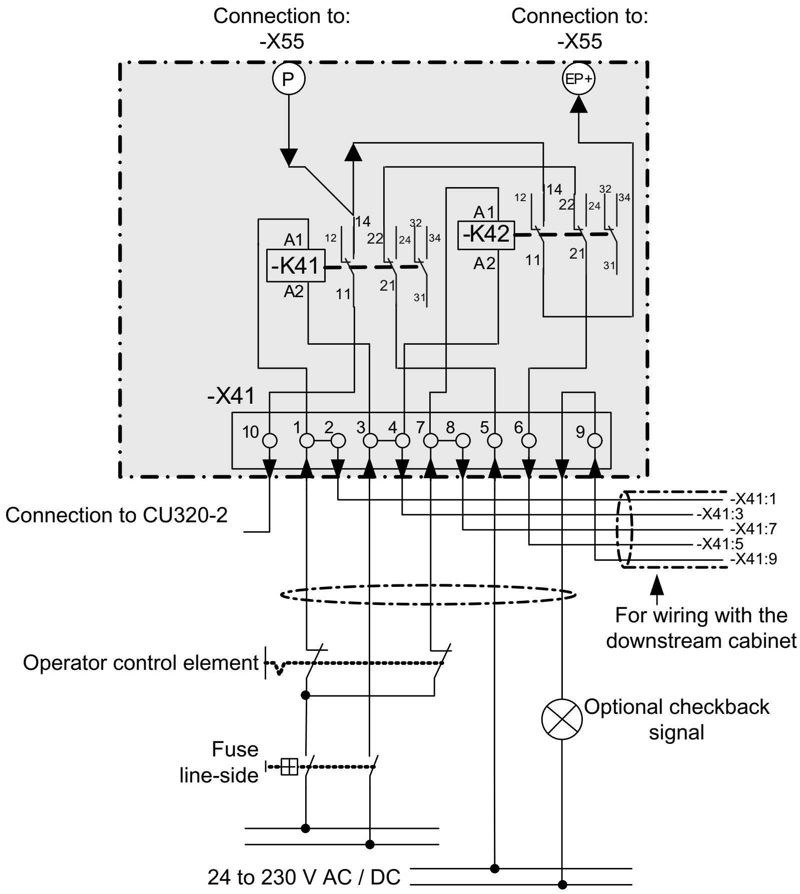


Figure 7-2 Circuit terminal module for option K82

A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

7.2.2.2 Use of the K82 option with Control Unit CU320-2

In conjunction with option K90 (CU320-2), terminal -X41:10 is already connected to digital input DI7 of the CU320-2 within the cabinet.

In the double motor module, digital input DI6 is also wired on the CU320-2.

These interconnections have to be taken into account when Safety function parameters are assigned.

7.2.2.3 Use of the K82 option with Control Unit CU320-2

If option K90 is not present, connect terminal -X41:10 to each Motor Module's Control Unit. Digital inputs DI0 to DI7 are available for this purpose.

These interconnections have to be taken into account when Safety function parameters are assigned.

If the line is laid to the control unit outside the cabinet unit, the cable may not be any more than 30 m in length. For longer line lengths, suitable protective circuitry must be provided on the plant side for overvoltage protection (Weidmüller: Type no.: MCZ OVP TAZ).

Note

Terminal -X41:10 can only be connected to digital inputs DI0 to DI7 of the Control Unit; other digital inputs cannot be interconnected.

7.2.2.4 Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.2.3 Terminal module for control of "STO" and "SS1" for SINAMICS S150

Description

The K82 option (terminal module for activating "Safe Torque Off" and "Safe Stop 1" is used for optically isolated activation via a variable control voltage range of the safety functions already present in the standard, which can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

Option K82 is used to activate the following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2):

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In combination with the option K82, the requirements specified in EN 61800-5-2, EN 60204-1, as well as in DIN EN ISO 13849-1 category 3 (formerly EN954-1) are satisfied for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This option is used when:

- Activation will be executed optically isolated in a voltage range of 24 V – 230 V DC/AC.
- You will be working with non-shielded control lines with lengths greater than 30 m.
- The devices will be used in plants with greater spatial elongation (ideal PA not present).

Functional principle

Two independent channels of the integrated safety function are activated via the relays (K41, K42).

Relay K41 activates the signal to the control unit that is necessary for the safety function and the relay K42 on the Motor Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The circuit is structured so that it is protected against wire break, i.e. if the relay's control voltage fails then the safety function is active.

A checkback signal can be derived for information, diagnostics, or troubleshooting from the normally-closed contact switched in series of the relay. Wiring of the checkback signal can be executed optionally and is not part of the safety concept.

Note

The checkback signal is not necessary for compliance with the standard DIN EN ISO 13849-1 (formerly EN954-1) cat. 3 PL d and DIN EN 61508 SIL2.

The selection of the safety function must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER

Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

Customer interface –X41

Table 7- 3 Terminal strip -X41

Terminal	Meaning	Technical data
-X41:1	Activation –K41: A1	Connection for activation element at channel 1 "+"
-X41:2	Connected to -X41:1	
-X41:3	Activation –K41:A2, -K42:A2 , N conductor or ground	Connection of reference potential for activation elements at channel 1 and channel 2
-X41:4	Connected to -X41:3	
-X41:5	Checkback signal, status –K41, -K42	Connection of supply voltage for optional checkback signal
-X41:6	Checkback signal, status –K41, -K42	Connection of optional checkback signal
-X41:7	Activation –K42: A1	Connection for activation element at channel 2 "+"
-X41:8	Connected to -X41:7	
-X41:9	Not assigned	
-X41:10	Output -K41: Permanently wired with CU320-2: -X132:4 (DI7)	

Control circuit:

Rated voltage: DC/AC 24 to 230 V (0.85 to 1.1 x Us)

Max. line length (applies to total of current and return conductors):

- AC (line capacity: 300 pF/m):
  - 24 V: 5000 m
  - 110 V: 800 m
  - 230 V: 200 m

  The values apply for 50 Hz, at 60 Hz the line lengths must be reduced by 20%.

⚠ WARNING
If the permissible cable lengths and/or the permissible cable capacity is exceeded, then due to the couple capacity of the cable and the associated residual current it may be the case that the relay remains energized in spite of opened activation element.

- DC (min. cross-section 0.75 mm²): 1500 m

Max. connectable cross-section: 2.5 mm²

Fuse: max. 4 A

Load side:

Operational voltage: max. 250 V DC/AC

Rated operating currents:

- AC-15 (in accordance with IEC 60947-5-1): 24 - 230 V = 3 A
- DC-13 (in accordance with IEC 60947-5-1):
  - 24 V = 1 A
  - 10 V = 0.2 A
  - 230 V = 0.1 A

Min. contact load: 5 V DC, 1 mA at 1 ppm error

Fuse: max. 4 A (fuse weld-free, duty category gL/gG with Ik ≥ 1 kA)

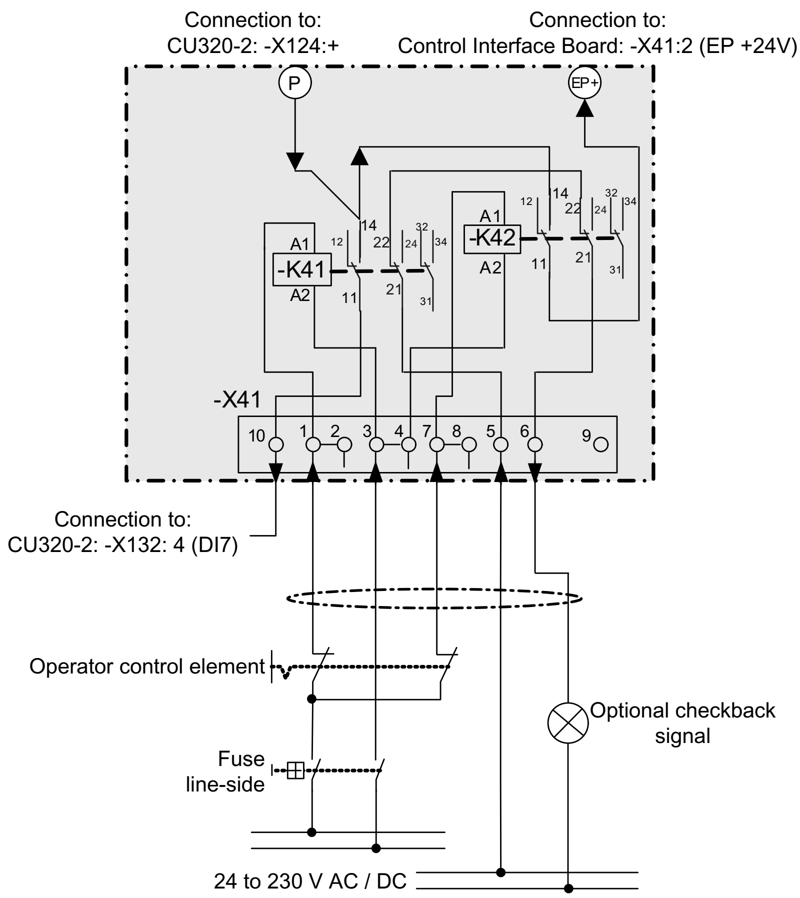


Figure 7-3 Circuit terminal module for option K82

A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

Note

The terminal -X41:10 is permanently connected to the digital input DI7 of the Control Unit.

Interconnection in groups

When using a single activation element for multiple cabinet units, the following terminals have to be used on terminal strip -X41:

- -X41:2: Interconnection to the next cabinet unit, terminal -X41:1
- -X41:4: Interconnection to the next cabinet unit, terminal -X41:3
- -X41:6: Interconnection to the next cabinet unit, terminal -X41:5
- -X41:8: Interconnection to the next cabinet unit, terminal -X41:7
- -X41:9: Interconnection to the next cabinet unit, terminal -X41:6
- Connection of the optional checkback signal to terminal -X41:9

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g. as specified in IEC 60204-1).

7.3 Control of "STO" and "SS1" via terminals on the Control Unit and the Motor/Power Module

7.3.1 General information

7.3.1.1 Control signals by way of terminals on the Control Unit and Motor/Power Module

Features

- Only for the STO, SS1 (time-controlled) and SBC functions
- Dual-channel structure via two digital inputs (Control Unit/power unit)
- A debounce function can be applied to the terminals of the Control Unit and the Motor Module to prevent incorrect trips due to signal disturbances or asymmetrical test signals. The filter times are set using parameters p9651 and p9851.
- Different terminal blocks depending on the format
- Automatic AND operation of up to 8 digital inputs (p9620[0..7]) on the Control Unit for chassis format power units connected parallel switching

Overview of the terminals for safety functions

The different power unit formats have different terminal designations for the inputs of the safety functions. These are shown in the following table.

Table 7- 4 Inputs for safety functions

Module	1. Switch-off signal path (p9620[0])	2. Switch-off signal path	EP terminals
Control Unit CU320-2 DP	X122.1....6 / X132.1…6 DI 0...7/16/17/20/21		
Single Motor Module booksize	(see CU320-2 DP)	X21.3 and X21.4 (on the Motor Module)	X21.3 X21.4
Single Motor Module/ Power Module in chassis format	(see CU320-2 DP)	X41.1 and X41.2	X41.1 X41.2
Double Motor Module booksize	(see CU320-2 DP)	X21.3 and X21.4 (motor connection X1)/X22.3 and X22.4 (motor connection X2) (on the Motor Module)	X21.3 X21.4 X22.3 X22.4

Terminals for STO, SS1 (time-controlled), SBC

The functions are separately selected/deselected for each drive using two terminals.

1. **Switch-off signal path, Control Unit**

   The desired input terminal is selected via BICO interconnection (BI: p9620[0]).

2. **Switch-off signal path Motor Module/Power Module**

   The input terminal is the "EP" terminal ("Enable Pulses")

   The EP terminal is periodically interrogated with a sampling time, which is rounded off to an integer multiple of the current controller cycle; however, it is a minimum of 1 ms. (example: t_i = 400 µs, t_{EP} => 3 x t_i = 1.2 ms)

Both terminals must be operated simultaneously, otherwise a fault will be issued.

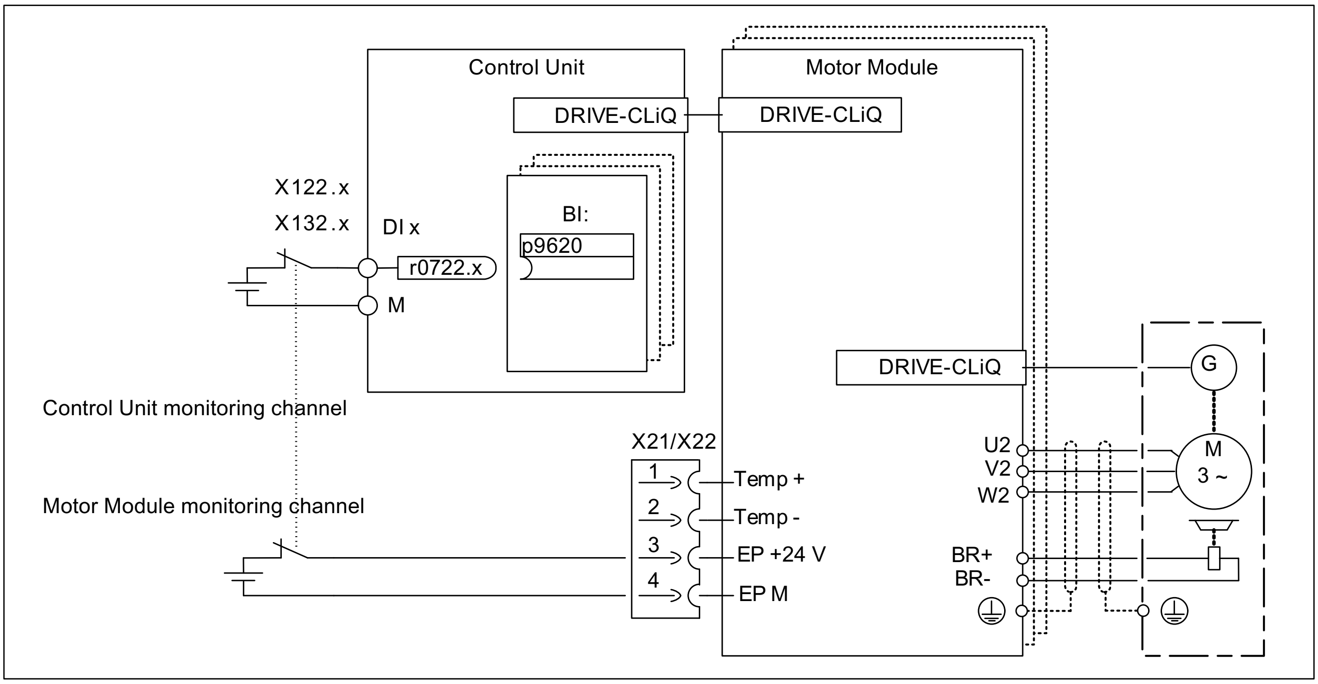


Figure 7-4 Example: Terminals for "Safe Torque Off", example for Motor Modules booksize and CU320-2 DP

Grouping drives

To ensure that the function works for more than one drive at the same time, the terminals for the corresponding drives must be grouped together as follows:

1. Switch-off signal path

   By connecting the binector input to the joint input terminal on the drives in one group.
2. Switch-off signal path (Motor Module/Power Module)

   By appropriately wiring the terminals for the individual Motor Modules/Power Modules belonging to the group.

Note

The grouping must be identical in both monitoring channels.

If a fault in a drive results in a "Safe Torque Off" (STO), this does not automatically mean that the other drives in the same group also switch to "Safe Torque Off" (STO).

The assignment is checked during the test for the switch-off signal paths, The operator selects "Safe Torque Off" for each group. The check is drive-specific.

Example: Terminal groups

It must be possible to select/deselect "Safe Torque Off" separately for group 1 (drive 1 and 2) and group 2 (drive 3 and 4).

For this purpose, the same grouping for "Safe Torque Off" must be performed on both the Control Unit and the Motor Modules.

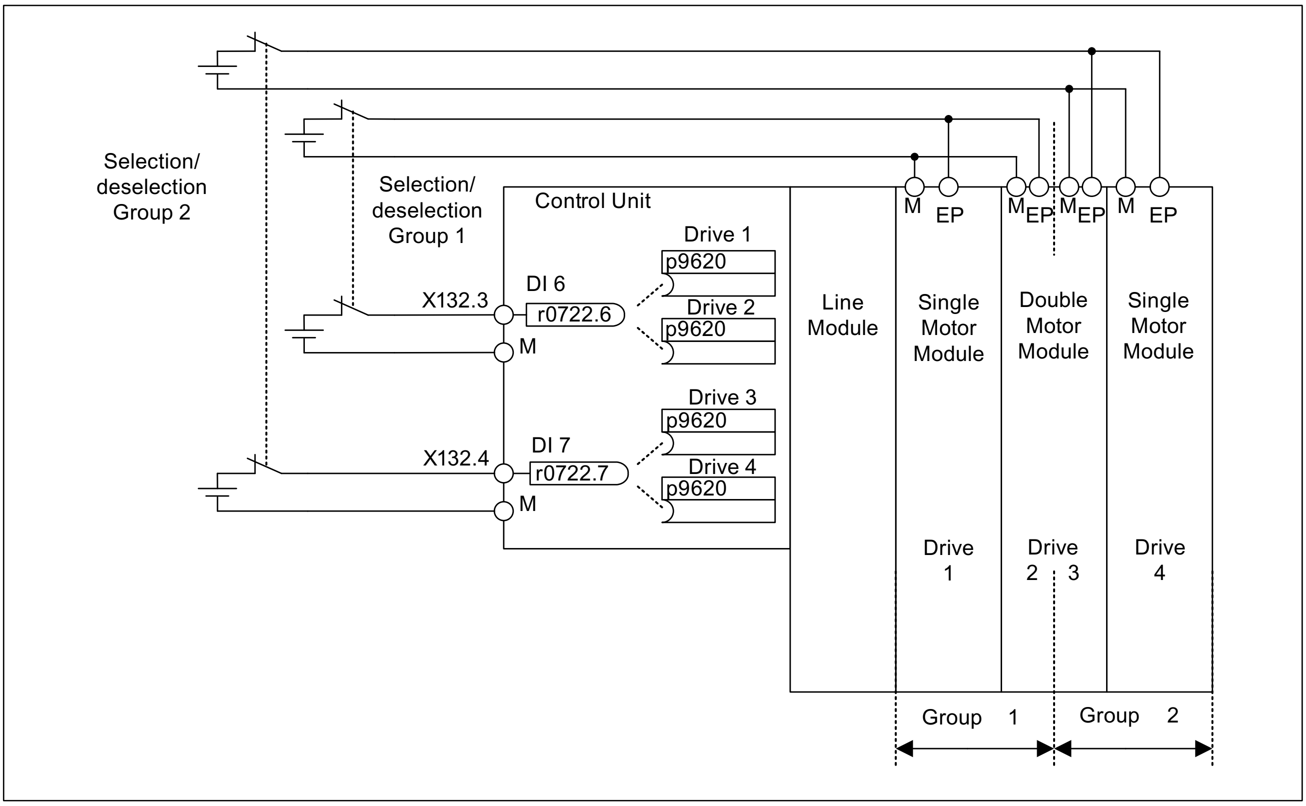


Figure 7-5 Example: Grouping terminals with Motor Modules booksize and CU320-2 DP

Information on the parallel connection of chassis type Motor Modules

When chassis format Motor Modules are connected in parallel, a safe AND element is created on the parallel drive object. The number of indexes in p9620 corresponds to the number of parallel chassis components in p0120.

7.3.1.2 Simultaneity and tolerance time of the two monitoring channels

Simultaneity and tolerance time of the two monitoring channels

The "Safe Torque Off" function must be selected/deselected simultaneously in both monitoring channels using the input terminals and is only effective for the associated drive.

1 signal: Deselecting the function

0 signal: Selecting the function

"Simultaneously" means:

The changeover must be complete in both monitoring channels within the parameterized tolerance time.

- p9650 SI SGE changeover tolerance time (Control Unit)
- p9850 SI SGE changeover tolerance time (Motor Module)

If the "Safe Torque Off" function is not selected/deselected within the tolerance time, this is detected by the cross-comparison, and fault F01611 or F30611 (STOP F) is output. In this case, the pulses have already been canceled as a result of the selection of "Safe Torque Off" on one channel.

7.3.1.3 Bit pattern test

Bit pattern test of fail-safe outputs

The converter normally responds immediately to signal changes in its fail-safe inputs. This is not desired in the following case: Several control modules test their fail-safe outputs using bit pattern tests (light/darkness tests) to identify faults due to either short circuiting or cross circuiting. When you interconnect a fail-safe input of the converter with a fail-safe output of a control module, the converter responds to these test signals.

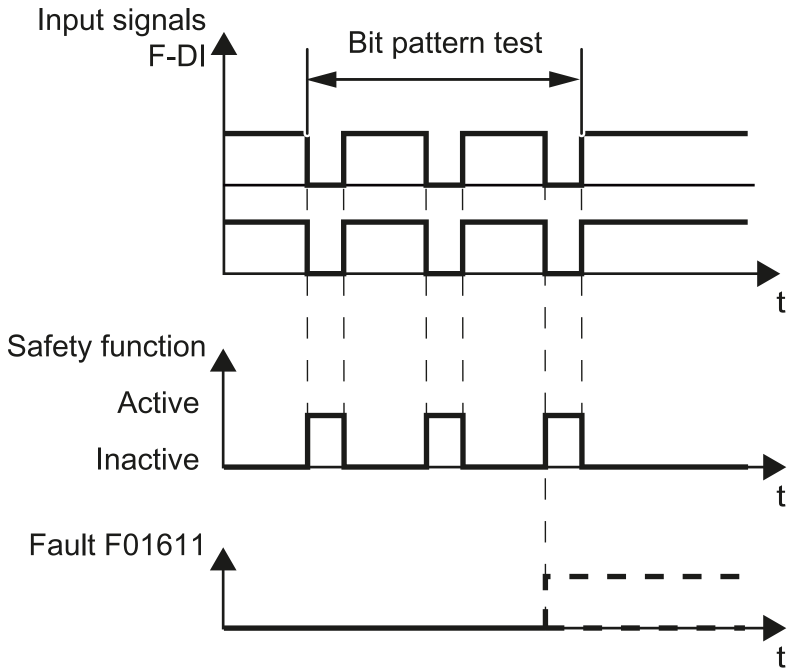


Figure 7-6 Converter response to a bit pattern test

Note

If the test impulses lead to unintended triggering of the Safety Integrated Functions, a filtering (p9651/p9851 SI STO/SBC/SS1 debounce time) of the terminal inputs must be assigned parameters.

Overview of important parameters

- p0799[0...2] CU inputs/outputs sampling time
- p9650 SI SGE changeover tolerance time (Control Unit)
- p9850 SI SGE changeover tolerance time (Motor Module)

7.3.2 Control of "STO" and "SS1" for SINAMICS G130

Description

The safety functions contained in the standard ("Safe Torque Off" and "Safe Stop 1") can be used with the power module.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

The following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2) can be activated:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1, (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This variant is used when:

- Activation will be executed optically isolated with a voltage of 24 V DC.
- Working with control lines that are shorter than 30 m.
- When devices are used in plants with low spatial elongation
(watch out for the drop in voltage at 24 V DC!).

Functional principle

The first shutdown path for the integrated safety functions is activated via a digital input on the control unit; digital inputs DI0 to DI7 are available for this purpose.

The second shutdown path for the integrated safety functions is activated via the terminals (-X41:1, -X42:2) on the Control Interface module of the Power Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The selection of the safety function on the Control Unit and on the Control Interface Module of the Power Module must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER

Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

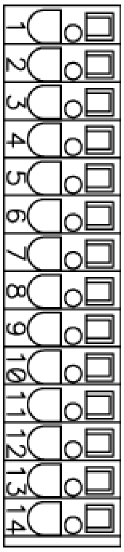
Terminal strip –X41 on the Control Interface Module of the Power Module

Table 7- 5 Terminal strip –X41 on the Control Interface Module of the Power Module

Terminal	Function	Technical data
-X41:2	EP +24V (enable pulses)	Supply voltage: 24 V DC (20.4 V - 28.8 V) Current consumption: 10 mA Signal propagation times: L → H 100 µs H → L: 1000 µs
-X41:1	EP M1 (Enable Pulses)	

Terminal strip –X122 on the CU320-2 control unit

Table 7- 6 Terminal strip –X122 on the CU320-2 control unit

	Terminal	Designation[1)]	Technical data
	1	DI 0	Voltage: -30 V ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: The reference potential is terminal M1 Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 μs For "1" → "0": 150 μs
	2	DI 1	
	3	DI 2	
	4	DI 3	
	5	DI 16	
	6	DI 17	
	7	M1	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 8	**As input**: Voltage: -30 V ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 8, 9, 10, and 11 are "rapid inputs" [2)] Input delay (typ.): For "0" → "1": 5 μs For "1" → "0": 50 μs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3)]: For "0" → "1": 150 μs / 400 μs For "1" → "0": 75 μs / 100 μs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 9	
	11	M	
	12	DI/DO 10	
	13	DI/DO 11	
	14	M	
Max. connectable cross-section: 1.5 mm^2			

1) DI: digital input; DI/DO: bidirectional digital input/output; M: Electronic ground; M1: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE

An open input is interpreted as "low".

To enable the digital inputs (DI) to function, terminal M1 must be connected.

This is achieved by:

1. Providing the ground reference of the digital inputs, or
2. A jumper to terminal M.

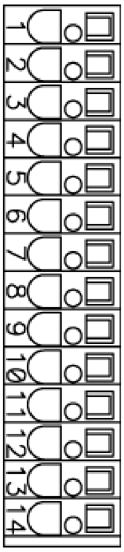
Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Terminal strip –X132 on the CU320-2 control unit

Table 7- 7 Terminal strip –X132 on the CU320-2 control unit

	Terminal	Designation[1]	Technical data
	1	DI 4	Voltage: -30 V ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: reference potential is M2 terminal Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 5	
	3	DI 6	
	4	DI 7	
	5	DI 20	
	6	DI 21	
	7	M2	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 12	**As input**: Voltage: -30 V ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 12, 13, 14, and 15 are "rapid inputs" [2] Input delay (typ.): For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3]: For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 13	
	11	M	
	12	DI/DO 14	
	13	DI/DO 15	
	14	M	
Max. connectable cross-section: 1.5 mm^2			

1) DI: digital input; DI/DO: Bidirectional digital input/output; M: Electronic ground; M2: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M2 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. A jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.3.3 Control of "STO" and "SS1" for SINAMICS G150

Description

The activation of the safety functions already contained in the standard (i.e., "Safe Torque Off" and "Safe Stop 1") can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

The following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2) can be activated:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This variant is used when:

- Activation will be executed optically isolated with a voltage of 24 V DC.
- Working with control lines that are shorter than 30 m.
- When devices are used in plants with low spatial elongation (watch out for the drop in voltage at 24 V DC!).

Functional principle

The first shutdown path for the integrated safety functions is activated via a digital input on the control unit; digital inputs DI0 to DI7 are available for this purpose.

The second shutdown path for the integrated safety functions is activated via the terminals (-X41:1, -X42:2) on the Control Interface module of the Power Module.

Note

Additional inputs must be activated in the following cabinet units (automatic synchronizers):
- an additional digital input on the CU320-2 and
- the terminals (-X41:1, -X42:2) on the Control Interface Module of the second Power Module, which is connected in parallel.

- For 3 AC 380 to 480 V:
  6SL3710-2GE41-1AAx, 6SL3710-2GE41-4AAx, 6SL3710-2GE41-6AAx
- For 3 AC 500 to 600 V:
  6SL3710-2GF38-6AAx, 6SL3710-2GF41-1AAx, 6SL3710-2GF41-4AAx
- For 3 AC 660 to 690 V:
  6SL3710-2GH41-1AAx, 6SL3710-2GH41-4AAx, 6SL3710-2GH41-5AAx

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The selection of the safety function on the Control Unit and on the Control Interface Module of the Power Module must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER

Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

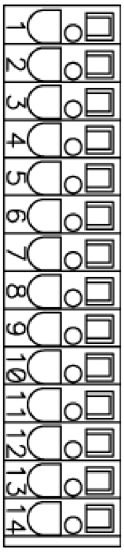
Terminal strip –X41 on the Control Interface Module of the Power Module

Table 7- 8 Terminal strip –X41 on the Control Interface Module of the Power Module

Terminal	Function	Technical data
-X41:2	EP +24V (enable pulses)	Supply voltage: 24 V DC (20.4 V...28.8 V) Power consumption: 10 mA Signal propagation times: L → H 100 µs H → L: 1000 µs
-X41:1	EP M1 (Enable Pulses)	

Terminal strip –X122 on the CU320-2 control unit

Table 7- 9 Terminal strip –X122 on the CU320-2 control unit

	Terminal	Designation 1)	Technical data
	1	DI 0	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: The reference potential is terminal M1 Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 1	
	3	DI 2	
	4	DI 3	
	5	DI 16	
	6	DI 17	
	7	M1	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 8	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 8, 9, 10, and 11 are "rapid inputs" 2) Input delay (typ.) For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) 3): For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 9	
	11	M	
	12	DI/DO 10	
	13	DI/DO 11	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: bidirectional digital input/output; M: Electronic ground; M1: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE

An open input is interpreted as "low".

To enable the digital inputs (DI) to function, terminal M1 must be connected.

This is achieved by:

1. Providing the ground reference of the digital inputs, or
2. a jumper to terminal M.

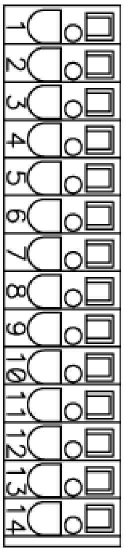
Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Terminal strip –X132 on the CU320-2 control unit

Table 7- 10 Terminal strip –X132 on the CU320-2 control unit

	Terminal	Designation 1)	Technical data
	1	DI 4	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: reference potential is M2 terminal Level (incl. ripple) High level: 15 ... 30 V Low level: -30 to +5 V Input delay (typ.): For "0" → "1": 50 μs For "1" → "0": 150 μs
	2	DI 5	
	3	DI 6	
	4	DI 7	
	5	DI 20	
	6	DI 21	
	7	M2	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 12	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 12, 13, 14, and 15 are "rapid inputs" 2) Input delay (typ.): For "0" → "1": 5 μs For "1" → "0": 50 μs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) 3): For "0" → "1": 150 μs / 400 μs For "1" → "0": 75 μs / 100 μs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 13	
	11	M	
	12	DI/DO 14	
	13	DI/DO 15	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M2 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.3.4 Control of "STO" and "SS1" for SINAMICS S120 Chassis

Description

The safety functions contained in the standard ("Safe Torque Off" and "Safe Stop 1") can be used with the Motor Module.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

The following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2) can be activated:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This variant is used when:

- Activation will be executed optically isolated with a voltage of 24 V DC.
- Working with control lines that are shorter than 30 m.
- When devices are used in plants with low spatial elongation (watch out for the drop in voltage at 24 V DC!).

Functional principle

The first shutdown path for the integrated safety functions is activated via a digital input on the control unit; digital inputs DI0 to DI7 are available for this purpose.

The second shutdown path for the integrated safety functions is activated via the terminals (-X41:1, -X42:2) on the Control Interface Module of the Power Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The selection of the safety function on the control unit and on the motor module must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

DANGER

Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

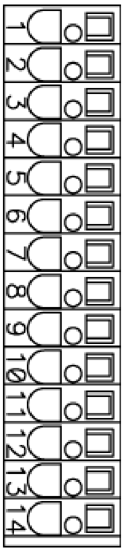
Terminal strip –X41 on the Control Interface Module of the chassis Motor Module

Table 7- 11 Terminal strip –X41 on the Control Interface Module of the chassis Motor Module

<table>
<tr><th>Terminal</th><th>Function</th><th>Technical data</th></tr>
<tr><td>-X41:2</td><td>EP +24V (enable pulses)</td><td rowspan="2">Supply voltage: 24 V DC (20.4 V...28.8 V)
Power consumption: 10 mA
Signal propagation times:
L → H 100 µs
H → L: 1000 µs</td></tr>
<tr><td>-X41:1</td><td>EP M1 (Enable Pulses)</td></tr>
</table>

Terminal strip –X122 on the CU320-2 control unit

Table 7- 12 Terminal strip –X122 on the CU320-2 control unit

	Terminal	Designation [1]	Technical data
	1	DI 0	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: The reference potential is terminal M1 Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 1	
	3	DI 2	
	4	DI 3	
	5	DI 16	
	6	DI 17	
	7	M1	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 8	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 to 30 V Low level: -30 to +5 V DI/DO 8, 9, 10, and 11 are "rapid inputs" [2] Input delay (typ.) For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3]: For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 9	
	11	M	
	12	DI/DO 10	
	13	DI/DO 11	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronic ground; M1: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

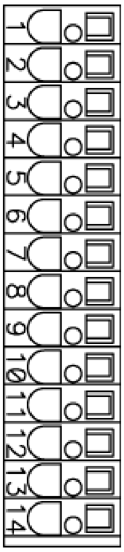
NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M1 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Terminal strip –X132 on the CU320-2 control unit

Table 7- 13 Terminal strip –X132 on the CU320-2 control unit

	Terminal	Designation 1)	Technical data
	1	DI 4	Voltage: -30 V...+30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: reference potential is M2 terminal Level (incl. ripple) High level: 15 to 30 V Low level: -30 to +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 5	
	3	DI 6	
	4	DI 7	
	5	DI 20	
	6	DI 21	
	7	M2	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 12	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 to 30 V Low level: -30 to+5 V DI/DO 12, 13, 14, and 15 are "rapid inputs" 2) Input delay (typ.): For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) 3): For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 13	
	11	M	
	12	DI/DO 14	
	13	DI/DO 15	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M2 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.3.5 Control of "STO" and "SS1" for SINAMICS S120 Cabinet Modules

Description

The activation of the safety functions already contained in the standard (i.e., "Safe Torque Off" and "Safe Stop 1") can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

The following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2) can be activated:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This variant is used when:

- Activation will be executed optically isolated with a voltage of 24 V DC.
- Working with control lines that are shorter than 30 m.
- When devices are used in plants with low spatial elongation (watch out for the drop in voltage at 24 V DC!).

Functional principle

The first shutdown path for the integrated safety functions is activated via a digital input on the control unit; digital inputs DI0 to DI7 are available for this purpose.

Chassis Motor Module

- The second shutdown path for the integrated safety functions is activated via the terminals (-X41:1, -X42:2) on the Control Interface Module of the Power Module.

Booksize Cabinet Kit

- The second shutdown path for the integrated safety functions is activated via the terminals (-X21:3, -X21:4) on the booksize Motor Module.
  In the case of a booksize Double Motor Module, terminals -X22:3 and -X22:4 are at the disposal of the second motor connection for the activation of the second shutdown path.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The selection of the safety function on the control unit and on the motor module must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠DANGER
Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

Terminal strip –X41 on the Control Interface Module of the chassis Motor Module

Table 7- 14 Terminal strip –X41 on the Control Interface Module of the chassis Motor Module

Terminal	Function	Technical data
-X41:2	EP +24V (enable pulses)	Supply voltage: 24 V DC (20.4 V...28.8 V) Power consumption: 10 mA Signal propagation times: L → H 100 µs H → L: 1000 µs
-X41:1	EP M1 (Enable Pulses)	

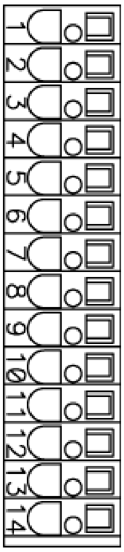
Terminal strip –X21/–X22 on the Control Interface Module of the booksize Motor Module

Table 7- 15 Terminal strip –X21/–X22 on the Control Interface Module of the booksize Motor Module

Terminal	Function	Technical data
-X21:3 -X22:3	EP +24V (enable pulses)	Supply voltage: 24 V DC (20.4 V...28.8 V) Power consumption: 10 mA Signal propagation times: L → H 100 µs H → L: 1000 µs
-X21:4 -X22:4	EP M1 (Enable Pulses)	

Terminal strip –X122 on the CU320-2 control unit

Table 7- 16 Terminal strip –X122 on the CU320-2 control unit

	Terminal	Designation [1]	Technical data
	1	DI 0	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: The reference potential is terminal M1 Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 1	
	3	DI 2	
	4	DI 3	
	5	DI 16	
	6	DI 17	
	7	M1	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 8	**As input**: Voltage: -30 V...+30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 to 30 V Low level: -30 ... +5 V DI/DO 8, 9, 10, and 11 are "rapid inputs" [2] Input delay (typ.) For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3]: For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 9	
	11	M	
	12	DI/DO 10	
	13	DI/DO 11	
	14	M	
Max. connectable cross-section: 1.5 mm^2			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronic ground; M1: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

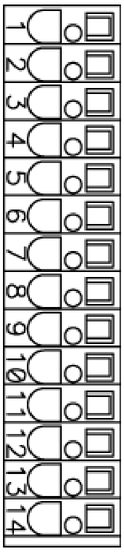
NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M1 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Terminal strip –X132 on the CU320-2 control unit

Table 7- 17 Terminal strip –X132 on the CU320-2 control unit

	Terminal	Designation [1)]	Technical data
	1	DI 4	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: reference potential is M2 terminal Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 5	
	3	DI 6	
	4	DI 7	
	5	DI 20	
	6	DI 21	
	7	M2	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 12	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 12, 13, 14, and 15 are "rapid inputs" [2)] Input delay (typ.): For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3)]: For "0" → "1": 150 µs / 400 µs For "0" → "1": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 13	
	11	M	
	12	DI/DO 14	
	13	DI/DO 15	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M2 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.3.6 Control of "STO" and "SS1" for SINAMICS S150

Description

The activation of the safety functions already contained in the standard (i.e., "Safe Torque Off" and "Safe Stop 1") can also be used without option K82.

