SIEMENS

Function Manual

SINAMICS

S120

Safety Integrated

Edition 12/2018

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SIEMENS

SINAMICS

S120
Safety Integrated

Function Manual

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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
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

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, 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 complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

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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Preface

SINAMICS documentation

The SINAMICS documentation is organized in the following categories:

- General documentation/catalogs
- User documentation
- Manufacturer/service documentation

Additional information

You can find information on the topics below at the following address (https://support.industry.siemens.com/cs/de/en/view/108993276):

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

Please send any questions about the technical documentation (e.g. suggestions for improvement, corrections) to the following email address (mailto:docu.motioncontrol@siemens.com).

Siemens MySupport/Documentation

At the following address (https://support.industry.siemens.com/My/ww/en/documentation), you can find information on how to create your own individual documentation based on Siemens' content, and adapt it for your own machine documentation.

Training

At the following address (http://www.siemens.com/sitrain), you can find information about SITRAIN (Siemens training on products, systems and solutions for automation and drives).

FAQs

You can find Frequently Asked Questions in the Service&Support pages at Product Support (https://support.industry.siemens.com/cs/de/en/ps/faq).

SINAMICS

You can find information about SINAMICS at the following address (http://www.siemens.com/sinamics).

Usage phases and their documents/tools (as an example)

Usage phase	Document/tool
Orientation	SINAMICS S Sales Documentation
Planning/configuration	• SIZER Engineering Tool • Configuration Manuals, Motors
Deciding/ordering	SINAMICS S120 catalogs • SINAMICS S120 and SIMOTICS (Catalog D 21.4) • SINAMICS Converters for Single-Axis Drives and SIMOTICS Motors (Catalog D 31) • SINAMICS Converters for Single-Axis Drives – Built-In Units (D 31.1) • SINAMICS Converters for Single-Axis Drives – Distributed Converters (D 31.2) • SINUMERIK 840 Equipment for Machine Tools (Catalog NC 62)
Installation/assembly	• SINAMICS S120 Equipment Manual for Control Units and Additional System Components • SINAMICS S120 Equipment Manual for Booksize Power Units • SINAMICS S120 Equipment Manual for Booksize Power Units C/D Type • SINAMICS S120 Equipment Manual for Chassis Power Units • SINAMICS S120 Equipment Manual for Chassis Power Units, Liquid-cooled • SINAMICS S120 Equipment Manual water-cooled chassis power units for common cooling circuits • SINAMICS S120 Equipment Manual for Chassis Power Units, Air-cooled • SINAMICS S120 Equipment Manual for AC Drives • SINAMICS S120 Equipment Manual Combi • SINAMICS S120M Equipment Manual Distributed Drive Technology • SINAMICS HLA System Manual Hydraulic Drives
Commissioning	• Startdrive Commissioning Tool • SINAMICS S120 Getting Started • SINAMICS S120 Commissioning Manual • SINAMICS S120 Function Manual Drive Functions • SINAMICS S120 Safety Integrated Function Manual • SINAMICS S120 Function Manual Communication • SINAMICS S120/S150 List Manual • SINAMICS HLA System Manual Hydraulic Drives
Usage/operation	• SINAMICS S120 Commissioning Manual • SINAMICS S120/S150 List Manual • SINAMICS HLA System Manual Hydraulic Drives
Maintenance/servicing	• SINAMICS S120 Commissioning Manual • SINAMICS S120/S150 List Manual
References	• SINAMICS S120/S150 List Manual

Where can the various topics be found?

Software			Manual
Alarms	Described in order of ascending numbers		SINAMICS S120/S150 List Manual
Parameters	Described in order of ascending numbers		SINAMICS S120/S150 List Manual
Function block diagrams	Sorted according to topic		SINAMICS S120/S150 List Manual
	Described in order of ascending numbers		
Drive functions			SINAMICS S120 Function Manual Drive Functions
Communication topics			SINAMICS S120 Function Manual Communication (from firmware V5.2)
Safety Integrated	Basic and Extended Functions		SINAMICS S120 Safety Integrated Function Manual
	Basic Functions		SINAMICS S120 Function Manual Drive Functions
Commissioning	Of a simple SINAMICS S120 drive with STARTER		Getting Started (up to Firmware V5.1 SP1)
Commissioning	With STARTER		SINAMICS S120 Commissioning Manual (up to firmware V5.1 SP1)
Commissioning	Of a simple SINAMICS S120 drive with Startdrive		Getting Started (from Firmware V5.2)
Commissioning	With Startdrive		SINAMICS S120 Commissioning Manual (from firmware V5.2)
Web server			SINAMICS S120 Function Manual Drive Functions
Hardware			**Manual**
Control Units	And expansion components: • Control Units • Option Boards • Terminal Modules	• HUB Modules • VSM10 • Encoder system connection	SINAMICS S120 Equipment Manual for Control Units and Additional System Components
Power units booksize	• Line connection • Line Modules • Motor Modules	• DC link components • Braking resistors • Control cabinet design	SINAMICS S120 Equipment Manual for Booksize Power Units
Power units, booksize C/D type format			SINAMICS S120 Equipment Manual for Booksize Power Units C/D Type
Chassis power units			SINAMICS S120 Equipment Manual for Chassis Power Units, Air-cooled or Liquid-cooled
AC drive components			SINAMICS S120 Equipment Manual for AC Drives
S120 Combi components			SINAMICS S120 Equipment Manual Combi
Diagnostics via LEDs	STARTER		SINAMICS S120 Commissioning Manual (up to firmware V5.1 SP1)
	Startdrive		SINAMICS S120 Commissioning Manual (from firmware V5.2)
Meaning of the LEDs			Equipment Manuals
High Frequency Drive components			SINAMICS S120 System Manual High Frequency Drives

Target group

This documentation is intended for machine manufacturers, commissioning engineers, and service personnel who use the SINAMICS drive system.

Benefits

This manual provides all of the information, procedures and operator actions required for the particular usage phase.

Standard scope

The scope of the functionality described in this document can differ from that of the drive system that is actually supplied.

- Other functions not described in this documentation might be able to be executed in the drive system. However, no claim can be made regarding the availability of these functions when the equipment is first supplied or in the event of service.
- The documentation can also contain descriptions of functions that are not available in a particular product version of the drive system. Please refer to the ordering documentation only for the functionality of the supplied drive system.
- Extensions or changes made by the machine manufacturer must be documented by the machine manufacturer.

For reasons of clarity, this documentation does not contain all of the detailed information on all of the product types, and cannot take into consideration every conceivable type of installation, operation and service/maintenance.

Technical Support

Country-specific telephone numbers for technical support are provided in the Internet at the following address (https://support.industry.siemens.com/sc/ww/en/sc/2090) in the "Contact" area.

Compliance with the General Data Protection Regulation

Siemens respects the principles of data protection, in particular the data minimization rules (privacy by design).

For this product, this means:
The product does not process neither store any person-related data, only technical function data (e.g. time stamps). If the user links these data with other data (e.g. shift plans) or if he stores person-related data on the same data medium (e.g. hard disk), thus personalizing these data, he has to ensure compliance with the applicable data protection stipulations.

Notation

The following notation and abbreviations are used in this documentation:

Notation for faults and alarms (examples):

- F12345 Fault 12345
- A67890 Alarm 67890
- C23456 Safety message

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

Table of Contents

1 Fundamental safety instructions

1.1 Fundamental safety instructions

1.1.1 General safety instructions

⚠WARNING

Danger to life if the safety instructions and residual risks are not observed

If the safety instructions and residual risks in the associated hardware documentation are not observed, accidents involving severe injuries or death can occur.

- Observe the safety instructions given in the hardware documentation.
- Consider the residual risks for the risk evaluation.

⚠WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization (parameter assignments) against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

1.1.2 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment or any eventuality which may arise. Application examples do not represent specific customer solutions, but are only intended to provide support for typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

1.1.3 Industrial security

Note

Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the Internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit:

Industrial security (http://www.siemens.com/industrialsecurity)

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed at:

Industrial security (http://www.siemens.com/industrialsecurity)

Further information is provided on the Internet:

Industrial Security Configuration Manual (https://support.industry.siemens.com/cs/ww/en/view/108862708)

⚠ WARNING

Unsafe operating states resulting from software manipulation

Software manipulations (e.g. viruses, trojans, malware or worms) can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.
- Make sure that you include all installed products into the holistic industrial security concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Protect the drive against unauthorized changes by activating the "know-how protection" drive function.

1.2 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks

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

DANGER

Risk minimization through Safety Integrated

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 observes 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 Safety Integrated Functions, further risk reduction measures must be implemented.

NOTICE

Danger to life as a result of inactive Safety Integrated Functions after powering up

The Safety Integrated Functions are only activated after the system has completely powered up. System startup is a critical operating state with increased risk. When accidents occur, this can result in death or severe injury.

- Make sure that the machine is safe during the system start-up.

⚠WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

The Emergency Stop function must bring the machine to a standstill according to Stop Category 0 or 1 (STO or SS1) (EN 60204-1).
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
When individual safety functions (Safety Integrated Extended Functions or Safety Integrated Advanced 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.

- For the cases listed above, ensure that an automatic restart is absolutely not possible.

⚠WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after changing or replacing hardware and/or software

After hardware and/or software components have been modified or replaced, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. 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 after having made certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).
- **When switching on carefully observed the following:**

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

⚠WARNING

Parameterizing the encoder system

Encoder faults are detected using different hardware and software monitoring functions.

- It is not permissible to disable these monitoring functions (i.e. the encoder monitoring in the Sensor Module) and they must be parameterized 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 (see "Table 9-1 Overview of stop responses (Page 375)").

Note

EDS switchover for safe motion monitoring

An encoder which is used for safety functions must not be switched over when a drive data set (DDS) 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.

⚠ WARNING

Converter operation despite active messages

With activated safety functions, there are a number of system messages that still permit the drive to be traversed. In these cases, you must ensure that the causes of the messages are corrected immediately. These messages include, among others, the following:

- A01774 SI Motion CU: Test stop required

  A01697 SI Motion: Motion monitoring test required

  Perform the required test stop.
- F13000 licensing is insufficient.

  Purchase the license required for operation of the Extended/Advanced Functions or activate a Trial License.
- A01669 (F, N) SI Motion: Unsuitable combination of motor and power unit.

  The motor / power unit combination can result in decreased robustness (incorrect detection of errors) in the system when operating with SI Motion.

1.3 Residual risk

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

⚠ WARNING

Danger due to short, limited movements

If two power transistors simultaneously fail in the power unit (one in the upper and one in the lower inverter bridge), then this can cause cause brief, limited movement.

The maximum movement can be:

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

NOTICE

Material damage due to overshooting the speed or position that briefly violates the limit value.

Violation of limits may briefly lead to a speed higher than the speed setpoint, or the axis may pass the defined position to a certain extent, depending on the dynamic response of the drive and on parameter settings.

- Design your machine appropriately.

⚠ WARNING

Residual risk for a single-encoder system

Within a single-encoder system:

a) A single electrical fault in the encoder

b) A break of the encoder shaft (or loose encoder shaft coupling), or a loose encoder housing will cause the encoder signals to remain static (that is, they no longer follow a movement while still returning a correct level), and prevent fault detection while the drive is in stop state (for example, drive in SOS state).