Note

Refer to the circuit diagrams enclosed for the interconnections for your device.

Note

The Safety functions must be activated prior to use via parameter assignment. An acceptance test must be performed and an acceptance log must be created.

The following Safety Integrated Basic Functions (terms and definitions in accordance with IEC 61800-5-2) can be activated:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1) (time controlled)

Note

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements of EN 61800-5-2, EN 60204-1, and DIN EN ISO 13849-1 category 3 (formerly EN 954-1), as well as the requirements for Performance Level (PL) d and IEC 61508 SIL2.

In addition, most of the SINAMICS safety functions have been certified by independent institutes. An up-to-date list of certified components is available on request from your local Siemens office.

Recommended application

This variant is used when:

- Activation will be executed optically isolated with a voltage of 24 V DC.
- Working with control lines that are shorter than 30 m.
- When devices are used in plants with low spatial elongation (watch out for the drop in voltage at 24 V DC!).

Functional principle

The first shutdown path for the integrated safety functions is activated via a digital input on the control unit; digital inputs DI0 to DI7 are available for this purpose.

The second shutdown path for the integrated safety functions is activated via the terminals (-X41:1, -X42:2) on the Control Interface Module of the Power Module.

The selection and deselection must be executed concurrently. The time delay that is unavoidable due to mechanical switch processes, for instance, can be adapted via parameters.

The selection of the safety function on the Control Unit and on the Control Interface Module of the Motor Module must be executed over two channels. A switch in accordance with ISO 13850/ EN 418, positive opening in accordance with EC 60947-5-1, or a certified safety controller must be used as activation element.

⚠ DANGER
Responsibility for selecting the correct activation element for the purpose of compliance of the overall system with the required standard (DIN EN ISO 13849-1 (formerly EN954-1) Cat. 3 PL d or DIN EN 61508 SIL2) rests with the user.

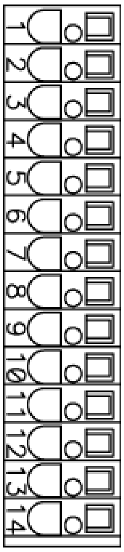
Terminal strip –X41 on the Control Interface Module of the Motor Module

Table 7- 18 Terminal strip –X41 on the Control Interface Module of the Motor Module

Terminal	Function	Technical data
-X41:2	EP +24V (enable pulses)	Supply voltage: 24 V DC (20.4 V...28.8 V) Power consumption: 10 mA Signal propagation times: L → H 100 µs H → L: 1000 µs
-X41:1	EP M1 (Enable Pulses)	

Terminal strip –X122 on the CU320-2 control unit

Table 7- 19 Terminal strip –X122 on the CU320-2 control unit

	Terminal	Designation [1]	Technical data
	1	DI 0	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: The reference potential is terminal M1 Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 1	
	3	DI 2	
	4	DI 3	
	5	DI 16	
	6	DI 17	
	7	M1	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 8	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 8, 9, 10, and 11 are "rapid inputs" [2] Input delay (typ.) For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3]: For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 9	
	11	M	
	12	DI/DO 10	
	13	DI/DO 11	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronic ground; M1: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

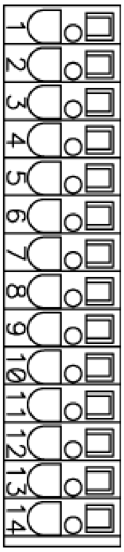
NOTICE
An open input is interpreted as "low". To enable the digital inputs (DI) to function, terminal M1 must be connected. This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M. Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Terminal strip –X132 on the CU320-2 control unit

Table 7- 20 Terminal strip –X132 on the CU320-2 control unit

	Terminal	Designation [1]	Technical data
	1	DI 4	Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Electrical isolation: reference potential is M2 terminal Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V Input delay (typ.): For "0" → "1": 50 µs For "1" → "0": 150 µs
	2	DI 5	
	3	DI 6	
	4	DI 7	
	5	DI 20	
	6	DI 21	
	7	M2	Reference potential for terminal 1 ... 6
	8	M	Ground
	9	DI/DO 12	**As input**: Voltage: -30 ... +30 VDC Typical power consumption: 9 mA at 24 V Level (incl. ripple) High level: 15 ... 30 V Low level: -30 ... +5 V DI/DO 12, 13, 14, and 15 are "rapid inputs" [2] Input delay (typ.): For "0" → "1": 5 µs For "1" → "0": 50 µs **As output**: Voltage: 24 V DC Max. load current per output: 500 mA Continued-short-circuit-proof Output delay (typ./max.) [3]: For "0" → "1": 150 µs / 400 µs For "1" → "0": 75 µs / 100 µs Switching frequency: For resistive load: Max. 100 Hz For inductive load: Max. 0.5 Hz For lamp load: Max. 10 Hz Maximum lamp load: 5 W
	10	DI/DO 13	
	11	M	
	12	DI/DO 14	
	13	DI/DO 15	
	14	M	
Max. connectable cross-section: 1.5 mm²			

1) DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Ground reference

2) The rapid inputs can be used as probe inputs or as inputs for the external zero mark

3) Data for: V_{cc}= 24 V; load 48 Ω; high ("1") = 90% V_{out}; low ("0") = 10% V_{out}

NOTICE
An open input is interpreted as "low".
To enable the digital inputs (DI) to function, terminal M2 must be connected.
This is achieved by: 1. Providing the ground reference of the digital inputs, or 2. a jumper to terminal M.
Caution! This removes the electrical isolation for these digital inputs.

Note

If a momentary interruption in the voltage occurs in the 24 V supply, the digital outputs will be deactivated until the interruption has been rectified.

Wiring

The control lines must be permanently laid.

Signal cables and encoder cables should be installed separated from one another.

The shields of the control lines must be wide-area grounded directly after entry into the control cabinet.

Outside the control cabinet the cables must be laid in such a way that they are safe to walk on (e.g., conforming to IEC 60204-1).

7.4 Control via TM54F / option K87

7.4.1 General information

7.4.1.1 TM54F design

Terminal Module TM54F is a terminal expansion module for snap-on rail mounting in accordance with DIN EN 60715. The TM54F features fail-safe digital I/O for controlling the Safety Integrated Extended Functions.

Each Control Unit can be assigned only one TM54F which is connected via DRIVE-CLiQ.

NOTICE
The TM54F may not be interconnected in series with the Motor Modules and must be operated on a separate DRIVE-CLiQ line (separate port on the Control Unit). Other Terminal and Sensor Modules can be connected to this DRIVE-CLiQ line.

TM54F features the following terminals:

Table 7- 21 Overview of the TM54F interfaces

Type	Number
Fail-safe digital outputs (F-DO)	4
Fail-safe digital inputs (F-DI)	10
Sensor [1)] power supplies, dynamic response supported [2)]	2
Sensor [1)] power supply, no dynamic response	1
Digital inputs for checking the F-DO with activated forced dormant error detection	4

1) Sensors: Fail-safe devices for command operations and status logging (e.g. emergency stop buttons, safety door locks, position switches, and light arrays / light curtains).

2) Dynamic response: The sensor power supply is cycled on and off by the TM54F when the forced dormant error detection is active for the sensors, cable routing, and the evaluation electronics.

The TM54F provides 4 fail-safe digital outputs and 10 fail-safe digital inputs. A fail-safe digital output consists of a 24 V DC switching output, an output switching to ground and a digital input for reading back the switching state. A fail-safe digital input consists of two digital inputs.

Note

You have the following options of acknowledging TM54F faults after troubleshooting:

- POWER ON
- Falling edge in signal "Internal Event ACK" with subsequent acknowledgement on the Control Unit.

The signal states of the two digital inputs of the F-DI are frozen at logical 0 (safety function selected) when different signal states are present within a fail-safe F-DI of the TM54F, until a safe acknowledgment has been carried out by means of an F-DI via parameter p10006 (SI acknowledgment internal event input terminal) or the extended alarm acknowledgment has been carried out.

The monitoring time (p10002) for the discrepancy of the two digital inputs of an F-DI may have to be increased so that switching operations do not trigger an undesired response, thereby necessitating a safe acknowledgment. Therefore, the signal states at the two related digital inputs (F-DI) must have the same state within this monitoring time, otherwise the following fault will be output F35151 TM54F: Discrepancy error. This requires safe acknowledgement.

Note

The discrepancy time must be set so that it is always smaller than the smallest expected switching interval of the signal to this F-DI.

7.4.1.2 F-DI function

Description

Fail-safe digital inputs (F-DI) consist of two digital inputs. The cathode (M) of the optocoupler is routed to the second digital input to allow the connection of an M-switching F-DO output (the anode must be connected to 24 V DC).

Parameter p10040 is used to determine whether an F-DI is operated as NC/NC or NC/NO contact. The status of DI can be read at parameter r10051 for the drive objects TM54F_MA and TM54F_SL. The same bits of both drive objects are logically linked by AND operation and return the status of the relevant F-DI.

Test signals from controllers can be filtered out using parameter p10017, so that faults are not incorrectly interpreted.

Explanation of terms:

NC contact / NC contact: to select the safety function, a "zero level" must be present on both inputs.

NC contact / NO contact: to select the safety function, a "zero level" at input 1 and a "1 level" at input 2 must be present.

The signal states at the two associated digital inputs (F-DI) must assume the same status configured in p10040 within the monitoring time set in p10002.

In order to enable forced dormant error detection, connect the digital inputs of F-DI 0 ... 4 with the dynamic voltage supply L1+ and the digital inputs with F-DI 5 ... 9 to L2+ (for additional information on forced dormant error detection, see the corresponding function description in the chapter "Extended Functions").

In the SINAMICS Parameter Manual, function diagrams 2850 and 2851 show an overview of the fail-safe inputs F-DI 0 .... 4 or F-DI 5 ... 9.

F-DI features

- Fail-safe configuration with two digital inputs per F-DI
- Input filter for test signals with an adjustable gating time (p10017)
- Configurable connection of NC/NC or NC/NO contacts by means of parameter p10040
- Status parameter r10051
- Adjustable time window for monitoring discrepancy at both digital inputs by means of parameter p10002 for all F-DIs

---

Note

To avoid incorrect triggering of fault messages, on these inputs the discrepancy time must always be set less than the shortest time between two switching events (ON/OFF, OFF/ON).

- Second digital input with additional tap of the optocoupler cathode for connecting an M-switching output of a fail-safe controller.

> **⚠ WARNING**
>
> As opposed to mechanical switching contacts (e.g. Emergency Stop switches), leakage currents can still flow through semiconductor switches even when they are switched off. This can lead to false switching states if digital inputs are not connected correctly.
>
> The conditions for digital inputs/outputs specified in the relevant manufacturer documentation must be observed.

> **⚠ WARNING**
>
> In accordance with IEC 61131 Part 2, Chapter 5.2 (2008), only outputs that have a maximum residual current of 0.5 mA when "OFF" can be used to connect TM54F digital inputs with digital semiconductor outputs.

The inclusion of additional load resistors makes it possible to use digital outputs with larger residual currents to connect TM54F inputs.

Overview of important parameters

- p9651 SI STO/SBC/SS1 debounce time (Control Unit)
- p9851 SI STO/SBC/SS1 debounce time (Control Unit)
- p10002 SI discrepancy monitoring time
- p10017 SI digital inputs, debounce time
- p10040 SI F-DI input mode
- r10051.0...9 CO/BO: SI status of digital inputs

7.4.1.3 Function of the F-DO

Description

Fail-safe digital outputs (F-DO) consist of two digital outputs plus one digital input that checks the switching state for forced dormant error detection. The first digital input switches 24 V DC, and the second switches M of the X514 voltage supply.

The status of each F-DO can be read at parameter r10052. The status of the associated DIs can be read at parameter r10053 for the drive objects of the slave (TM54F_SL).

In order to enable forced dormant error detection, connect the corresponding digital input for the forced feedback signals of the relays (more information on forced dormant error detection is provided in the chapter "Safety Integrated Extended Functions").

In the SINAMICS Parameter Manual, function diagram 2853 provides an overview of the fail-safe outputs F-DO 0...3, and the associated checking inputs F-DI 20...23.

F-DO signal sources

A drive group contains several drives with similar characteristics. The groups are parameterized at the p10010 and p10011 parameters.

The following signals are available for interconnecting (p10042, ..., p10045) each one of the four drive groups with the F-DO:

- STO active (power removed)
- SS1 active
- SS2 active
- SOS active
- SLS active
- SLS level
- SSM feedback active
- SOS selected
- Internal event (no active safety fault)
- Safe state

The following signals can be requested by means of p10039[0...3] for each drive group (index 0 corresponds with drive group 1 etc.):

- STO active (power removed)
- SS1 active
- SS2 active
- SOS active
- SLS active

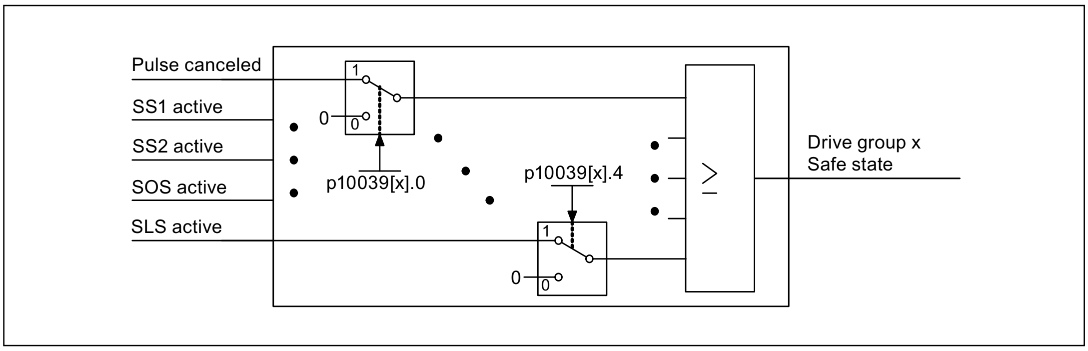


Figure 7-7 Safe state selection

The same signals (high-active) of each drive or drive group are logically linked by means of AND operation. The different signals selected through p10039 are logically linked by means of OR operation. Result of these logic operations is the "Safe State" for each drive group.

Each F-DO supports the interconnection of up to 6 signals by way of indexing (p10042[0...5] to p10045[0...5]) and their output as logical AND operation.

F-DO features

- Each F-DO with fail-safe configuration consisting of two digital outputs plus one digital input for checking the switching state for forced dormant error detection
- Status parameters r10052/r10053

Function diagrams

- 2853 TM54F (F-DO 0 ... F-DO 3, DI 20 ... DI 23)
- 2856 TM54F Safe State selection
- 2857 TM54F assignment (F-DO 0 ... F-DO 3)

Overview of important parameters

- p10039 SI Safe State signal selection
- p10042[0...5] SI F-DO 0 signal sources
- p10043[0...5] SI F-DO 1 signal sources
- p10044[0...5] SI F-DO 2 signal sources
- p10045[0...5] SI F-DO 3 signal sources
- r10052.0...3 CO/BO: SI status of digital outputs
- r10053.0...3 CO/BO: SI digital inputs 20 ... 23

7.4.2 Control via TM54F for SINAMICS S120 Chassis

The Terminal Module TM54F must be supplied with DC 24 V and connected with the Control Unit via DRIVE-CLiQ.

7.4.3 Control via option K87 for SINAMICS S120 Cabinet Modules

With option K87 the Terminal Module TM54F is integrated in the cabinet unit (-A70) and connected with the Control Unit via DRIVE-CLiQ.

7.4.4 Control via K87 for SINAMICS S150

With option K87 the Terminal Module TM54F is integrated in the cabinet unit (-A70) and connected with the Control Unit via DRIVE-CLiQ.

7.5 Control by way of PROFIsafe

7.5.1 Safety Integrated Functions

As an alternative to controlling Safety Integrated Functions via terminals or TM54F, they can also be controlled via PROFIsafe. PROFIsafe telegram 30 is used for communication using PROFIBUS and PROFINET.

Control via PROFIsafe is available for both Safety Integrated Basic Functions and Safety Integrated Extended Functions.

7.5.2 Enabling of the control via PROFIsafe

For PROFIsafe communication, SINAMICS devices require a PROFIBUS or a PROFINET interface.

Every drive with configured PROFIsafe in the drive unit represents a PROFIsafe slave (F slave) with a fail-safe communication to the F host via PROFIBUS or PROFINET and is assigned its own PROFIsafe telegram.

In so doing, a PROFIsafe safety channel, a so-called safety-slot is created using the HW Config tool from SIMATIC Manager Step 7. It is then possible to also control the Basic Functions using PROFIsafe telegram 30. The structure of the associated control and status words is described in more detail later in this document (see the "PROFIsafe STW" and "PROFIsafe ZSW" tables). The PROFIsafe telegram 30 is placed in front of the standard telegram for communication (e.g. telegram 2).

Enabling PROFIsafe

The Safety Integrated Functions are enabled via PROFIsafe using parameters p9601 and p9801:

- Basic Functions: p9601.2 = 0, p9801.2 = 0
  Extended Functions: p9601.2 = 1, p9801.2 = 1
- p9601.3 = 1, p9801.3 = 1

Note

License requirement for Safety Integrated via PROFIsafe

A license is not required for use of the Basic Functions, this also applies for control via PROFIsafe.

However, for Extended Functions, you require an appropriate license that will be charged for.

All parameters involved in PROFIsafe communication are password protected against undesirable changes and secured using a checksum. The telegrams are configured using a configuration tool (e.g. HW Config + F-Configuration Pack or SCOUT) on the F host.

Safety Integrated Basic Functions via PROFIsafe and terminals

Control of the Basic Functions via terminals on the Control Unit and on the Motor/Power Module (parameters p9601.0 = p9801.0 = 1) may be enabled in parallel. In this way, the STO and SS1 functions (time controlled) can be selected via PROFIsafe telegram 30 as well as in parallel via the onboard terminals of the Control Unit and Motor Module/Power Module.

STO has priority over SS1, i.e. if SS1 and STO are simultaneously initiated, then STO is executed.

7.5.3 Structure of telegram 30

7.5.3.1 Structure of telegram 30 (Basic Functions)

PROFIsafe control word (STW)

S_STW1, PZD1 in telegram 30, output signals
See function diagram [2840].

Table 7- 22 Description of the PROFIsafe STW

Bit	Meaning	Remarks	
0	STO	1	Deselect STO
		0	Select STO
1	SS1	1	Deselect SS1
		0	Select SS1
2	SS2	0	– 1)
3	SOS	0	– 1)
4	SLS	0	– 1)
5	Reserved	-	–
6	Reserved	-	–
7	Internal Event ACK	1/0	Acknowledgment
		0	No acknowledgment
8	Reserved	-	–
9	Select SLS bit 0	-	– 1)
10	Select SLS bit 1	-	
11 ... 15	Reserved	-	–

1) Signals not relevant to Basic Functions should be set to "0".

PROFIsafe status word (ZSW)

S_ZSW1, PZD1 in telegram 30, input signals
See function diagram [2840].

Table 7- 23 Description of the PROFIsafe status word (ZSW)

Bit	Meaning	Remarks	
0	STO active	1	STO active
		0	STO not active
1	SS1 active	1	SS1 active
		0	SS1 not active
2	SS2 active	0	– [1]
3	SOS active	0	– [1]
4	SLS active	0	– [1]
5	Reserved	-	–
6	Reserved	-	–
7	Internal event	1	Internal event
		0	No internal event
8	Reserved	-	–
9	Active SLS level bit 0	-	– [1]
10	Active SLS level bit 1	-	
11	SOS selected	0	– [1]
12 ... 14	Reserved	-	–
15	SSM (speed)	0	– [1]

[1] Signals not relevant to Basic Functions should be set to "0".

7.5.3.2 Structure of telegram 30 (Extended Functions)

PROFIsafe control word (STW)

S_STW1, PZD1 in telegram 30, output signals
See function diagram [2840].

Table 7- 24 Description of the PROFIsafe STW

Bit	Meaning	Remarks	
0	STO	1	Deselect STO
		0	Select STO
1	SS1	1	Deselect SS1
		0	Select SS1
2	SS2	1	Deselect SS2
		0	Select SS2
3	SOS	1	Deselect SOS
		0	Select SOS
4	SLS	1	Deselect SLS
		0	Select SLS
5	Reserved	-	-
6	Reserved	-	-
7	Internal Event ACK	1/0	Acknowledgment
		0	No acknowledgment
8	Reserved	-	-
		-	-
9	Select SLS bit 0	-	Selection of the speed limit for SLS (2 bits)
10	Select SLS bit 1	-	
11 ... 15	Reserved	-	-

PROFIsafe status word (ZSW)

S_ZSW1, PZD1 in telegram 30, input signals
See function diagram [2840].

Table 7- 25 Description of the PROFIsafe status word (ZSW)

Bit	Meaning	Remarks	
0	STO active	1	STO active
		0	STO not active
1	SS1 active	1	SS1 active
		0	SS1 not active
2	SS2 active	1	SS2 active
		0	SS2 not active
3	SOS active	1	SOS active
		0	SOS not active
4	SLS active	1	SLS active
		0	SLS not active
5	Reserved	-	-
6	Reserved	-	-
7	Internal event	1	Internal event
		0	No internal event
8	Reserved	-	-
		-	-
9	Active SLS level bit 0	-	Display of the speed limit for SLS (2 bits)
10	Active SLS level bit 1	-	
11	SOS selected	1	SOS selected
		0	SOS deactivated
12 ... 14	Reserved	-	-
15	SSM (speed)	1	SSM (speed below limit value)
		0	SSM (speed higher than/equal to limit)

Commissioning 8

8.1 General information about commissioning safety functions

Commissioning notes

Note

The commissioning steps described here can be carried out via either STARTER or the advanced operator panel (AOP30).

The SINAMICS Safety Integrated Functions, both the Basic and also Extended Functions, are drive-specific, i. e. the commissioning of the functions must be performed once for each drive.

If the version in the Motor/Power Module is incompatible, the Control Unit responds as follows during the switchover to safety commissioning mode (p0010 = 95):

- Fault F01655 (SI CU: Align the monitoring functions) is output. The fault triggers fault reaction OFF2.
- The fault cannot be acknowledged until Safety commissioning mode (p0010 ≠ 95) is exited.
- The Control Unit triggers a safe pulse suppression via its own Safety switch-off signal path.
- If parameterized (p1215), the motor holding brake is applied.
- The Safety functions cannot be enabled (p9601/p9801 and p9602/p9802).

8.2 Safety Integrated firmware versions

Firmware versions for Safety Integrated

The safety firmware installed on the Control Unit and the safety firmware installed on the Motor/Power Module each has a separate version code. The parameters listed below can be used to read the version IDs from the relevant hardware.

Read the overall firmware version via:

- r0018 Control Unit firmware version

The following firmware data can be read for the basic functions:

- r9770[0...3] SI version, drive-autonomous safety functions (Control Unit)
- r9870[0...3] SI version, drive-autonomous safety functions (Motor Module)

The following firmware data can be read for the extended functions:

- r9590[0...3] SI Motion version safety motion monitoring (Control Unit)
- r9390[0...3] SI Motion version safety motion monitoring (Motor Module)
- r9890[0...2] SI version (Sensor Module)
- r10090[0...3] SI TM54F version

Basic Functions and Extended Functions

Basic and/or Extended Functions that have been enabled are checked to determine whether the parameter for the automatic firmware update is set (p7826 = 1).
This means that at each boot, the firmware version of the DRIVE-CLiQ components involved is checked in comparison to the firmware version of the Control Unit and, if required, updated.

During the acceptance test for the Safety Integrated basic functions, the safety firmware versions of the Motor/Power Modules must be read, logged, and checked against the list below.

During the acceptance test for the Safety Integrated extended functions, the safety firmware versions of the Motor/Power Modules, Sensor Modules and, if necessary, the Terminal Module TM54F required for the safety functions are read, logged, and checked against the list below.

When the extended functions are used, the firmware requirements for the basic functions must also be fulfilled at all times.

The list of permissible safety firmware version combinations, which must be used as a reference during the test, can be found under "Product Support" at the following address:
http://support.automation.siemens.com/WW/view/de/28554461
The testing procedure is described at the end of the chapter.

Procedure for checking the safety firmware version combinations

The document in the link provided contains tables listing the permissible safety firmware version combinations for the different safety function classes (SINAMICS basic functions, SINAMICS extended functions, SINUMERIK Safety Integrated).

The Safety firmware version relevant for the Safety function can be read from the Control Unit. The row containing this version number specifies the associated, permissible safety firmware versions of the relevant drive components. These versions must be compatible with the versions installed on your system.

8.3 Commissioning of Safety Integrated functions

8.3.1 Introduction

The Safety functions are commissioned using the screen forms in the STARTER. You will find these functions for each drive under "Functions" -> "Safety Integrated".

The password "0" is set by default.

NOTICE
For safety-related reasons, when using the STARTER commissioning tool from V4.1.5 and higher you can only set the safety-relevant parameters of the Control Unit offline. In order to set the safety-relevant parameters of the Motor/Power Module, set a check in the checkbox "Copy Parameters after Download" and then establish an online connection to the drive. Alternatively you can first establish an online connection to the drive and then duplicate the parameters by pressing the "Copy Parameters" button on the start screen of the configuration.

Note

Activating changed safety parameters

When exiting the commissioning mode (p0010 = 0), most of the changed parameters immediately become active. However, for some parameters, a POWER ON is required. If this is the case, a STARTER message or an alarm from the drive will inform you about this.

When performing an acceptance test, a POWER ON is always required.

8.3.2 Prerequisites for commissioning the Safety Integrated functions

1. Commissioning of the drives must be complete.
2. A POWER ON (switching off/on) is carried out on the drives.
3. Non-safe pulse suppression must be present, e.g. via OFF1 = "0" or OFF2 = "0".

   If the motor holding brake is connected and parameterized, the holding brake is applied.
4. For operation with SBC, the following applies:

   A motor with a motor holding brake must be connected to the appropriate terminal of the module.

8.3.3 Default settings for commissioning Safety Integrated functions without encoder

Additional default settings are required before commissioning Safety functions without an encoder.

Vector drive

The ramp-function generator is automatically created if a vector drive is configured. Please continue to the ramp-function generator configuration.

Servo drive

If a servodrive is configured, proceed as follows to call the ramp-function generator:

1. Activate the ramp-function generator: In the configured project, call the "Drive Navigator" offline, select the device configuration and click on "Configure drive". In the next window, under the function modules, select "Extended setpoint channel". With "Next", proceed with the configuration and when completed, exit with "Finish". The ramp-function generator is now active and can be parameterized.
2. In the project window, open the ramp-function generator by double-clicking on **<Drive unit> → Drives → <Drive> → Setpoint channel → Ramp-function generator**:

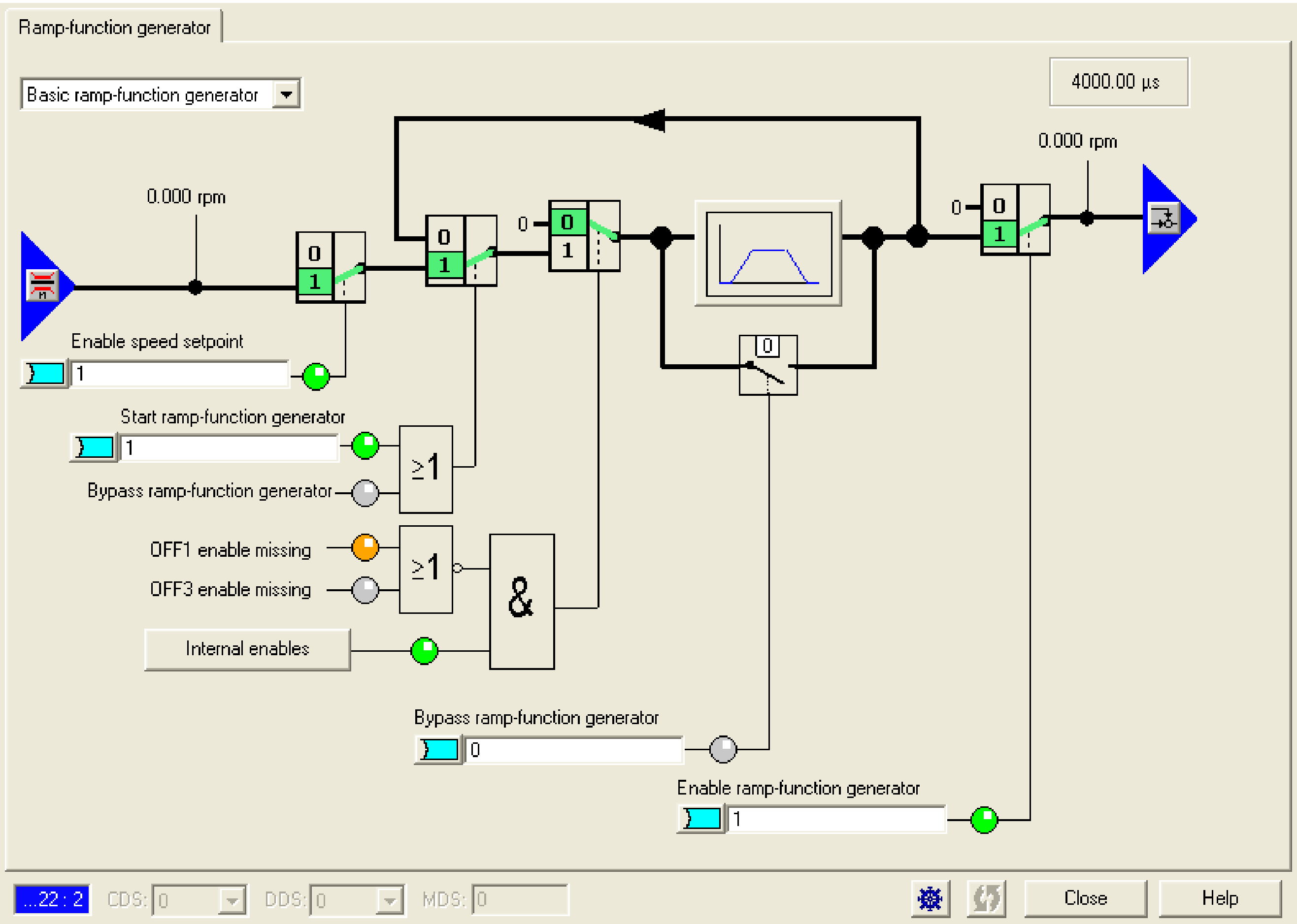


Figure 8-1 Ramp-function generator

3. Clicking on the button with the ramp opens the following window:

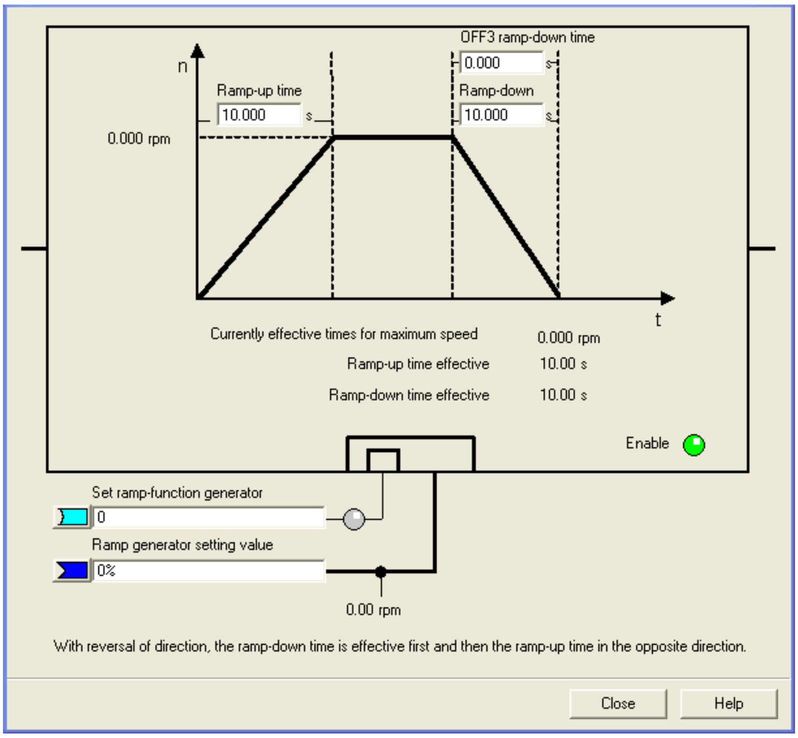


Figure 8-2 Ramp-function generator ramp

4. Here, enter the data to define the ramp-function generator ramp.
5. Then you must carry out the motor measurements: Start with static measurements and then take rotating measurements.

Activating Safety Integrated

1. Open the Safety Integrated selection window via **<Drive unit> →Drives→ <Drive> → Functions → Safety Integrated** and select the Safety function you require.

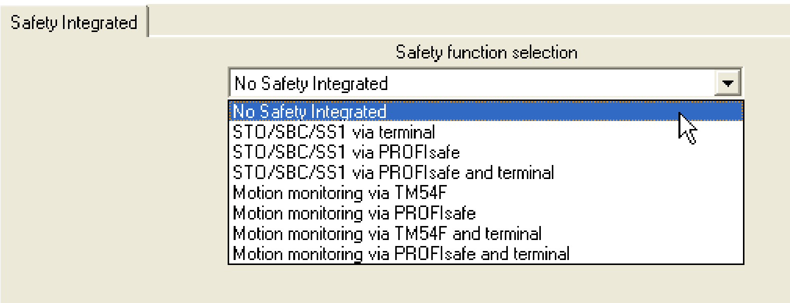


Figure 8-3 Safety Integrated selection

2. In the drop-down menu below, select "[1] Safety without encoder".
3. Then, open the configuration window and set the actual value acquisition cycle (p9511) to the value of the current controller cycle (p0115[0]) (e.g. 125 µsec).

4. Click "Gear factor" and set the actual value tolerance (p9542) to a larger value (e.g. 10 mm/min or 10 rpm) and the number of motor revolutions to match the pole pair number (r0313).
5. Open SS1 and set the shutdown speed to >0.
6. Call the Safely-Limited Speed, change all of the stop responses to "[0]STOP A" or "[1]STOP B" and close the window.
7. The user-specific Safety settings can now be performed.
8. Click on "Copy parameters".
9. Switch off/switch on the drive to accept the changes.

Note

If, during acceleration or deceleration, the drive outputs the message C01711/C30711 (message value 1041 to1043), this indicates problems due to ramping that is too steep in conjunction with the precontrol. You have the following options to remedy this:

- Reduce the ramp gradient.
- Use the extended ramp-function generator (with rounding) to set a more gentle ramp up.
- Reduce the precontrol.
- Change the values of parameters p9588 and p9589 (see specifications in the List Manual).

8.3.4 Standard commissioning of Safety Integrated functions

Standard commissioning of the safety functions

1. A commissioned project that has been uploaded to STARTER can be transferred to another drive unit keeping the existing Safety parameter assignment.
2. If the source and target devices have different software versions, the reference checksums may have to be adapted. This is displayed via a fault:
   Target checksum fault
   p9729[0…2] - F01680(0…2)
   p9399[0…1] - F30680(0…1)
   p9799 - F01650 (fault value: 1000)
   p9899 - F30650 (fault value: 1000)
   p10005[0...1] - F01650(0...1) (TM54F)
3. Once the project has been downloaded to the target device, an acceptance must be carried out. This is indicated by fault F01650 (fault value: 2004 or 2005). For more information on the acceptance test see chapter "Acceptance test and acceptance report".

8.3.5 Setting the sampling times

Terminology

The software functions installed in the system are executed cyclically at different **sampling times** (p0115, p0799, p4099).

Safety functions are executed within the **monitoring clock cycle** (p9300/p9500) and TM54F is executed within the **sampling time** (p10000).

Communication on PROFIBUS is handled cyclically by means of the **communication clock cycle.**

During the PROFIsafe scan cycle, the PROFIsafe telegrams issued by the master are evaluated.

Rules

- The monitoring clock cycle (p9300/p9500) can be set between 500 µs to 25 ms.

  Note

  The monitoring clock cycle must be the same on all drives.

  However, the calculation time required for the Extended Functions in the Control Unit depends on the monitoring clock cycle, that is, shorter clock cycles extend the calculation time. The availability of a specific monitoring clock cycle therefore depends on calculation time resources of the Control Unit.

  Calculation time resources on the Control Unit are influenced primarily by the number of drives, the number of drives with enabled Extended Functions, the connected DRIVE-CLiQ components, the selected DRIVE-CLiQ topology, the use of a CBE20 and by the selected technological functions.
- PROFIBUS
  - The monitoring clock cycle (p9300/p9500) must be an integer multiple of the actual value update clock cycle. p9311/p9511 are generally used for the clock cycle for actual value acquisition. If p9311/p9511 = 0 in *isochronous operation* the isochronous PROFIBUS communication clock cycle is used, in *non-isochronous* operation the actual update clock cycle in this case is 1 ms.
  - The current controller cycle must be no more than a quarter of the length of the actual value update clock cycle.
  - The sampling time of the current controller (p0115[0]) must be at least 125 µs.
- The sampling time of the TM54F must be the same as the monitoring clock cycle (p10000 = p9300/p9500).

Note

The Safety functions are carried out in the monitoring cycle (r9780/r9880 for Basic Functions or p9500/p9300 for Extended Functions). PROFIsafe telegrams are evaluated in the PROFIsafe scan cycle, which corresponds to twice the monitoring clock cycle.

Overview of important parameters

- p9300 SI Motion monitoring clock cycle (Motor Module) (only Extended Functions)
- p9500 SI Motion monitoring clock cycle (Control Unit) (only Extended Functions)
- p9311 SI Motion actual value sensing clock cycle (Motor Module)
- p9511 SI Motion actual value sensing clock cycle (Control Unit)
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)
- p10000 SI sampling time (TM54F)

8.4 Commissioning of Safety Integrated Basic Functions

8.4.1 Procedure for commissioning "STO", "SS1" and "SBC"

To commission the "STO", "SS1" and "SBC" functions via terminals, carry out the following steps:

Table 8- 1 Commissioning the "STO", "SS1" and "SBC" functions

No.	Parameter	Description/comments
1	p0010 = 95	**Safety Integrated: set commissioning mode.** • The following alarms and faults are output: – A01698 (SI CU: Commissioning mode active) During first commissioning only: – F01650 (SI CU: acceptance test required) with fault value = 130 (no safety parameters exist for the Motor/Power Module). – F30650 (SI MM: Acceptance test required) with fault value = 130 (no Safety parameters exist for the Motor/Power Module). Acceptance test and test certificate, see step 15. • The pulses are safely canceled and monitored by the Control Unit and Motor/Power Module. • The safety heartbeat is monitored by the Control Unit and Motor/Power Module. • The function for exchanging stop responses between the Control Unit and Motor/Power Module is active. • An existing and parameterized motor holding brake has already been applied. • In this mode, fault F01650 or F30650 with fault value = 2003 is output after a Safety parameter is changed for the first time. This behavior applies for the entire duration of Safety commissioning, that is, the "STO" function cannot be selected/deselected while safety commissioning mode is active because this would constantly force safe pulse suppression.
2	p9761 = "Value"	**Set the Safety password.** When Safety Integrated is commissioned for the first time, the following applies: • Safety password = 0 • Default setting for p9761 = 0 This means that the Safety password does not need to be set during first commissioning.
3	 p9601.0 p9801.0	**Enable "Safe Torque Off" function.** STO via Control Unit terminals STO via Motor/Power Module terminals • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the data cross-check and must, therefore, be identical.

No.	Parameter	Description/comments
4	 p9602 = 1 p9802 = 1	**Enable the "Safe brake control" function.** Enable "SBC" on the Control Unit Enable "SBC" on the Motor/Power Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the data cross-check and must, therefore, be identical. • The "safe brake control" function is not activated until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).
5	 p9652 > 0 p9852 > 0	**Enable "Safe Stop 1" function.** Enable "SS1" on the Control Unit Enable "SS1" on the Motor/Power Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the data cross-check and must, therefore, be identical. • The "Safe Stop 1" function is not activated until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).
6	 p9620 = "Value" Terminal "EP"	**Set terminals for "Safe Torque Off (STO)".** Set the signal source for STO on the Control Unit. Wire terminal "EP" (enable pulses) on the Motor/Power Module. • Control Unit monitoring channel: By appropriately interconnecting BI: p9620 for the individual drives, the following is possible: – Selecting/deselecting the STO – Grouping the terminals for STO • Motor/Power Module monitoring channel: By wiring the "EP" terminal accordingly on the individual Motor/Power Modules, the following is possible: – Selecting/deselecting the STO – Grouping the terminals for STO **Note:** • The STO terminals must be grouped identically in both monitoring channels. • If n power modules are connected in parallel, the indices p9620 [0 ... n-1] must be assigned parameters.
7	 p9651 = "Value" p9851 = "Value"	**Set the filter time for the "STO" terminals** Parameterize the filter time for the STO terminals p9651/p9851 as necessary.

No.	Parameter	Description/comments
8	 p9650 = "Value" p9850 = "Value"	**Set F-DI changeover tolerance time.** F-DI changeover tolerance time on Control Unit F-DI changeover tolerance time on the Motor/Power Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Due to the different runtimes in the two monitoring channels, an F-DI changeover (e.g., selection/deselection of STO) does not take immediate effect. After an F-DI changeover, dynamic data are not subject to a data cross-check during this tolerance time. • Both parameters are included in the data cross-check and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.
9	 p9658 = "Value" p9858 = "Value"	**Set transition period from STOP F to STOP A.** Transitional period from STOP F to STOP A on Control Unit Transitional period from STOP F to STOP A on the Motor/Power Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • STOP F is the stop response that is initiated when the data cross-check is violated as a result of fault F01611 or F30611 (SI: defect in a monitoring channel). STOP F normally initiates "no stop response". • After the parameterized time has expired, STOP A (immediate safety pulse inhibit) is triggered by the fault F01600 or F30600 (SI: STOP A triggered). The default setting for p9658 and p9858 is 0 (i.e., STOP F immediately results in STOP A). • Both parameters are included in the data cross-check and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.
10	p9659 = "Value"	**Time for carrying out forced dormant error detection and testing the safety switch-off paths.** • After this time has expired, the user is requested to test the switch-off paths as a result of alarm A01699 (SI CU: Necessary to test the switch-off signal paths) (i.e. select/de-select STO). • The commissioning engineer can change the time required for carrying out the forced dormant error detection and testing the safety switch-off paths.
11	 p9799 = "r9798" p9899 = "r9898"	**Adjust specified checksums.** Specified checksum on the Control Unit Specified checksum on the Motor/Power Module The current checksums for the Safety parameters that have undergone a checksum check are displayed as follows: • Actual checksum on the Control Unit: r9798 • Actual checksum on the Motor Module: r9898 By setting the actual checksum in the parameter for the specified checksum, the commissioning engineer confirms the Safety parameters in each monitoring channel. This procedure is performed automatically when STARTER and the commissioning wizard for SINAMICS Safety Integrated are used.

No.	Parameter	Description/comments
12	 p9762 = "Value" p9763 = "Value"	**Set the new Safety password.** Enter a new password. Confirm the new password. • The new password is not valid until it has been entered in p9762 and confirmed in p9763. • As of now, you must enter the new password in p9761 so that you can change Safety parameters. • Changing the Safety password does not mean that you have to change the checksums in p9799 and p9899.
13	p0010 = Value not equal to 95	**Safety Integrated: exit commissioning mode** • If at least one safety monitoring function is enabled (p9601 = p9801 ≠ 0), the checksums are checked: If the target checksum on the Control Unit has not been correctly adapted, then fault F01650 (SI CU: Acceptance test required) is output with fault code 2000 and it is not possible to exit the safety commissioning mode. If the target checksum on Motor/Power Modules has not been correctly adapted, then fault F01650 (SI CU: Acceptance test required) is output with fault code 2001 and it is not possible to exit the safety commissioning mode. • If a safety monitoring function has not been enabled (p9601 = p9801 = 0), safety commissioning mode is exited without the checksums being checked. When safety commissioning mode is exited, the following is carried out: • The new safety parameters are effective on the Control Unit and Motor/Power Module.
14		All drive parameters (entire drive group or only single axis) must be manually saved from RAM to ROM. These data are not saved automatically!
15	POWER ON	**Carry out a POWER ON.** After commissioning, a POWER ON reset must be carried out.
16	-	**Carry out acceptance test and create test certificate.** Once safety commissioning is complete, the commissioning engineer must carry out an acceptance test for the enabled safety monitoring functions. The results of the acceptance test must be documented in an acceptance certificate.

8.5 Commissioning TM54F by means of STARTER/SCOUT

8.5.1 Basic sequence of commissioning

The following conditions must be met before you can configure the TM54F:

- Concluded initial commissioning of all drives

Table 8- 2 Configuration sequence

Step	Execution
1	Insert the TM54F
2	Configure the TM54F and generate the drive groups
3	Configure the drive groups
4	Configure the inputs
5	Configure the outputs
6	Copy the parameters to the second drive object (TM54F_SL)
7	Change the safety password
8	Activate the configuration by selecting "Activate settings"
9	Save the project in STARTER
10	Save the project in the drive by selecting "Copy RAM to ROM"
11	Execute POWER ON
12	Acceptance test

8.5.2 Configuration start screen

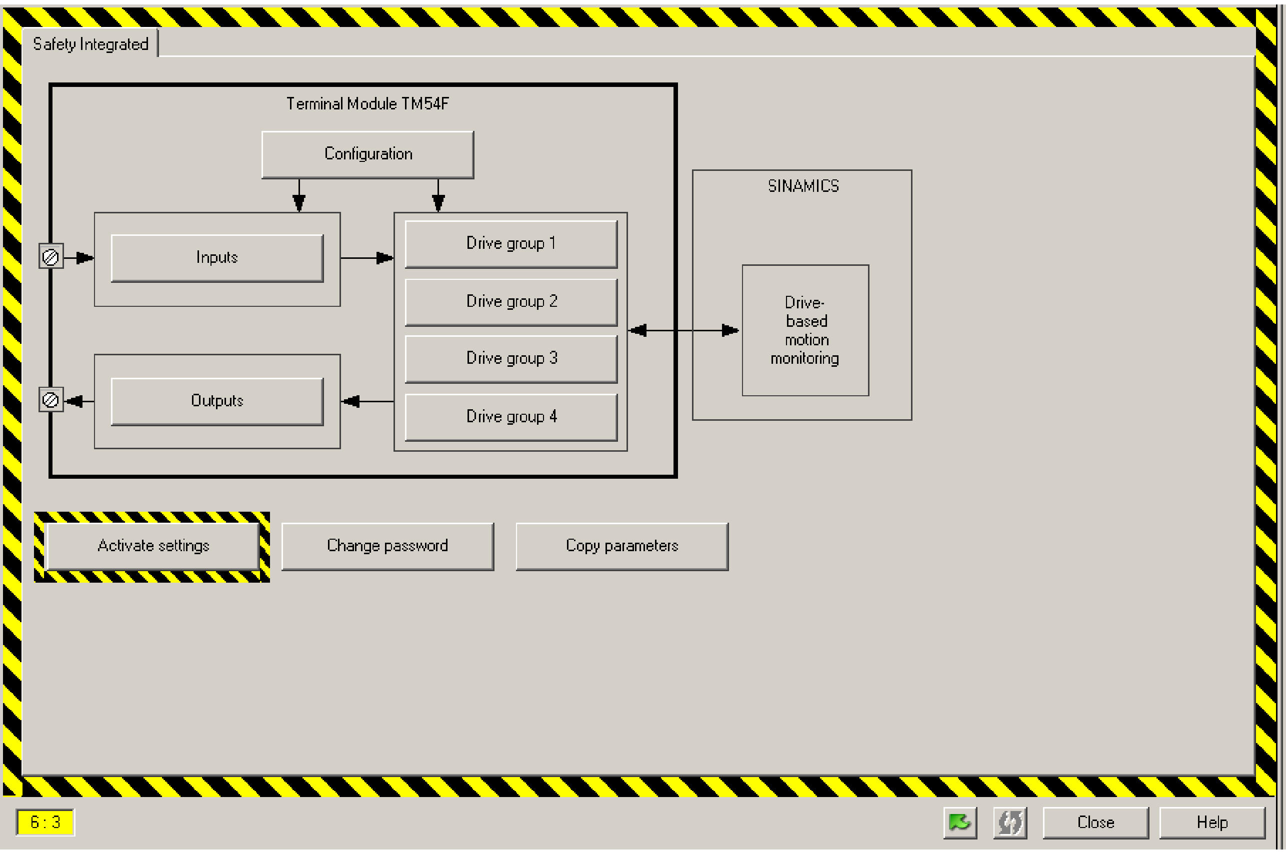


Figure 8-4 Configuration start screen TM54F

The following functions can be selected in the start screen:

- Configuration

  Opens the "Configuration" screen
- Inputs

  Opens the "Inputs" screen
- Outputs

  Opens the "Outputs" screen
- Drive group 1 ... 4

  Opens the corresponding screen of drive group 1.... 4
- Copy parameters

  To copy the configuration to the second drive object (TM54F_SL), press "Copy parameters".

- Change/activate settings
  - Change settings

    You can select this button and enter the TM54F password in order to edit the configuration data. The button function changes to "Activate settings".
  - Activate settings

    This function activates your parameter settings and initiates calculation of the actual CRC and the corresponding transfer to the target CRC.

    The parameters are activated after restart, and you are requested to carry out the acceptance test.

    A message is output requesting you to save the project and then restart the system. It is also required to carry out an acceptance test.
- Change password (p10061... p10063)

  In order to change the password, enter the old password (factory setting: 0) and then enter and confirm the new password.

8.5.3 TM54F configuration

Configuration screen of TM54F for Safety Integrated

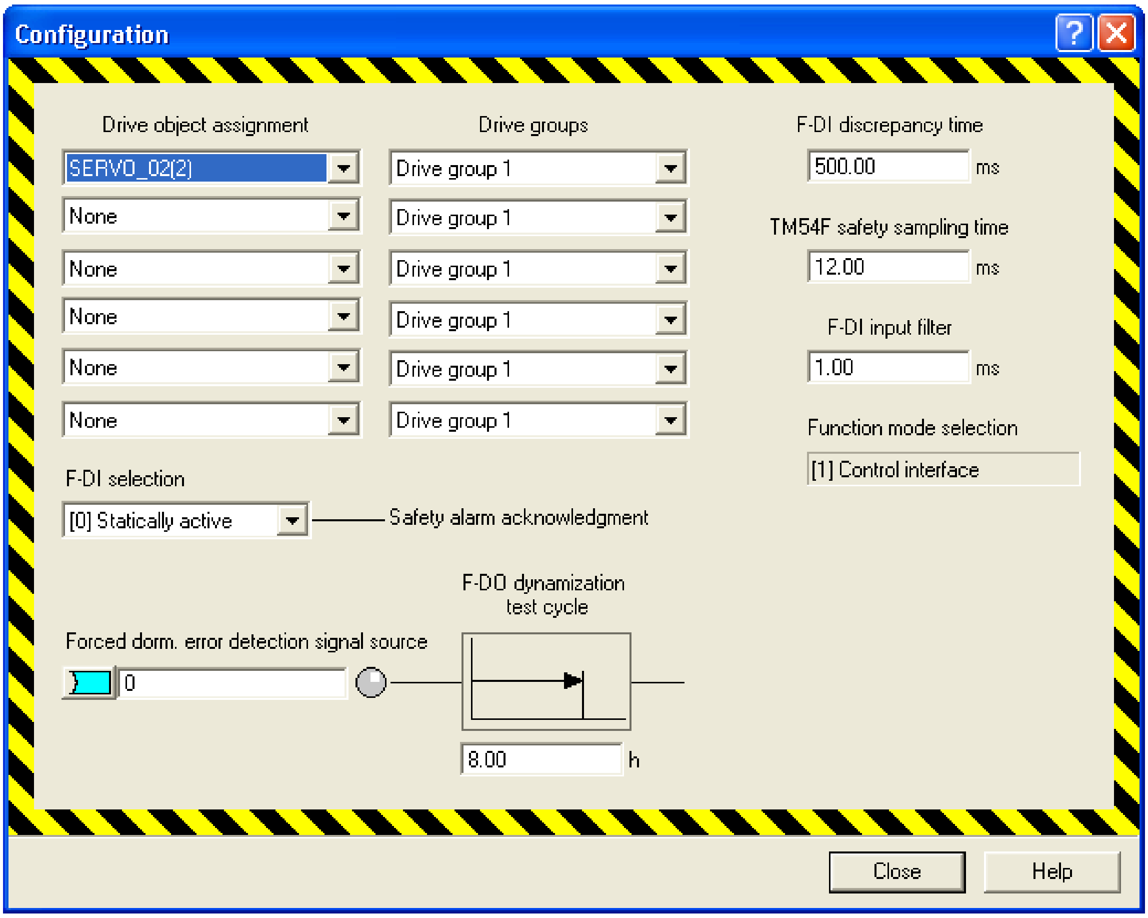


Figure 8-5 TM54F configuration

Functions of this screen:

- Assigning drive objects (p10010)

  Select a drive object to be assigned to a drive group.
- Drive groups (p10011)

  Each configured safety drive can be assigned to a drive group using a drop-down list box. The list box displays the drives and their names.
- Discrepancy time (p10002)

  The signal states at the two terminals of an F-DI are monitored in order to determine whether these have assumed the same logical state within the discrepancy time.

Note

The discrepancy time must be set so that it is always smaller than the smallest expected switching interval of the signal to this F-DI.

- Safety sampling time (p10000)

  The Safety sampling time corresponds to the sampling time of TM54F.

  Note

  The Safety clock cycle (p10000) of the TM54F must be set so it is the same as the monitoring clock cycle in p9300/p9500 for all the drives controlled by the TM54F.

- F-DI input filter (p10017)

  Parameterizing the debounce time of the F-DIs and single-channel DIs of the TM54F. The debounce time is rounded off to whole ms and then accepted. The debounce time specifies the maximum time an interference pulse can be present at F-DIs before being interpreted as a switching operation.

- F-DI selection (p10006)

  The Extended Functions enter a safety message in a special message buffer upon detection of internal errors or violations of limits. This alarm must be acknowledged safely. You can assign an F-DI terminal pair for safe acknowledgment.

- Signal source, forced dormant error detection (p10007)

  Select an input terminal to start the test stop: The test stop is started with a 0/1 signal at the input terminal and is then only possible if the drive is not in commissioning mode.

- Test cycle, dynamization F-DO (p10003)

  Fail-safe I/O must be tested at defined intervals in order to validate their fail-safety (test stop, or forced dormant error detection). The TM54F module is provided with a function block which is selected by means of a BICO source to execute this forced dormant error detection (e.g. switch the L1+ and L2+ sensor power supply). Each selection triggers a timer in order to monitor the test cycle. A message is set on expiration of the monitored time.

8.5.4 Test stop of the TM54F

Test of the fail-safe inputs and outputs

Fail-safe I/O must be tested at defined intervals in order to validate their fail-safety (test stop, or forced dormant error detection). For this purpose, the TM54F contains a function block which carries out this forced dormant error detection when selected via a BICO source. To monitor the time until the next required test, a timer is started after every error-free test stop. A message is set on expiration of the monitored time and each time the Control Unit is switched on.

The failsafe digital inputs are always tested during a test stop. Three test stop modes can be selected for testing the outputs (see following section). After a time interval (p10003) has expired, the user is notified via message A35014 that a test stop must be performed for the F-DI/DO of the TM54F.

Carrying out a test stop:

Proceed as follows to parameterize the test stop:

1. Determine the appropriate test stop mode for the circuits used in your application (see diagrams in the following sections).
2. Set the test stop mode which is to be used via parameter p10047.
3. Use parameter p10046 to define which digital outputs (F-DO 0 to F-DO 3) are to be tested. Note the following:

   Digital outputs which are not tested will be switched off during the test stop.
4. Use parameter p10041 to define which fail-safe digital inputs are to be checked during the test.

   Inputs which do not have L1+ and L2+ power supplies may not be selected for the test.
5. Set the debounce time for the digital inputs using parameter p10017.
6. Use parameter p10001 to set the time within which the digital output signals to the corresponding digital inputs DI 20 ... DI 23 or DIAG inputs must be recognized. Select this time depending on the maximum response time of the external F-DO circuit.
7. Use parameter p10003 to set the interval within which a test stop should be carried out. After this time interval has expired, you will be notified via message A35014 that a test stop must be performed for the F-DI/DO of the TM54F.
8. Set the signal source which triggers the start of the test stop using parameter p10007. This can be, for example, a control signal or switch via a BICO switchable signal.

While the test stop is being carried out, the message A35012 (TM54F: Test stop active is displayed). The messages A35014 and A35012 only disappear again after the test stop has been performed. If an error is found during the test stop, fault F35013 is output. Using the test sequence specified for each test stop mode, you can see which error has occurred from the fault value of the test step.

Duration of test stop

You can calculate the duration of the test stop with this formula:

$T_{Teststop} = T_{FDIs} + T_{FDOs}$

- Test of the FDIs:
  3 * p10000 + 3 * X ms
  (X = 20 ms or p10000 or p10017 - the greatest time value of the 3 values determines the waiting time X)
- Test of the FDOs:
  8 * p10000 + 6 * Y ms
  (Y = p10001 or p10000 or p10017 - the greatest time value of the 3 values determines the waiting time Y)

8.5.4.1 Test stop mode 1

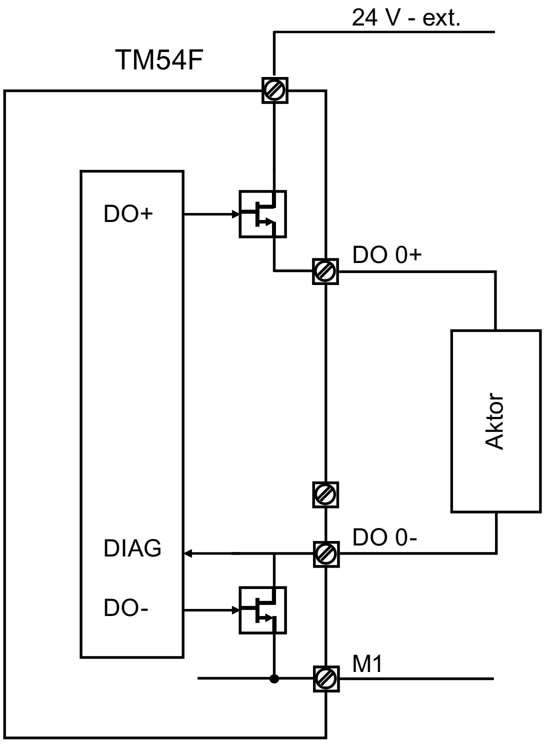


Figure 8-6 F-DO circuit, test stop mode 1

Test step [1)]	L1+	L2+	Comment
1	OFF	ON	Synchronization
3	OFF	OFF	F-DIs 0 ... 4 Check at 0 V
5	ON	ON	F-DIs 5 ... 9 Check at 0 V

Test step [1)]	DO+	DO-	Expected response, DIAG signal
6	OFF	OFF	LOW
8	ON	ON	LOW
10	OFF	ON	LOW
12	ON	OFF	HIGH
14	OFF	OFF	LOW

Test sequence for test stop mode 1

1) You can find a complete list of the steps in the SINAMICS List Manual under message F35013.

8.5.4.2 Test stop mode 2

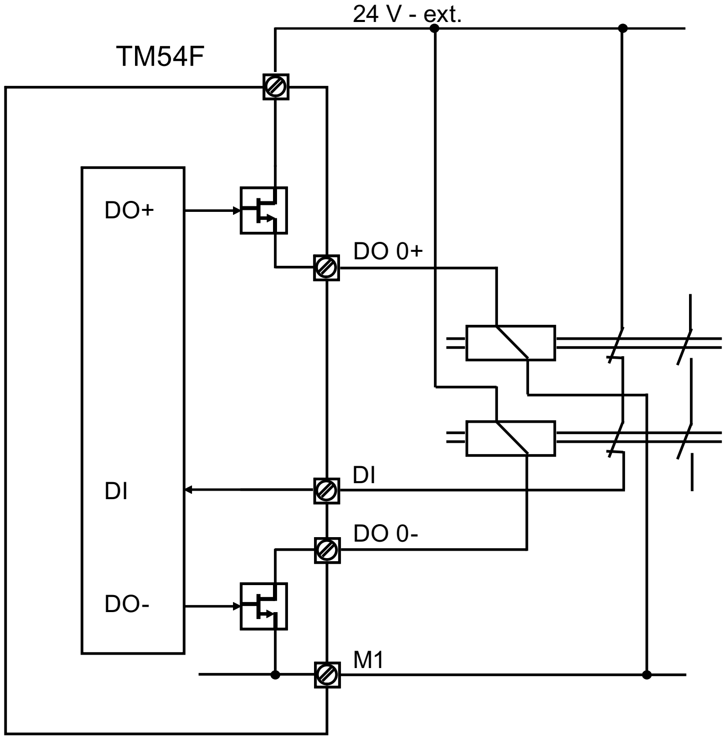


Figure 8-7 F-DO circuit, test stop mode 2

Test step[1)]	L1+	L2+	Comment
1	OFF	ON	Synchronization
3	OFF	OFF	F-DIs 0 ... 4 Check at 0 V
5	ON	ON	F-DIs 5 ... 9 Check at 0 V

Test step[1)]	DO+	DO-	Expected response, DI signal
6	OFF	OFF	HIGH
8	ON	ON	LOW
10	OFF	ON	LOW
12	ON	OFF	LOW
14	OFF	OFF	HIGH

Test sequence for test stop mode 2

1) You can find a complete list of the steps in the SINAMICS List Manual under message F35013.

8.5.4.3 Test stop mode 3

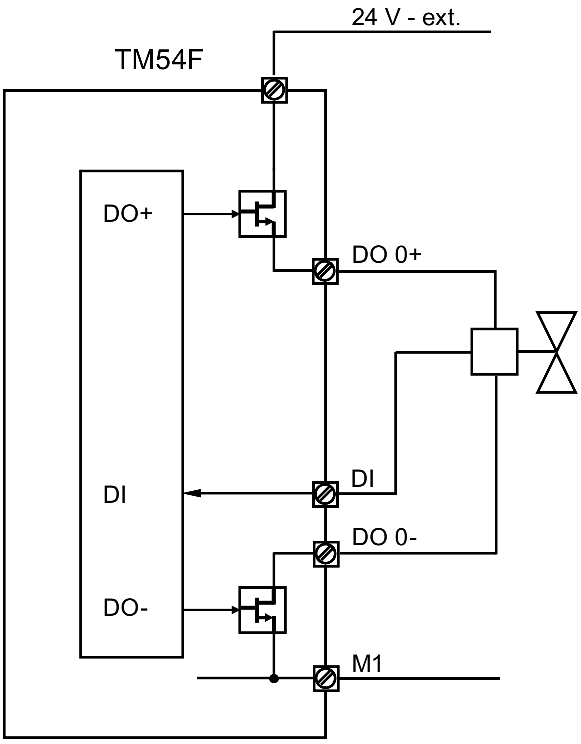


Figure 8-8 F-DO circuit, test stop mode 3

Test step[1)]	L1+	L2+	Comment
1	OFF	ON	Synchronization
3	OFF	ON	F-DIs 0 ... 4 Check at 0 V
5	ON	ON	F-DIs 5 ... 9 Check at 0 V

Test step[1)]	DO+	DO-	Expected response, DI signal
6	OFF	OFF	HIGH
8	ON	ON	LOW
10	OFF	ON	HIGH
12	ON	OFF	HIGH
14	OFF	OFF	HIGH

Test sequence for test stop mode 3

[1)] You can find a complete list of the steps in the SINAMICS List Manual under message F35013.

8.5.4.4 Test stop mode parameters

Overview of important parameters

- p10000 SI sampling time
- p10001 SI wait time for test stop at DO 0 ... DO 3
- p10003 SI forced dormant error detection timer
- p10007 BI: SI forced dormant error detection F-DO 0 ... 3 signal source
- p10017 SI digital inputs, debounce time
- p10046 SI test sensor feedback input DI 20 ... 23
- p10047[0...3] SI select test mode for test stop

8.5.5 F-DI/F-DO configuration

Inputs screen F-DI

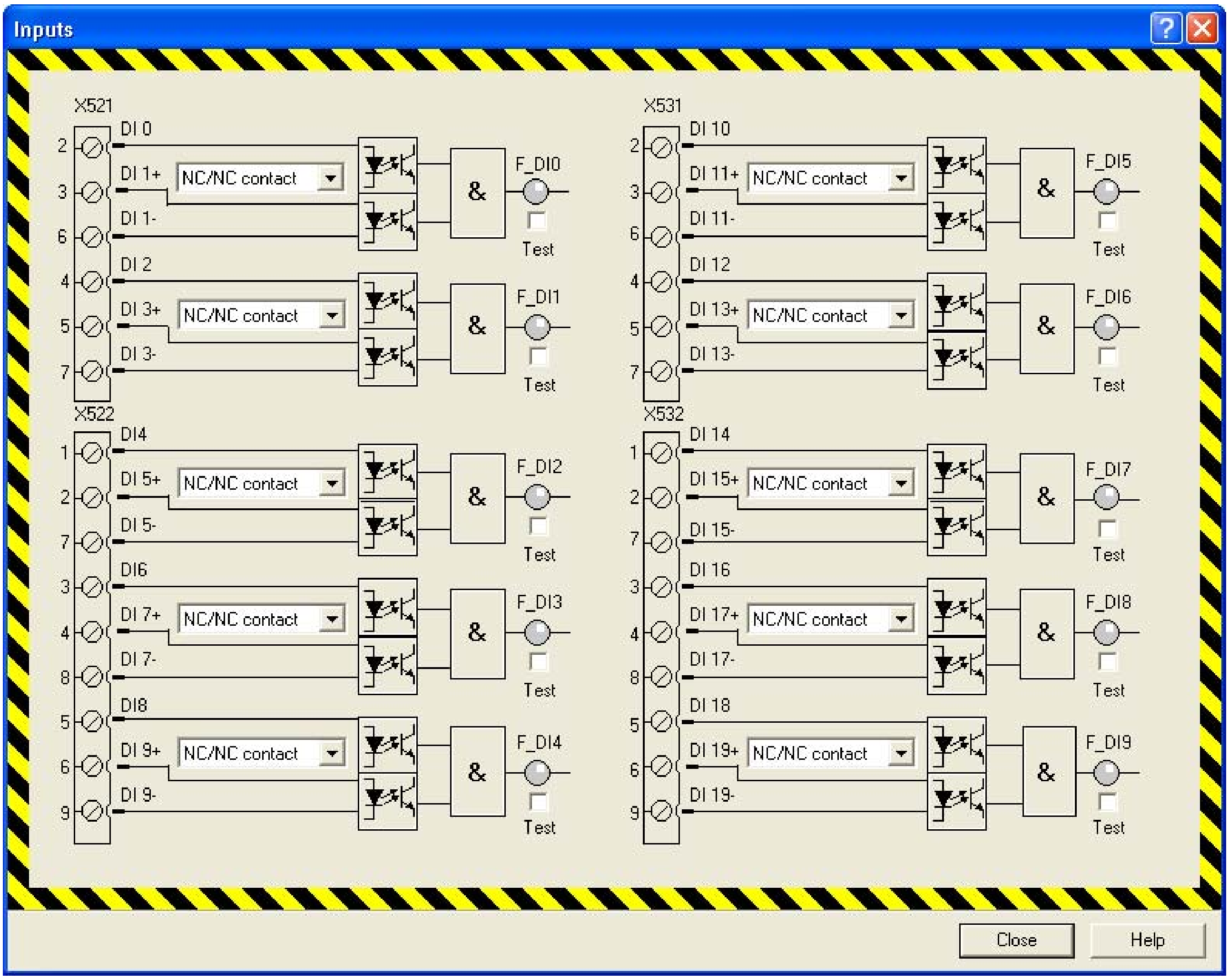


Figure 8-9 Inputs screen

NC/NO contact (p10040)

Terminal property F-DI 0-9 (p10040.0 = F-DI 0, ... p10040.9 = F-DI 9), only the property of the second (lower) digital input is set. Always connect an NC contact to digital input 1 (upper). Digital input 2 can be configured as NO contact.

Activate test mode (p10041)

A check mark at an F-DI defines whether the pair of digital inputs is to be integrated in the forced dormant error detection test of the assigned power supply (L1+ or L2+) (for additional information, see chapter "Forced dormant error detection", under Extended Functions).

LED in F-DI screen

The LED downstream of the AND element indicates the logical state (inactive: gray, active: green, discrepancy error: red).

Outputs screen F-DO

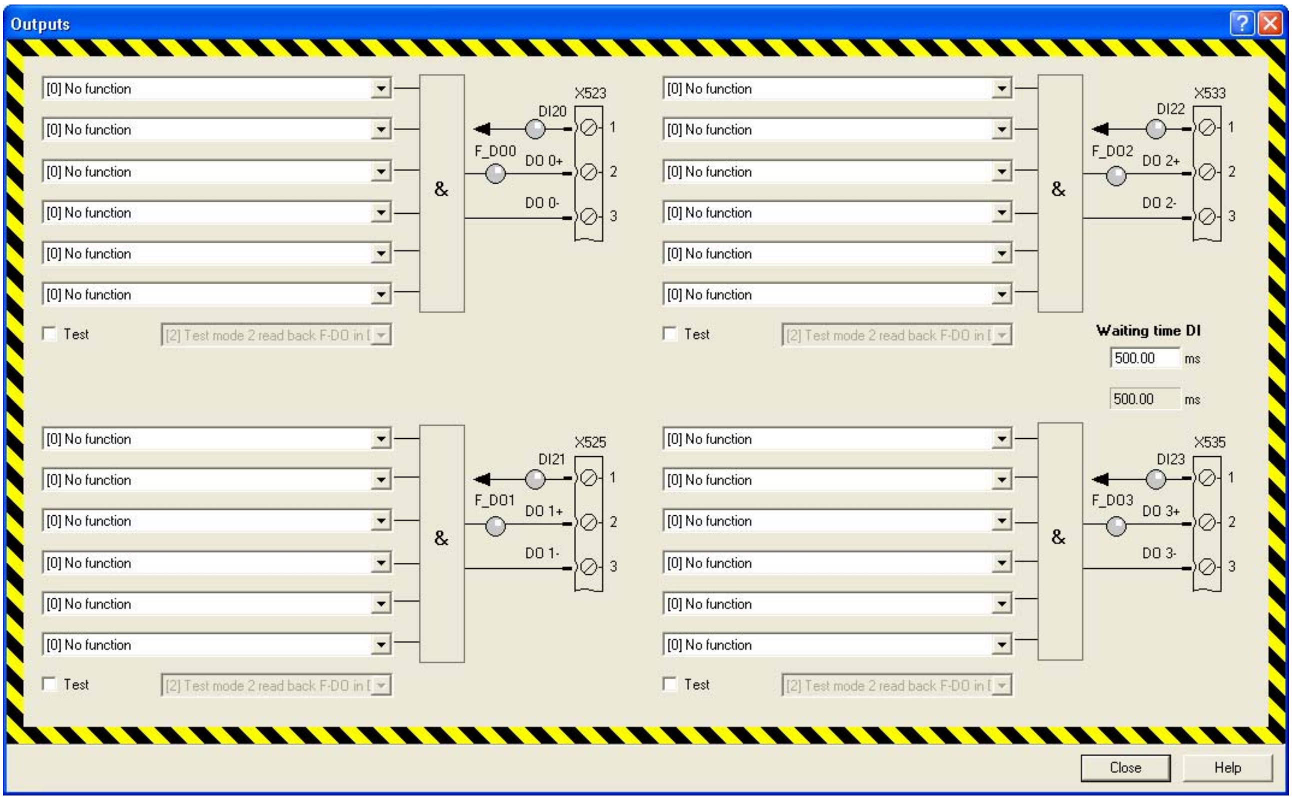


Figure 8-10 Outputs screen

Signal source for F-DO (p10042 - p10045)

An AND element with 6 inputs is interconnected with each output terminal pair of an F-DO; the signal sources for the AND inputs can be selected:

- If a signal source is not connected to an input, then the input is set to HIGH (default), exception: If a signal source is not connected at any input, then the output signal = 0
- Status signals of the drive of drive group 1 to 4

  For additional information on status signals, see chapter "F-DO overview" in the "Control by means of TM54F terminals".