Generally, the drive is held by the active closed-loop control. Especially for drives with suspended load, from a closed-loop control perspective, it is conceivable that drives such as these move without this being detected.

The risk of an electrical fault in the encoder as described under a) is only present for few encoder types employing a specific principal of operation.

- All of the faults described above must be included in the risk analysis of the machine manufacturer. Additional safety measures have to be taken for drives with suspended/vertical or pulling loads - e.g. in order to exclude faults under a):
  - Use of an encoder with analog signal generation
  - Use of a two-encoder system
- Failsafe detection of slip on the encoder shaft - or a broken encoder shaft connection.

  You can implement failsafe detection of slip on the encoder shaft or a broken motor-encoder shaft by checking the plausibility of the acquired safety-relevant actual value with respect to the expected setpoint. If the actual value does not lie within a configurable tolerance bandwidth around the setpoint within a defined time, then it can be assumed that there is either slip - or that there is a broken connection between the encoder and the motor. You must ensure this monitoring functionality in the safety user program according to SIL 2 or PL d.
- For excluding the fault under b):
  - Perform an FMEA regarding encoder shaft breakage (or slip of the encoder shaft coupling) as well as loose encoder housings and use a fault exclusion process according to IEC 61800-5-2, or
  - Implementation of a two-encoder system (the encoders must not be mounted on the same shaft).

See also

Safe Brake Control (SBC) (Page 78)

2 General information about SINAMICS Safety Integrated

2.1 Supported functions

All of the Safety Integrated functions available under SINAMICS S120 are listed in this section.

The safety functions listed here conform to:

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

The safety functions correspond to the functions according to DIN EN 61800-5-2 (under the assumption that they are defined there).

SINAMICS makes a distinction between the following function groups:

- Safety Integrated Basic Functions (Page 26)
- Safety Integrated Extended Functions (Page 27)
- Safety Integrated Advanced Functions (Page 28)

2.1.1 Safety Integrated Basic Functions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license. These functions are always available. These functions do not require an encoder and/or do not place any special requirements on the encoder used.

- Safe Torque Off (STO)

  Safe Torque Off is a safety function to avoid unexpected startup in accordance with EN 60204-1. STO prevents the supply of power to the motor, which can produce a torque. This is equivalent to stop category 0.

- 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)

  Safe Brake Control is used to safely control a holding brake.[1) 2)]

1) Note regarding Power/Motor Modules in the chassis format: For the chassis format, SBC is only supported by Power/Motor Modules with article number ...3 or higher. A Safe Brake Adapter is also needed for this design.

2) Note regarding Power/Motor Modules in the blocksize format: Blocksize Power Modules also require a Safe Brake Relay for this function.

Note

Parallel use of Safety Integrated Functions

All Safety Integrated Functions can be used simultaneously.

Exception: If SOS and SLS are activated simultaneously, SOS has higher priority and overrides the SLS reaction.

2.1.2 Safety Integrated Extended Functions

The Safety Integrated Extended Functions require an additional Safety Extended license. Extended Functions with encoder require an encoder with safety capability (see Chapter "Notes regarding safe actual value sensing using an encoder system (Page 155)").

- Safe Torque Off (STO)

  Safe Torque Off is a safety function to avoid unexpected starting in accordance with EN 60204-1.

- Safe Stop 1 (SS1, time and acceleration 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)

  Safe Brake Control is used to safely control a holding brake.[1) 2)]

- Safe Operating Stop (SOS)

  Safe Operating Stop is used to protect against unintentional movement. The drive is in closed-loop control mode and is not disconnected from the power supply.

- Safe Stop 2 (SS2)

  Safe Stop 2 is used to safely brake the motor with a subsequent transition into the "Safe Operating Stop" state (SOS). This means that a Category 2 stop in accordance with EN 60204-1 can be implemented.

- Safely-Limited Speed (SLS)

  Safely-Limited Speed ensures that the drive does not exceed a preset speed/velocity limit.

- Safe Speed Monitor (SSM)

  Safe Speed Monitor is used for safely identifying when a speed limit is undershot in both directions of motion, e.g. to identify zero speed. A failsafe output signal is available for further processing.

- Safe Direction (SDI)

  Safe Direction is used to safely monitor the direction of motion.

- Safe gearbox stage switchover

  The "Safe gearbox stage switchover" function facilitates reliable switching between different gearbox stages. The switchover is only possible via PROFIsafe.

- Safely-Limited Acceleration (SLA)

  Safely-Limited Acceleration monitors (the same as SLS) the acceleration, and intervenes when a limit value is violated. SLA cannot prevent that the acceleration threshold is briefly exceeded.

- Safe Brake Test (SBT)

  The **diagnostic function** "Safe Brake Test" function (SBT) checks the required holding torque of a brake (operating or holding brake).

[1)] Note regarding Power/Motor Modules in the chassis format: For the chassis format, SBC is only supported by Power/Motor Modules with article number ...3 or higher. A Safe Brake Adapter is also needed for this design.

[2)] Note regarding Power/Motor Modules in the blocksize format: Blocksize Power Modules also require a Safe Brake Relay for this function.

2.1.3 Safety Integrated Advanced Functions

The Safety Integrated Advanced Functions require an additional Safety Advanced license. Advanced Functions with encoder require an encoder with safety capability (see Chapter "Notes regarding safe actual value sensing using an encoder system (Page 155)").

- Safely Limited Position (SLP)

  Safely Limited Position ensures that a freely definable traversing range is not left.

- Transferring safe position values (SP)

  The "Transfer safe position values (SP)" function enables you to transfer a safe position to the higher-level control via PROFIsafe.

- Safe Cam (SCA)

  The "Safe Cam" function outputs a safe signal if the drive is within a specified position range. It facilitates the realization of safe axis-specific range detection.

2.2 Supported functions: HLA module

SINAMICS HLA supports the following Safety Integrated functions:

- Safety Integrated Basic Functions
- Safety Integrated Extended Functions
- Safety Integrated Advanced Functions

Note

Only "linear" axis type permitted

For SINAMICS HLA, only the "linear" axis type is permitted.

Note

Commissioning

SINAMICS HLA can only be commissioned with STARTER.

2.2.1 HLA: Safety Integrated Basic Functions

The Safety Integrated Basic Functions are part of the standard scope of the drive and can be used without an additional license. These functions are always available. These functions do not require an encoder and/or do not place any special requirements on the encoder used.

- Safe Torque Off (STO)

  Safe Torque Off is a safety function to avoid unexpected startup in accordance with EN 60204-1. STO prevents the supply of power to the valve, which can produce a force. It is equivalent to Stop Category 0.

- 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.

2.2.2 HLA: Safety Integrated Extended Functions

SINAMICS HLA and Safety Integrated

SINAMICS HLA supports the following Safety Integrated functions:

- The Safety Integrated Extended Functions require an additional Safety Extended license. Extended Functions with encoder require an encoder with safety capability (see Chapter "Notes regarding safe actual value sensing using an encoder system (Page 155)").

  Note

  Only Safety Integrated with encoder is possible

  SINAMICS HLA only supports Safety Integrated Extended Functions with encoder.

  These functions require an additional safety license. Extended Functions with encoder require an encoder with safety capability.

  Note

  Encoder types for SINAMICS HLA

  The following encoder types are permissible for SINAMICS HLA:

  - Single-encoder systems
    - DRIVE-CLiQ encoder with safety capability
    - sin/cos encoder connected via SME20/25, SME120/125 or SMC20 (1 V_{PP}, pure analog signal processing)
  - 2-encoder systems
    - Encoders with DRIVE-CLiQ connection
    - sin/cos encoder connected via SME20/25, SME120/125 or SMC20 (1 V_{PP}, pure analog signal processing)
    - HTL/TTL encoder connected via SMC30 (not in connection with SINUMERIK)
    - TTL encoder connected via the onboard interface of the HLA module (not in connection with SINUMERIK)

  – Safe Torque Off (STO)

    Safe Torque Off is a safety function to avoid unexpected startup in accordance with EN 60204-1.

  – Safe Stop 1 (SS1, time and acceleration 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 Operating Stop (SOS)

    Safe Operating Stop provides protection against unwanted movements. The drive is in closed-loop control mode and is not disconnected from the power supply.

  – Safe Stop 2 (SS2)

    Safe Stop 2 is used to safely brake the valve with a subsequent transition into the "Safe Operating Stop" state (SOS). This means that a Category 2 stop in accordance with EN 60204-1 can be implemented.

– Safely-Limited Speed (SLS)

  Safely-Limited Speed ensures that the drive does not exceed a preset speed limit.

– Safe Speed Monitor (SSM)

  Safe Speed Monitor is used for safely identifying when a speed limit is undershot in both directions of motion, e.g. to identify zero speed. A failsafe output signal is available for further processing.

– Safe Direction (SDI)

  Safe Direction is used to safely monitor the direction of motion.

– Safely-Limited Acceleration (SLA)

  Safely-Limited Acceleration monitors (the same as SLS) the acceleration, and intervenes when a limit value is violated. SLA cannot prevent that the acceleration threshold is briefly exceeded.

2.2.3 HLA: Safety Integrated Advanced Functions

The Safety Integrated Advanced Functions require an additional Safety Advanced license. Advanced Functions with encoder require an encoder with safety capability (see Chapter "Notes regarding safe actual value sensing using an encoder system (Page 155)").

- Safely Limited Position (SLP)

  Safely Limited Position ensures that a freely definable traversing range is not left.

- Transferring safe position values (SP)

  The "Transfer safe position values (SP)" function enables you to transfer a safe position to the higher-level control via PROFIsafe.

- Safe Cam (SCA)

  The "Safe Cam" function outputs a safe signal if the drive is within a specified position range. It facilitates the realization of safe axis-specific range detection.

2.3 Drive products with integrated safety functions

	Applications with fixed speed		Applications with variable speed						High Performance and Motion Control applications		
	SIMATIC ET 200S Motor starter	SIMATIC ET 200pro Motor starter	SIMATIC ET 200pro FC-2	SINAMICS G120C	SINAMICS G120	SINAMICS G120D	SINAMICS G130	SINAMICS G150	SINAMICS S110	SINAMICS S120	SINAMICS S150
Integrated safety functions according to IEC 61800-5-2											
STO Safe Torque Off	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SS1 Safe Stop 1	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SBC Safe Brake Control	-	-	-	-	Yes[2]	-	Yes[3]	Yes[3]	Yes[4]	Yes[3][4][6]	Yes[3]
SOS Safe Operating Stop	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
SS2 Safe Stop 2	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
SLS Safely-Limited Speed	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SSM Safe Speed Monitor	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SDI Safe Direction	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SLP Safely-Limited Position	-	-	-	-	-	-	Yes	Yes	-	Yes	Yes
SCA Safe Cam	-	-	-	-	-	-	Yes	Yes	-	Yes	Yes
SLA Safely-Limited Acceleration	-	-	-	-	-	-	-	-	-	Yes	Yes
Integrated safe diagnostic function											
SBT Safe Brake Test	-	-	-	-	-	-	Yes	Yes	-	Yes[6]	Yes
Fail-safe interfaces											
PROFIBUS/PROFINET with PROFIsafe profile	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fail-safe inputs	Yes, with external components			Yes	Yes	Yes	Yes	Yes	Yes[5]	Yes[5]	Yes[5]
Fail-safe outputs	-	-	-	-	Yes[8]	Yes	Yes[5]	Yes[5]	Yes	Yes[5]	Yes[5]
Certifications											
EN ISO 13849-1	Cat. 4/ PL e	Cat. 4/ PL e	Cat. 3/ PL d	Cat. 3/ PL d	Cat. 3/ PL d[7]	Cat. 3/ PL d	Cat. 3/ PL d	Cat. 3/ PL d	Cat. 3/ PL d	Cat. 3/ PL d[7]	Yes
IEC 61508	SIL 3	SIL 3	SIL 2	SIL 2	SIL 2[7]	SIL 2	SIL 2	SIL 2	SIL 2	SIL 2[7]	SIL 2
NFPA 79	Yes	Yes	-	-	-	-	Yes	Yes	Yes	Yes	-
NRTL-listed	Yes	Yes	-	-	-	-	-	-	-	Yes[1]	-