Select test sensor feedback signal (p10046 [0..3]) and select test mode for test stop (p10047 [0..3])

The test of the feedback line for the dynamization can be activated at each F-DO and the test mode can be selected for the test stop (for additional information, see Chapter "Forced dormant error detection" under Extended Functions).

LED in the F-DO screen

The LED downstream of the AND element indicates the logical state (inactive: gray, active: green).

The LED of the digital inputs DI20 to DI23 indicate the status of the digital input (inactive: gray, active: green).

8.5.6 Control interface of the drive group

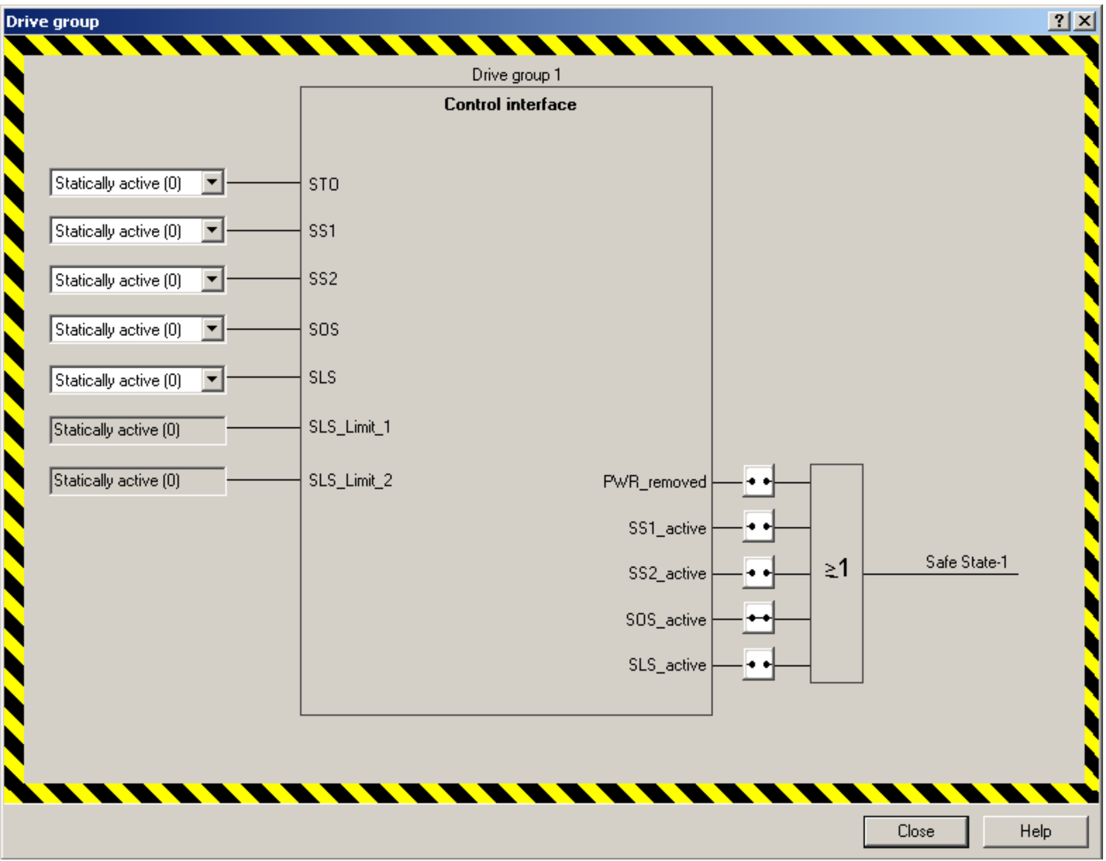


Figure 8-11 Screen, drive group

Functions of this screen:

- Selection of an F-DI for the STO, SS1, SS2, SOS and SLS functions and for SLS speed limits (bit coded) (p10022 to p10028).

  A separate screen is available for each drive group. An F-DI can be assigned several functions in several drive groups.

- Configuration of the "Safe State" signal (p10039)

  A safety output signal "Safe State" can be generated for each drive group from the following status signals:

  – STO active (Power_removed)

  – SS1 active

  – SS2 active

  – SOS active

  – SLS active

  The status signals from the same functions for different drives of a drive group are logically AND'ed. The status signals of the individual functions (STO active, SS1 active, etc.) are ORed.

  The "Safe State" signals can be assigned to a an F-DO.

8.6 Procedure for configuring PROFIsafe communication

8.6.1 Configuring PROFIsafe via PROFIBUS

The next sections deal with a sample configuration of PROFIsafe communication between a SINAMICS S120 drive unit and higher-level SIMATIC F-CPU operating as PROFIBUS master. Here a special safety connection ("Safety-Slot") between the Master and Slave is set up automatically, which may not be changed.

HW Config can then be used to configure PROFIsafe telegram 30 (sub-module ID = 30) for the drive objects (abbreviation: DO).

8.6.2 Requirements for PROFIsafe communication

Requirements for PROFIsafe communication

The following minimum software and hardware requirements apply for the configuration and operation of safety-oriented communication (F communication):

Software:

- SIMATIC Manager STEP 7 V5.4 SP4 [1)] or higher
- S7 F Configuration Pack V5.5 SP3 [1)] or higher
- S7 Distributed Safety Programming V5.4 SP3 [1)] or higher
- STARTER V4.1.5 + SSP V4.3 or SIMOTION SCOUT V4.1.5 + SSP V4.3 or higher
- Drive ES Basic V5.4 SP4 [1)] or higher

Hardware:

- A controller with safety functions (in our example, SIMATIC F-CPU 317F-2) [1)]
- SINAMICS S120 (in our example, a CU320-2)
- Correct installation of the devices

[1)] When using a SIMATIC F-CPU

NOTICE
If a single software or hardware component is either older than those specified in this document or is missing, PROFIsafe cannot be configured via PROFIBUS or PROFINET.

8.6.3 Configuring PROFIsafe via PROFIBUS

Topology (network view of the project)

Components participating in F communication via PROFIBUS are basically wired as follows:

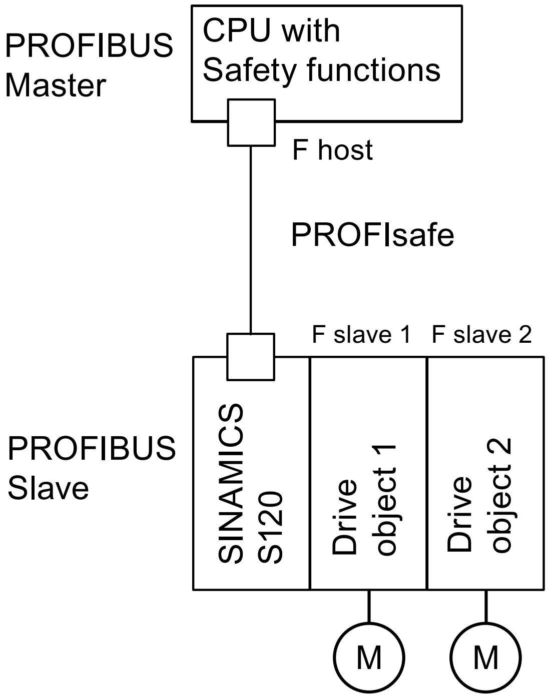


Figure 8-12 Example of a PROFIsafe topology

Configuring PROFIsafe communication (example based on a Siemens F-CPU)

The next sections describe a configuration of PROFIsafe communication between a SIMATIC F-CPU and a drive unit. It is helpful to regularly save intermediate states.

Creating a safety master

1. Create an F-CPU, e.g. CPU 317F-2, and a drive, e.g. SINAMICS S120 with CU320-2, in accordance with the hardware installed in HW Config.

   To do this, start SIMATIC Manager and create a new project.

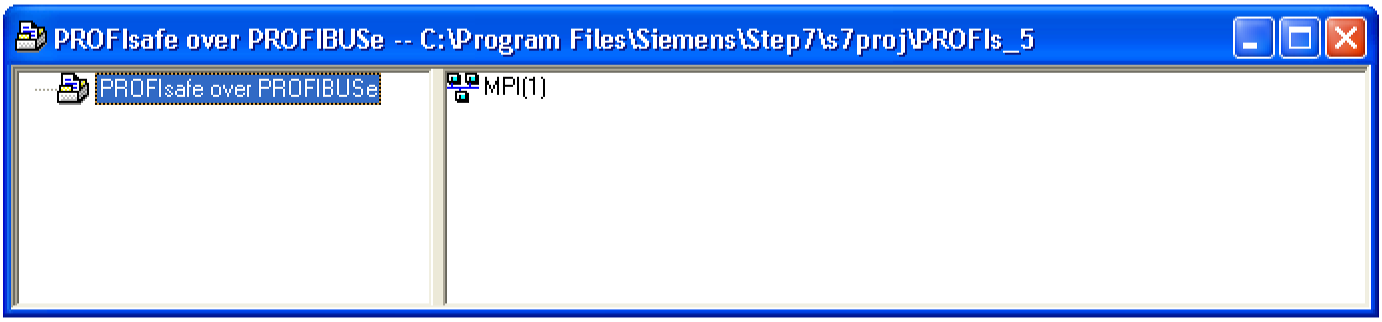


Figure 8-13 Creating a new project

2. Create a SIMATIC S300 Station under "Insert".

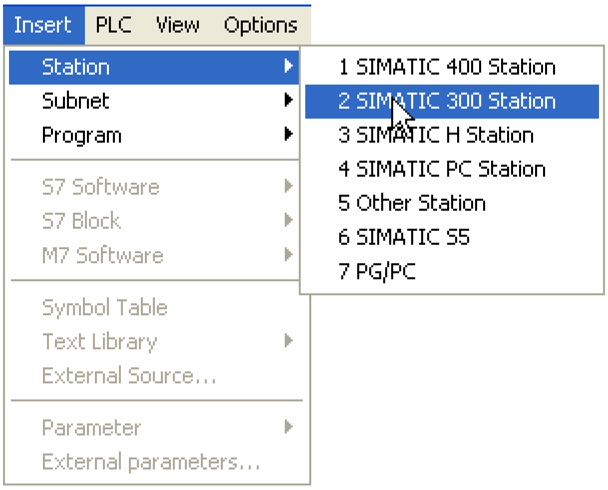


Figure 8-14 Creating a new station

3. The HW Config tool opens by double-clicking on SIMATIC S300(1), and then on "Hardware".

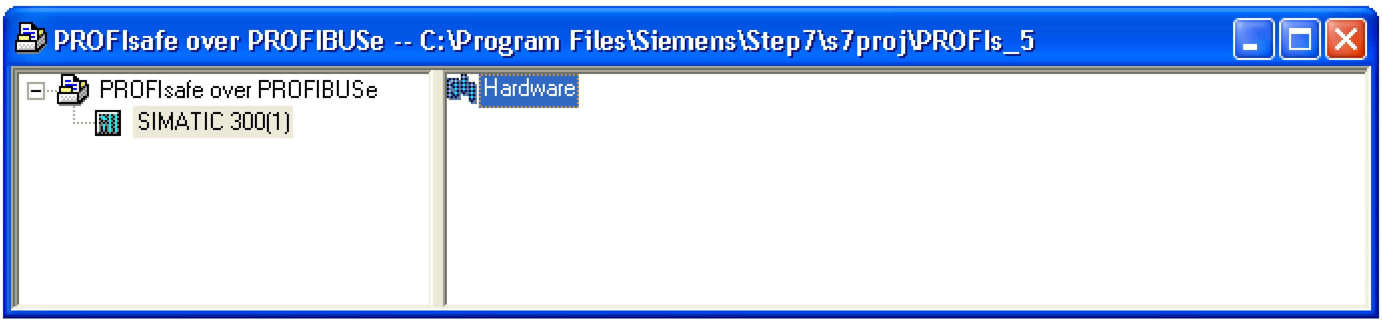


Figure 8-15 Calling HW Config

4. First create a mounting rail ((0)UR) under HW Config in the lefthand window:
   From the standard catalog under SIMATIC 300/RACK-300, drag the mounting rail to the upper lefthand field (the cursor has a "+" character).

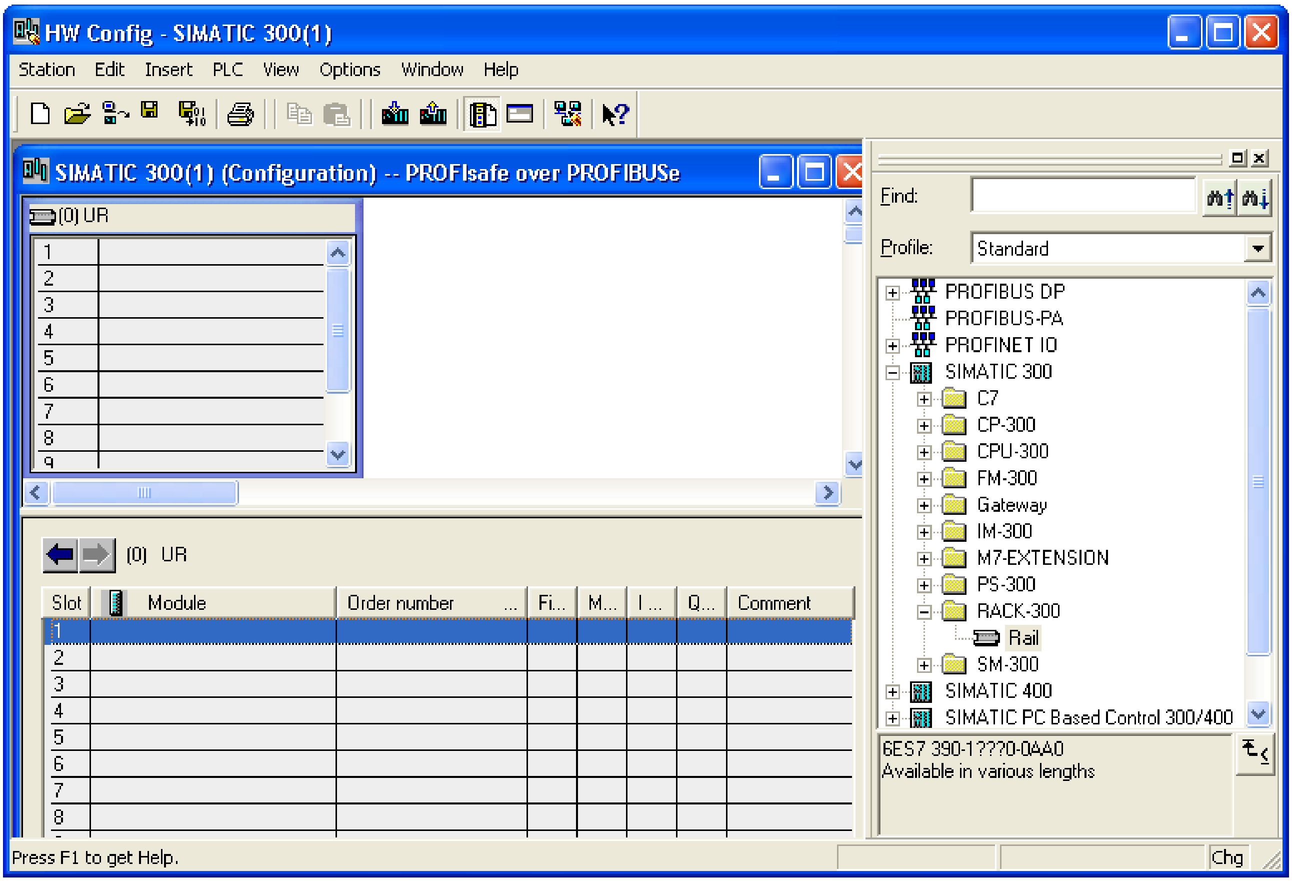


Figure 8-16 Creating a mounting rail

5. Select a safety-capable CPU under SIMATIC 300/CPU 300:
   In this case, for example, drag CPU 317F-2, V2.6 into the RACK on slot 2 (highlighted).

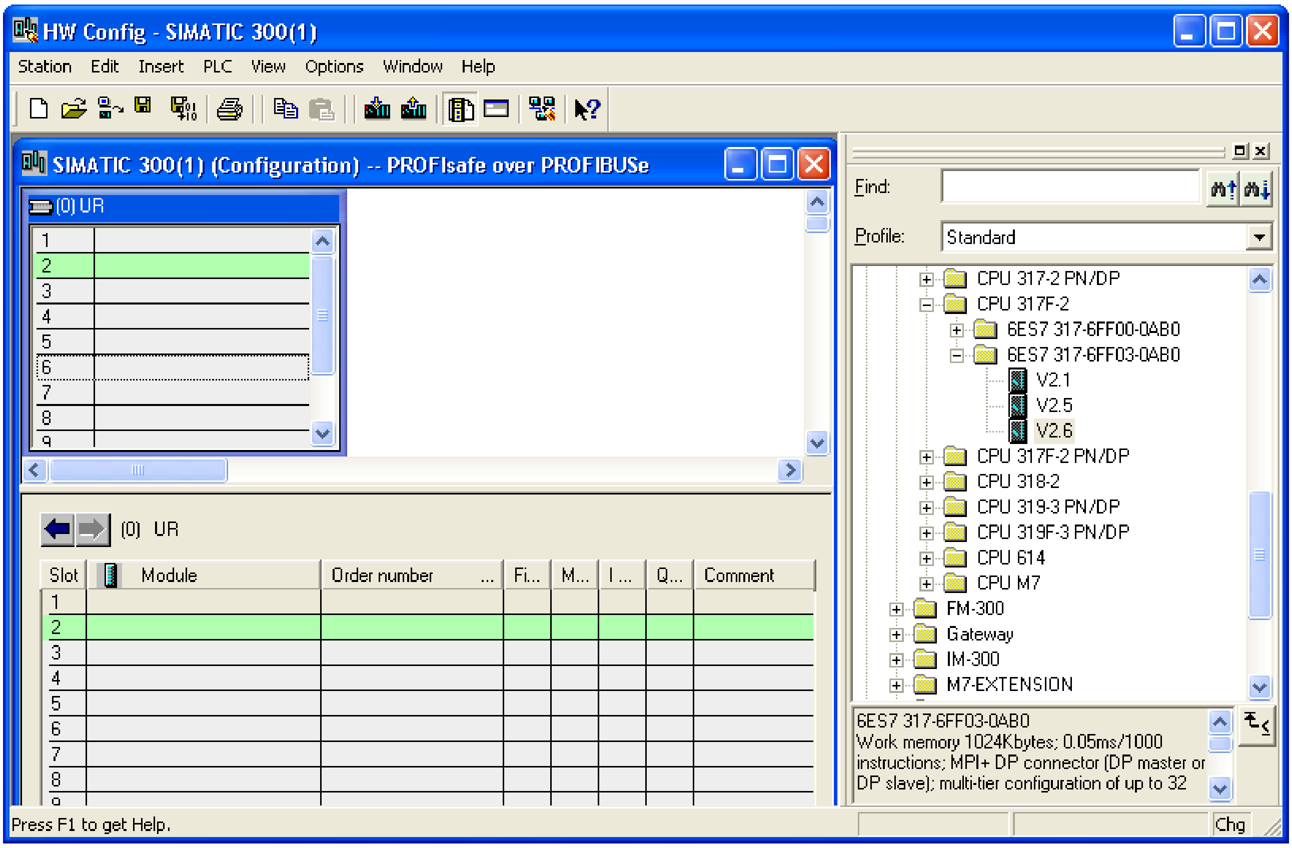


Figure 8-17 Creating an F host (master)

6. In the rack: The "Properties - PROFIBUS interface DP" window is opened by double-clicking on line X2. Under the tab "Parameter", click on "Properties..." in the interface field.

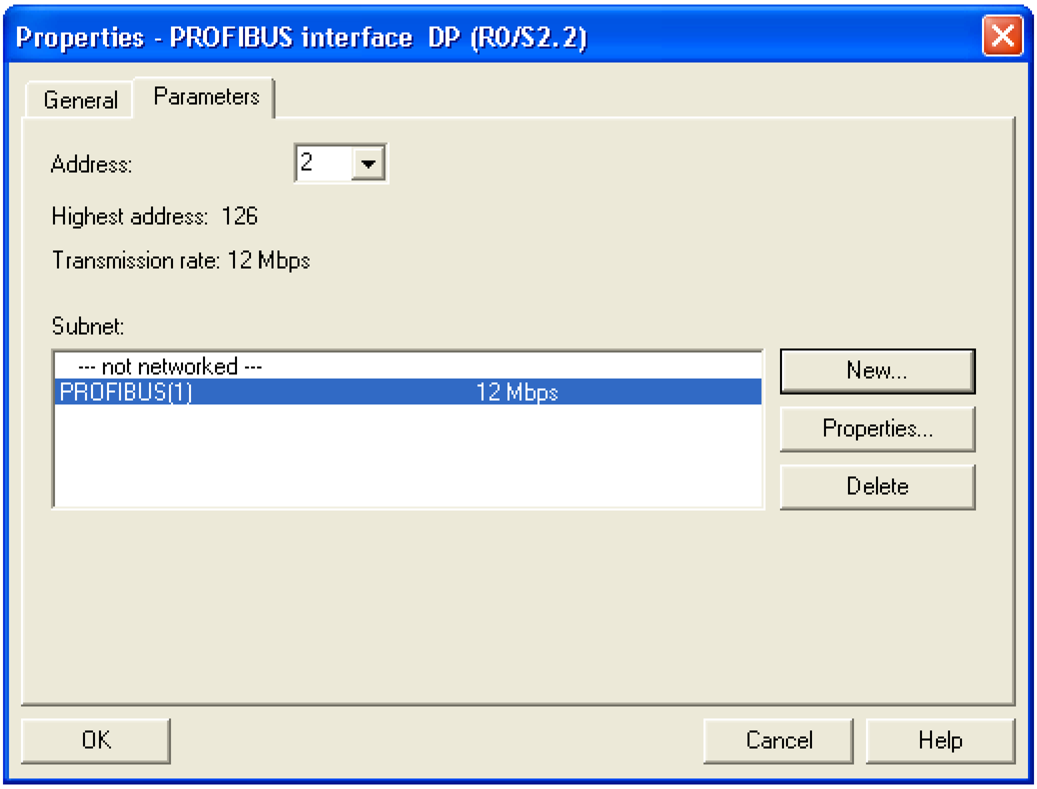


Figure 8-18 Setting the PROFIBUS interface

7. Set the PROFIBUS interface under the "Parameter" tab, set the address, and with the "Properties..." button, set the network settings, the transmission rate (e.g. 12 Mbit/s), the profile (DP) and then acknowledge with "OK". This sets up the master.

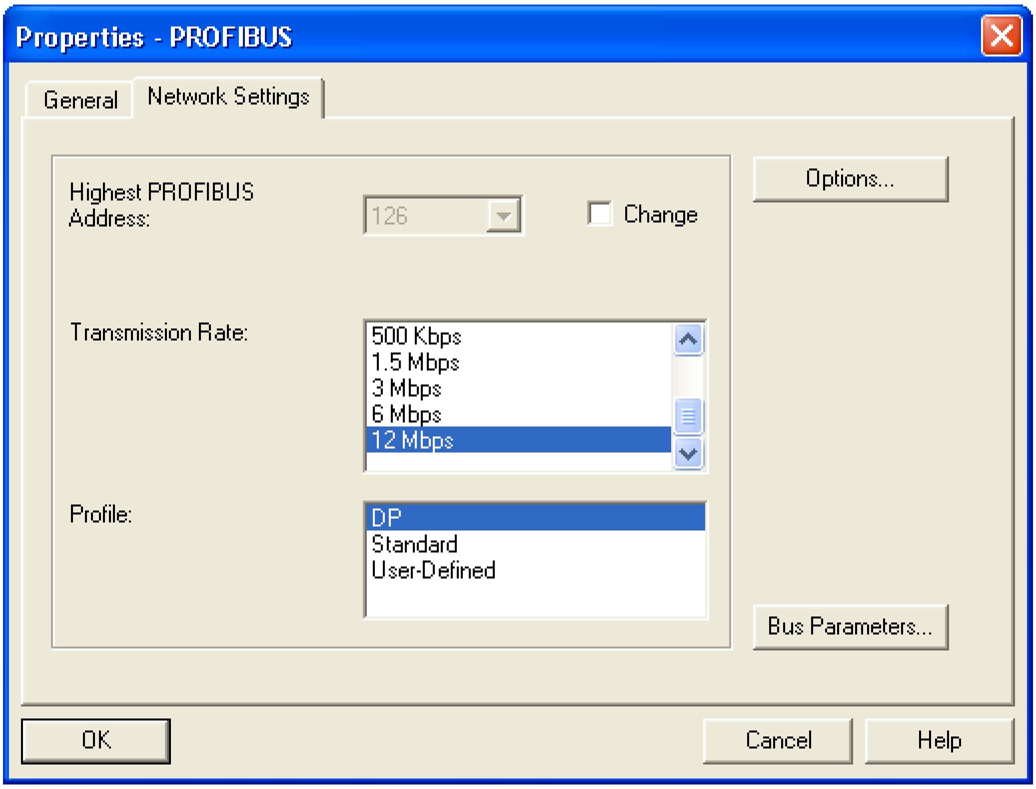


Figure 8-19 Setting the PROFIBUS profile

Creating a safety slave (drive)

1. The drive can either be selected in the catalog window under PROFIBUS-DP/SINAMICS /SINAMICS S120/SINAMICS S120 CU320 or by installing a GSD file. Using the left mouse button, drag the "SINAMICS S120 CU320-2" drive to the PROFIBUS line in the upper lefthand window (the cursor has a + character) and release the mouse button. In the following properties window, set the PROFIBUS address of the drive and exit the following window with "OK".

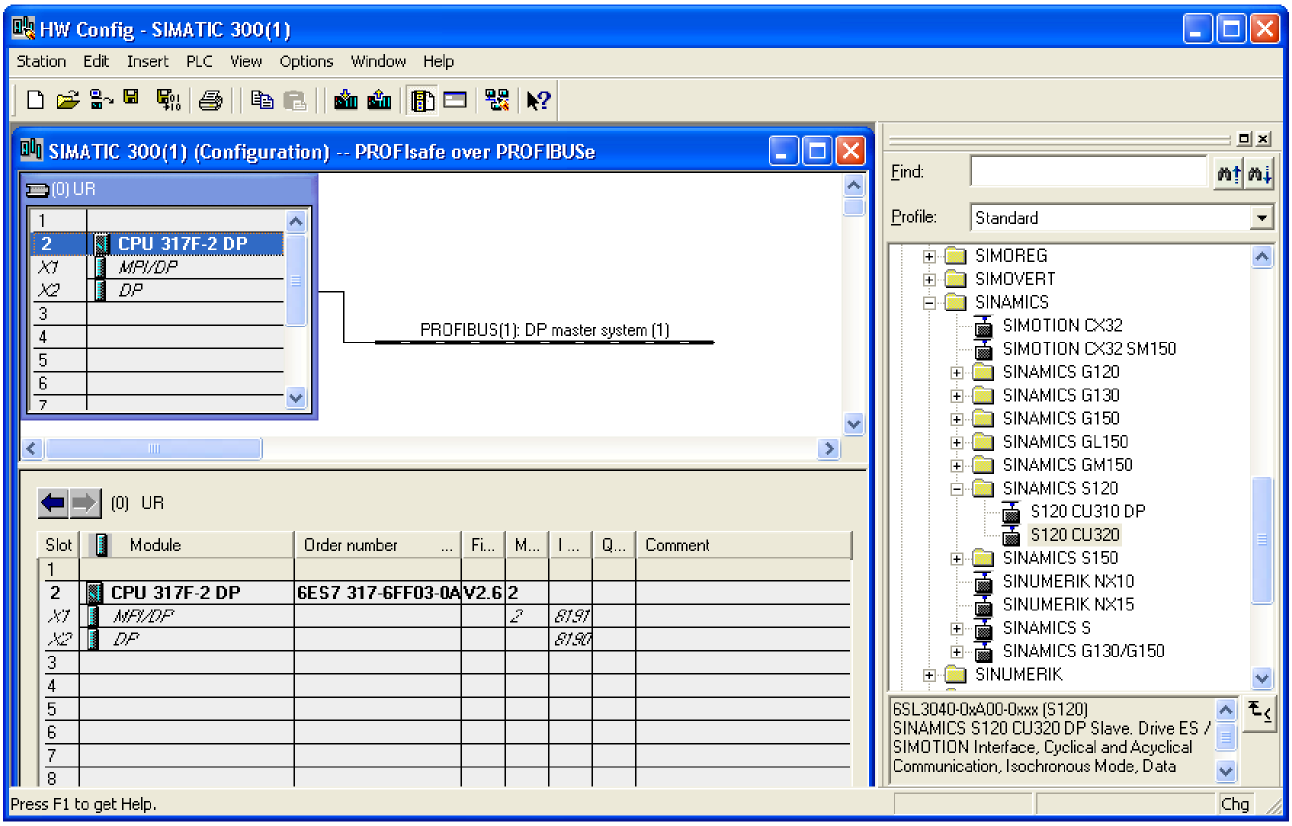


Figure 8-20 Selecting a drive

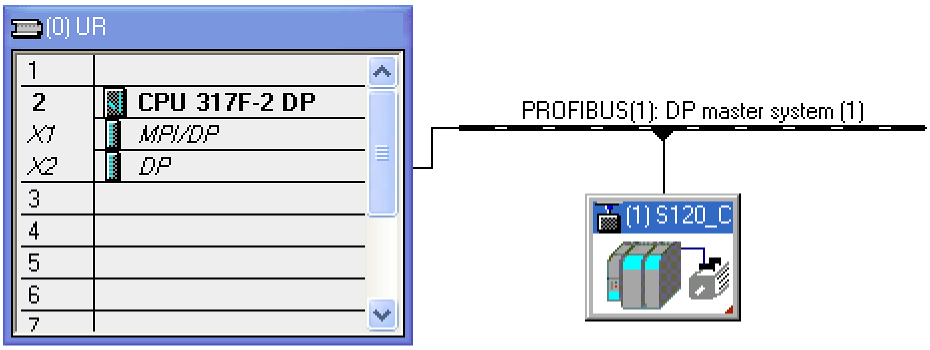


Figure 8-21 Drive created

2. Double-clicking on the drive symbol opens the properties of the DP slave (here: (7)SINAMICS S120). The telegrams for F communication are selected and displayed (e.g. Siemens telegram 105) under "Configuration". Select the PROFIsafe telegram 30 under the option column. As a result, the "PROFIsafe..." button at the center left is activated.

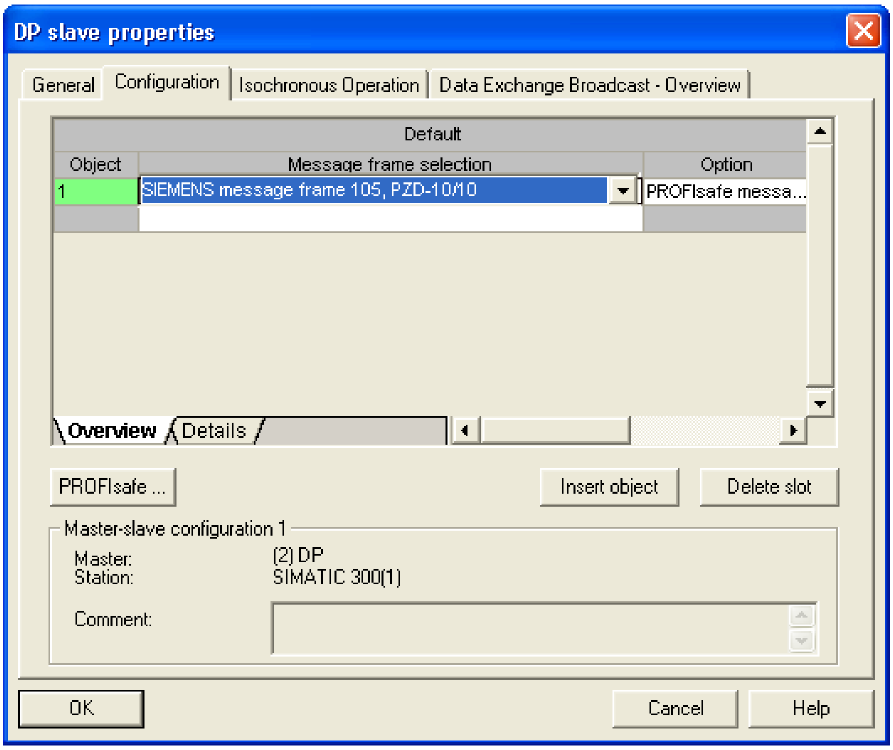


Figure 8-22 PROFIBUS DP slave properties

3. The F parameters important for F communication are set using the "PROFIsafe…" button.

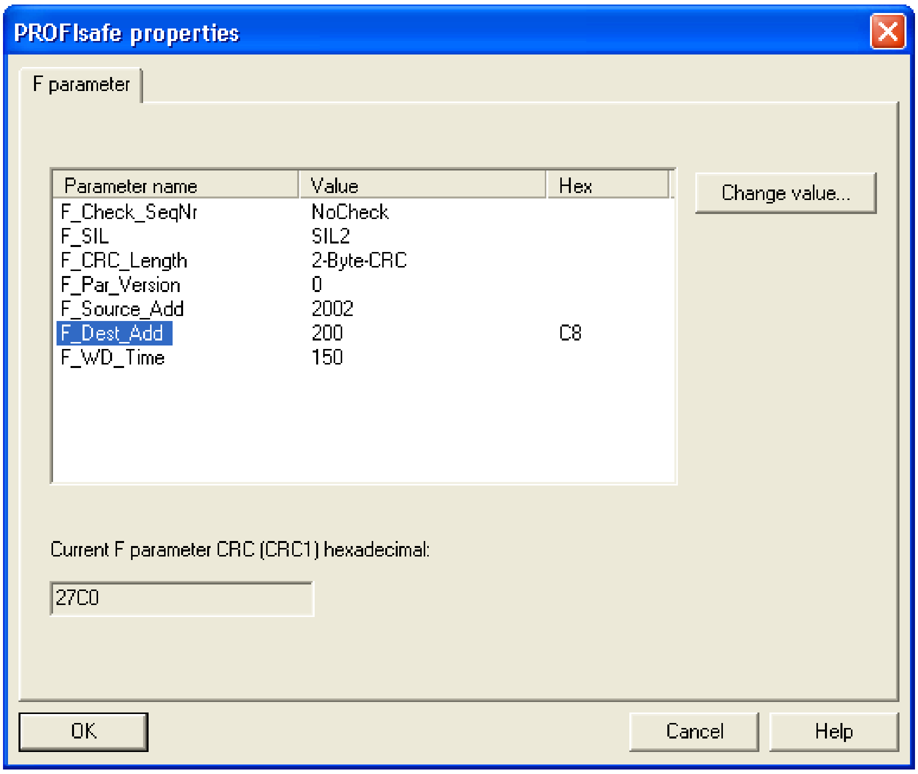


Figure 8-23 Setting the F parameters

The PROFIsafe mode is selected using parameters F_CRC_Length and P_Par_Version. The PROFIsafe address is set using parameter F_Dest_Add.

Selecting the PROFIsafe mode

The two PROFIsafe modes V1.0 and V2.0 can be selected.

- In the "F parameter" window, first click on the value that is to be changed.
- Then on the button "Change value..."
- A window will open. Select and confirm the desired value.
- Using these parameters, you can select either PROFIBUS mode version V1.0 or V2.0:
  - **PROFIsafe V1.0 mode**: F_CRC_Length = 2 byte-CRC, then P_Par_Version: 0
  - **PROFIsafe V2.0 mode**: F_CRC_Length = 3 byte-CRC, then P_Par_Version: 1

The following value ranges can be set for the last two parameters of the list:

1. PROFIsafe destination address F_Dest_Add: 1-65534

F_Dest_Add determines the PROFIsafe destination address of the drive object.
Any value within the range is allowed, although it must be manually entered again in the Safety configuration of the drive in the SINAMICS drive unit. The F_Dest_Add value must be set in p9610 (Control Unit) and in p9810 (Motor Module). This can be done in a user-friendly fashion via the PROFIsafe STARTER screen form (refer to the following diagram). The PROFIsafe destination address of the F parameters must be entered here in the hexadecimal format (C8H in the example).

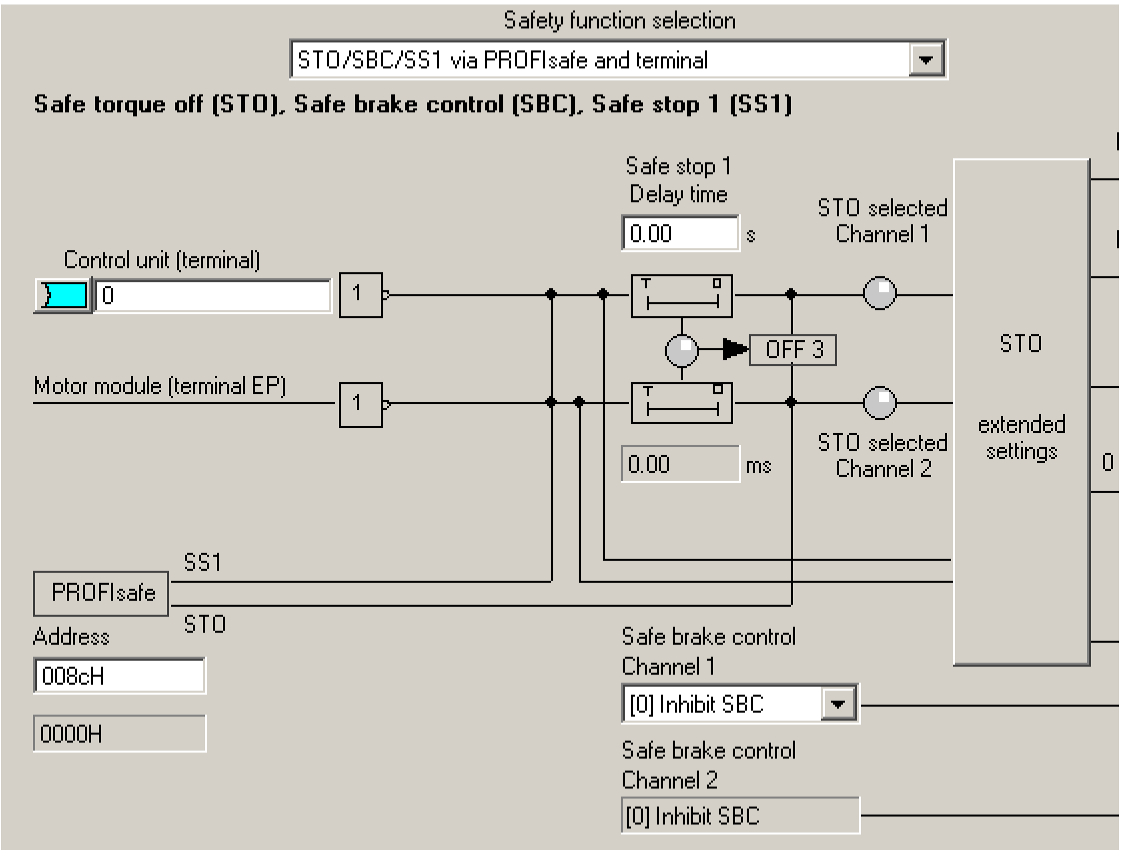


Figure 8-24 STARTER screen section from Safety Integrated: Setting the PROFIsafe address (example)

2. PROFIsafe monitoring time F_WD_Time: 10-65535

A valid current safety telegram must be received from the F-CPU within the monitoring time. The drive will otherwise switch to the safe state.
The monitoring time should be of sufficient length to ensure not only that the communication functions tolerate telegram delays, but also that the fault response is triggered quickly enough if a fault occurs (e.g. interruption of the communication connection).

For additional information on F parameters, refer to the online help of the ("Help subjects" button).

8.7 PROFIsafe via PROFINET

8.7.1 Configuring PROFIsafe via PROFINET

The next sections deal with a sample configuration of PROFIsafe communication between a SINAMICS S120 drive unit and a higher-level SIMATIC F-CPU operating as PROFINET master.

HW Config can then be used to configure PROFIsafe telegram 30 (sub-module ID = 30) for the drive objects (abbreviation: DO).

8.7.2 Requirements for PROFIsafe communication

The following minimum software and hardware requirements apply for the configuration and operation of safety-oriented communication (F communication):

Software:

- SIMATIC Manager STEP 7 V5.4 SP4 [1)] or higher
- S7 F Configuration Pack V5.5 SP3 [1)] or higher
- S7 Distributed Safety Programming V5.4 SP3 [1)] or higher
- STARTER V4.1.5 + SSP V4.3 or SIMOTION SCOUT V4.1.5 + SSP V4.3 or higher
- Drive ES Basic V5.4 SP4 [1)] or higher

Hardware:

- A controller with safety functions (in our example, SIMATIC F-CPU 317F-2) [1)]
- SINAMICS S120 (in our example, a CU320-2)
- Correct installation of the devices

  [1)] When using a SIMATIC F-CPU

NOTICE
If a single software or hardware component is either older than those specified in this document or is missing, PROFIsafe cannot be configured via PROFIBUS or PROFINET.

8.7.3 Configuring PROFIsafe via PROFINET

Configuring PROFIsafe communication using SINAMICS S120 as an example

Configuring PROFIsafe via PROFINET is almost identical to configuring "PROFIsafe via PROFIBUS".

The difference is that the SINAMICS drive unit and SIMATIC F-CPU are in the same PROFINET subnet instead of in the same PROFIBUS subnet.

1. In HW Config, create a PROFINET-capable F-CPU, e.g. CPU 317F-2 PN/DP, corresponding to the hardware that has been installed. Create a PROFINET subnet and configure the F-CPU as an IO controller. Information about configuring an IO controller of F-CPU 317F-2 can be found in this reference:
   Reference: SIMATIC PROFINET IO Getting Started: Collection
2. In the standard module catalog, under PROFINET IO, choose the module that you want to connect to the PROFINET IO subnet as an IO device, e.g. a CU320-2.
3. Drag the module to the line of the PROFINET IO subnet. The IO device is inserted. The Properties -> Ethernet Interface SINAMICS-S120-2 window opens. A suggested IP address will already be displayed here and the subnet selected. Confirm with "OK" to accept the setting.
4. Save and compile the settings in HW Config, and then load them to the target device.

This sets up a PROFINET connection between the F-CPU and the SINAMICS S120 drive.

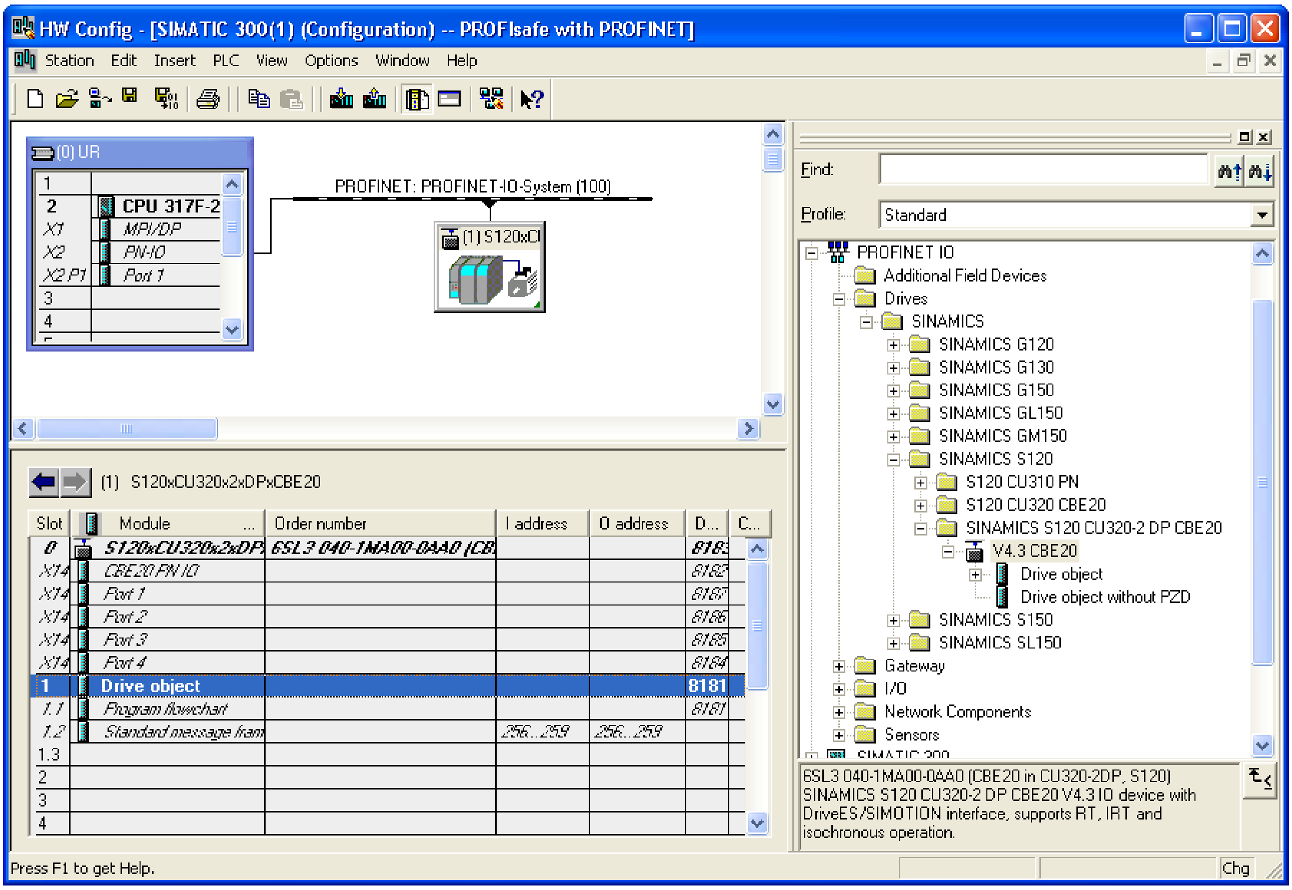


Figure 8-25 Configuration of the PROFINET connection in HW Config

1. Open the context menu of the drive object and select the command "Object properties": The "Properties – drive object" window appears. Select the PROFIsafe telegram via PROFINET in this window. Using the "Options" tab, create the "PROFIsafe telegram 30".

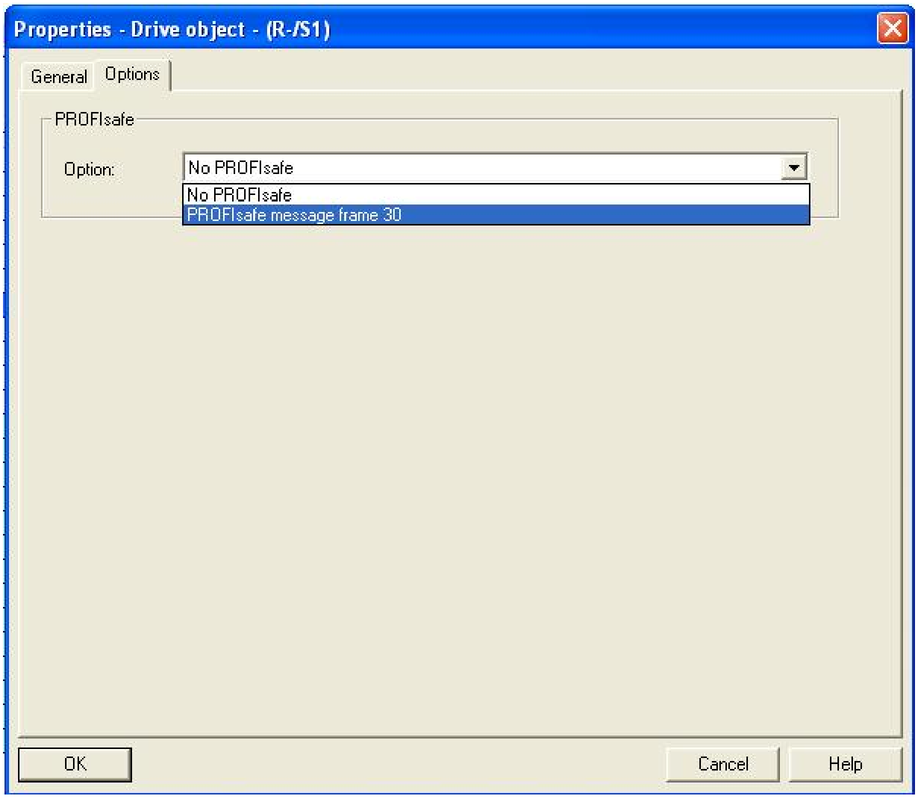


Figure 8-26 Drive object option "PROFIsafe telegram"

In the overview for the SINAMICS drive, a PROFIsafe slot that needs to be configured is displayed under "Drive object".

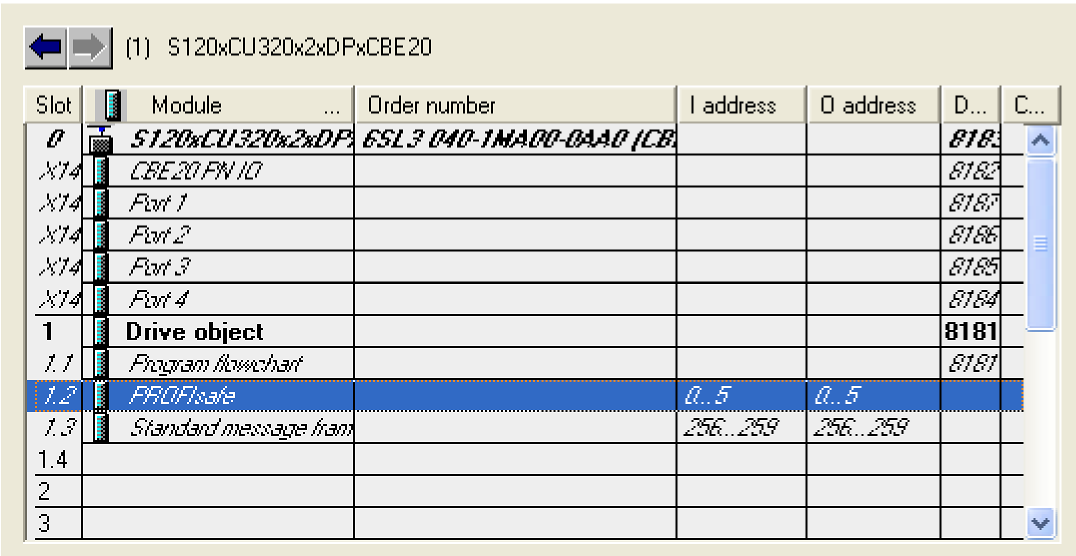


Figure 8-27 Defining PROFIsafe for a drive

1. Under the drive module, select the "PROFIsafe" line and use the right-hand mouse key to call up the properties of the PROFIsafe slot.
2. Define the address area of the PROFIsafe telegram under the "Addresses" tab. The start address for inputs and output is identical. To confirm your entries, choose "OK".

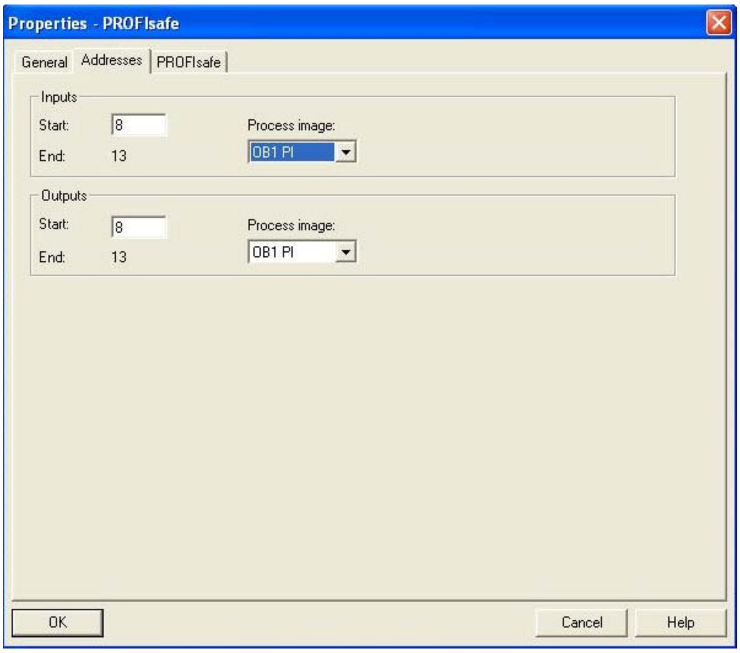


Figure 8-28 Setting PROFINET addresses

3. Using the "PROFIsafe" tab, define the parameters important for Safety communication ("F parameters"). If the "PROFIsafe…" tab is inactive, then you can activate this button for control using the "Activate..." button.

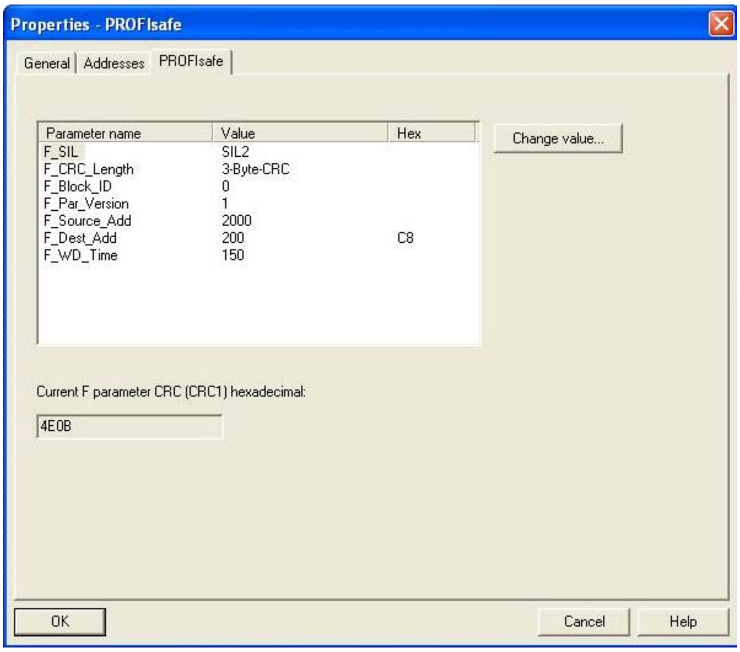


Figure 8-29 Setting F parameters

Setting F parameters:

The following range of values is valid for the the two last parameters of the list:

PROFIsafe destination address F_Dest_Add: 1 to 65534
F_Dest_Add determines the PROFIsafe destination address of the drive object.
Any value within the range is allowed, although it must be manually entered again in the Safety configuration of the drive in the SINAMICS drive unit. The F_Dest_Add value must be set in p9610 (Control Unit) and in p9810 (Motor Module). This can be done in a user-friendly fashion via the PROFIsafe STARTER screen form (refer to the diagram in the chapter, Commissioning PROFIsafe via PROFIBUS).

PROFIsafe monitoring time F_WD_Time: 10 to 65535
A valid current safety telegram must be received from the F-CPU within the monitoring time. The drive will otherwise switch to the safe state.
The monitoring time should be of sufficient length to ensure not only that the communication functions tolerate telegram delays, but also that the fault response is triggered quickly enough if a fault occurs (e.g. interruption of the communication connection).

Note

When you close the "PROFIsafe properties" dialog box, the fail-safe addresses (F_Dest_Add and F_Source_Add) are checked to ensure that they are unique. This function is only available, however, when the PROFINET link between SINAMICS S120 and SIMATIC F-CPU has already been established.

For additional information about creating a safety program and accessing PROFIsafe user data (e.g STW and ZSW) within the safety program, refer to the "SIMATIC, S7 Distributed Safety - Configuring and Programming" Programming and Operating Manual.

Safety configuration (online) in the SINAMICS drive

The process of configuring the SINAMICS drive via PROFINET by means of Safety Integrated screen forms is identical to that for configuration via PROFIBUS. Here, refer to the following chapter, PROFIsafe configuration with STARTER.

Acceptance inspection

Once configuring and commissioning have been successfully completed, you need to carry out an acceptance test of the drive safety functions (see chapter "Acceptance test and acceptance report").

Note

If F parameters of the SINAMICS drive are changed in HW Config, the global signature of the safety program in the SIMATIC F-CPU changes. In this way, the global signature can be used to identify whether safety-relevant settings in the F-CPU (F parameters of the SINAMICS slave) have changed. The global signature does not, however, contain any changes to safety-relevant drive parameters set in SCOUT or STARTER.

8.8 PROFIsafe configuration with STARTER (Basic Functions)

The Safety Integrated Basic Functions can be commissioned using STARTER in three ways.

1. STO/SBC/SS1 only via terminals,
2. STO/SBC/SS1 only via PROFIsafe,
3. STO/SS1/SBC via PROFIsafe and terminals simultaneously.

The STARTER screen forms for using the Safety Integrated Basic Functions using terminals, PROFIsafe or terminals and PROFIsafe are described together here.

Safety slot

In order to use the Safety Integrated functions via PROFIBUS or PROFINET, a safety slot must first be created using the SIMATIC Manager Step 7 and HW Config. The procedure to do this was described in the previous chapters.

Expert list

The Safety Integrated Basic Functions can be individually and manually set using the expert list – but the settings using the STARTER screen forms are more user friendly and you are less prone to making mistakes.

Calling Safety Integrated in STARTER using SINAMICS S120 as example

The STARTER screen form for "Safety Integrated" is called under Drives/Functions with a double-click and can look like this (tree-type view depends on the specific project):

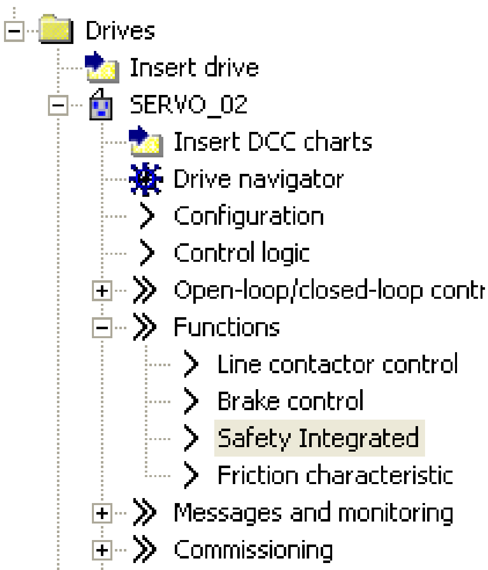


Figure 8-30 STARTER tree to call Safety Integrated

To use the full functionality of STARTER screen forms, there must be an online connection between the drives, the controller and STARTER.

Selecting using the pulldown menu:

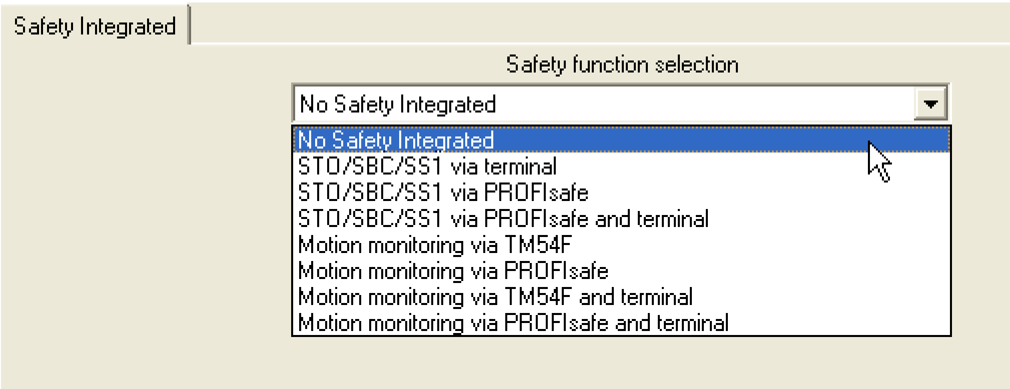


Figure 8-31 Safety_Integrated_Auswahl

Depending on the selection, different setting screen forms open:

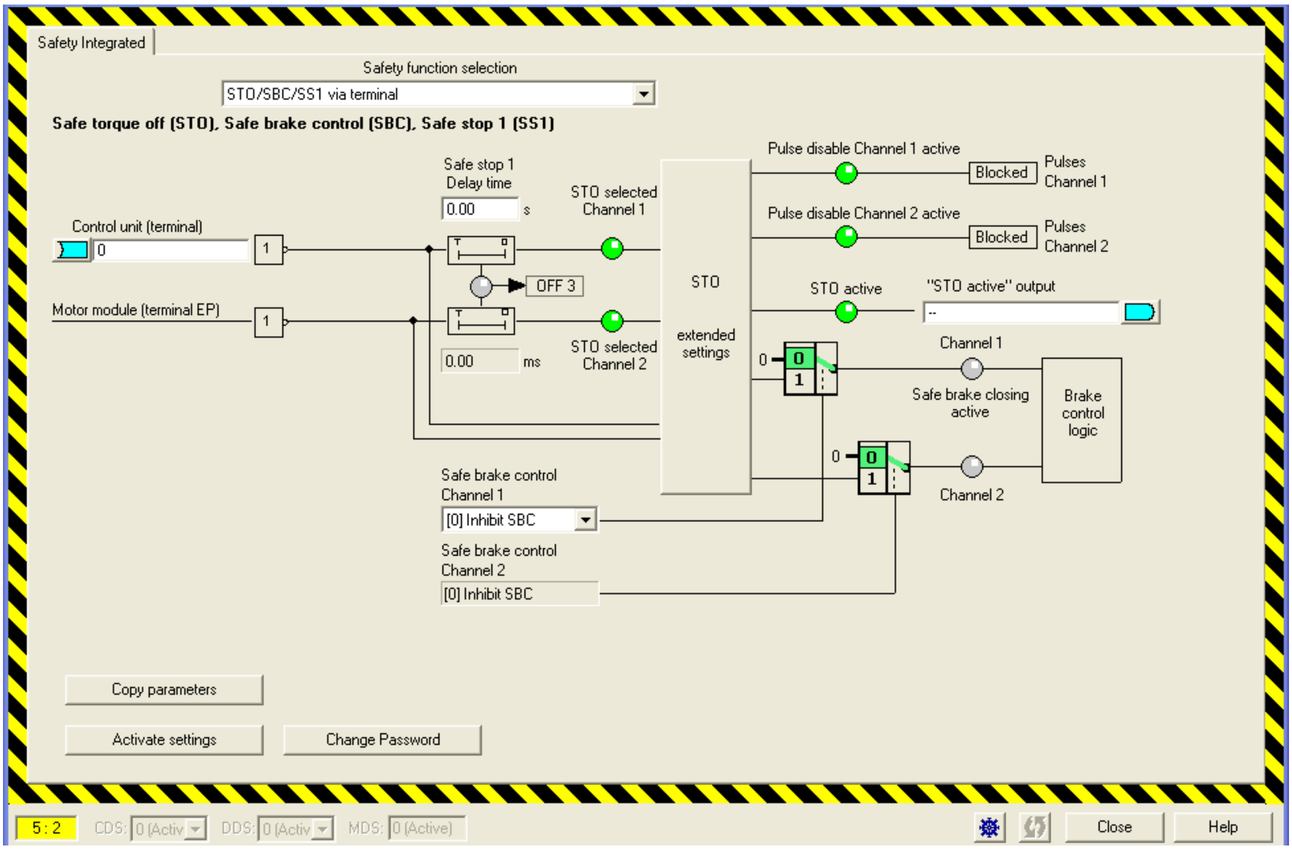


Figure 8-32 STO/SBC/SS1 via terminals

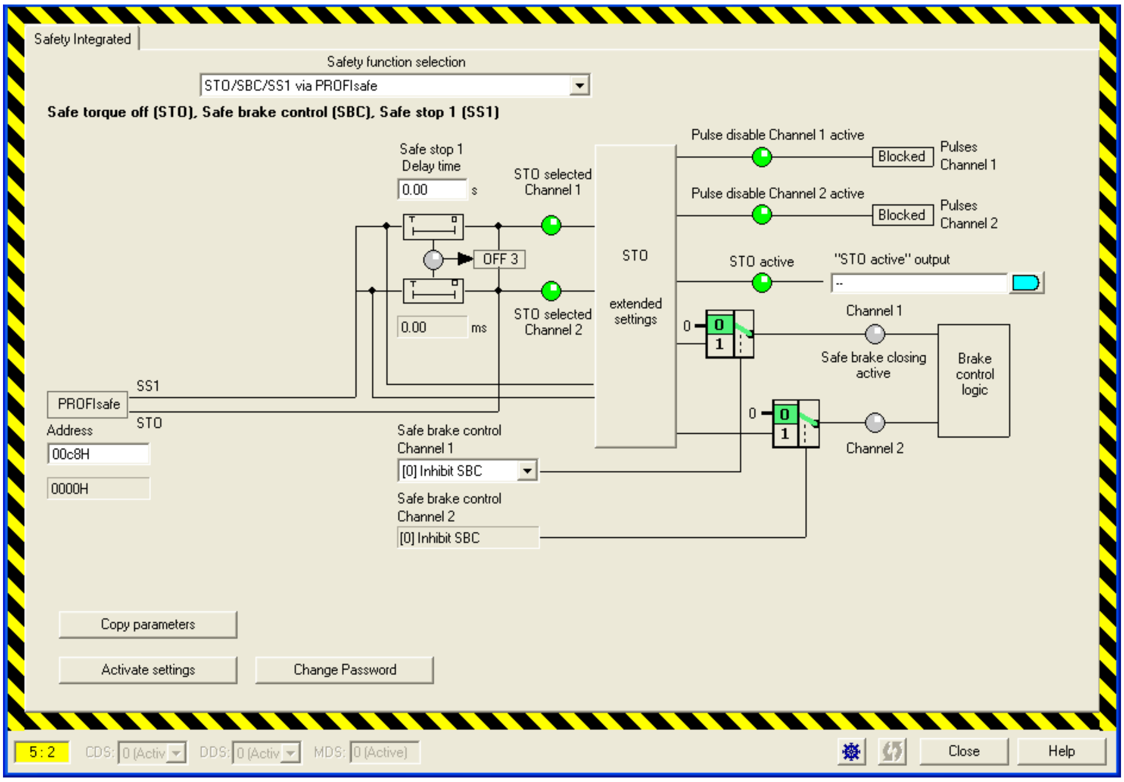


Figure 8-33 STO/SBC/SS1 via PROFIsafe

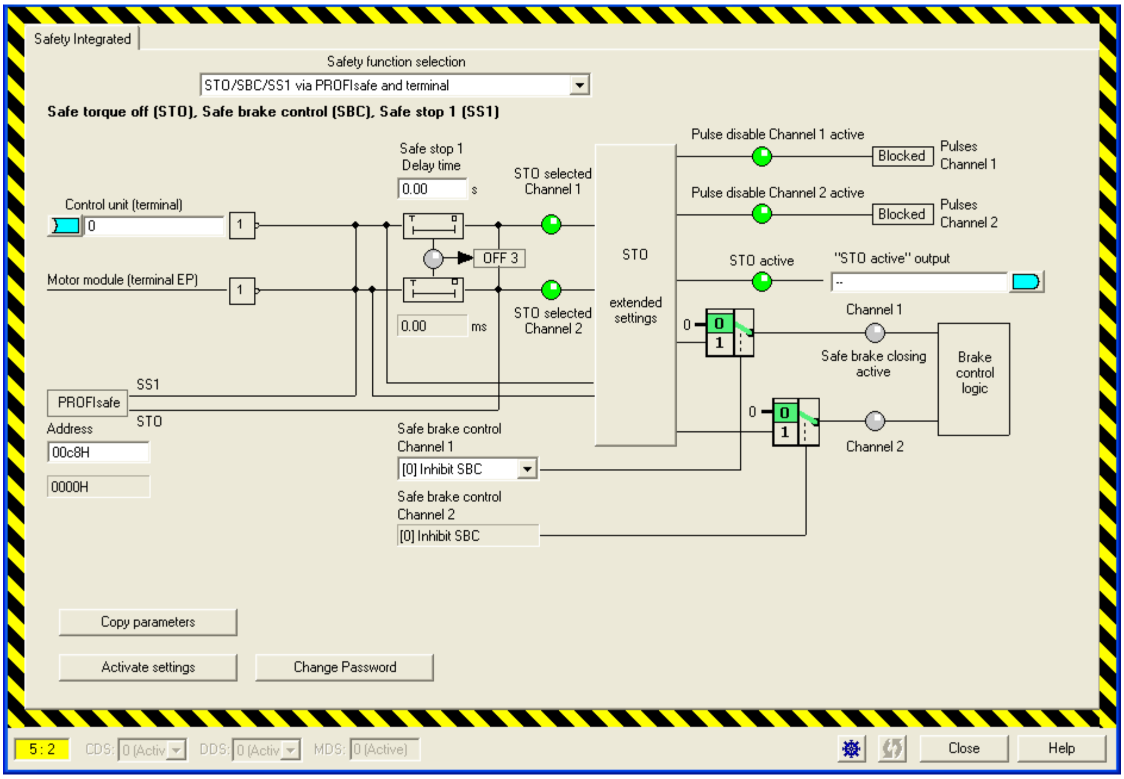


Figure 8-34 STO/SBC/SS1 via PROFIsafe and terminal

Activating PROFIsafe via the expert list

In order to activate Safety Integrated Basic Functions via PROFIsafe, in the expert list, bit 3 of p9601 and p9801 must be set to "1" and bit 2 to "0". Bit 0 must be set to either "1" or "0", depending on whether the control via terminals is to be enabled in parallel via PROFIsafe or not.

Saving and copying the Basic Function parameters

After setting the specific parameters for Safety Integrated functions (e.g. the PROFIsafe address) using the "Copy parameters" button, these must be copied from the CU into the Motor/Power Module and activated using the "Activate settings" button.

Acceptance test

An acceptance test must be carried out once configuration and commissioning are complete (see chapter "Acceptance test and acceptance report").

Note

If F parameters of the SINAMICS drive are changed in HW Config, the global signature of the safety program in the SIMATIC F-CPU changes. This means that using the global signature it is possible to identify whether safety-relevant settings have changed in the F-CPU (F parameters of the SINAMICS slave). However, this global signature does not include the safety-relevant drive parameters so that their change cannot be checked in this way.

8.9 Commissioning a linear/rotary axis

The next section outlines the safety commissioning procedure for a linear axis/rotary axis when a TM54F is used.

1. Connect a PD to the drive and link it to the target device via STARTER.
2. In the STARTER project tree, select the required drive object and under **Functions → Safety Integrated** open the start screen to configure Safety Integrated.
3. Click on the **Change settings** button. The window for selecting Safety Integrated opens.

4. It is only possible to change Safety parameters after entering the valid Safety password (parameter p9761 for the drives or p10061 for the TM54F).