Content of this manual

1) Only for SINAMICS S120 Booksize
2) Only for CU250S-2 with Safe Brake Relay
3) With Chassis and Cabinet Modules with Safe Brake Adapter
4) CU305, CU310-2/SIMOTION D410-2, CUA31/CUA32: With Safe Brake Relay
5) CU320-2, G130, G150: With use of the TM54F
CU310-2: Onboard interfaces or TM54F
6) Not available for SINAMICS HLA
7) STO via terminals of Power Module PM240-2: Cat. 4/PL e, SIL 3
STO via the Control Unit terminals and all other safety functions: Cat. 3/PL d, SIL 2
8) Only with CU250S-2 Control Unit

Comparison, description of electric ↔ hydraulic drives

In the Safety Integrated Function Manual, Safety Integrated functions are described from the perspective of an electric drive. However, these descriptions essentially also apply in the same way for hydraulic systems. You will find parameters and messages for the drive object HLA in the SINAMICS S120/S150 List Manual.

2.4 Examples of how the safety/diagnostic functions can be applied

Safety function	Application examples	Possible solution
STO	It is only permissible to open a protective door if the motor torque has been switched off.	• Select STO in the converter via a terminal or via PROFIsafe. • The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that several drives cannot unintentionally start.	Evaluating the Emergency Stop button in a central controller, selecting STO in the converter via PROFIsafe.
SS1	A drive must brake as quickly as possible after the Emergency Stop button has been pressed. It is not permissible that the stationary motor undesirably accelerates.	Select SS1 in the converter using a failsafe input or via PROFIsafe.
SBC	Safe control of a motor holding brake must be guaranteed to guarantee the motor is at a standstill.	SBC is (if configured) initiated together with STO. The Motor Module / Safe Brake Relay / Safe Brake Adapter then carries out the action and safely controls the outputs for the brake.
SOS	The standstill position of the motor must be monitored and ensured.	Select SOS, e.g. through SS2, in order to monitor the standstill position of the motor after braking.
SS2	A drive must brake as quickly as possible after the Emergency Stop button has been pressed. The standstill position of the motor must be monitored and ensured.	Select SS2 in the converter using a failsafe input or via PROFIsafe.
SLS	The machine operator must be able to enter the machine after the protective door has been opened and slowly move a horizontal conveyor with an acknowledgment button in the danger zone.	Selecting SLS in the converter. The converter limits and monitors the velocity of the horizontal conveyor.
	A spindle drive, depending on the selection of the cutting tool, must not exceed a specific maximum speed.	Selecting SLS and the corresponding SLS level in the converter via PROFIsafe.
SSM	A centrifuge may only be filled below a velocity defined by the user.	If the Extended Functions are enabled, SSM is always available[1)]. The function does not have to be selected. The converter safely monitors the centrifuge speed and enables the process to advance to the next step using the "SSM status" bit. [1)] Exception: Motion monitoring without selection (Page 249)
SDI	A protective door must only be opened if a drive moves in the safe direction (away from the operator).	Selecting SDI in the converter; enable the protective doors via status bit (PROFIsafe) of the converter.
	When replacing the plates of the pressure cylinders, the drive must only move in the safe direction of rotation.	Selecting SDI in the converter. Disabling the hazardous direction of rotation.
	Once the protection against jamming has been triggered, a roller shutter gate must only be able to start moving in one direction.	
	At an operational limit switch, the trolley of a crane must only start in the opposite direction.	

Safety function	Application examples	Possible solution
SLP	The drive must not exit the specified position ranges.	Selection of SLP in the converter; inhibits the range that is not permitted.

SP	It is necessary to transmit a "safe position," for example, in the following use cases:
	• Safe cam sequencer
	• Calculation of the safe velocity
	• Safety concepts across axes
	  – Multi-dimensional protection areas
	• Zone concepts
	  – Safe response depending on the position of the axes
	  – Different reaction to sensors
		The selection of SP in the converter enables you to transfer a safe position (i.e. absolute or relative position) to the higher-level controller via PROFIsafe.

Safe gearbox stage switch-over	For a machine equipped with selector gearbox it must be ensured that the switchover is actually performed.	The "Safe gearbox stage switchover" function ensures safe switchover between the gearbox stages.
SCA	It is only permissible that a protective door is opened if a drive is in a certain position range.	• Select SCA • Interlock protective door in response to the SCA feedback signals via PROFIsafe
	The drive must only be traversed with reduced speed when it located in a certain position range.	• Select SCA • Activate a SLS stage in response to the SCA feedback signals via PROFIsafe
SLA	In the setup mode, it is not permissible that the drive exceeds the permissible acceleration.	Selecting SLA in the converter. The converter limits and monitors the acceleration of the machine.

Diagnostic function	Application examples	Possible solution
SBT	The effect of a brake is reduced through wear.	The diagnostic function "Safe Brake Test SBT" detects whether a brake is provided the required braking effect.

2.5 Drive monitoring with or without encoder

If motors without a (safety-capable) encoder are being used, not all Safety Integrated Functions can be used.

Note

Definition: "Without encoder"

When "without encoder" is used in this manual, then this always means that either no encoder or no safety-capable encoder is being used.

In operation without encoder the actual speed values are calculated from the measured electrical actual values. Therefore, speed monitoring is also possible during operation without encoder.

Table 2- 1 Overview of Safety Integrated Functions

	Functions	**Abbr.**	**With encoder**	**Without encoder**	**Brief description**
Basic Functions	Safe Torque Off	STO	Yes	Yes	Safe torque off
	Safe Stop 1	SS1	Yes	Yes	Safe stopping process in accordance with 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 stopping process in accordance with Stop Category 1
	Safe Brake Control	SBC	Yes	Yes 1)	Safe brake control
	Safe Operating Stop	SOS	Yes	No	Safe monitoring of the standstill position
	Safe Stop 2	SS2	Yes	No	Safe stopping process in accordance with Stop Category 2
	Safely-Limited Speed	SLS	Yes	Yes 1)	Safe monitoring of the maximum speed
	Safe Speed Monitor	SSM	Yes	Yes 1)	Safe monitoring of the minimum speed
	Safe Direction	SDI	Yes	Yes 1)	Safe monitoring of the direction of motion
	Safe referencing	SR	Yes	No	Safe referencing
	Safe Acceleration Monitor	SAM	Yes	Yes 1)	Safe monitoring of drive acceleration
	Safe Brake Ramp	SBR	Yes	Yes 1)	Safe braking ramp
	Safe gearbox stage switch-over	–	Yes	No	–
	Safely-Limited Acceleration	SLA	Yes	No	Safely limited acceleration
	Diagnostic function Safe Brake Test	SBT	Yes	No	Safe test of the required holding torque of a brake

	Functions	Abbr.	With encoder	Without encoder	Brief description
Advanced Functions	Safely-Limited Position	SLP	Yes	No	Safely Limited Position
	Transfer safe position values	SP	Yes	Yes 1)	Transfer safe position values
	Safe Cam	SCA	Yes	No	Safe cam

1) The use of this safety function without an encoder is permitted only for the following motors:

- Induction motors
- SIMOTICS A-1FU synchronous motors (previously: SIEMOSYN)
- Reluctance motors

The configuration of the Safety Integrated Functions and the selection of monitoring with or without encoder is realized in the safety screens of the Startdrive commissioning tool.

2.6 General information about operating components with Safety Integrated activated

It is not permissible to withdraw and insert components. Malfunctions can occur when components are withdrawn or inserted that are used for Safety Integrated. However, this does not mean that the fail-safe state is exited. For example, PROFIsafe communication is not reestablished after this event.

Withdrawing and inserting components used for Safety Integrated (power units, Sensor Modules, TM54F) during operation **and** in the deactivated state is **not** permissible. Activating the components always requires a POWER ON (see Chapter "Modular machine concept Safety Integrated (Page 325)").

Overview of Safety Integrated functions 3

3.1 Safety Integrated Basic Functions

Note

Basic Functions do not require an encoder

The Safety Integrated Basic Functions are functions for safely stopping the drive. You do not require an encoder.

Note

Application of the Basic Functions

Basic Functions are available in all control modes with and without encoder for synchronous and induction motors without any restrictions.

Note

Control via TM54F

If you want to control the Safety Integrated Basic Functions via TM54F, set p9601.6 = 1.

This chapter should provide first users with a quick overview of the principle mode of operation of safety functions.

The entry into the description of the safety functions is based on the definition according to standard EN 61800-5-2 and some simple examples for using the function.

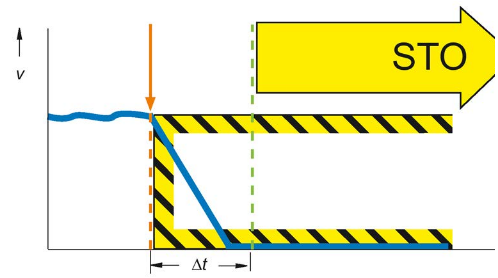
The description of the functions is simplified, as far as possible to clearly shown essential properties and setting options.

You will find more information on the functions in the following chapters,
e.g. "Safety Integrated basic functions (Page 70)".

3.1.1 Safe Torque Off (STO)

Definition according to EN 61800-5-2:

"The STO function prevents energy from being supplied to the motor, which can generate a torque."



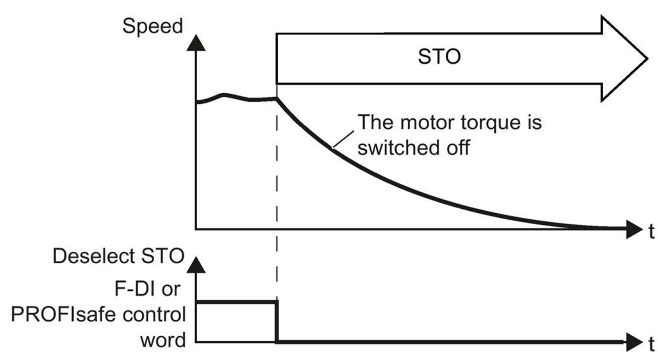
Examples of how the function can be used

Example	Possible solution
It is only permissible to open a protective door if the motor torque has been switched off.	• Select STO in the converter. • The pulses are suppressed and the motor coasts to a standstill.

How does STO function in detail?

The converter recognizes the selection ofSTO via a fail-safe input or via the safe communicationPROFIsafe.

The converter then safely switches off the torque of the connected motor.