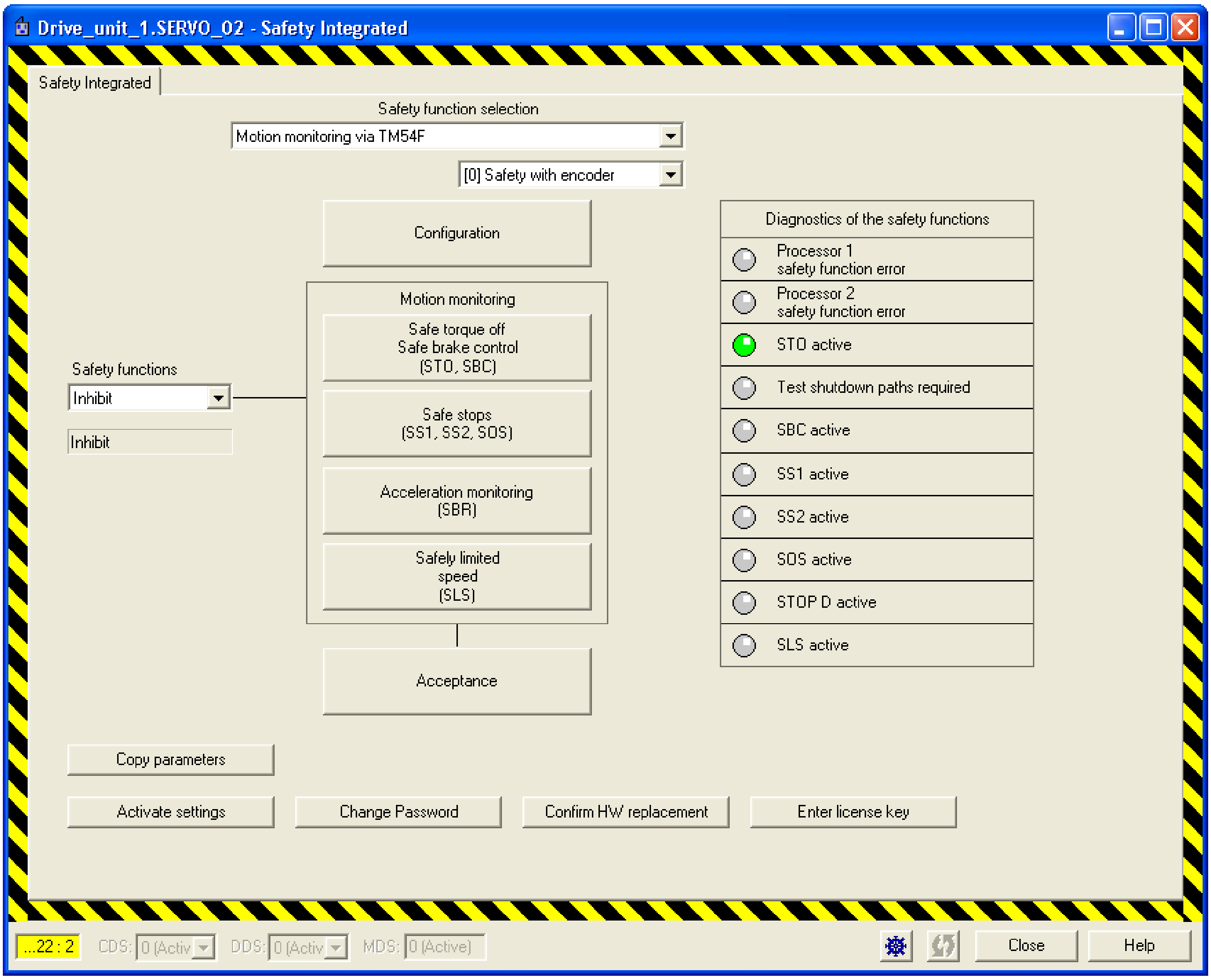


Figure 8-35 Safety Integrated commissioning of a linear/rotary axis

5. Select **Motion Monitoring via TM54F** from the list **Select Safety Function**.
6. Use the list of **safety functions** to enable the safety functions (p9501). Then click on the **Configuration** button.

7. The safety configuration screen of the drive opens.

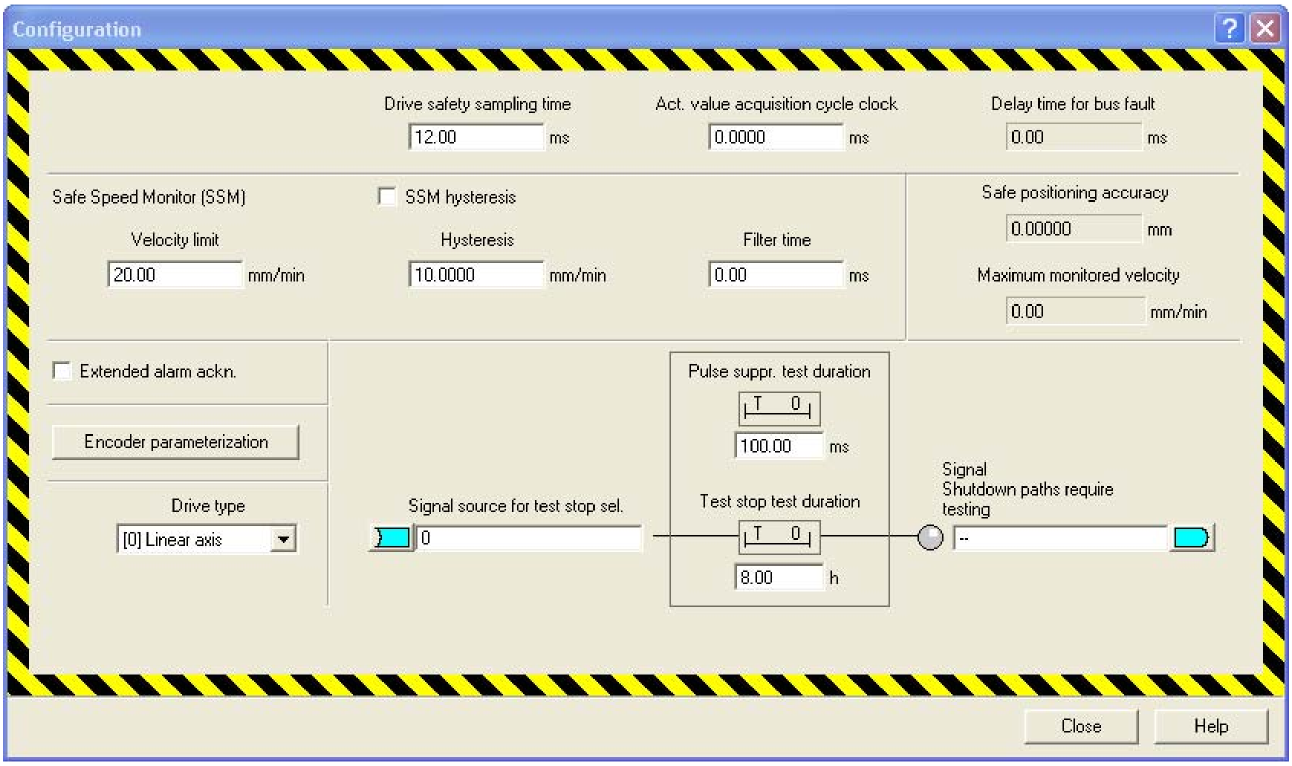


Figure 8-36 Safety configuration: Drive

8. For the drive, set the same **Monitoring clock cycle** (safety clock cycle) as for the TM54F (see "TM54F Configuration").
9. Set the required **Drive type** (linear axis / rotary axis) (p9502). Continue at item 15 if you have not changed the selected drive type.
10. Close the screen. Click on the **Copy parameters** and then click on **Activate settings** (exit commissioning mode, p0010=0).
11. Execute the "Copy RAM to ROM" function for the **Entire project** by clicking the "Entire project" button.
12. Perform a POWER ON. The new parameterization is now active.
13. Reconnect STARTER to the target device. The messages that are displayed indicate that safety commissioning was not completed (different actual and target checksum) can be ignored.
14. Load the project into the PD. The display of parameter units (rotary/linear axis) will be updated accordingly in STARTER.
15. Complete the configuration by adapting the parameterization of the required monitoring limits, timers, encoder settings, etc.

8.10 Modular machine concept Safety Integrated

The modular machine concept for Safety Integrated Basic Functions and Extended Functions provides support for commissioning modular machines. A complete machine, including all its available options, is created in a topology. Only those components that are actually implemented in the finished machine are later activated. Likewise, certain components can also be deactivated to begin with and reactivated if they are required at a later stage.

With the modular machine concept, a distinction is made between the following applications:

- Once the components with Safety functions have been activated for the first time after series commissioning, the hardware replacement needs to be confirmed (see "Information about replacing components" in this manual).
- Once all the drives (including Safety Integrated Extended Functions) have been commissioned, they are to be deactivated (p0105) without changing the hardware. They can only be activated again with a subsequent warm start or by means of POWER ON.
- The DOs of the TM54F can be deactivated by means of parameter p0105. The TM54F itself can only be deactivated when all the drives entered in p10010 "SI drive object assignment" were deactivated separately by means of p0105 beforehand.
- When spare parts are required and the drive is deactivated (p0105) during the delivery period for the required hardware component. Reactivation with subsequent warm start or POWER ON and confirmation of hardware replacement (see "Information about replacing components" in this manual).
- Component exchange on a Control Unit (e.g. to localize faults). For Safety Integrated, this is the same as a hardware replacement. After a warm start or POWER ON, the process of exchanging hardware must be confirmed in order to complete it (see "Information about replacing components" in this manual).

8.11 Information pertaining to component replacements

Replacing a component from the perspective of Safety Integrated

Note

When replacing certain components (Motor/Power Modules when using a TM54F, Sensor Modules or motors with DRIVE-CLiQ interface), this process must be acknowledged to safeguard the communication connections to be renewed within the device. When replacing other components, no acknowledgement is required since the communication connections to be renewed are saved automatically.

⚠ WARNING

Observe the instructions with regard to changing or replacing software components in the chapter "Safety instructions".

1. The faulty component was replaced in accordance with safety regulations.
2. Switch on the machine, but first ensure that there are no persons in the danger zone.
3. Only when you control the Extended Functions via TM54F:
   – Fault F35150 is output if a TM54F communication error is recognized after exchanging a Motor/Power Module.
   – Fault C30711 with a fault value 1031 is output if a defect in a monitoring channel is recognized after exchanging a Sensor Module.
   – With STARTER/SCOUT:

     Click on the "Acknowledge hardware replacement" button in the start screen of the safety functions.

     - The alarms F01650/F30650 (acceptance test required) are output.
   – If you are working without STARTER with SINAMICS with BOP or with SIMOTION with HMI:

     - Start the copy function for Node Identifier (p9700 = 1D hex).

     - Confirm the hardware CRC on the drive object (p9701 = EC hex).

   Carry out these two tasks after having replaced a Sensor Module at drive object servo or vector, and after having replaced a Motor Module at drive object TM54F_MA (if installed).
4. Back up all parameters on the memory card:
   – With BOP or AOP30: Set p0977 = 1.
   – With STARTER: "Copy RAM to ROM" function.

5. Carry out a POWER ON (power off/on) for all components.

Note

In this case, the system will not notify you with a flashing LED that a POWER ON is required.

---

6. Carry out an acceptance text and acceptance report according to Chapter "Acceptance test and acceptance report" and table "Effect of the acceptance test for certain measures".

WARNING
Before re-entering the danger area and before resuming operation, a (partial) acceptance test must be carried out for all the drives affected by the component exchange (see the "Acceptance test and acceptance report" chapter).

8.12 Information pertaining to series commissioning

A commissioned project that has been uploaded to STARTER can be transferred to another drive unit keeping the existing safety parameter assignment.

1. Load the STARTER project into the drive unit.
2. Switch on the machine, but first ensure that there are no persons in the danger zone.
3. Fault F35150 (communication error after replacing a Motor/Power Module) or C30711 with fault value 1031 (data transfer error after replacing a Sensor Module) is only output if you control Extended Functions via TM54F.
4. With STARTER/SCOUT:
   – Click on the **"Acknowledge hardware replacement"** button in the start screen of the safety functions.
5. Faults F01650/F30650 are output (acceptance test required, see chapter "Acceptance test and acceptance report", table "Effect of the acceptance tests for specific measures").
6. If you are using SINAMICS with a BOP or SIMOTION with HMI, then you must perform the following steps:
   – Start the copy function for Node Identifier (p9700 = 1D hex)
   – Confirm the hardware CRC on the drive object (p9701 = EC hex)

   Carry out these two tasks after having replaced a Motor/Power Module at drive object servo or vector, and after having replaced a Motor Module at drive object TM54F_MA (if installed).
7. Back up all parameters on the memory card (p0977 = 1).
8. Carry out a POWER ON (power off/on) for all components.

⚠ WARNING
Before re-entering the danger area and before resuming operation, a simplified function test must be carried out for all the drives affected by the component exchange (see chapter "Acceptance test and acceptance report").

Safety message for standard commissioning with Safety Integrated Extended Functions

If third-party motors with absolute encoders are being used, a situation may arise where a Safety message prevents commissioning.
One reason for this may be that a different serial number of the absolute encoder is saved on the memory card than that in the Control Unit which is to be commissioned. The Safety message can only be acknowledged once the serial number for the absolute encoder has been corrected manually (e.g. with STARTER). Instructions on this are provided in the chapter "Information about replacing components". You can then carry on with the commissioning.

Application examples 9

9.1 Input/output interconnections for a safety switching device with TM54F

TM54F: interconnecting F-DO with safe input on safety switching device

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Note

These typical circuit diagrams are only valid for version B of TM54F devices.

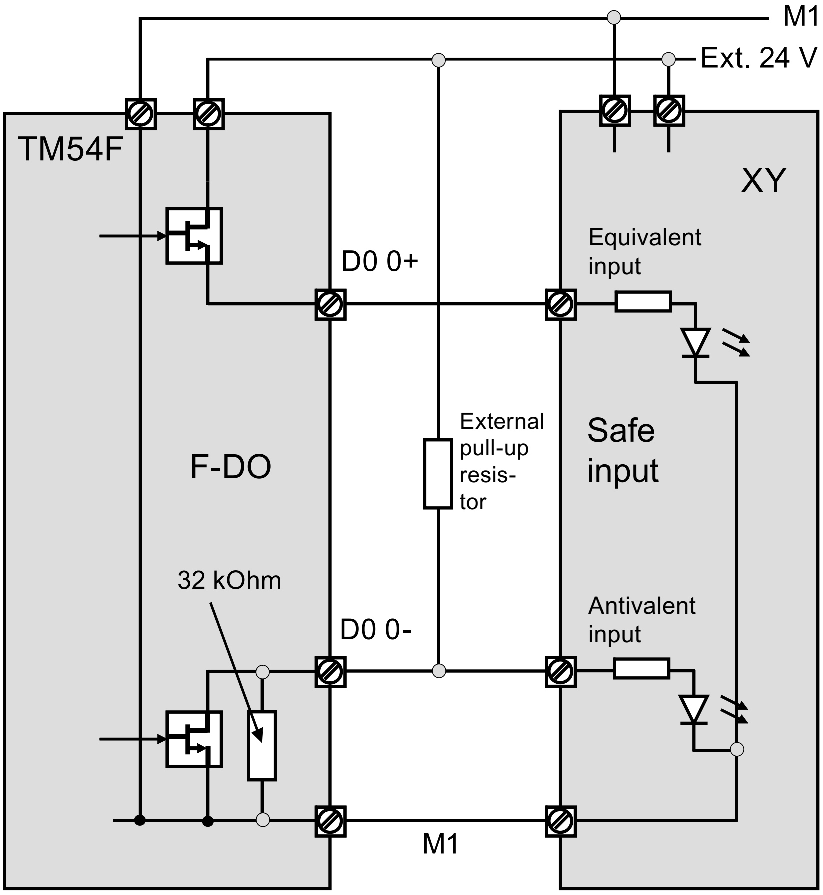

Figure 9-1 TM54F F-DO at equivalent/antivalent safe input on safety switching device (e.g. safety PLC)

The external pull-up resistor is only required in exceptional cases, see below.

TM54F: Interconnecting F-DI with a plus-minus switching output on a safety switching device

WARNING

In contrast to mechanical switching contacts (e.g. Emergency Stop switches), leakage currents can still flow in semiconductor switches such as those usually used at digital outputs even when they have been switched off. This can lead to false switching states if digital inputs are not connected correctly.

The conditions for digital inputs/outputs specified in the relevant manufacturer documentation must be observed.

WARNING

In accordance with IEC 61131 Part 2, Chapter 5.2, when interconnecting the digital inputs of the TM54F with digital semiconductor outputs, only outputs that have a maximum residual current of 0.5 mA when in the "OFF" state can be used.

Debounce

Test signals from the controls can be filtered out using parameter p10017 (SI digital inputs, debounce time) so that faults are not misinterpreted.

F-DI = safety-oriented dual-channel digital input
F-DO = safety-oriented dual-channel digital output

If digital outputs from another device (e.g. F-DOs on a safety PLC) with a residual current greater than 0.5 mA in the "OFF" state are connected to the F-DIs of the TM54F, then F-DI load resistors should be connected up in the channel involved.

The maximum permissible voltage for a TM54F F-DI when "OFF" is 5 V (in accordance with IEC 61131-2).

The following two diagrams show exactly how the protective circuits for F-DIs with additional load resistors are wired.

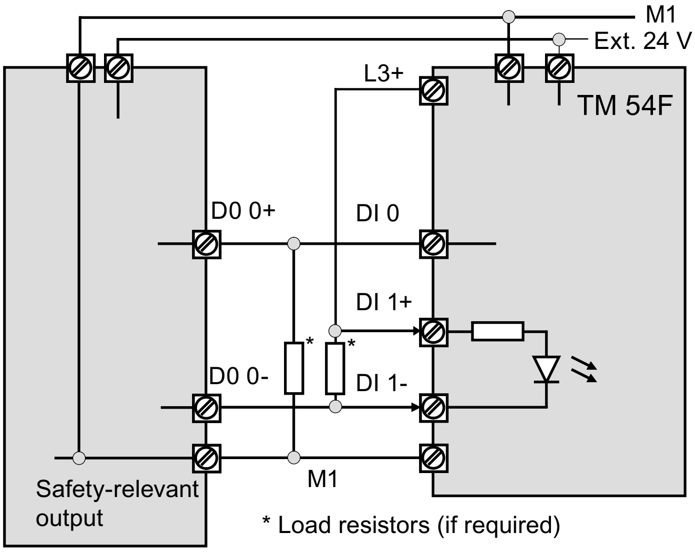

Figure 9-2 TM54F F-DI at plus-minus switching safe output on safety switching device (e.g. safety PLC)

TM54F: interconnecting F-DI with plus-plus switching output on safety switching device

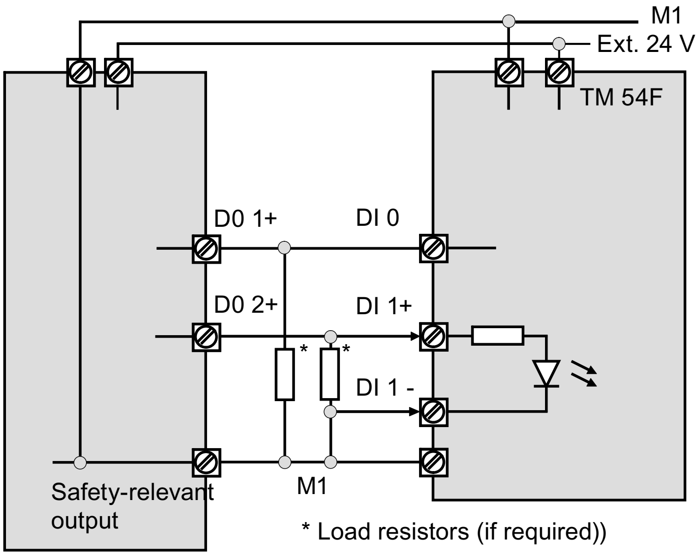

Figure 9-3 TM54F F-DI at plus-plus-switching safe output on a safety switching device (e.g. safety PLC).

Dimensioning the load resistors - example 1:
According to the manufacturer's documentation, the leakage current of an F-DO of a safety PLC for the P and F channels is 1 mA; in other words, it is around 0.5 mA higher than is permissible for the F-DI.
The necessary load resistance is therefore R = 5 V/0.5 mA = 10 kΩ.
At the maximum supply voltage, the power loss for this resistor is:
P = (28.8 V)²/R = 83 mW. The resistor is to be permanently dimensioned for this power loss.

Dimensioning the load resistors - example 2:
If additional conditions for the digital output (e.g. a minimum load or a maximum load resistance) are specified in the manufacturer's documentation, then these must be taken into account.
For example, a load between 12 Ω and 1 kΩ is specified for the SIMATIC ET200S I/O module 4 F-DO (6ES7138-4FB02-0AB0).
Therefore, two additional load resistors with a continuous load capacity of at least P = $(28.8\ V)^2/R$ = 830 mW are required to connect an F-DO of this kind to a TM54F F-DI.

If a controlled 24 V power supply is used (e.g. SITOP), a resistor with a significantly lower power loss is sufficient.

Note

Open-circuit detection for a pull-up resistor

If the pull-up resistor is higher than 1 kΩ, then the open-circuit detection no longer reliably functions and must be disabled.

9.2 Application examples

Application examples can be found at the following Siemens website:

http://support.automation.siemens.com/WW/view/en/20810941/136000t

10 Acceptance test and acceptance report

10.1 General information

The acceptance test requirements (configuration check) for electrical drive safety functions emanate from DIN EN 61800-5-2, Chapter 7.1 Point f). The acceptance test "configuration check" is cited in this standard.

- Description of the application including a picture
- Description of the safety-relevant components (including software versions) that are used in the application
- List of the PDS(SR) [Power Drive System(Safety Related)] safety functions used
- Results of all tests of these safety functions, using the specified testing procedure
- List of all safety-relevant parameters and their values in the PDS(SR)
- Checksum, test date and confirmation by testing personnel

The acceptance test for systems with Safety Integrated Functions (SI functions) is focused on validating the functionality of Safety Integrated monitoring and stop functions implemented in the drive system. The test objective is to verify proper implementation of the defined safety functions and of test mechanisms (forced dormant error detection measures) and to examine the response of specific monitoring functions to the explicit input of values outside tolerance limits. The test must cover all drive-specific Safety Integrated motion monitoring functions and global Safety Integrated functionality of Terminal Module TM54F (if used).

⚠ WARNING

A new acceptance test must be carried out if any changes were made to SI function parameters and must be logged in the acceptance report.

Note

The acceptance test is designed to ensure that the safety functions are correctly parameterized. The measured values (e.g. distance, time) and the system behavior identified (e.g. initiation of a specific stop) can be used for checking the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot be used, for example, to derive maximum values for over-travel.

10.2 Acceptance test structure

Authorized person, acceptance report

The test of each SI function must be carried out by an authorized person and logged in the acceptance report. The report must be signed by the person who performed the acceptance test. The acceptance report must be kept in the logbook of the relevant machine. Access rights for SI parameters must be password protected and be documented accordingly in the acceptance report. Authorized in this sense refers to a person who has the necessary technical training and knowledge of the safety functions and is authorized by the machine manufacturer to carry out the acceptance test.

Note

Comply with the information in the chapter "Procedures for initial commissioning".

The acceptance report presented below is both an example and recommendation.

An acceptance report template in electronic format is available at your local Siemens sales office.

Necessity of an acceptance test

For first commissioning of the Safety Integrated functionality on a machine, a "complete acceptance test" is required. Safety-related function extensions, transfer of the commissioning settings to other series machines, hardware changes, software upgrades, etc., permit the acceptance test to be performed with a reduced scope if necessary. A summary of conditions which determine the necessary test scope or proposals in this context is provided below.

In order to define a partial acceptance test, it is necessary in the first instance to specify the acceptance test objects, and in the second instance to define logical groups which represent the elements of the acceptance test. The acceptance test must be carried out separately for each individual drive (as far as the machine allows).

Prerequisites for the acceptance test

- The machine is properly wired.
- All safety equipment such as protective door monitoring devices, light barriers or emergency limit switches are connected and ready for operation.
- Commissioning of the open-loop and closed-loop control should be completed, as e.g. the over-travel distance may otherwise change as a result of a changed dynamic response of the drive control. These include, for example:
  - Configuration of the setpoint channel
  - Position control in the higher-level controller
  - Drive control

Information about the acceptance tests

Note

As far as possible, the acceptance tests are to be carried out at the maximum possible machine speed and acceleration rates to determine the maximum braking distances and braking times that can be expected.

Note on the acceptance test mode

The acceptance test mode can be activated for a definable period (p9358/p9558) by setting the appropriate parameters (p9370/p9570). It tolerates specific limit violations during the acceptance test. For instance, the setpoint speed limits are no longer active in the acceptance test mode. To ensure that this state is not accidentally kept, the acceptance test mode is automatically exited after the time set in p9358/p9558.

It is only worth activating acceptance test mode during the acceptance test for functions SS2, SOS and SLS. It has no effect on other functions.

Normally, SOS can be selected directly or via SS2. In order to also be able to initiate violation of the standstill limits in state SS2 when the acceptance test mode is active, the acceptance test mode deactivates the brake ramp of SS2 so that the motor can be moved. When an SOS violation is acknowledged in the active acceptance test mode, the current position is adopted as the new stop position so that an SOS violation is not immediately identified again.

WARNING

If a speed setpoint other than zero is present, the active stop function SS2 is set, and the motor is at a standstill (active SOS), the axis starts to move as soon as the acceptance test is activated.

10.2.1 Content of the complete acceptance test

A) Documentation

Documentation of the machine and of safety functions

1. Machine description (with overview)
2. Specification of the controller (if this exists)
3. Configuration diagram
4. Function table:
   - Active monitoring functions depending on the operating mode and the protective door,
   - Other sensors with protective functions,
   - The table is part or is the result of the configuring work.
5. SI functions for each drive
6. Information about safety equipment

B) Functional testing of safety functions

Detailed function test and evaluation of SI functions used. For some functions this contains trace recordings of individual parameters. The procedure is described in detail in the "Acceptance test" section.

1. Test of the SI function "Safe Torque Off" (STO)
   - Required when used in Basic and/or Extended Functions
   - This test is also required if you are not explicitly using STO, but just one function for which STOP A occurs as an error response.

     Alternatively you can also perform the quality test yourself with STOP A, if you use the tables from the sections "Acceptance test Safe Torque Off (Basic Functions)", "Acceptance test Safe Torque Off with encoder (Extended Functions)" or. "Acceptance test Safe Torque Off without encoder (Extended Functions)".
   - You do not need to prepare trace recording for this test.
2. Test of the SI function "Safe Stop 1" (SS1)
   - Required when used in Basic and/or Extended Functions
   - This test is also required if you are not explicitly using SS1, but just one function for which STOP B occurs as an error response.

     Alternatively you can also perform the quality test yourself with STOP B, if you use the tables from the sections "Acceptance test for Safe Stop 1 with encoder (Extended Functions)" or "Acceptance test for Safe Stop 1 without encoder (Extended Functions)".
   - Trace recording only required if Extended Functions are used
3. Test of the SI function "Safe Brake Control" (SBC)
   - Required when using Basic and/or Extended Functions
   - You do not need to prepare trace recording for this test.

4. Test of the SI function "Safe Stop 2" (SS2)
   – Only required when used in Extended Functions
   – This test is also required if you are not explicitly using SS2 but just one function for which STOP C occurs as a fault reaction.

     Alternatively, you can also carry out the quality test using STOP C yourself, if you use the table from section "Acceptance test for Safe Stop 2 (Extended Functions)".
   – Trace recording is required
5. Test of the SI function "Safe Operating Stop" (SOS)
   – Only required when used in Extended Functions
   – This test is also required if you are not explicitly using SOS, but just one function for which STOP C or STOP D occurs as a fault reaction.

     Alternatively, you can also perform the quality test using STOP C and STOP D yourself, if you use the table from section "Acceptance test for Safe Operating Stop (Extended Functions)".
   – Trace recording is required
6. Test of the SI function "Safely Limited Speed" (SLS)
   – Only required when used in Extended Functions
   – Trace recordings are required for each SLS limit
7. Test of the SI function "Safe Speed Monitor" (SSM)
   – Only required when used in Extended Functions
   – Trace recording is required

C) Functional testing of forced dormant error detection

Test of the forced dormant error detection of the safety functions on each drive (for each control mode) and the TM54F (if used).

1. Test of the forced dormant error detection of the safety function on the drive
   – If you are using Basic Functions, you need to activate and then deactivate STO once again.
   – If you are using Extended Functions, you need to carry out a test stop.
2. Test of the forced dormant error detection of the TM54F (if present)
   – Only if Extended Functions are used
   – Carry out test stop of the TM54F

D) Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Inspection of SI parameters
2. Logging of checksums (for each drive)
3. Issuing of the Safety password and documenting this process (do not specify the Safety password in the report!)
4. RAM to ROM backup, upload of project data to STARTER, and backup of the project
5. Countersignature

10.2.2 Content of the partial acceptance test

A) Documentation

Documentation of the machine and of safety functions

1. Extending/changing the hardware data
2. Extending/changing the software data (specify version)
3. Extending/changing the configuration diagram
4. Extending/changing the function table:
   – Active monitoring functions depending on the operating mode and the protective door
   – Other sensors with protective functions
   – The table is part or is the result of the configuring work
5. Extending/changing the SI functions per drive
6. Extending/changing the specifications of the safety equipment

B) Functional testing of safety functions

Detailed function test and evaluation of SI functions used. For some functions this contains trace recordings of individual parameters. The procedure is described in detail in the "Acceptance test" section.

The function test can be left out if no parameters of the individual safety functions have been changed. In the case that only parameters of individual functions have been changed, only these functions need to be tested anew.

1. Test of the SI function "Safe Torque Off" (STO)
   – Required when used in Basic and/or Extended Functions
   – This test is also required if you are not explicitly using STO, but just one function for which STOP A occurs as an error response.

     Alternatively you can also perform the quality test yourself with STOP A, if you use the tables from the sections "Acceptance test Safe Torque Off (Basic Functions)", "Acceptance test Safe Torque Off with encoder (Extended Functions)" or. "Acceptance test Safe Torque Off without encoder (Extended Functions)".
   – You do not need to prepare trace recording for this test.
2. Test of the SI function "Safe Stop 1" (SS1)
   – Required when used in Basic and/or Extended Functions
   – This test is also required if you are not explicitly using SS1, but just one function for which STOP B occurs as an error response.

     Alternatively you can also perform the quality test yourself with STOP B, if you use the tables from the sections "Acceptance test for Safe Stop 1 with encoder (Extended Functions)" or "Acceptance test for Safe Stop 1 without encoder (Extended Functions)".
   – Trace recording only required if Extended Functions are used
3. Test of the SI function "Safe Brake Control" (SBC)
   – Required when using Basic and/or Extended Functions
   – You do not need to prepare trace recording for this test.

4. Test of the SI function "Safe Stop 2" (SS2)
   – Only required when used in Extended Functions
   – This test is also required if you are not explicitly using SS2 but just one function for which STOP C occurs as a fault reaction.

     Alternatively, you can also carry out the quality test using STOP C yourself, if you use the table from section "Acceptance test for Safe Stop 2 (Extended Functions)".
   – Trace recording is required
5. Test of the SI function "Safe Operating Stop" (SOS)
   – Only required when used in Extended Functions
   – This test is also required if you are not explicitly using SOS, but just one function for which STOP C or STOP D occurs as a fault reaction.

     Alternatively, you can also perform the quality test using STOP C and STOP D yourself, if you use the table from section "Acceptance test for Safe Operating Stop (Extended Functions)".
   – Trace recording is required
6. Test of the SI function "Safely Limited Speed" (SLS)
   – Only required when used in Extended Functions
   – A trace recording is required for each SLS limit
7. Test of the SI function "Safe Speed Monitor" (SSM)
   – Only required when used in Extended Functions
   – Trace recording is required

C) Functional testing of forced dormant error detection

Test of the forced dormant error detection of the safety functions on each drive (for each control mode) and the TM54F (if used).

1. Test of the forced dormant error detection of the safety function on the drive
   – If you are using Basic Functions, you need to activate and then deactivate STO once again.
   – If you are using Extended Functions, you need to carry out a test stop.
2. Test of the forced dormant error detection of the TM54F (if present)
   – Only if Extended Functions are used
   – Carry out test stop of the TM54F

D) Functional testing of actual value acquisition

1. General testing of actual value acquisition
   – After exchanging the component, initial activation and brief operation in both directions.

   > **⚠ WARNING**
   >
   > **During this process, all personnel must keep out of the danger area.**

2. Test of failsafe actual value acquisition
   – Only necessary if Extended Functions are used
   – If the motion monitoring functions are activated (e.g. SLS or SSM with hysteresis), briefly operate the drive in both directions.

E) Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Extension of checksums (for each drive)
2. Countersignature

10.2.3 Test scope for specific measures

Scope of partial acceptance tests for specific measures

Table 10- 1 Scope of partial acceptance tests for specific measures

Measure	A) Documentation	B) Functional testing of safety functions	C) Functional testing of forced dormant error detection	D) Functional testing of actual value acquisition	E) Conclusion of the report
Replacement of the encoder system	No	No	No	Yes	Yes
Replacement of an SMC/SME	Yes, Points 1 and 2	No	No	Yes	Yes
Replacement of a motor with DRIVE-CLiQ	Yes, Points 1 and 2	No	No	Yes	Yes
Replacement of the Control Unit / power unit hardware	Yes, Points 1 and 2	No	Yes, only Point 1	Yes, only Point 1	Yes
Replacing the Power Module	Yes, Points 1 and 2	Yes, Points 1 and 3	Yes, only Point 1	Yes, only Point 1	Yes
Replacing the TM54F	Yes, Points 1 and 2	Yes, but only testing of the selection of the safety functions	Yes	Yes, only Point 1	Yes
Firmware - upgrade(CU/power unit/ Sensor Modules)	Yes, only Point 2	Yes, if new safety functions are to be used	Yes	Yes, only Point 1	Yes
Change to a single parameter of a safety function (e.g. SLS limit)	Yes, Points 4 and 5.	Yes, test the appropriate function	No	Yes	Yes
Transfer of project data to other machines (series commissioning)	Yes	Yes, but only testing of the selection of the safety functions	Yes	Yes	Yes

Note

Forced dormant error detection functional testing (C) and actual value acquisition functional testing (D) together represent the "simplified function test" mentioned in previous chapters.

10.3 Safety logbook

Description

The "Safety Logbook" function is used to detect changes to safety parameters that affect the associated CRC sums. Cyclic redundancy checks are only generated when p9601/p9801 (SI enable, functions integrated in the drive CU/Motor Module) is > 0.

Data changes are detected when the CRCs of the SI parameters change. Each SI parameter change that is to become active requires the reference CRC to be changed so that the drive can be operated without SI fault messages. In addition to functional safety changes, safety changes as a result of hardware being replaced can be detected when the cyclic redundancy check has changed.

The following changes are recorded by the safety logbook:

- Functional changes are recorded in the checksum r9781[0]:
  - Functional cyclic redundancy checks of the motion monitoring functions (p9729[0...1]), axial (Extended Functions)
  - Functional cyclic redundancy checks of the basic safety functions integrated in the drive (p9799, SI setpoint checksum SI parameters CU), axial
  - Functional cyclic redundancy checks of the TM54F (p10005[0]), global (Extended Functions)
  - Enabling of functions integrated in the drive (p9601), axial (basic and extended functions)
- Hardware-dependent changes are recorded in the checksum r9781[1]:
  - Hardware-dependent cyclic redundancy check of the motion monitoring functions (p9729[2]), axial (Extended Functions)
  - Hardware-dependent cyclic redundancy check of the TM54F (p10005[1]), global (Extended Functions)

10.4 Acceptance report

10.4.1 Plant description - Documentation part 1

Table 10- 2 Machine description and overview diagram

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Electrical drives	
Other drives	
Overview diagram of machine	

Table 10- 3 Values of relevant parameters

Versions of the firmware and of Safety Integrated			
Component	DO number	Firmware version	SI version
Parameters Control Unit		r0018 =	r9590 = r9770 = Note: Parameters can be found in the drive.
	DO number	Firmware version	SI version
Parameters Motor Modules		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
	DO number	Firmware version	SI version
Parameters Sensor Modules		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
	DO number	Firmware version	SI version
TM54F parameters		r0158 =	r10090 =
Monitoring clock cycles of Safety Integrated			
	DO number	SI monitoring clock cycle Control Unit	SI monitoring clock cycle Motor Module
Basic functions		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
	DO number	SI monitoring clock cycle Motor Module	SI monitoring clock cycle Control Unit
Extended functions		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
TM54F parameters	DO number	SI monitoring clock cycle TM54F	
		p10000 =	

10.4.2 Description of safety functions - documentation part 2

Note

This description of a system is for illustration purposes only. In each case, the actual settings for the system concerned will need to be modified as required.

10.4.2.1 Function table

Table 10- 4 Example table: Active monitoring functions depending on the operating mode, the protective doors or other sensors

Mode of operation	Protective door	Drive	Status of monitoring functions
Production	closed and locked	1 2	All deactivated SLS 1 enabled
	unlocked	1 2	SOS activated STO switched off
Setup	closed and locked	1 2	All deactivated SLS 1 enabled
	unlocked	1 2	SLS 1 deactivated, enabled
...	...	...	...

10.4.2.2 Safety Integrated functions used

Table 10- 5 Example: functional overview of the safety functions

Drive	SI function	Limit	Active if
1	SOS	100 mm	refer to the function table
	SLS 1	200000 mm/min	refer to the function table
2	SOS	100 mm	refer to the function table
	SLS 1	50 rpm	refer to the function table
...	...	...	...

Comments:

All drives use the SI function SS1 for the EMERGENCY STOP functionality.

Drive 2 is equipped with a holding brake which is controlled by two channels via the corresponding Motor Module output.

Drive-specific Safety Parameter

Note

You need to fill out this table for each axis.