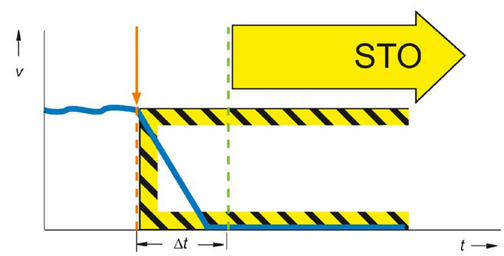


Details and parameterization

For further details and information on how to parameterize this function, refer to Chapter "Safe Torque Off (STO) (Page 70)".

3.1.2 Safe Stop 1 (SS1)

Definition according to EN 61800-5-2:
"The function SS1 brakes the motor and trips the function STO after a delay time."



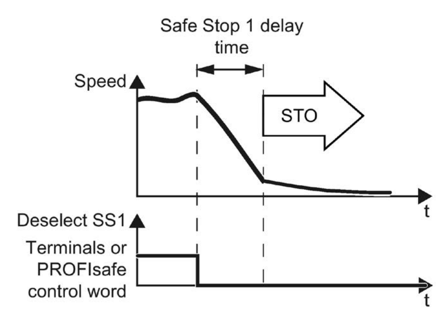
Example of how the function can be used

Example	Possible solution
After an Emergency Stop button has been pressed, the drive must be braked as quickly as possible and brought into the STO state.	• Wire the Emergency Stop button with a fail-safe input. • Select SS1 via the fail-safe input.
A central Emergency Stop button ensures that several drives are braked as quickly as possible and brought into the STO state.	• Evaluating an emergency stop pushbutton in a central control. • Select SS1 via PROFIsafe.

How does SS1 function in detail?

Overview

The drive decelerates once "Safe Stop 1" has been selected, and goes into the "Safe Torque Off" state once the delay time has expired.



Select SS1

As soon as the converter identifies that SS1 has been selected via a terminal or via the PROFIsafe safe communication, the following happens:

- If, when selecting SS1, the motor is already switched off, then until the SS1 delay time expires, there is no response. STO becomes active after the time expires.
- If the motor is switched on when SS1 is selected, the inverter brakes the motor with the OFF3 ramp-down time. After the delay time, STO is triggered automatically.

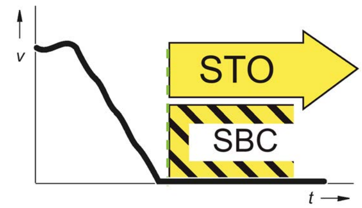
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Stop 1 (SS1, time controlled) (Page 75)".

3.1.3 Safe Brake Control (SBC)

Definition according to EN 61800-5-2:

"The SBC function supplies a safe output signal to control a holding brake."



Safe Brake Control (SBC)

Example of how the function can be used

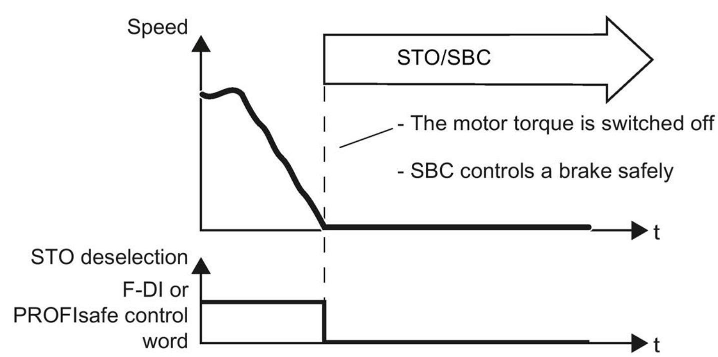
Example	Possible solution
The safe control of a motor holding brake must be guaranteed in order to guarantee the motor is at a standstill.	SBC is (if configured) initiated together with STO. The Motor Module / Safe Brake Relay / Safe Brake Adapter then carries out the action and safely controls the outputs for the brake.

How does SBC function in detail?

The converter recognizes the selection ofSTO via a fail-safe input or via the safe communicationPROFIsafe.

The converter then safely switches off the torque of the connected motor.

SBC is (if configured) initiated together with STO. The Motor Module / Safe Brake Relay / Safe Brake Adapter then carries out the action and safely controls the outputs for the brake.



Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Brake Control (SBC) (Page 78)".

3.2 Safety Integrated Extended Functions

This chapter should provide first users with a quick overview of the principle mode of operation of safety functions.

The entry into the description of the safety functions is based on the definition according to standard EN 61800-5-2 and some simple examples for using the function.

The description of the functions is simplified, as far as possible to clearly shown essential properties and setting options.

You will find more information on the functions in the following chapters, e.g. "Safety Integrated Extended Functions (Page 90)".

3.2.1 Preconditions for Safety Integrated Extended Functions

- For operation of the Safety Integrated Extended Functions, **one** license is required for **each** axis.
- To use Safety Integrated Advanced Functions, **one** license is required for **each** axis. The license for Safety Integrated Advanced Functions also includes the license for Safety Integrated Extended Functions.
- Overview of hardware components that support the Extended/Advanced Functions:
  - Control Unit CU320-2
  - Control Unit CU310-2
  - SINAMICS HLA
  - Motor Modules Booksize Compact
  - Motor Modules booksize C/D type with article No.: -..C. or -..D.
  - Motor Modules booksize with an article number ending: -...3 or higher
  - Motor Modules chassis with an article number ending: -...3 or higher
  - Motor Modules cabinet with an article number ending: -...2 or higher
  - Power Modules blocksize
  - Control Unit Adapter CUA31 as of article number: 6SL3040-0PA00-0AA1
  - Control Unit Adapter CUA32 as of article number: 6SL3040-0PA01-0AA0
  - For the safety functions with encoder:

    Motors with sin/cos encoder and encoder evaluation with DRIVE-CLiQ interface or via Sensor Module SMC20, SME20/25/120/125, square wave signal encoder with SMC30, EnDat-2.2 encoder with SMC40

    The list of approved encoders can be found on the Internet at:

    Approved encoders (https://support.industry.siemens.com/cs/ww/en/)

    Enter the number **33512621** there as search term or contact your local Siemens office.

3.2.2 Control possibilities

The following options are available for controlling Safety Integrated Extended Functions:

- PROFIsafe
- TM54F
- Onboard F-DI (CU310-2)
- Permanent selection (Safety Integrated functions without selection)

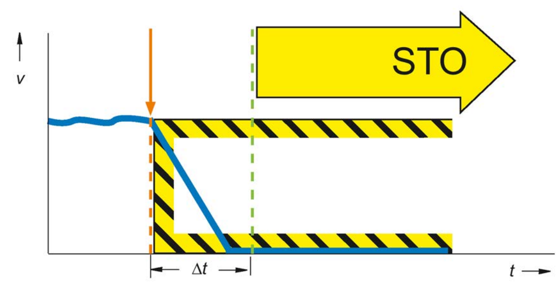
3.2.3 Safe Torque Off (STO)

For the control options and the functionality for "Safe Torque Off" (STO), see Section "Safe Torque Off (STO) (Page 70)".

3.2.4 Safe Stop 1 (SS1)

Definition according to EN 61800-5-2:

"The function SS1 brakes the motor, monitors the magnitude of the motor deceleration within specified limits, and after a delay time or violation of a speed threshold, initiates the STO function."



Example of how the function can be used

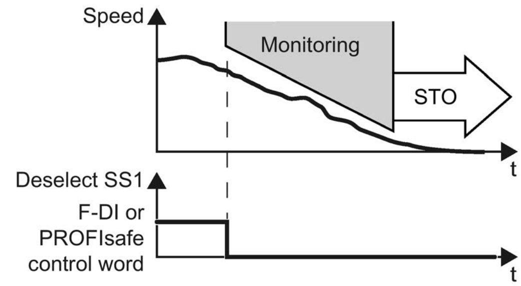
Example	Possible solution
After an Emergency Stop button has been pressed, the drive must be braked as quickly as possible and brought into the STO state.	• Wire the Emergency Stop button with a fail-safe input. • Select SS1 via the fail-safe input. • SS1 brakes the drive and then brings it into the STO state.
A central Emergency Stop button ensures that several drives are braked as quickly as possible and brought into the STO state.	• Evaluating an emergency stop pushbutton in a central control. • Select SS1 via PROFIsafe. • SS1 brakes the drives and then brings them into the STO state.

How does SS1 function in detail?

Overview

Using the SS1 function, the converter brakes the motor and monitors the absolute speed.

If the motor speed is low enough or the delay time has expired, the converter safely switches off the motor torque using STO .



Select SS1

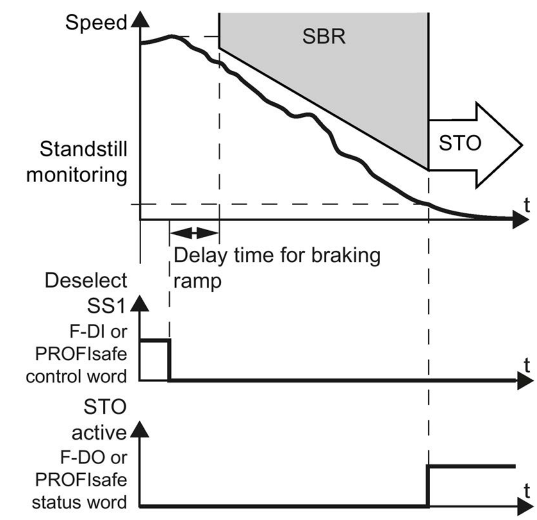
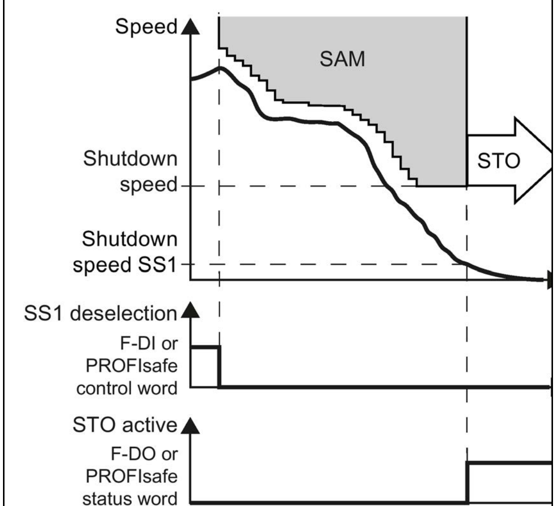
As soon as the converter identifies that SS1 has been selected via a failsafe input or via PROFIsafe safe communication, the following happens:

- If the motor has already been switched off when selecting SS1 then the converter safely switches off the motor torque (STO).
- If the motor is switched on when SS1 is selected, the converter brakes the motor with the AUS3 ramp-down time.

Monitoring modes

For the Extended Functions **with** or **without** encoder, you can choose between 2 different monitoring modes of the function SS1:

- Safe Brake Ramp (SBR)
- Safe Acceleration Monitor (SAM)

<table>
<tr><th>Brake ramp monitoring
(with or without encoder)</th><th>Acceleration monitoring
(with or without encoder)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>
Using the SBR (Safe Brake Ramp) function, the converter monitors whether the motor speed decreases.
The gradient of the SBR function can be set via the reference velocity and the ramp-down time. The SBR function only starts after the "Delay for braking ramp".
The SBR function starts with the speed setpoint, which was present at the instant in time that SS1 was selected.
If the converter detects that the speed has fallen below the speed threshold (standstill monitoring), it safely switches off the motor torque (STO).
</td><td>
The converter monitors the speed of the motor with the SAM function.
The converter prevents the motor from accelerating again by having the monitoring function continuously track the speed as it decreases.
The converter reduces the monitoring threshold until the "Shutdown speed" has been reached.
The converter safely switches off the motor torque (STO), if one of the following conditions is fulfilled:

The speed has fallen below the shutdown speed SS1.
The maximum time until the torque is switched off has expired.