Table 10- 6 Drive-specific data

SI function	Parameter Motor Modules / CU	Motor Module value / CU value
Enable safety functions	p9301 / p9501	0000 bin
Axis type	p9302 / p9502	0
Function specification	p9306 / p9506	0
Function configuration	p9307 / p9507	0000 bin
Actual value acquisition clock cycle	p9311 / p9511	0.0 ms
Coarse position value configuration	p9315 / p9515	0000 bin
Encoder configuration, safety functions	p9316 / p9516	0000 bin
Linear scale graduations	p9317 / p9517	10 nm
Encoder pulses per revolution	p9318 / p9518	2048
Fine resolution G1_XIST1	p9319 / p9519	11
Spindle pitch	p9320 / p9520	10 mm
Gearbox encoder (motor) / load denominator	p9321[0] / p9521[0] p9321[1] / p9521[1] p9321[2] / p9521[2] p9321[3] / p9521[3] p9321[4] / p9521[4] p9321[5] / p9521[5] p9321[6] / p9521[6] p9321[7] / p9521[7]	1 1 1 1 1 1 1 1
Gearbox encoder (motor) / load numerator	p9322[0] / p9522[0] p9322[1] / p9522[1] p9322[2] / p9522[2] p9322[3] / p9522[3] p9322[4] / p9522[4] p9322[5] / p9522[5] p9322[6] / p9522[6] p9322[7] / p9522[7]	1 1 1 1 1 1 1 1
Redundant coarse position value valid bits	p9323 / p9523	9
Redundant coarse position value fine resolution bits	p9324 / p9524	-2
Redundant coarse position value relevant bits	p9325 / p9525	16
Encoder assignment	p9326 / p9526	1

SI function	Parameter Motor Modules / CU	Motor Module value / CU value
Sensor Module node identifier	p9328[0] p9328[1] p9328[2] p9328[3] p9328[4] p9328[5] p9328[6] p9328[7] p9328[8] p9328[9] p9328[10] p9328[11]	0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex 0000 hex
SI Motion Gx_XIST1 coarse position safety most significant bit	p9329 / p9529	14
SOS standstill tolerance	p9330 / p9530	1.000°
PLC limit values	p9331[0] / p9531[0] p9331[1] / p9531[1] p9331[2] / p9531[2] p9331[3] / p9531[3]	2000.00 mm/min 2000.00 mm/min 2000.00 mm/min 2000.00 mm/min
Actual value comparison tolerance	p9342 / p9542	0.1000°
SSM Filter time	p9345 / p9545	0.0 ms
SSM speed limit	p9346 / p9546	20.00 mm/min
SSM speed hysteresis	p9347 / p9547	10 mm/min
SBR actual speed tolerance	p9348 / p9548	300.00 1/min
Slip speed tolerance	p9349 / p9549	6.0 1/min
SLS switchover delay time	p9351 / p9551	100.00 ms
STOP C -> SOS delay time	p9352 / p9552	100.00 ms
STOP D -> SOS delay time	p9353 / p9553	100.00 ms
STOP F -> STOP B delay time	p9355 / p9555	0.00 ms
Pulse cancelation delay time	p9356 / p9556	100.00 ms
Pulse suppression test time	p9357 / p9557	100.00 ms
Acceptance test mode time limit	p9358 / p9558	40000.00 ms
Pulse suppression shutdown speed	p9360 / p9560	0.0 1/min
SLS stop response	p9363[0] / p9563[0] p9363[1] / p9563[1] p9363[2] / p9563[2] p9363[3] / p9563[3]	2 2 2 2
SBR speed limit	p9368 / p9568	0.0 mm/min
Forced dormant error detection timer	p9559	8.00 h
Brakeramp reference value	p9381 / p9581	1500 1/min
Brake ramp delay time	p9382 / p9582	250 ms
Brake ramp monitoring time	p9383 / p9583	10.00 s

SI function	Parameter Motor Modules / CU	Motor Module value / CU value
Minimum current actual value acquisition without encoder	p9388 / p9588	10.00 %
Acceleration voltage tolerance	p9389 / p9589	100.00 %
Test stop signal source	p9705	1:722:5
Enable drive-integrated functions	p9801 / p9601	0000 bin
Enable safe brake control	p9802 / p9602	0
PROFIsafe address	p9810 / p9610	0000 hex
Signal source for STO/SBC/SS1	p9620[0] p9620[1] p9620[2] p9620[3] p9620[4] p9620[5] p9620[6] p9620[7]	0 0 0 0 0 0 0 0
Signal source for SBA	p9821 / p9621	0
SBA relay wait times	p9822[0] / p9622[0] p9822[1] / p9622[1]	100.00 ms 65.00 ms
SGE switchover tolerance time	p9850 / p9650	500.00 ms
STO/SBC/SS1 debounce time	p9851 / p9651	0.00 ms
Safe Stop 1 delay time	p9852 / p9652	0.00 s
STOP F -> STOP A delay time	p9858 / p9658	0.00 µs
Forced dormant error detection timer	p9659	8.00 h

10.4.2.3 Safety Parameter of the TM54F

Table 10- 7 Parameter for control via the TM54F (excerpt)

SI function	Parameter	Value
Sampling time	p10000	12.00 ms
Wait time for test stop on DO	p10001	500.00 ms
Monitoring time discrepancy	p10002	12.00 ms
Forced dormant error detection timer	p10003	8.00 h
Acknowledging internal event input terminal	p10006	0
Input terminal forced dormant error detection	p10007	0
Assignment of drive objects	p10010[0] p10010[1] p10010[2] p10010[3] p10010[4] p10010[5]	0 0 0 0 0 0
Assignment of drive groups	p10011[0] p10011[1] p10011[2] p10011[3] p10011[4] p10011[5]	1 1 1 1 1 1
Digital inputs debounce time	p10017	1.00 ms
STO input terminal	p10022[0] p10022[1] p10022[2] p10022[3]	0 0 0 0
SS1 input terminal	p10023[0] p10023[1] p10023[2] p10023[3]	0 0 0 0
SS2 input terminal	p10024[0] p10024[1] p10024[2] p10024[3]	0 0 0 0
SOS input terminal	p10025[0] p10025[1] p10025[2] p10025[3]	0 0 0 0
PLC input terminal	p10026[0] p10026[1] p10026[2] p10026[3]	0 0 0 0
SLS_Limit(1) input terminal	p10027[0] p10027[1] p10027[2] p10027[3]	0 0 0 0

SI function	Parameter	Value
SLS_Limit(2) input terminal	p10028[0] p10028[1] p10028[2] p10028[3]	0 0 0 0
Safe state signal selection	p10039[0] p10039[1] p10039[2] p10039[3]	1 hex 1 hex 1 hex 1 hex
F-DI input mode	p10040	0 hex
F-DI test enable	p10041	0 hex
F-DO 0 signal sources	p10042[0] p10042[1] p10042[2] p10042[3] p10042[4] p10042[5]	0 0 0 0 0 0
F-DO 1 signal sources	p10043[0] p10043[1] p10043[2] p10043[3] p10043[4] p10043[5]	0 0 0 0 0 0
F-DO 2 signal sources	p10044[0] p10044[1] p10044[2] p10044[3] p10044[4] p10044[5]	0 0 0 0 0 0
F-DO 3 signal sources	p10045[0] p10045[1] p10045[2] p10045[3] p10045[4] p10045[5]	0 0 0 0 0 0
Test Sensor feedback signal	p10046	0 hex
Selection of test mode for test stop	p10047[0] p10047[1] p10047[2] p10047[3]	2 2 2 2

10.4.2.4 Safety devices

Protective door The protective door is unlocked by means of single-channel request key
Protective door switch The protective door is equipped with a protective door switch. The protective door switch returns the dual-channel signal "Door closed and locked". Switchover and selection of safety functions in accordance with the table shown above.
Mode selector switch The "Production" and "Setup" modes are set by means of a mode selector switch. The key-operated switch features two contact levels. Switchover and selection of safety functions in accordance with the table shown above.
EMERGENCY-STOP pushbutton The dual-channel EMERGENCY-STOP pushbuttons are wired in series. The EMERGENCY STOP signal activates SS1 for all drives. Then the external brakes and STO are activated.
Test stop Activation by means of: • Machine switch on • Unlocking the protective door

10.5 Acceptance tests

Note

As far as possible, the acceptance tests are to be carried out at the maximum possible machine speed and acceleration rates to determine the maximum braking distances and braking times that can be expected.

Note

If Basic Functions and Extended Functions are combined, the acceptance test for both types must be carried out for the functions used.

Note

The trace recordings for the Extended Functions aid evaluation of the more complex functionality compared to the Basic Functions (for which trace recording is not required). If necessary you can also use other recording possibilities.

Note

Non-critical alarms

When evaluating the alarm buffer you can tolerate the following alarms:

- A01697 SI Motion: Motion monitoring test required
- A01796 SI Motion CU: Waiting for communication

These alarms occur after every system startup and can be evaluated as non-critical. You do not need to include these alarms in the acceptance report.

10.5.1 Acceptance tests – Basic Functions

10.5.1.1 Safe Torque Off (Basic Functions)

Table 10- 8 "Safe Torque Off" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7]); see note "non-critical alarms" in section Acceptance tests.	
	• r9772.17 = r9872.17 = 0 (STO deselection via terminals - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 0 (STO deselection via PROFIsafe); only relevant for STO via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
2.	Run the drive	
	• Ensure that the correct drive is running	
	Select STO when you issue the traversing command and check the following:	
	• The drive coasts to a standstill or is braked and stopped by the mechanical brake (if available and configured (p1215, p9602, p9802)).	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.17 = r9872.17 = 1 (STO selection via terminal - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 1 (STO selection via PROFIsafe); only relevant for STO via PROFIsafe	
	• r9772.0 = r9772.1 = 1 (STO selected and active – Control Unit)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – Motor Module)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.17 = r9872.17 = 0 (STO deselection via terminals - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 0 (STO deselection via PROFIsafe); only relevant for STO via PROFIsafe	

No.	Description	Status
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	The following is tested: • Correct DRIVE-CLiQ wiring between Control Unit and Motor/Power Modules • Correct assignment of drive No. – Motor/Power Module – motor • The hardware is functioning properly • Correct wiring of the switch-off signal path (only via terminal) • Correct assignment of the terminals for STO on the Control Unit • Correct STO grouping (if available) • Correct parameterization of the STO function • Forced Checking Procedure of the Shutdown Paths	

10.5.1.2 Safe Stop 1 (Basic Functions)

Table 10- 9 "Safe Stop 1" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• Enable SS1 function (p9652 > 0, p9852 > 0)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7]); see note "non-critical alarms" in section Acceptance tests.	
	• r9772.22 = r9872.22 = 0 (SS1 deselection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 0 (SS1 deselection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9772.5 = r9772.6 = 0 (SS1 deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9872.5 = r9872.6 = 0 (SS1 deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9773.5 = r9773.6 = 0 (SS1 deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 0 (SS1 deselected and inactive - group); only relevant for grouping	
2.	Run the drive	
	Check whether the correct drive is operational	
	Select SS1 when you issue the traversing command and check the following:	
	• The drive is braked along the OFF3 ramp (p1135)	
	Before the SS1 delay time (p9652, p9852) expires, the following applies:	
	• r9772.22 = r9872.22 = 1 (SS1 selection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 1 (SS1 selection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive - CU)	
	• r9772.5 = r9772.6 = 1 (SS1 selected and active – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9872.5 = r9872.6 = 1 (SS1 selected and active – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive)	
	• r9773.5 = r9773.6 = 1 (SS1 selected and active – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	

No.	Description	Status
	• r9774.5 = r9774.6 = 1 (SS1 selected and active - group); only relevant for grouping	
	STO is initiated after the SS1 delay time expires (p9652, p9852).	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.0 = r9772.1 = 1 (STO selected and active - CU)	
	• r9772.5 = r9772.6 = 1 (SS1 selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9872.5 = r9872.6 = 1 (SS1 selected and active – MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active)	
	• r9773.5 = r9773.6 = 1 (SS1 selected and active – drive)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 1 (SS1 selected and active - group); only relevant for grouping	
3.	Canceling SS1	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.22 = r9872.22 = 0 (SS1 deselection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 0 (SS1 deselection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9772.5 = r9772.6 = 0 (SS1 deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9872.5 = r9872.6 = 0 (SS1 deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9773.5 = r9773.6 = 0 (SS1 deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 0 (SS1 deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	The following is tested: • Correct parameterization of the SS1 function	

10.5.1.3 Safe Brake Control (Basic Functions)

Table 10- 10 "Safe Brake Control" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Brake as in sequence control or brake always released (p1215 = 1 or p1215 = 2)	
	• No Safety faults and alarms (r0945, r2122); see note "Non-critical alarms" in section Acceptance tests.	
	• r9772.4 = r9872.4 = 0 (SBC not requested)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
2.	Run drive (if applied, brake is released)	
	• Check whether the correct drive is operational	
	Select STO/SS1 when you issue the traversing command and check the following:	
	• The brake is applied (for SS1 the drive is previously decelerated along the OFF3 ramp)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.4 = r9872.4 = 1 (SBC requested)	
	• r9772.0 = r9772.1 = 1 (STO selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.4 = r9872.4 = 0 (deselect SBC)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	

No.	Description	Status
4.	Acknowledge "switch-on inhibit" and run the drive. Check whether the correct drive is operational.	
	The following is tested: • The brake is connected properly • The hardware is functioning properly • The SBC is parameterized correctly • Routine for the forced dormant error detection of the brake control	

10.5.2 Acceptance tests for Extended Functions (with encoder)

10.5.2.1 Acceptance test Safe Torque Off with encoder (Extended Functions)

Table 10- 11 "Safe Torque Off" function

No.	Description	Status
Notes: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
2.	Run the drive	
	• Check whether the correct drive is operational	
	Select STO when you issue the traversing command and check the following:	
	• The drive coasts to a standstill or is braked and stopped by the mechanical brake (if available and configured (p1215, p9602, p9802)).	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.18 = r9872.18 = 1 (STO selected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 1 (STO selected and active – Control Unit)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – Motor Module)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9720.0 = 0 (STO selected)	
	• r9722.0 = 1 (STO active)	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	

No.	Description	Status
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	The following is tested: • Correct DRIVE-CLiQ wiring between Control Unit and Motor/Power Modules • Correct assignment of drive No. – Motor/Power Module – motor • The hardware is functioning properly • Correct parameterization of the STO function • Forced Checking Procedure of the Shutdown Paths	

10.5.2.2 Acceptance test for Safe Stop 1, time and acceleration controlled

Table 10- 12 "Safe Stop 1" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	Run the drive	
	• Check whether the correct drive is operational	
3.	Configure and activate trace recording.	
	• Trigger: Trigger on variable - bit pattern (r9720.1 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9722	
	• Select the time interval and pretrigger so you can recognize the selection of SS1 and the transition into the subsequent STO state	
	For better analysis, display the following bit values:	
	• r9720.1 (deactivation SS1)	
	• r9722.0 (STO active)	
	• r9722.1 (SS1 active)	
	Select SS1 while the drive is moving	
	• The drive decelerates along the OFF3 ramp	
	• Subsequent state STO is activated	
4.	Analyze trace:	
	• The STO is triggered after the SS1 timer (p9356/9556) has expired or if the speed drops below the shutdown speed (p9360/9560)	
	• r9714[0] is displayed in the unit [µm/Safety clock cycle or m°/Safety clock cycle]	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SS1	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	Acknowledge "switch-on inhibit" and run the drive	
	• Ensure that the correct drive is running	

Example Trace SS1 with encoder

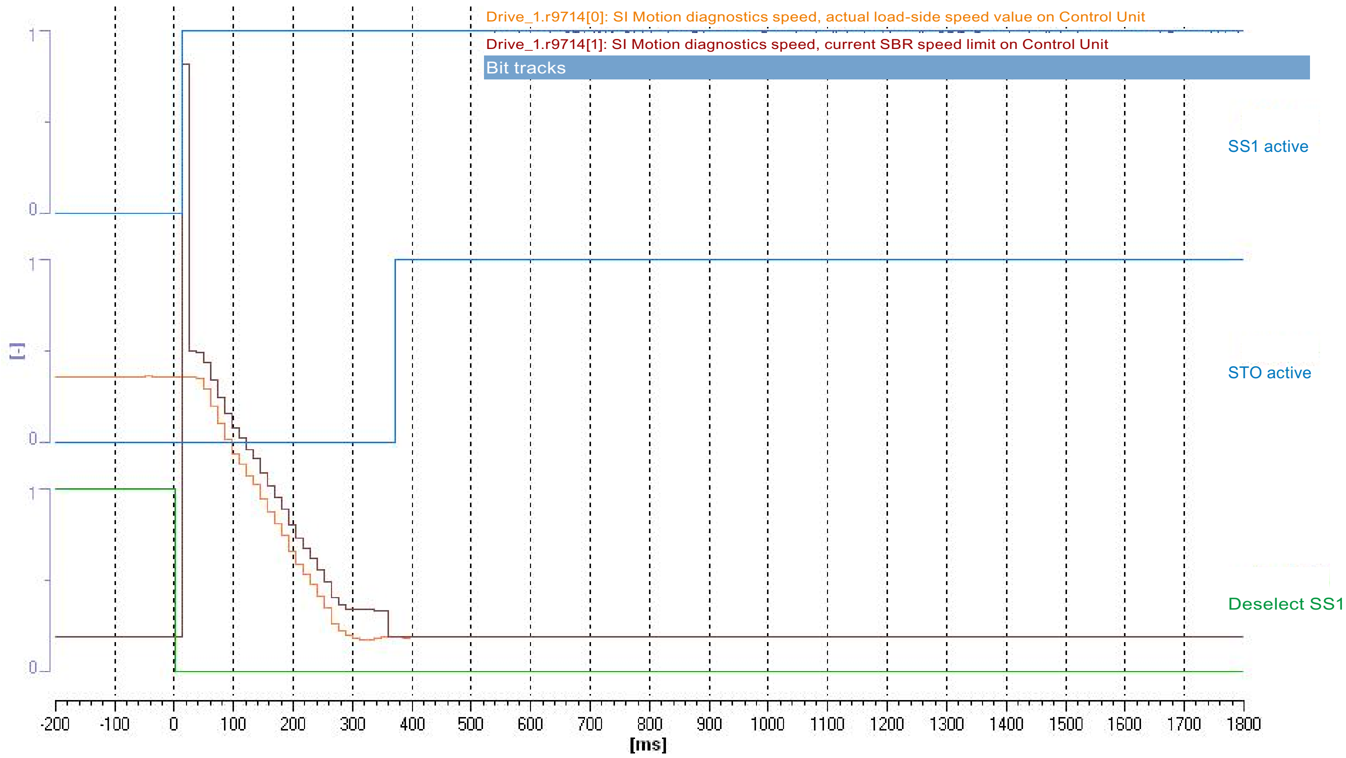

Figure 10-1 Example Trace SS1 with encoder

Trace evaluation:

- SS1 function is selected (time axis 0 ms; see bit "deselection SS1")
- Response bit "SS1 active" is set (time axis approx 20 ms)
- The drive decelerates along the configured OFF3 ramp (p1135)
- Recording of r9714[0] (orange curve) shows whether the OFF3 ramp is active
- STO is activated (time axis approx. 370 ms; see bit "STO active"); at this point the speed underranges the shutdown speed SS1 (p9560/p9360) (in this case shutdown speed SS1 is underranged before SS1 timer p9556/p9356 has expired)
- Brown curve: Envelope curve of function SBR (r9714[1]); a fault is generated if this is exceeded by the actual speed (r9714[0])

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.2.3 Acceptance test for Safe Brake Control with encoder (Extended Functions)

Table 10- 13 "Safe Brake Control" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Brake as in sequence control or brake always released (p1215 = 1 or p1215 = 2)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
	• r9722.4 = 0 (SBC deselected)	
2.	Run drive (if applied, brake is released)	
	• Check whether the correct drive is operational	
	Select STO when you issue the traversing command and check the following:	
	• Brake is applied	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.4 = r9872.4 = 1 (SBC requested)	
	• r9772.18 = r9872.18 = 1 (STO selected via Safe Motion Monitoring)	
	• r9720.0 = 0 (STO selected)	
	• r9722.0 = 1 (STO active)	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.4 = r9872.4 = 0 (deselect SBC)	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	

No.	Description	Status
4.	Acknowledge "switch-on inhibit" and run the drive. Check whether the correct drive is operational.	
	The following is tested: • The brake is connected properly • The hardware is functioning properly • The SBC is parameterized correctly • Routine for the forced dormant error detection of the brake control	

10.5.2.4 Acceptance test for Safe Stop 2 (SS2)

Table 10- 14 "Safe Stop 2" function

No.	Description	Status
Note: The acceptance test must be individually performed for each configured control. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• SS2 selected (r9720.2 = 0)	
	• SS2 inactive (r9722.2 = 0)	
	• SOS inactive (r9722.3 = 0)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	Run the drive	
	• Ensure that the correct drive is running	
3.	Configure and activate trace recording.	
	• Trigger: Trigger on variable - bit pattern (r9720.2 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9722	
	• Select the time interval and pretrigger so you can recognize the selection of SS2 and the transition into the subsequent SOS state	
	For better analysis, display the following bit values:	
	• r9720.2 (deselection SS2)	
	• r9722.2 (SS2 active)	
	• r9722.3 (SOS active)	
	Select SS2 while the drive is moving	
	• The drive decelerates along the OFF3 ramp	
	• Subsequent SOS state is activated	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
4.	Analyze trace:	
	• SOS is triggered after the SS2 timer (p9352/9552) has expired.	
	• r9714[0] is displayed in the unit [µm/Safety clock cycle or m°/Safety clock cycle]	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SS2	
	• Ensure that the drive is running with the setpoint again	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	

Example Trace SS2

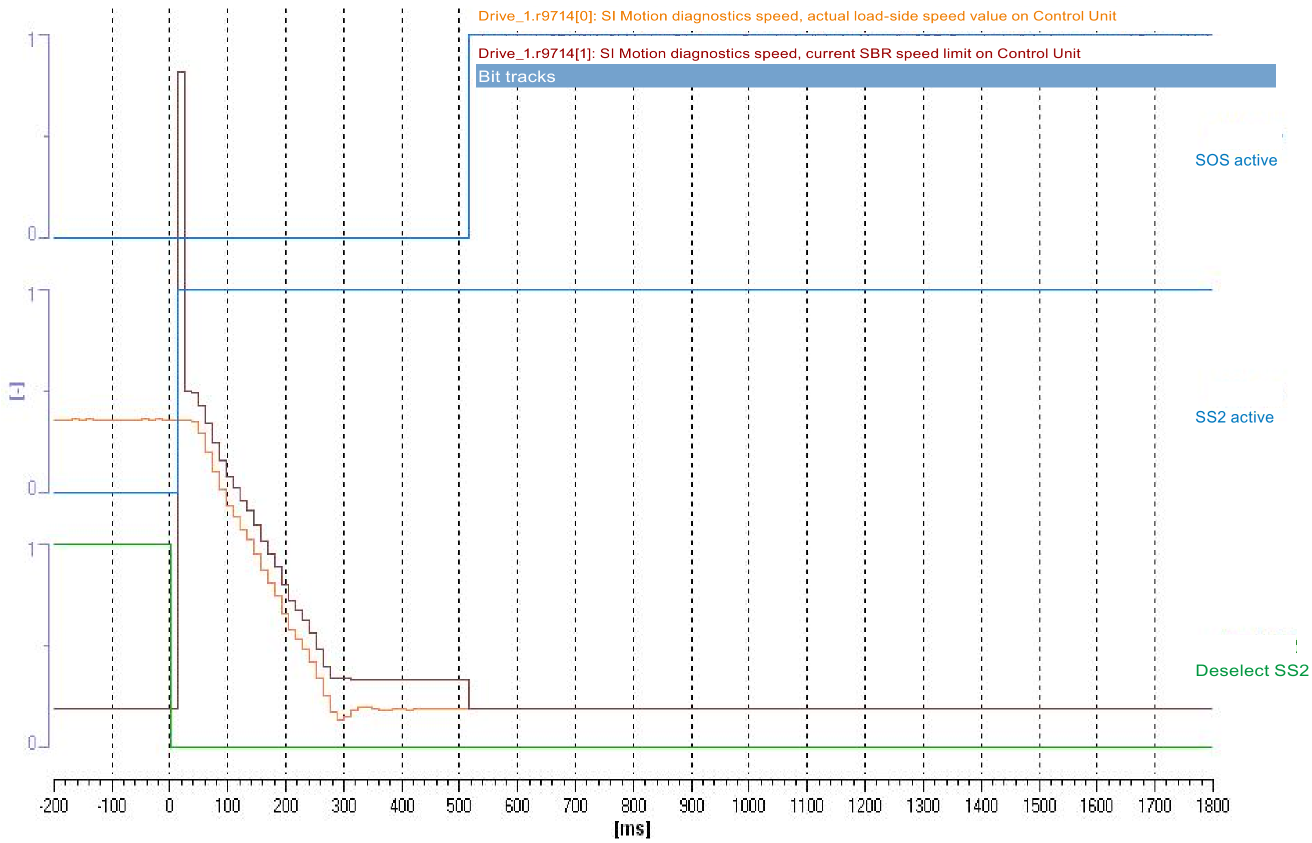

Figure 10-2 Example Trace SS2

Trace evaluation:

- SS2 function is selected (time axis 0 ms; see bit "deselection SS2")
- Response bit "SS2 active" is set (time axis approx 20 ms)
- The drive decelerates along the configured OFF3 ramp (p1135)
- Recording of r9714[0] (orange curve) shows whether the OFF3 ramp is active
- SOS is activated (time axis approx. 500 ms; see bit "SOS active"); at this point the SS2 timer (p9552/p9352) has expired
- Brown curve: Envelope curve of function SBR (r9714[1]); a fault is generated if this is exceeded by the actual speed (r9714[0])

Note

Minor time differences (of the order of 2 to 3 safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.2.5 Acceptance test for Safe Operating Stop (SOS)

Table 10- 15 "Safe Operating Stop" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• SOS inactive (r9722.3 = 0)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to run the drive with activated SOS.	
3.	Configure and activate trace recording.	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9713[0], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize start-up of the drive and infringement of the SOS tolerance window (p9330/p9530)	
	For better analysis, display the following bit values:	
	• r9720.3 (deselect SOS)	
	• r9721.12 (STOP A or B active)	
	• r9722.0 (STO active; set for STOP A)	
	• r9722.1 (SS1 active; set for STOP B)	
	• r9722.3 (SOS active)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	
	Select SOS	
	Run the drive beyond the standstill limit set in p9330/p9530	
	• Check that the drive moves briefly and then decelerates back to a standstill	
	Check whether the following Safety messages are pending:	
	• C01707, C30707 (Tolerance for safe operating stop exceeded)	
	• C01701, C30701 (STOP B initiated)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• As soon as r9713[0] (unit µm or m°) leaves the tolerance window, a Safety message (r9722.7 = 0) becomes active	
	• As a consequence, the drive is brought to a standstill with STOP B and STOP A	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SOS and acknowledge Safety messages	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	

No.	Description	Status
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
	Acknowledge "switch-on inhibit" and run the drive	
	• Check the drive is moving	

Example trace

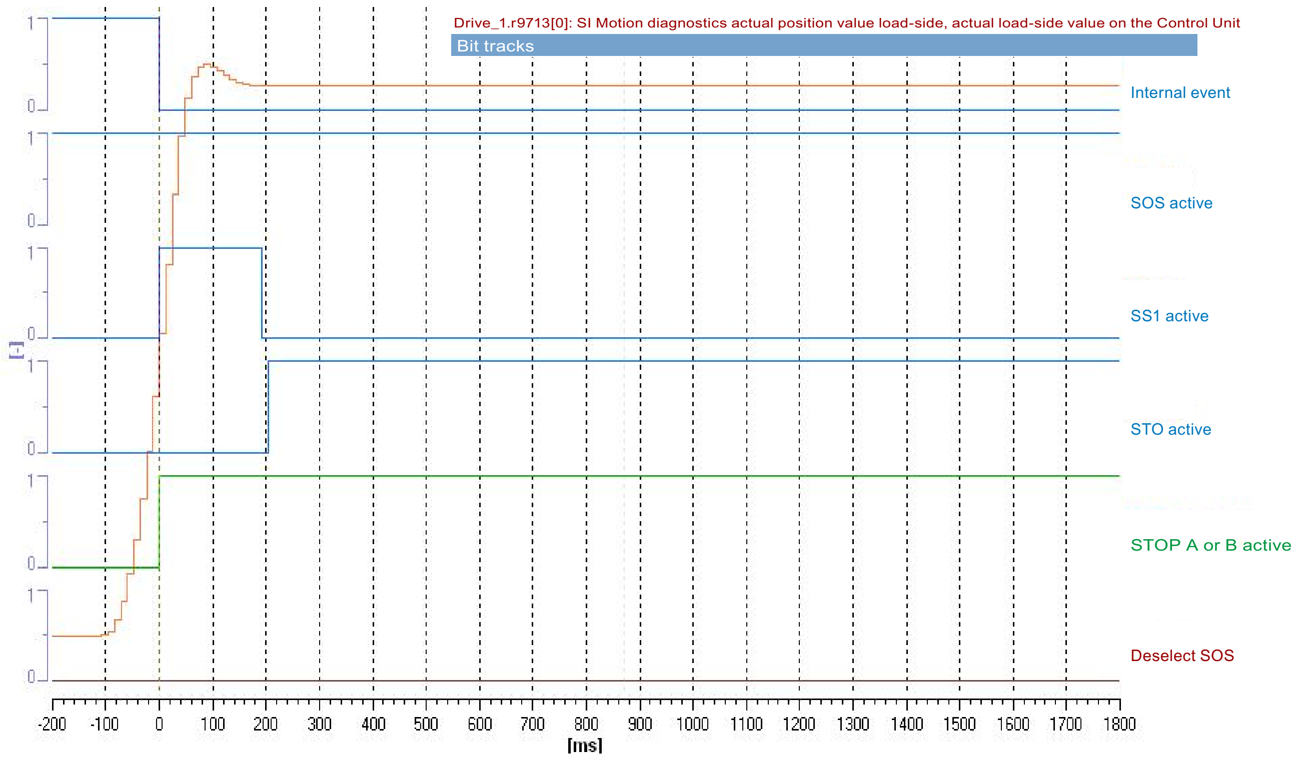

Figure 10-3 Example trace SOS

Trace evaluation:

- SOS function is activated (see bits "deselect SOS" and "SOS active")
- The drive starts moving (time axis approx -100 ms)
- Exiting the SOS tolerance window is recognized (time axis approx 0 ms)
- Safety fault is initiated (time axis approx. 0 ms; bit "internal event" is set to 0)
- Fault response STOP B is initiated (see bit "STOP A or B active" and "SS1 active")
- The drive is decelerated to a standstill
- Standstill reached (time axis approx. 200 ms)
- STOP A (as follow-up response to STOP B) is activated (see bit "STO active"); at this point the speed falls below the shutdown speed SS1 (p9560/p9360) before the SS1 timer (p9556/p9356) has expired (drops below the shutdown speed SS1 before SS1 timer (p9556/p9356) has expired)

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.2.6 Acceptance test for Safely-Limited Speed with encoder (Extended Functions)

SLS with stop response "STOP A"

Table 10- 16 Function "Safely Limited Speed with encoder" with STOP A

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• SLS inactive (r9722.4 = 0)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit.	
3.	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.12 (STOP A or B active)	
	• r9722.0 (STO active; set for STOP A)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) has been exceeded that it is coasting or a configured holding brake is applied	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• STOP A is initiated as a consequence	

No.	Description	Status
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SLS and acknowledge Safety messages	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
	Acknowledge "switch-on inhibit" and run the drive	
	Check the drive is moving	

Example trace SLS with STOP A

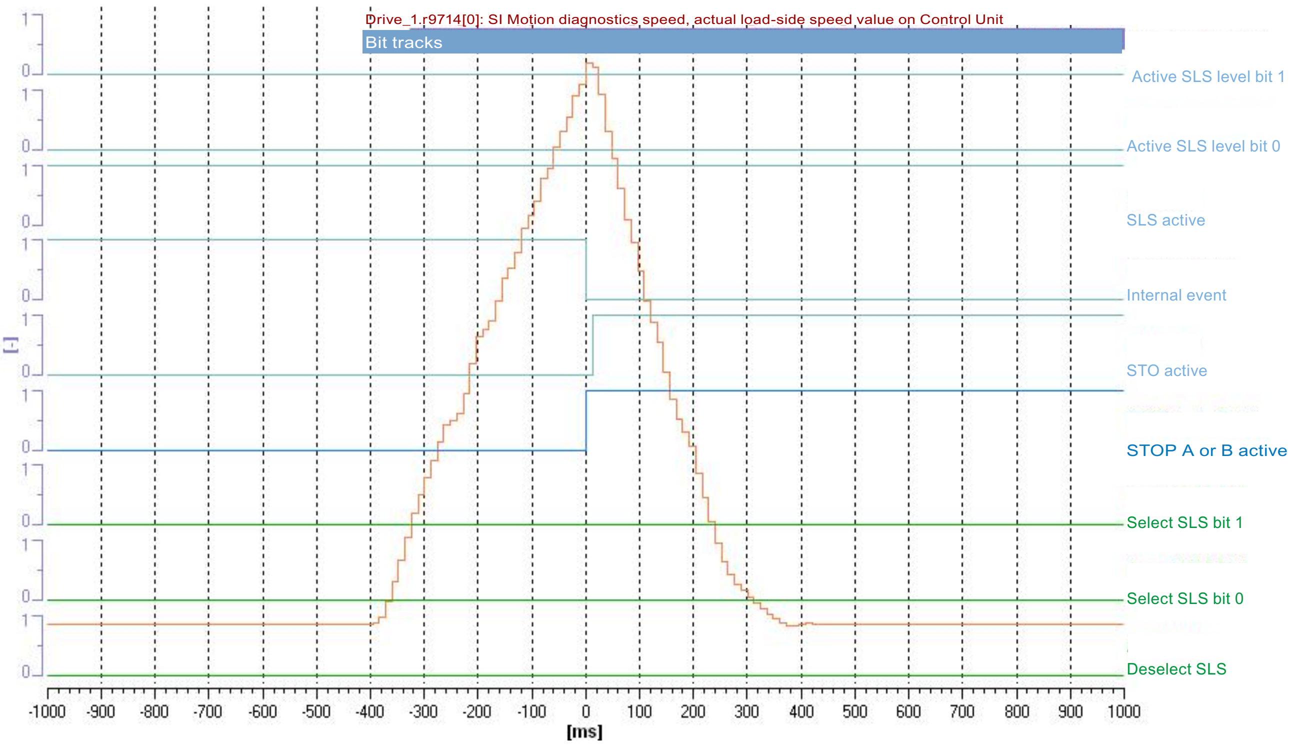

Figure 10-4 Example trace: SLS with STOP A

Trace evaluation:

- SLS function with SLS level 1 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -400 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP A is initiated (time axis 0 ms; see bit "STOP A or B active" and "STO active")
- Drive coasts (see orange curve of r9714[0])

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

SLS with stop response "STOP B"

Table 10- 17 Function "Safely Limited Speed with encoder" with STOP B

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit.	
3.	Configure and activate trace recording.	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.12 (STOP A or B active)	
	• r9722.0 (STO active; set for STOP A)	
	• r9722.1 (SS1 active; set for STOP B)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) has been exceeded that it is decelerated along the OFF3 ramp before STOP A becomes active	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01701, C30701 (STOP B initiated)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [μm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• A STOP B is initiated as a consequence (with subsequent stop STOP A)	

No.	Description	Status
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SLS and acknowledge Safety messages	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	
	Acknowledge "switch-on inhibit" and run the drive	
	• Check the drive is moving.	