</td></tr>
</table>

Note

SS1 with external stop (SS1E)

If you use SS1E, neither of the two monitoring functions (SBR, SAM) is active. The drive must be shut down in SS1E within the delay time, for example, by a user program of a CPU. STO becomes active after the delay time expires.

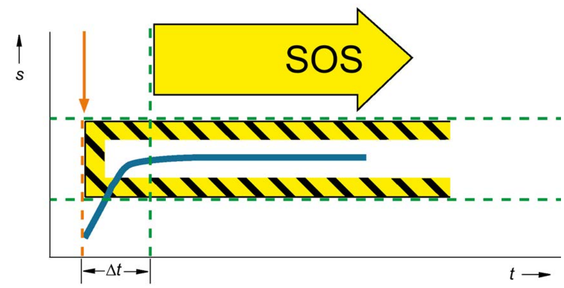
Details and parameterization

For further details and information on how to parameterize this function, see Chapter "Safe Stop 1 (SS1) (Page 98)".

3.2.5 Safe Operating Stop (SOS)

Definition according to EN 61800-5-2:

"This SOS function is used for safe monitoring of the standstill position of a drive."



Example of how the function can be used

Example	Possible solution
A protective door must only be opened if a motor is in the safe standstill state.	• Select SOS • A higher-level controller brakes the axis (e.g. position-controlled) down to standstill within the configured time between the selection of SOS and when it becomes active. • Standstill is then safely monitored via the SOS function.

The protected machine areas can be entered without having to shut down the machine as long as SOS is active.

After SOS has been selected it becomes active after the parameterizable delay time has expired. The drive must be braked to standstill within this delay time (e.g. by the controller).

Drive stopping is monitored using an SOS tolerance window. At the instant this function becomes active, the current actual position is stored as the comparison position until SOS is deselected again. Any delay time is cleared after SOS is deselected and the drive can be immediately moved.

The drive is stopped with SS1 when the standstill tolerance window is violated.

Note

Contrary to SS1 and SS2, SOS does not automatically brake the drive

The control still enters the setpoint.

This means that in the user program of the control system, the system must respond to the "SOS selected" bit so that the control system brings the drive to a standstill within the delay time.

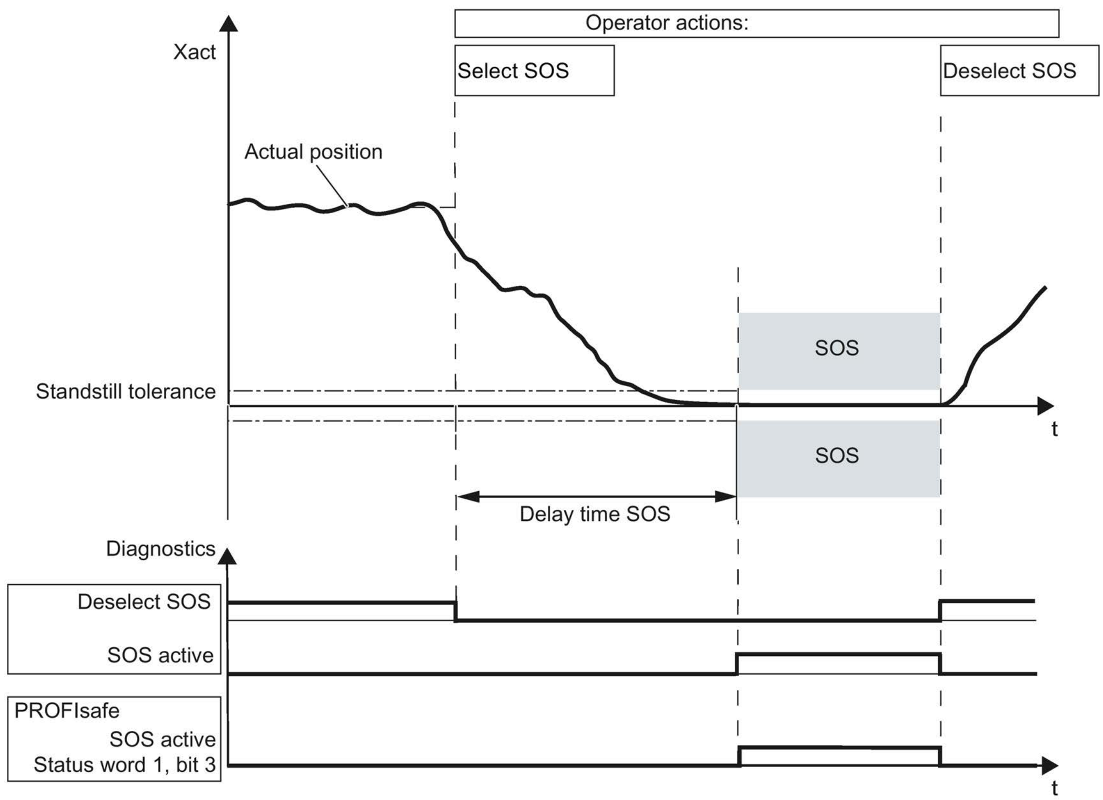


Figure 3-1 Standstill tolerance

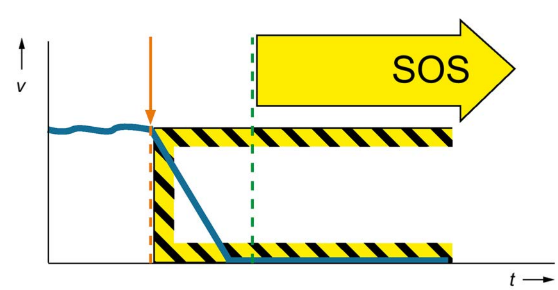
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Operating Stop (SOS) (Page 103)".

3.2.6 Safe Stop 2 (SS2)

Definition according to EN 61800-5-2:

"The function SS2 brakes the motor, monitors the magnitude of the motor deceleration, and after a delay time, initiates the SOS function."



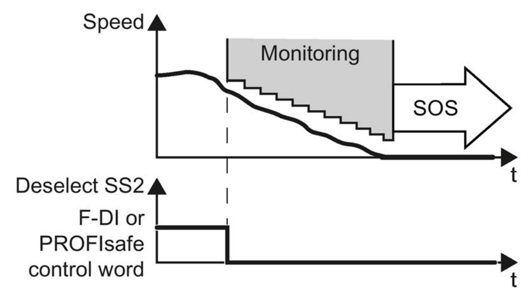
Example of how the function can be used

Example	Possible solution
A protective door must only be opened if a motor is in the safe standstill state.	• Select SS2 in the converter via a terminal or via PROFIsafe . • After braking, the converter goes into the SOS state. Only then may the protective door be released.

How does SS2 function in detail?

The safety function SS2 monitors the load speed and initiates the SOS function if the SS2 delay time has expired.

With SS2, braking is monitored on the OFF3 ramp. A faulty acceleration is detected and the drive then shuts down with STO.



If you are operating the motor with closed-loop torque control, the converter switches to the closed-loop speed control mode when SS2 is selected.

Detailed description

The failsafe logic (e.g. F-CPU) selects the SS2 safety function via a failsafe input or via the PROFIsafe safe communication.

- If, when selecting SS2, the motor is already at a standstill, after a delay time, the converter activates the Safe Operating Stop function (SOS).
- If the drive is not at standstill when SS2 is selected, it is braked along the OFF3 ramp. Braking is monitored with one of the following functions, depending on the setting in p9506:
  - "Safe Acceleration Monitor (SAM)"

    A faulty acceleration is therefore detected.
  - "Safe Brake Ramp (SBR)"

    In this way, a violation of the braking ramp is detected.

  After a delay time, the converter activates the Safe Operating Stop function (SOS). This function monitors the safe standstill of the drive.

Braking behavior

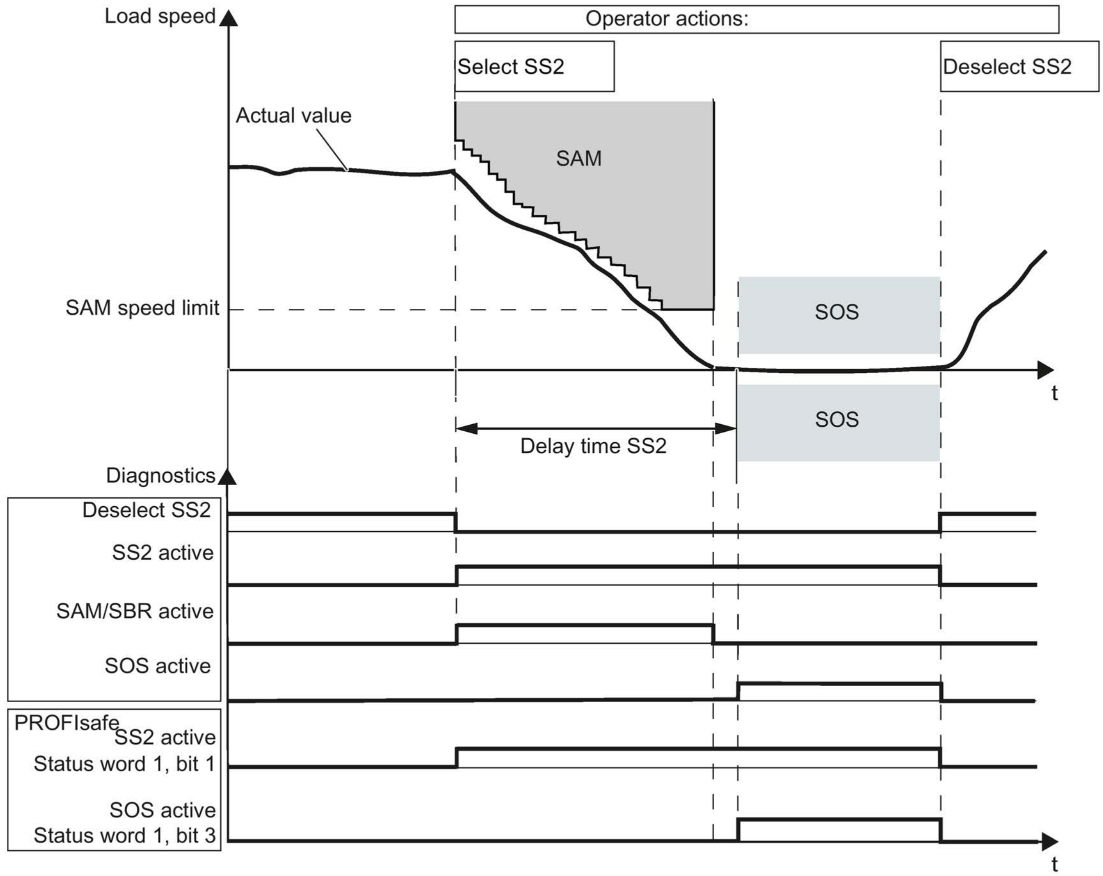


Figure 3-2 Braking behavior and diagnostics of the safety function SS2 (example of SS2 with SAM)

Note

SS2 with external stop (SS2E)

If you use SS2E, neither of the two monitoring functions (SBR, SAM) is active. The drive must be shut down in SS2E within the delay time, for example, by a user program of a CPU. SOS becomes active after the delay time expires.

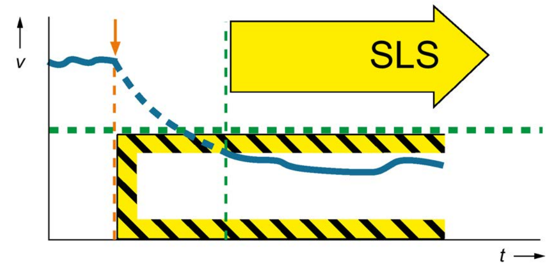
Details and parameterization

For further details and information on how to parameterize this function, see Chapter "Safe Stop 2 (SS2) (Page 105)".

3.2.7 Safely Limited Speed (SLS)

Definition according to EN 61800-5-2:

"The SLS function prevents the motor from exceeding the specified speed limit."



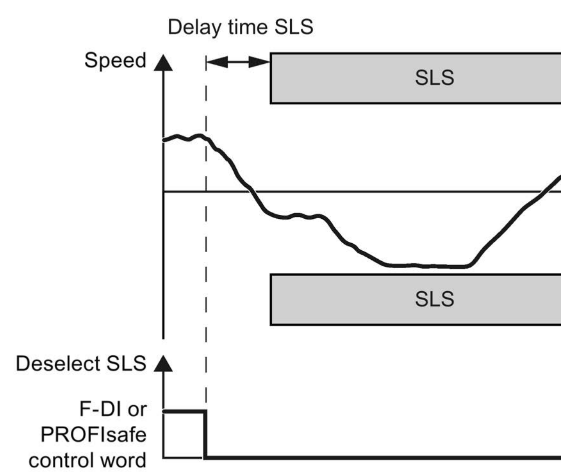
Examples of how the function can be used

Example	Possible solution
The machine operator must be able to enter the machine after the protective door has been opened and slowly move a horizontal conveyor with an acknowledgment button in the danger zone.	• Select SLS in the converter via a fail-safe input or PROFIsafe . • The converter limits and monitors the velocity of the horizontal conveyor.
A spindle drive, depending on the selection of the cutting tool, must not exceed a specific maximum velocity.	• Select SLS and the corresponding SLSlevel in the converter via PROFIsafe.

How does SLS function in detail?

1. The inverter recognizes the selection of SLS via a fail-safe input or via the PROFIsafe safe communication.
2. SLS allows a motor to reduce its possibly inadmissibly high speed within a defined time.
   SLS monitors the current speed.

   The SLS setpoint limit can be transferred to the higher-level motion controller (e.g. SIMOTION), where the speed setpoint can be limited.



In addition, you can configure the setpoint limit provided by SLS as maximum speed in the ramp-function generator. In this case, SLS limits the speed setpoint.

3. SLS monitors the absolute value of the current speed.

   The SLS setpoint limit can be transferred to the higher-level motion controller (e.g. SIMOTION), where the speed setpoint can be limited.

   In addition, you can configure the setpoint limit provided by SLS as maximum speed in the ramp-function generator. In this case, SLS limits the speed setpoint.

Note

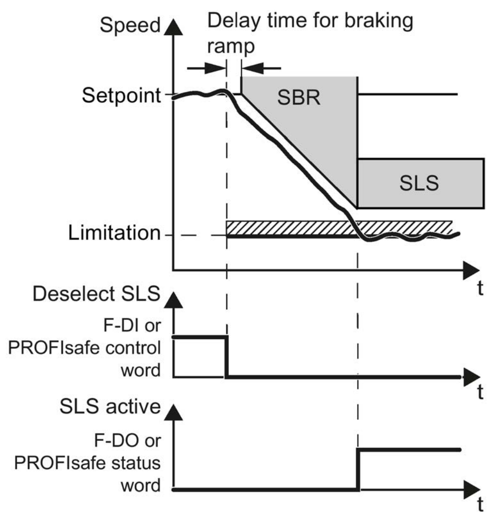
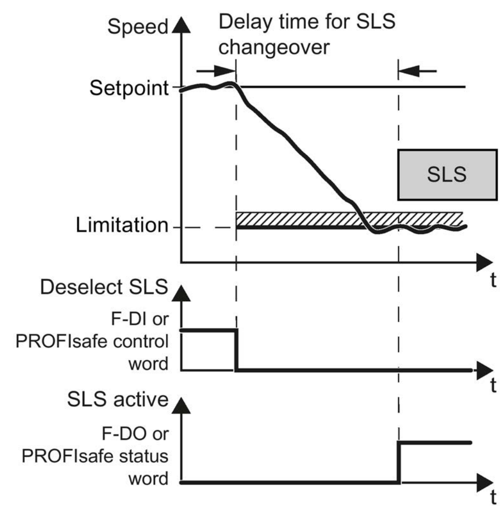
SLS without selection

As an alternative to controlling via terminals and/or PROFIsafe, there is also the option to parameterize the SLS function without selection. In this case, the SLS function is permanently active after POWER ON. You will find details about this in Section "Safely-Limited Speed without selection (Page 119)".

Selecting SLS when the motor is switched on

As soon as the converter detects the selection of SLS via a fail-safe input or via PROFIsafe safe communication, the following happens:

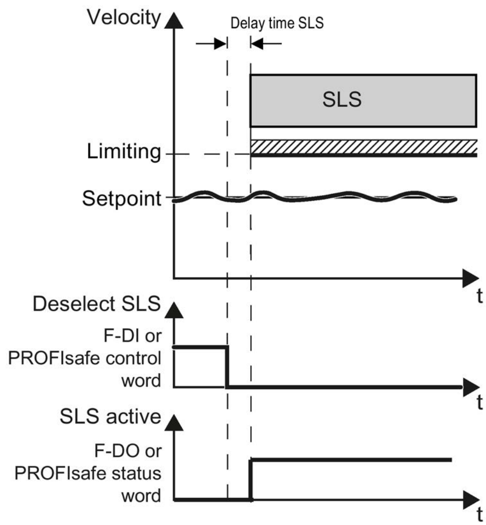
- To avoid a limit value being violated, the setpoint limit can be transferred to the higher-level motion controller (e.g. SIMOTION). The higher-level motion controller can then limit the velocity setpoint.
- If the speed setpoint limitation is interconnected to the ramp-function generator, the converter limits the speed to a value below the SLS monitoring.
- For SLS without encoder, you can select whether the converter monitors motor braking using the function SBR (Safe Brake Ramp) or not. For SLS with encoder, the SBR function cannot be selected.

With braking ramp monitoring[1)](only without encoder)	Without braking ramp monitoring (with or without encoder)
	
• After the adjustable "delay time for the braking ramp", using the SBR (Safe Brake Ramp) function, the converter monitors whether the velocity decreases. • The converter switches from SBR to SLS as soon as one of the following two conditions is fulfilled: – The SBR monitoring ramp has reached the value of the SLS monitoring. This case is shown in the diagram above. – After the actual velocity has reached the value of the SLS monitoring threshold, the system again waits for the "delay time for braking ramp" until SLS becomes active.	• The converter monitors the load velocity after the "delay time for SLS switchover" has expired.
Advantages: • Already when braking, the converter detects as to whether the load velocity decreases too slowly. • The feedback signal "SLS active" generally comes earlier than without acceleration monitoring.	Advantage: • Commissioning is simplified, because instead of the subfunction SBR or SAM of the alternative brake ramp monitoring, you only have to set the delay time.

1) The automatic reduction of the speed only takes effect when the ramp-function generator is interconnected to the speed setpoint limitation.

Selecting SLS at low velocities

If the motor velocity when selecting SLS is less than the SLSlimit, then the drive responds as follows:



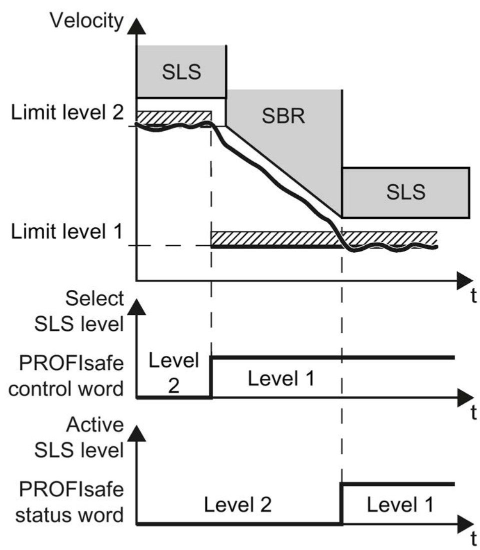
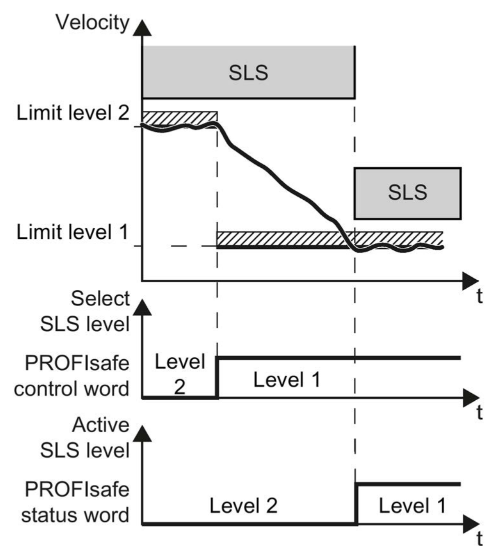
Deselecting SLS

If the higher-level controller deselects SLS , then the converter deactivates limiting and monitoring.

Switching over the monitoring limits

When SLS is active, you can switchover between 4 different speed levels. An exception is "SLS without selection": In this case, there is only one limit.

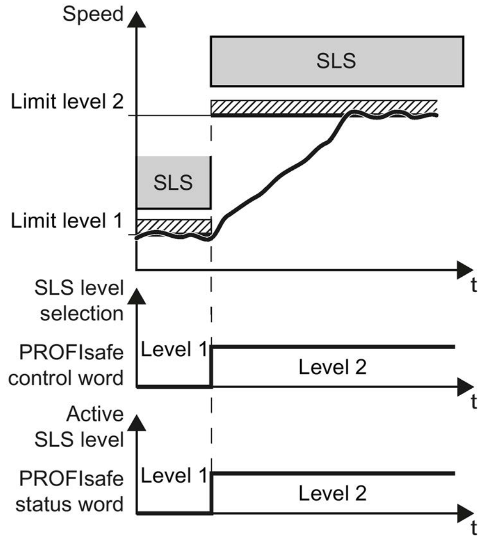
Switching to a lower speed level

<table>
<tr><th>With braking ramp monitoring[1)]
(only without encoder)</th><th>Without braking ramp monitoring
(with or without encoder)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Once the "delay time for braking ramp" has elapsed, the converter monitors the motor velocity using the function SBR (Safe Brake Ramp).
The converter switches over from SBR monitoring to level 2 of SLS monitoring as soon as one of the following conditions is fulfilled:
The SBR monitoring ramp has reached the value of the SLS monitoring.
This case is shown in the diagram above.
The load velocity has decreased down to the value SLS monitoring and the "delay time for braking ramp" has expired.</td><td>The converter monitors the velocity with the lower SLS level after the "delay time for SLS changeover" has expired (this is the same delay time that applies after selecting the function SLS).</td></tr>
</table>

1) The automatic reduction of the speed only takes effect when the ramp-function generator is interconnected to the speed setpoint limitation.