Example trace SLS with STOP B

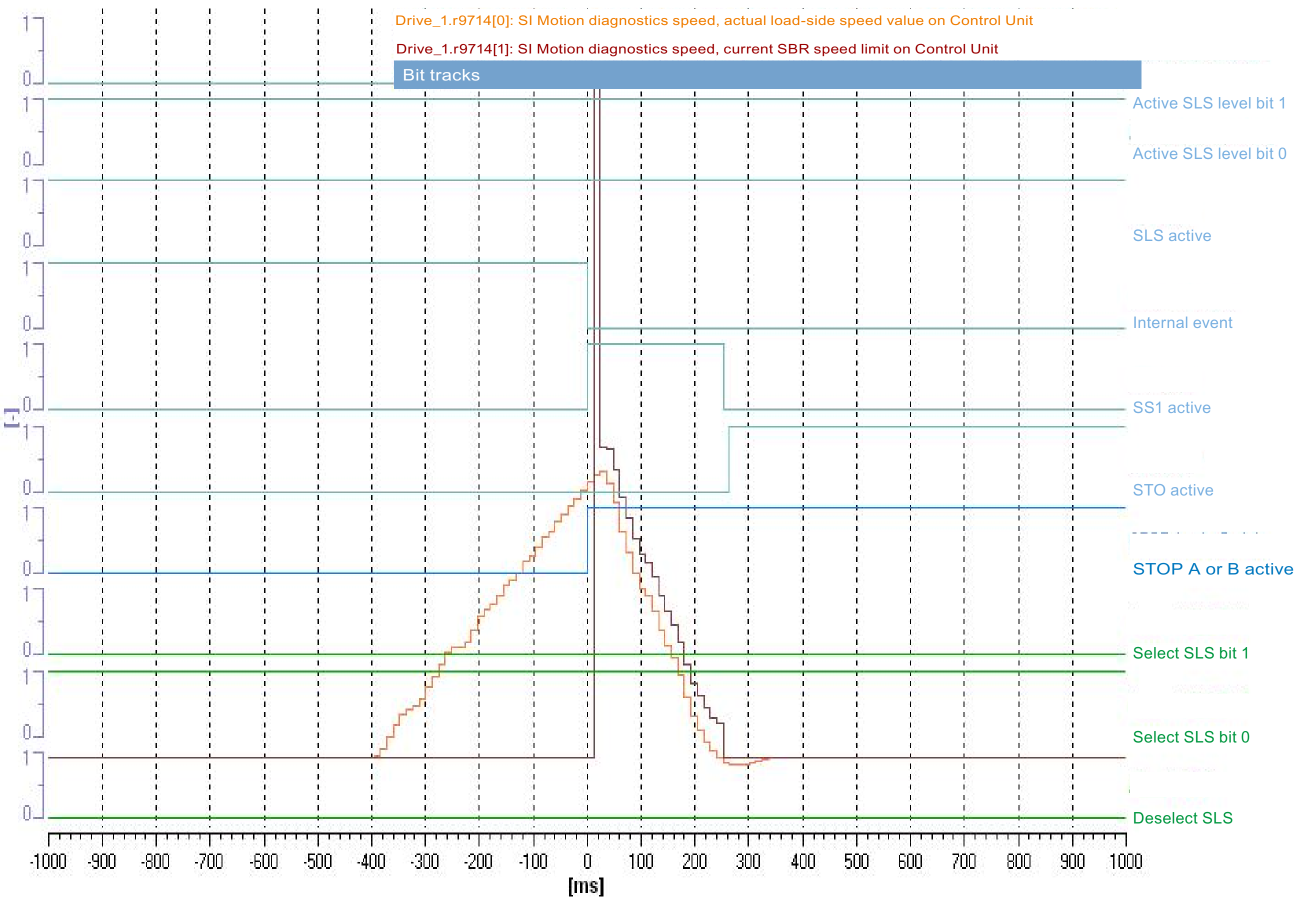

Figure 10-5 Example trace: SLS with STOP B

Trace evaluation:

- SLS function with SLS level 2 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -400 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP B is initiated (time axis 0 ms; see bit "STOP A or B active" and "SS1 active")
- Drive is decelerated to a standstill (see orange curve of r9714[0])
- Standstill reached (time axis from approx. 250 ms)
- STOP A (as follow-up response to STOP B) is activated (see bit "STO active"); at this point the speed falls below the shutdown speed SS1 (p9560/p9360) (drops below the shutdown speed SS1 before SS1 timer p9556/p9356 has expired)

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

SLS with stop response "STOP C"

Table 10- 18 Function "Safely Limited Speed with encoder" with STOP C

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit	
3.	Configure and activate trace recording.	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) has been exceeded that it is decelerated to a standstill along the OFF3 ramp	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01708, C30708 (STOP C initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• STOP C is initiated as a consequence	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.13 (STOP C active)	
	• r9722.2 (SS2 active; set for STOP C)	
	• r9722.3 (SOS active)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SLS and acknowledge Safety messages	
	• Ensure that the drive is running with the setpoint again	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	

Example trace SLS with STOP C

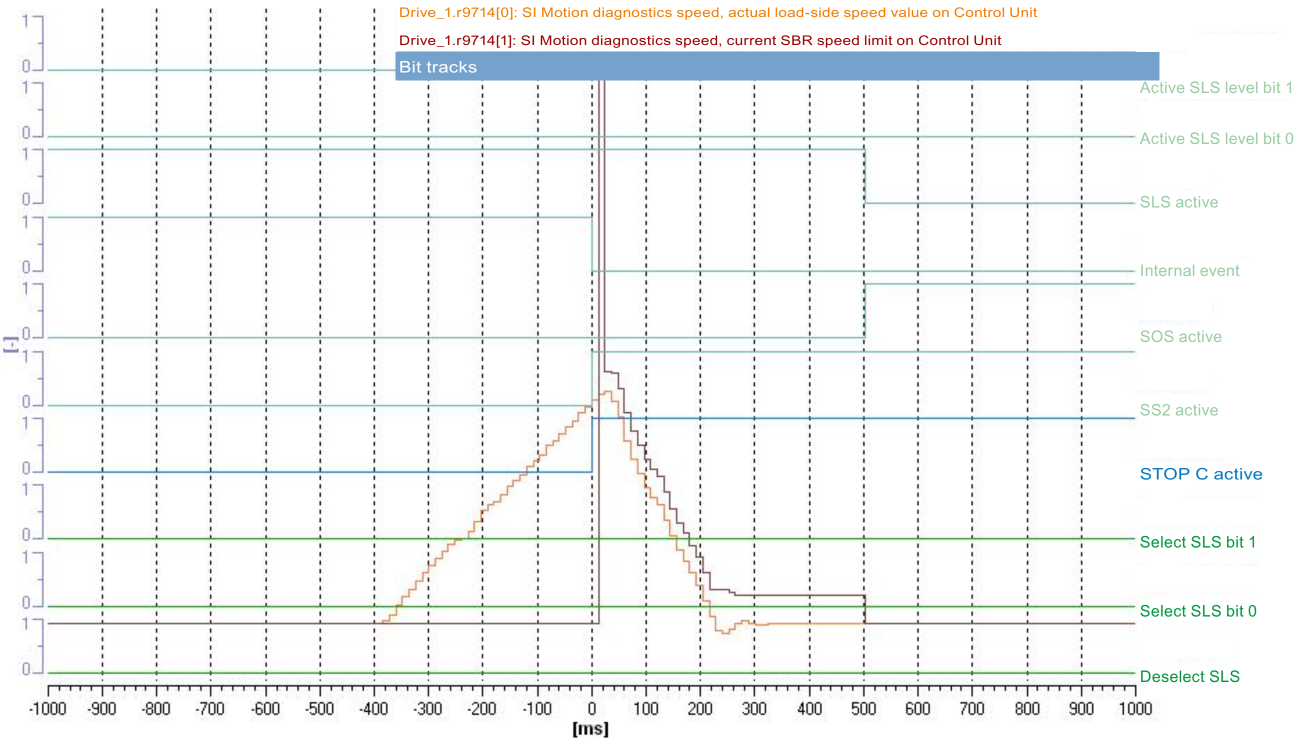

Figure 10-6 Example trace: SLS with STOP C

Trace evaluation:

- SLS function with SLS level 1 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -400 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP C is initiated (see bit "STOP C active" and "SS2 active")
- Drive is decelerated to a standstill (see orange curve of r9714[0])
- After the SS2 timer has expired the follow-up function SOS is activated (time axis 500 ms)
- The "SOS active" bit is set and "SLS active" is reset

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

SLS with stop response "STOP D"

Table 10- 19 Function "Safely Limited Speed with encoder" with STOP D

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit	
3.	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9720, r9721, r9722	
	• Select the time interval and pretrigger so that the exceeding of the active SLS limit and the subsequent drive responses can be recognized	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.14 (STOP D active)	
	• r9722.3 (SOS active; set for STOP D)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) and the SOS standstill tolerance window have been exceeded, that it is decelerated along the OFF3 ramp before STOP A becomes active as a consequence	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01709, C30709 (STOP D initiated)	
	• C01707, C30707 (Tolerance for safe operating stop exceeded)	
	• C01701, C30701 (STOP B initiated)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• STOP D is initiated as a consequence.	

No.	Description	Status
	• As a consequence of STOP D (selection SOS) the above-described responses will be triggered if the drive is not stopped by the higher-level control on activation of STOP D	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SLS and acknowledge Safety messages	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
	Acknowledge "switch-on inhibit" and run the drive	
	• Check the drive is moving	

Example trace SLS with STOP D

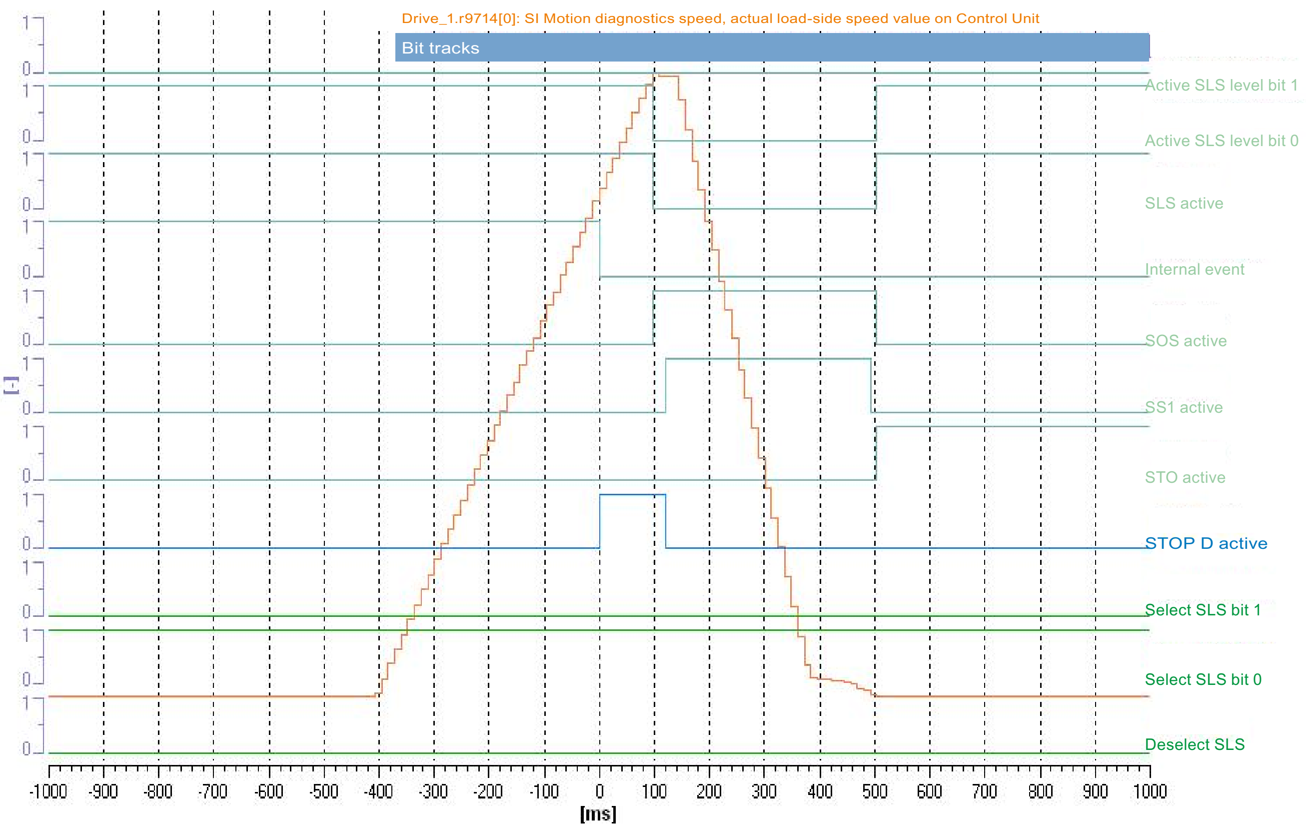

Figure 10-7 Example trace: SLS with STOP D

Trace evaluation:

- SLS function with SLS level 2 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -400 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP D (corresponds to selection SOS) is initiated (see bit "STOP D active")
- Only after the delay time between selection and activation SOS (p9551/p9351) has expired is the standstill position safely monitored (time axis 100 ms; see bit "SOS active")
- But as the axis continues to turn, the standstill tolerance window is violated (time axis approx. 120 ms)
- STOP B is initiated (see bit "SS1 active")
- The drive is decelerated to a standstill
- Standstill is reached (time axis approx. 500 ms)
- STOP A (as follow-up response to STOP B) is activated (see bit "STO active"); at this point the speed falls below the shutdown speed SS1 (p9560/p9360) (drops below the shutdown speed SS1 before SS1 timer p9556/p9356 has expired).

Note

Minor time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.2.7 Acceptance test for Safe Speed Monitor (SSM)

Table 10- 20 "Safe Speed Monitor" function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• No Safety message (r0945, r2122, r9747); see note "Non-critical alarms" in the section "Acceptance tests".	
2.	Switch off the drive or specify speed setpoint = 0	
	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9722.15 = 1)	
	• Record the following values: r9714[0], r9722	
	• Select the time interval and pretrigger so you can recognize when the level exceeds the SSM limit (p9346/9546) and subsequently falls below it again	
	Switch on the drive and specify the setpoint so that the level briefly exceeds the SSM limit and then drops below it once more	
	• Check the drive is turning	
3.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the SSM limit p9346/9546, r9722.15 = 0 is valid	
	• Once the level is lower than the limit r9722.15 = 1 is valid	
	• If hysteresis is active then r9722.15 only becomes 1 once more if r9714[0] falls below the limit p9346/9546 minus the hysteresis value p9347/9547	
	For better analysis, display the following bit values:	
	• r9722.15 (SSM speed under the limit value)	
4.	Save/print the trace and add it to the acceptance report (refer to the example below)	

Example Trace SSM (with hysteresis)

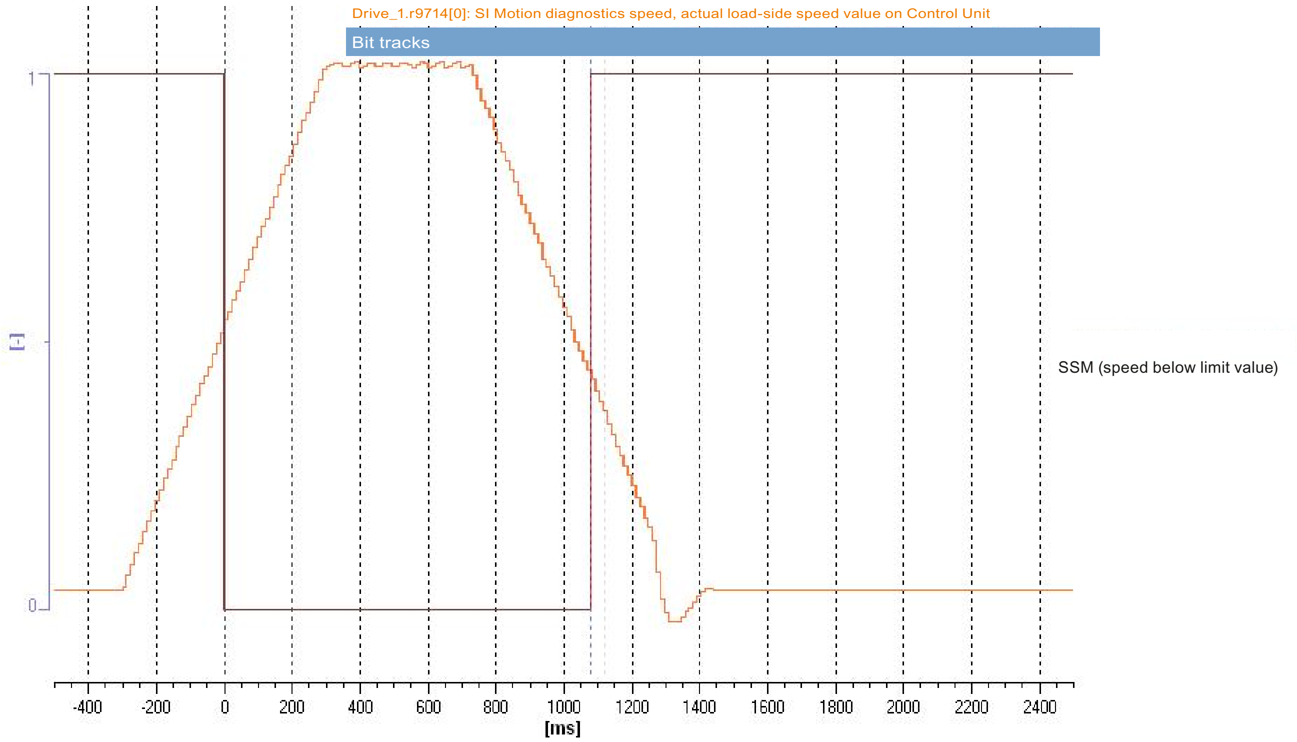

Figure 10-8 Example Trace SSM (with hysteresis)

Trace evaluation:

- Drive is accelerated (time axis from approx. -300 ms)
- SSM limit value (p9546/p9346) is exceeded (time axis 0 ms)
- Bit "SSM (speed below limit value)" is set to 0 (time axis 0 ms)
- Drive is braked again (time axis approx. 750 ms)
- Hysteresis active: The bit cited above is only set to 1 again if the speed falls below the SSM limit value minus the hysteresis value (p9547/p9347) (time axis approx. 1080 ms)

Note

Small time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.3 Acceptance tests for Extended Functions (without encoder)

10.5.3.1 Acceptance test Safe Torque Off without encoder (Extended Functions)

Table 10- 21 Function "Safe Torque Off without encoder"

No.	Description	Status
Notes: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Safety configured without encoder (p9506 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
2.	Run the drive	
	• Check whether the correct drive is operational	
	Select STO when you issue the traversing command and check the following:	
	• The drive coasts to a standstill or is braked and stopped by the mechanical brake (if available and configured (p1215, p9602, p9802)).	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.18 = r9872.18 = 1 (STO selected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 1 (STO selected and active – Control Unit)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – Motor Module)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9720.0 = 0 (STO selected)	
	• r9722.0 = 1 (STO active)	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	

No.	Description	Status
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO inactive)	
	• r0046.0 = 1 (drive in "switch-on inhibit" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	The following is tested: • Correct DRIVE-CLiQ wiring between Control Unit and Motor/Power Modules • Correct assignment of drive No. – Motor/Power Module – motor • The hardware is functioning properly • Correct parameterization of the STO function • Forced Checking Procedure of the Shutdown Paths	

10.5.3.2 Acceptance test for Safe Stop 1 without encoder (Extended Functions)

Table 10- 22 Function "Safe Stop 1 without encoder"

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Safety configured without encoder (p9506 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	Run the drive	
	• Check whether the correct drive is operational	
3.	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9720.1 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9722	
	• Select the time interval and pretrigger so you can recognize the selection of SS1 and the transition into the subsequent STO state	
	Select SS1 while the drive is moving	
	• The drive decelerates along the OFF3 ramp	
	• Subsequent state STO is activated	
	For better analysis, display the following bit values:	
	• r9720.1 (deactivation SS1)	
	• r9722.0 (STO active)	
	• r9722.1 (SS1 active)	
4.	Analyze trace:	
	• STO is triggered if the speed drops below the shutdown speed (p9360/9560)	
	• r9714[0] is displayed in the unit [μm/Safety clock cycle or m°/Safety clock cycle]	
	For better analysis, display the following bit values:	
	• r9720.1 (deactivation SS1)	
	• r9722.0 (STO active)	
	• r9722.1 (SS1 active)	
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Canceling SS1	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	Acknowledge "switch-on inhibit" and run the drive	
	• Ensure that the correct drive is running	

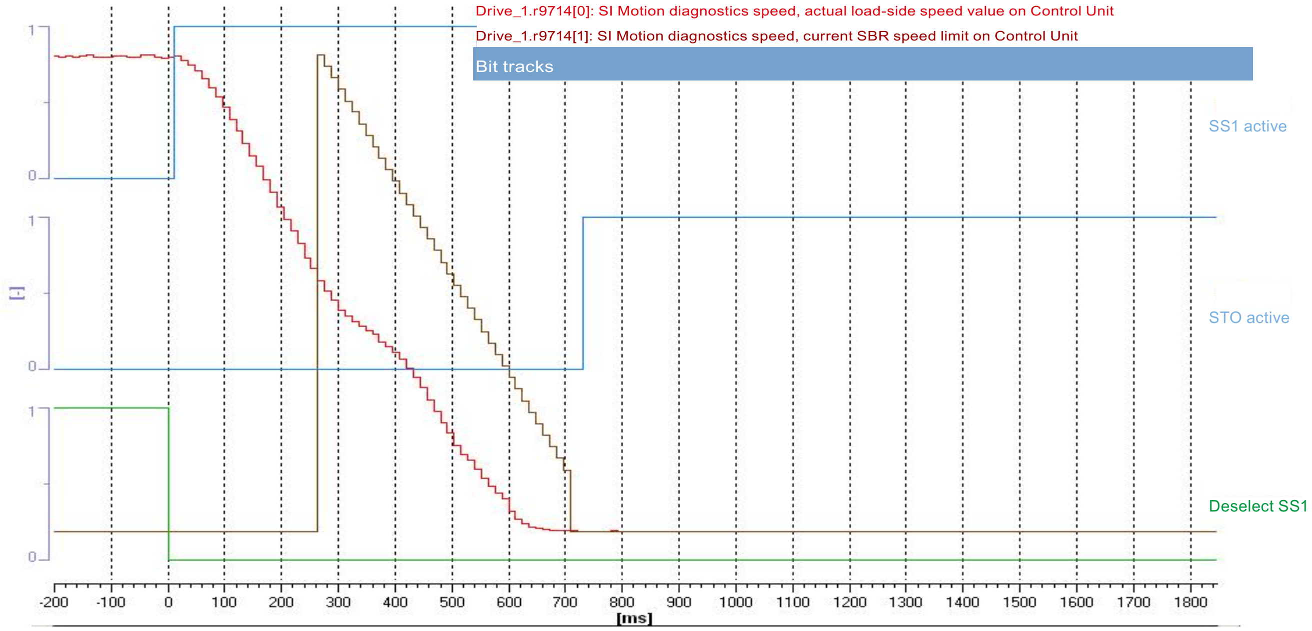

Figure 10-9 Example Trace SS1 without encoder

Trace evaluation:

- SS1 function is selected (time axis 0 ms; see bit "deselection SS1")
- Response bit "SS1 active" is set (time axis approx 20 ms)
- The drive decelerates along the configured OFF3 ramp (p1135)
- Recording of r9714[0] (orange curve) shows whether the OFF3 ramp is active
- STO is activated (time axis approx. 720 ms; see bit "STO active"); at this point the speed falls below the shutdown speed SS1 (p9560/p9360)
- Brown curve: Envelope curve of function SBR (r9714[1]); faults are generated if this is exceeded by the actual speed (r9714[0])

  In contrast to the SBR for Safety with encoder, this curve is not tracked according to actual speed but calculated using Safety parameters. Furthermore, this monitoring only becomes active after a configurable time has elapsed (in this case the time is 250 ms).

Note

Small time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.5.3.3 Acceptance test for Safe Brake Control without encoder (Extended Functions)

Table 10- 23 Acceptance test "Safe Brake Control without encoder"

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via TM54F or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Safety configured without encoder (p9506 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Brake as in sequence control or brake always released (p1215 = 1 or p1215 = 2)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO deselected)	
2.	Run drive (if applied, brake is released)	
	• Check whether the correct drive is operational	
	Select STO when you issue the traversing command and check the following:	
	• Brake is applied	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.4 = r9872.4 = 1 (SBC requested)	
	• r9772.18 = r9872.18 = 1 (STO selected via Safe Motion Monitoring)	
	• r9720.0 = 0 (STO selected)	
	• r9722.0 = 1 (STO selected)	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r9772.4 = r9872.4 = 0 (deselect SBC)	
	• r9772.18 = r9872.18 = 0 (STO deselected via Safe Motion Monitoring)	
	• r9720.0 = 1 (STO deselected)	
	• r9722.0 = 0 (STO deselected)	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	

No.	Description	Status
4.	Acknowledge "switch-on inhibit" and run the drive. Check whether the correct drive is operational.	
	The following is tested: • The brake is connected properly • The hardware is functioning properly • The SBC is parameterized correctly • Routine for the forced dormant error detection of the brake control	

10.5.3.4 Acceptance test for Safely Limited Speed without encoder (Extended Functions)

SLS with stop response "STOP A"

Table 10- 24 Function "Safely-Limited Speed without encoder" with "STOP A"

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Safety configured without encoder (p9506 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit	
3.	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) has been exceeded that it is coasting or a configured holding brake is applied	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• STOP A is initiated as a consequence	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.12 (STOP A or B active)	
	• r9722.0 (STO active; set for STOP A)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set on the occurrence of the first Safety message)	

No.	Description	Status
5.	Save/print the trace and add it to the acceptance report (refer to the example below)	
6.	Deselect SLS and acknowledge Safety messages.	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7])	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	
	Acknowledge "switch-on inhibit" and run the drive	
	• Check the drive is moving	

Example trace SLS without encoder (STOP A)

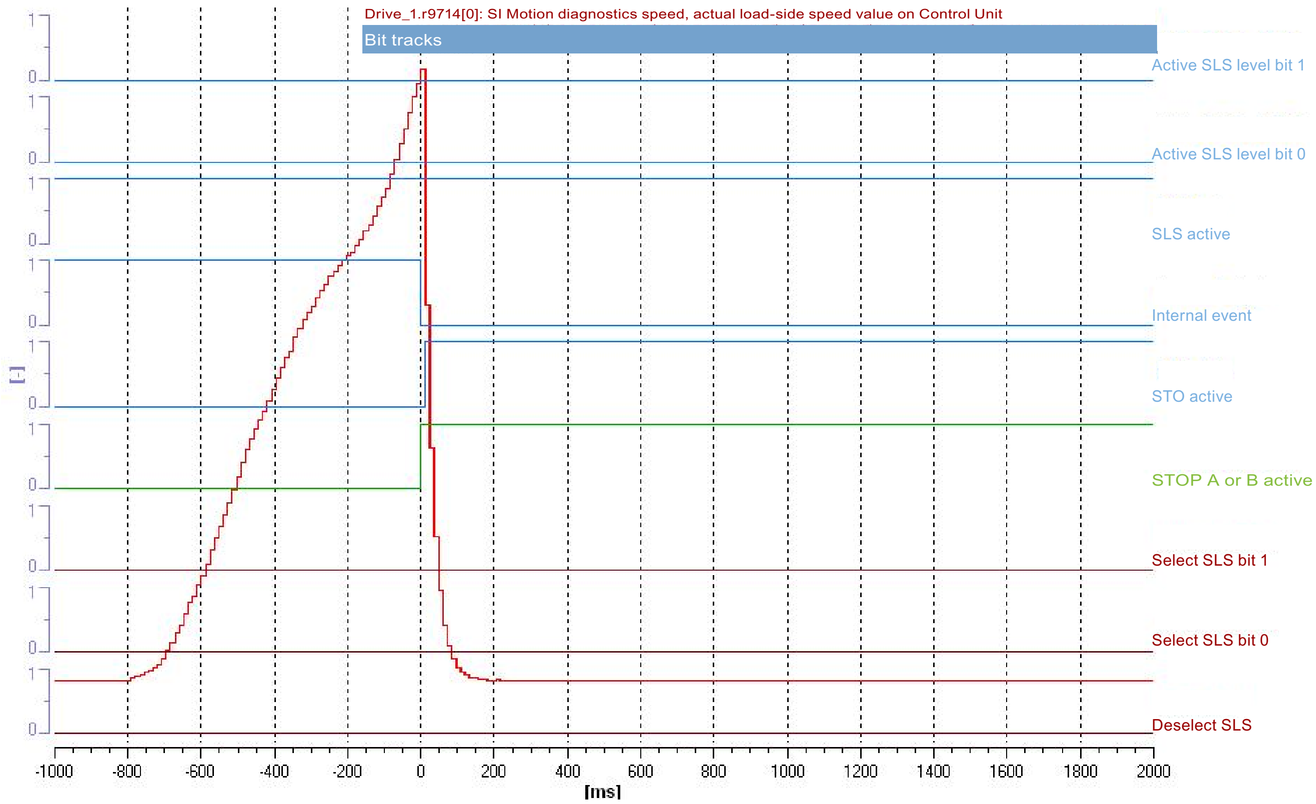

Figure 10-10 Example trace SLS without encoder with STOP A

Trace evaluation:

- SLS function with SLS level 1 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -800 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP A is initiated (time axis 0 ms; see bit "STOP A or B active" and "STO active")
- Drive coasts (see red curve of r9714[0])

Note

Small time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

SLS with stop response "STOP B"

Table 10- 25 Function "Safely-Limited Speed without encoder" with "STOP B"

No.	Description	Status
Note: The acceptance test must be carried out separately for each configured control and each SLS speed limit used. Control may be via TM54F or PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• Safety functions enabled (p9501.0 = 1)	
	• Safety configured without encoder (p9506 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7], r9747[0...7]); see note "non-critical alarms" in section "Acceptance tests".	
2.	It may be necessary to take measures in the higher-level control to be able to exceed the active speed limit	
3.	Configure and activate trace recording	
	• Trigger: Trigger on variable - bit pattern (r9722.7 = 0)	
	• Record the following values: r9714[0], r9714[1], r9720, r9721, r9722	
	• Select the time interval and pretrigger so you can recognize when the active SLS limit has been exceeded and the subsequent drive responses	
	Select SLS with level x	
	Switch on the drive and specify the setpoint above the SLS limit	
	• Check that the drive is moving, and after the SLS limit (p9331[x]/9531[x]) has been exceeded that it is decelerated along the OFF3 ramp before STOP A becomes active	
	Check whether the following Safety messages are pending:	
	• C01714 (x00), C30714 (x00); x = 1...4 depending on the SLS level (safely limited speed exceeded)	
	• C01701, C30701 (STOP B initiated)	
	• C01700, C30700 (STOP A initiated)	
4.	Analyze trace:	
	• If r9714[0] (unit [µm/Safety clock cycle] or [m°/Safety clock cycle]) exceeds the active SLS limit, a Safety message (r9722.7 = 0) becomes active	
	• A STOP B is initiated as a consequence (with subsequent stop STOP A)	
	For better analysis, display the following bit values:	
	• r9720.4 (deselection SLS) and r9720.9/.10 (selection SLS level)	
	• r9721.12 (STOP A or B active)	
	• r9722.0 (STO active; set for STOP A)	
	• r9722.1 (SS1 active; set for STOP B)	
	• r9722.4 (SLS active) and r9722.9/.10 (active SLS level)	
	• r9722.7 (internal event; set with the occurrence of the first Safety message)	

No.	Description		Status
5.	Save/print the trace and add it to the acceptance report (refer to the example below)		
6.	Deselect SLS and acknowledge Safety messages		
	• No Safety faults and alarms (r0945[0 ... 7], r2122[0 ... 7], r9747[0 ... 7])		
	• r0046.0 = 1 (drive in "switch-on inhibit" state)		
	Acknowledge "switch-on inhibit" and run the drive		
	• Check the drive is moving		

Example trace SLS without encoder (STOP B)

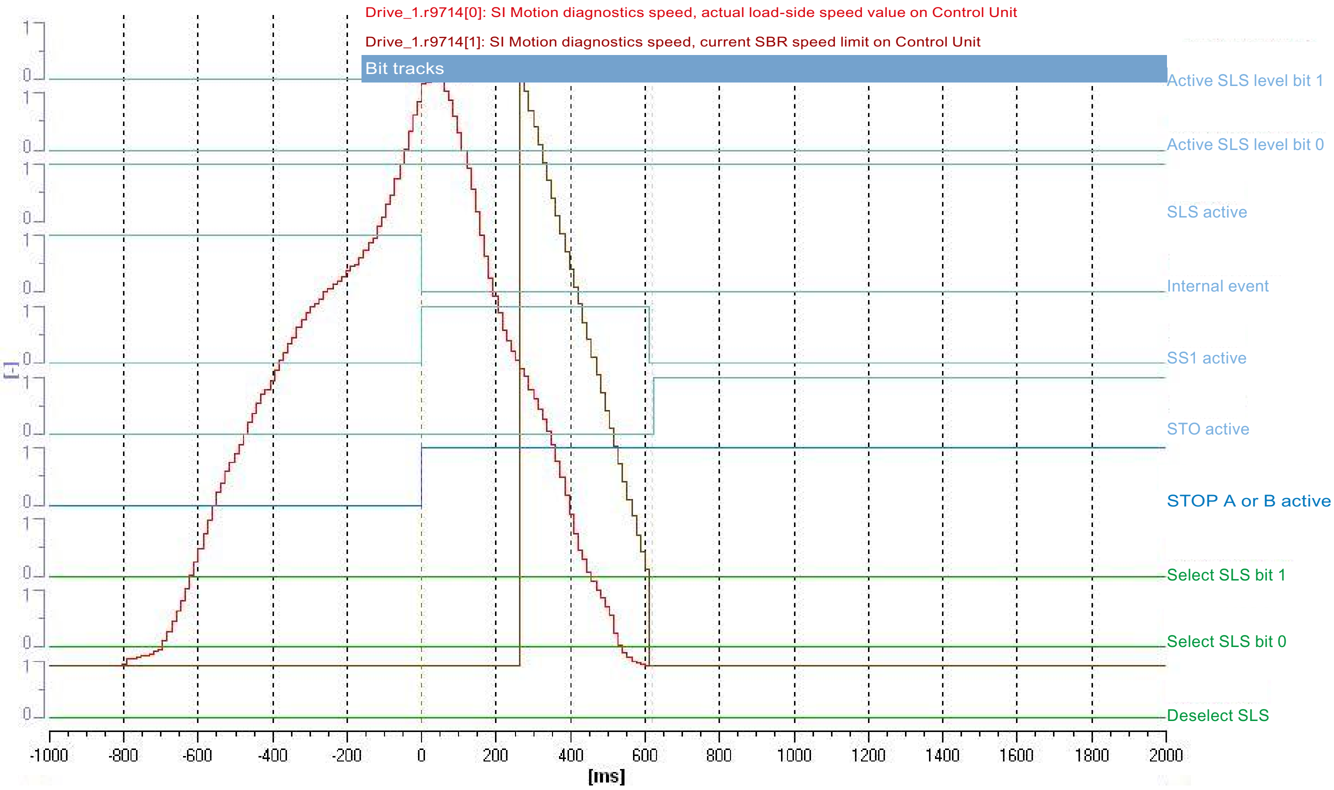

Figure 10-11 Example trace SLS without encoder with STOP B

Trace evaluation:

- SLS function with SLS level 1 is active (see bits "deselection SLS", "selection SLS bit 0", "selection SLS bit 1" and "SLS active", "active SLS level bit 0" and "active SLS level bit 1")
- Drive is accelerated beyond the SLS limit (time axis from approx. -800 ms)
- Exceeding of the limit is recognized (time axis 0 ms)
- Safety fault is initiated (time axis 0 ms; bit "internal event" is set to 0)
- Fault response STOP B is initiated (time axis 0 ms; see bit "STOP A or B active" and "SS1 active")
- Drive is decelerated to a standstill (see orange curve of r9714[0])
- Standstill reached (time axis from approx. 600 ms)
- STOP A (as follow-up response to STOP B) is activated (see bit "STO active"); at this point the speed falls below the shutdown speed SS1 (p9560/p9360)
- SBR monitoring is activated after 250 ms

Note

Small time differences (of the order of 2 to 3 Safety clock cycles (here up to 36 ms)) are caused by internal calculations and do not present a problem.

10.6 Conclusion of the report

SI parameters

	Were the specified values checked?	
	Yes	No
Control Unit		
Motor Module		

Checksums

Basic Functions + Extended Functions			
Drive name	Drive number	SI reference checksum SI parameters (Control Unit)	SI reference checksum SI parameters (Motor Module)
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
only Extended Functions			
Drive name	Drive number	SI reference checksum SI parameters (Control Unit)	SI reference checksum SI parameters (Motor Module)
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
TM54F			
	Reference checksum:	p10005[0] =	p10005[1] =

Safety logbook

	Functional [1)]
Checksum for functional tracking of changes	r9781[0] =
Checksum for hardware dependent tracking of changes	r9781[1] =
Time stamp for functional tracking of changes	r9782[0] =
Time stamp for hardware dependent tracking of changes	r9782[1] =

1) These parameters can be found in the expert list of the Control Unit.

Data backup

	Storage medium			Storage location
	Type	Designation	Date	
Parameter				
PLC program				
Circuit diagrams				

Countersignatures

Commissioning engineer

This confirms that the tests and checks have been carried out properly.

Date	Name	Company/dept.	Signature

Machine manufacturer

This confirms that the parameters recorded above are correct.

Date	Name	Company/dept.	Signature

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