Switching to a higher speed level

If you switch over from a lower to a higher speed level, the converter immediately monitors the actual velocity against the higher velocity.



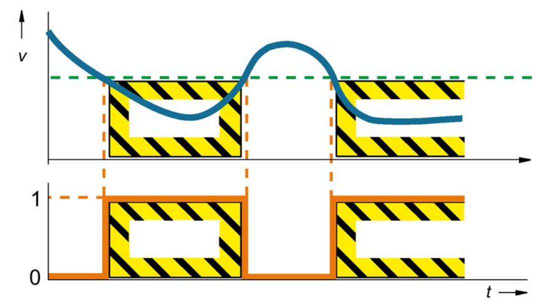
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safely-Limited Speed (SLS) (Page 112)".

3.2.8 Safe Speed Monitor (SSM)

Definition according to EN 61800-5-2:

"The SSM function supplies a safe output signal to indicate whether the motor speed is below a specified limit value."



Note

SSM is a pure signaling function

Contrary to other Safety Integrated functions, a violation of the SSM limit does not result in a drive-based stop response.

Example of how the function can be used

Example	Possible solution
A centrifuge may only be filled below a velocity defined by the user.	• SSM is activated by configuring the Safety Integrated Extended Functions. • The converter safely monitors the centrifuge speed and enables the process to advance to the next step using the "Status SSM" status bit.

How does SSM function in detail?

Requirements

The safety function SSM cannot be selected or deselected using external control signals. SSM is active when you have set a monitoring velocity > 0 for SSM .

Evaluating the speed

The converter compares the load speed with the speed limit and signals if the limit value is undershot to the high-level control.

Parameterizable hysteresis

The parameterizable hysteresis ensures that the SSM output signal does not jump between the values "0" and "1" in the limit range.

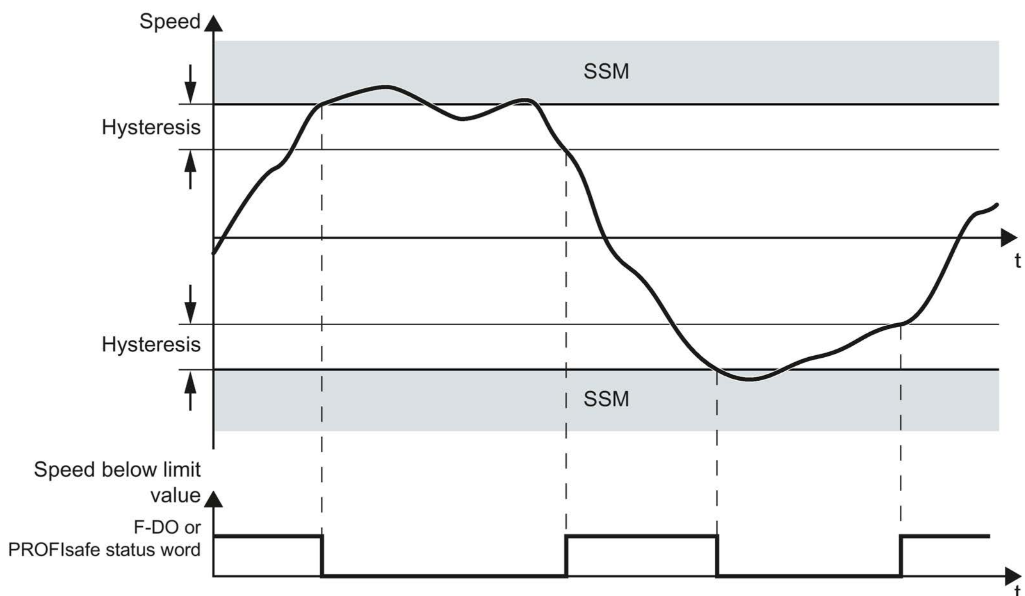


Figure 3-3 Time response of the safety function SSM (Safe Speed Monitor)

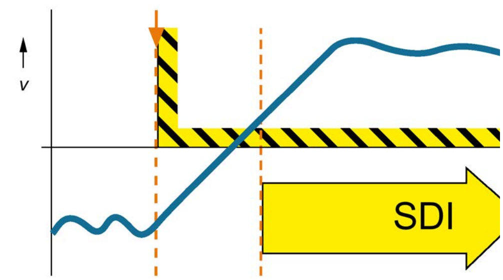
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Speed Monitor (SSM) (Page 121)".

3.2.9 Safe Direction (SDI)

Definition according to EN 61800-5-2:

"The SDI function prevents the motor shaft moving in the wrong direction."



Examples of how the function can be used

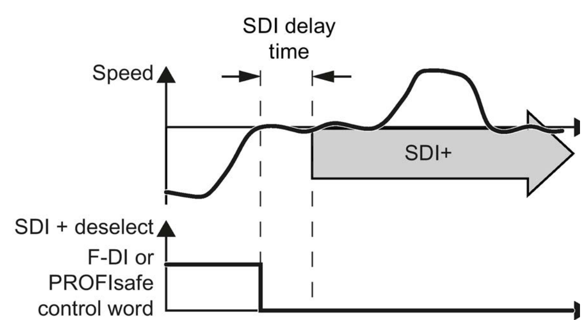
Example	Possible solution
A protective door must only be opened if a drive moves in the safe direction (away from the operator).	• Select SDI in the converter using a fail-safe input or PROFIsafe . • Enable the locking mechanism of the protective doors via the PROFIsafe status bit of the converter.
When replacing the pressure cylinders of the plates, the drive must only move in the safe direction of rotation.	• Select SDI in the converter using a fail-safe input or PROFIsafe . • In the converter, inhibit the direction of rotation that is not permitted.
Once the protection against jamming has been triggered, a roller shutter gate must only be able to start moving in one direction.	
At an operational limit switch, the trolley of a crane must only be able to start in the opposite direction.	

How does SDI function in detail?

SDI monitors the actual direction of rotation.

The SDI setpoint limit can be transmitted to the higher-level motion controller (e.g. SIMOTION) to enable limitation of the velocity setpoint there.

In addition, you can configure the setpoint limit provided by SDI as maximum speed in the ramp-function generator. In this case, SDI limits the speed setpoint to the permissible direction.



You can select to block either the positive or the negative direction of rotation via 2 fail-safe signals (F-DIs or PROFIsafe).

Selecting and deselecting SDI

As soon as the converter identifies that SDI has been selected via a failsafe input or via PROFIsafe safe communication, the following happens:

- You can also set a delay time, within which you can ensure that the converter moves in the enabled (safe) direction.
- You can also set a tolerance, within which the converter tolerates movement in the direction that has not been enabled (unsafe). You can avoid the triggering of faults during braking (overshoot) as well as in controlled standstill.
- After the delay time has expired, the converter monitors the direction of rotation of the motor.
- If the converter now moves in the blocked direction by more than the configured tolerance, a message will be output and the defined stop response will be initiated.

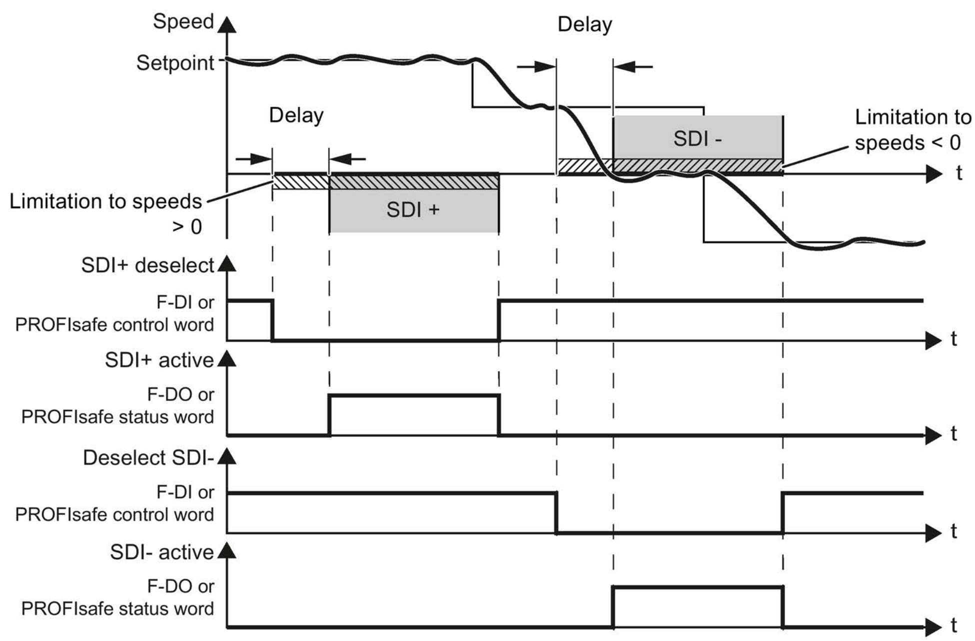


Figure 3-4 Time response of the safety function SDI (Safe Direction)

Note

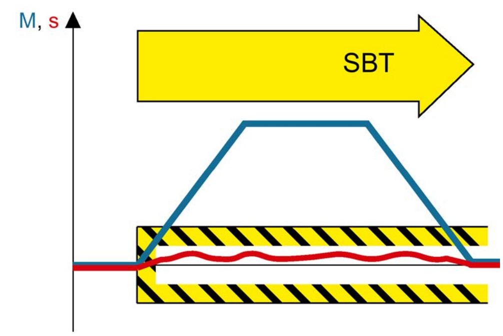
SDI without selection

As an alternative to controlling via terminals and/or PROFIsafe, there is also the option of parameterizing SDI without selection. In this case, SDI will be permanently active after POWER ON. You will find details about this in Section "Safe Direction without selection (Page 133)".

Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Direction (SDI) (Page 128)".

3.2.10 Safe Brake Test (SBT)



The diagnostic function "Safe Brake Test" function (SBT) checks the required holding torque of a brake (operating or holding brake).

You can test linear axes and rotary axes. The drive purposely generates a force/torque against the applied brake. If the brake is operating correctly, the axis motion remains within a parameterized tolerance. If, however, a larger axis motion is detected, it must be assumed that the braking force/torque has deteriorated and maintenance is required.

The "Safe Brake Test" function allows a safe test of up to two brakes:

- 1 motor holding brake and 1 external brake
- 2 external brakes
- 1 motor holding brake
- 1 external brake

The "Safe Brake Test" (SBT) diagnostic function is suitable for safety functions up to Category 2 according to ISO 13849-1.

Details and parameterization

For further details and information on how to parameterize this function, see Chapter "Safe Brake Test (SBT) (Page 138)".

3.2.11 Safely-Limited Acceleration (SLA)

Definition according to EN 61800-5-2:

"The SLA function prevents the motor from exceeding the defined acceleration limit."

Examples of how the function can be used

Example	Possible solution
In the setup mode, it is not permissible that the drive exceeds the permissible acceleration.	• Select SLA in the converter via PROFIsafe. • The converter limits and monitors the acceleration of the machine.

Details and parameterization

For further details and information on how to parameterize this function, see Chapter "Safely Limited Acceleration (SLA) (Page 135)".

3.3 Safety Integrated Advanced Functions

This chapter should provide first users with a quick overview of the principle mode of operation of safety functions.

The entry into the description of the safety functions is based on the definition according to standard EN 61800-5-2 and some simple examples for using the function.

The description of the functions is simplified, as far as possible to clearly shown essential properties and setting options.

You will find more information on the functions in the following chapters, e.g. "Safety Integrated Advanced Functions (Page 178)".

3.3.1 Preconditions for Safety Integrated Extended Functions

- For operation of the Safety Integrated Extended Functions, **one** license is required for **each** axis.
- To use Safety Integrated Advanced Functions, **one** license is required for **each** axis. The license for Safety Integrated Advanced Functions also includes the license for Safety Integrated Extended Functions.
- Overview of hardware components that support the Extended/Advanced Functions:
  - Control Unit CU320-2
  - Control Unit CU310-2
  - SINAMICS HLA
  - Motor Modules Booksize Compact
  - Motor Modules booksize C/D type with article No.: -..C. or -..D.
  - Motor Modules booksize with an article number ending: -...3 or higher
  - Motor Modules chassis with an article number ending: -...3 or higher
  - Motor Modules cabinet with an article number ending: -...2 or higher
  - Power Modules blocksize
  - Control Unit Adapter CUA31 as of article number: 6SL3040-0PA00-0AA1
  - Control Unit Adapter CUA32 as of article number: 6SL3040-0PA01-0AA0
  - For the safety functions with encoder:

    Motors with sin/cos encoder and encoder evaluation with DRIVE-CLiQ interface or via Sensor Module SMC20, SME20/25/120/125, square wave signal encoder with SMC30, EnDat-2.2 encoder with SMC40

    The list of approved encoders can be found on the Internet at:

    Approved encoders (https://support.industry.siemens.com/cs/ww/en/)

    Enter the number **33512621** there as search term or contact your local Siemens office.

3.3.2 Safely-Limited Position (SLP)

Definition according to EN 61800-5-2:

"The SLP function prevents the motor shaft from exceeding the specified position limit(s)."

The Safely-Limited Position function (SLP) is used to safely monitor the limits of two traversing and/or positioning ranges, which are toggled between using a safe signal.

Examples of how the function can be used

Example	Possible solution
The drive must not exit the specified position rang-es.	• Selection of SLP in the converter; inhibiting the range that is not permitted. • After the enabled range has been exited, a parameterizable stop response is initiated.

Features

- Selection via terminals or PROFIsafe
- 2 position ranges, each defined by a limit switch pair
- Safe switchover between the two position ranges
- Settable stop response
- To run the motor out of the prohibited range, you must perform a special sequence (see Chapter "Retraction (Page 182)").

Preconditions

- The function is only available with a suitable encoder.
- The drive has to be safely referenced (see Chapter "Safe referencing (Page 65)").

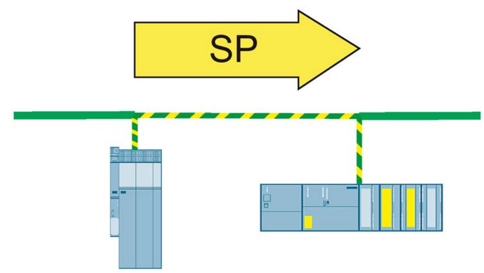
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safely-Limited Position (SLP) (Page 178)".

3.3.3 Transferring safe position values (SP)

The "Safe Position (SP)" function enables you to transfer safe position values to the higher-level fail-safe controller (F-CPU) via PROFIsafe (telegram 901 or 902).

On the F-CPU side, you can also calculate the current speed from the change in position per time. In telegram 902, the values are transferred in 32-bit format, in telegram 901, in 16-bit format.



After parameter assignment, enabling and POWER ON, the function is automatically selected. The drive transfers the value. Please observe the following:

- For use as the safe absolute position, the "Absolute position" must also be enabled and then safely homed.
- To allow the controller to continue using the transferred position, the actual position value must be valid.

Using the time stamp that is also transferred, you can also calculate the velocity from the position values. If you only want to calculate the speed, just enable the "Transfer of safe position values" without the "Absolute position."

Details and parameterization

For further details and information on how to parameterize this function, see Chapter "Transferring safe position values (SP) (Page 185)".

3.3.4 Safe referencing

The "safe referencing" function allows a safe absolute position to be defined. This safe position is used for the following functions:

- Safely-Limited Position (SLP) (Page 64)
- Transferring safe position values (SP) (Page 65)
- Safe Cam (SCA) (Page 67)

General description

In most cases, an external control performs referencing to an absolute position. The converter only performs this task in special cases (for example, EPOS).

- Referencing using an external control

  Requirement: No movement of the drive

  The reference position determined by the control is entered into parameter p9572 and is declared to be valid using p9573 = 89.

- Referencing by EPOS

  The SINAMICS EPOS function transfers, when referencing, the determined position directly to Safety Integrated. This can also take place during motion.

- User agreement

  The user agreement must be set (p9726 = p9740 = AC hex) within a certain time interval after homing (see Chapter "Safe referencing (Page 190)").

Safety Integrated only evaluates the home position if this is required by a function that has been enabled (e.g. SLP). Using diagnostics bit r9723.17, Safety Integrated indicates whether the drive has been referenced. Safety Integrated indicates the position of the drive in diagnostic parameters r9708 and r9713. Bit r9722.23 is set when the axis is safely referenced.

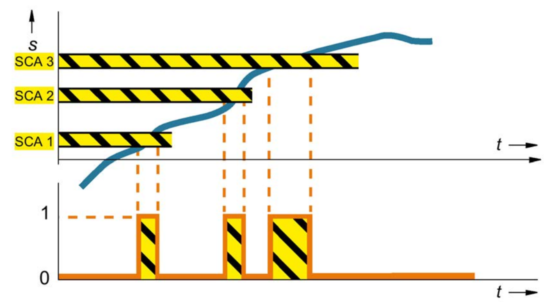
Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe referencing (Page 190)".

3.3.5 Safe Cam (SCA)

Definition according to EN 61800-5-2:

The function "Safe Cam" (SCA) safe supplies a safety-related output signal to indicate whether the motor shaft position is within a defined range.



The "Safe Cam" function outputs a safe signal if the drive is within a specified position range. It facilitates the realization of safe range detection for each individual axis.

Details and parameterization

For further details and information on how to parameterize this function, see Section "Safe Cam (SCA) (Page 192)".

Description of Safety Integrated functions 4

Two-channel parameterization

Parameterization of the Safety Integrated Functions must be performed in two channels; i.e. there is one parameter each for the 1st and 2nd channel. These two parameters must be identically parameterized.

For safety reasons, when using the Startdrive commissioning tool, only set the safety-related parameters of the 1st channel while offline. Startdrive copies the parameter of the 2nd channel automatically.

Because Startdrive sets the safety-related parameters of the 2nd channel by copying, only the parameters of the 1st channel are given in this manual. You will find the relevant parameters of the 2nd channel in the parameter description, e.g. in SINAMICS S120/S150 List Manual.

On faults and alarms, only the error number of the 1st channel is stated.

4.1 Safety Integrated basic functions

Note

Basic Functions do not require an encoder

The Safety Integrated Basic Functions are functions for safely stopping the drive. You do not require an encoder.

Note

Application of the Basic Functions

Basic Functions are available in all control modes with and without encoder for synchronous and induction motors without any restrictions.

Note

Control via TM54F

If you want to control the Safety Integrated Basic Functions via TM54F, set p9601.6 = 1.

Note

PFH values

The PFH values of the individual SINAMICS S120 safety components can be found at:

PFH values (https://support.industry.siemens.com/cs/ww/en/view/76254308)

4.1.1 Safe Torque Off (STO)

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 supply to the motor.

A restart is prevented by the two-channel pulse suppression. The switching on inhibited prevents an automatic restart after deselection of STO.

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

Functional features of "Safe Torque Off"

- The function is completely integrated in the drive. It can be selected via terminals, TM54F or PROFIsafe from an external source.
- The function is drive-specific, i.e. it is available for each drive and must be individually commissioned.
- The function must be enabled via parameter.

- 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 supply to the motor.
  – The power unit and motor are not electrically isolated.
- The selection/deselection of the STO function also acknowledges the safety faults when the Basic Functions are used. The standard acknowledgment mechanism must also be performed.
- Extended acknowledgement:

  The selection/deselection of STO can also acknowledge the safety messages of the extended safety functions. This requires that the extended message acknowledgement is configured (p9507.0 = 1).

  If in addition to the "Extended Functions", the "Basic Functions via terminals" are also enabled, in addition to selection/deselection of STO via PROFIsafe or TM54F, acknowledgement is also possible by selection/deselection of STO via terminals.
- The status of the "Safe Torque Off" function is displayed using parameters (r9772, r9872, r9773 and r9774).
- Effect on the "Setpoint speed limit effective" (r9733[0...2]):

  For STO (≙ STOP A), a setpoint of 0 is specified in r9733[0...2].

WARNING

Unplanned motor motion

After the energy feed has been disconnected (STO active) the motor can undesirably move (e.g. the motor can coast down), therefore presenting risk to persons.

- Take suitable measures to prevent undesirable movement, e.g. by using a brake with safety-relevant monitoring. For additional information, see Chapter "Safe Brake Control (SBC) (Page 78)".

WARNING

Danger due to short, limited movements

If two power transistors simultaneously fail in the power unit (one in the upper and one in the lower inverter bridge), then this can cause cause brief, limited movement.

The maximum movement can be:

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

Enabling the "Safe Torque Off" function

The "Safe Torque Off" function is enabled via parameter p9601:

- STO for the Safety Integrated Basic Functions:
  - p9601 = 1 hex (Basic Functions via onboard terminals)
  - p9601 = 8 hex (Basic Functions via PROFIsafe)
  - p9601 = 9 hex (Basic Functions via PROFIsafe and onboard terminals)
  - p9601 = 40 hex (basic functions via TM54F)
  - p9601 = 41 hex (basic functions via TM54F and onboard terminals)
- STO in the Safety Integrated Extended Functions (EF):
  - p9601 = 4 hex (EF via TM54F)
  - p9601 = 5 hex (EF via TM54F and basic functions via onboard terminals)
  - p9601 = C hex (EF via PROFIsafe)
  - p9601 = D hex (EF via PROFIsafe via onboard terminals)
  - p9601 = 25 hex (EF without selection and basic functions via onboard terminals)

Selecting/deselecting "Safe Torque Off"

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

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

Deselecting "Safe Torque Off" represents an internal safety acknowledgment. The following is executed if the cause of the fault has been removed:

- Each monitoring channel cancels safe pulse suppression via its switch-off signal path.
- The Safety requirement "Close motor holding brake" is canceled.
- Any pending STOP F or STOP A commands are canceled (see r9772).
- The messages in the fault memory must also be reset using the general acknowledgment mechanism.

Note

No message for selection/deselection within the tolerance time (p9650)

If "Safe Torque Off" is selected and deselected through one channel within the tolerance time p9650, the pulses are suppressed without a message being output.

However, if you want a message to be displayed, then you must reconfigure N01620 as an alarm or fault using p2118 and p2119.

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

1. Deselect the function.
2. Set drive enables.
3. After deselecting STO, wait until the converter is "ready to switch on".
4. Cancel the "switching on inhibited" and switch the drive back on.
   – 1/0 edge at input signal "ON/OFF1" (cancel "switching on inhibited")
   – 0/1 edge at input signal "ON/OFF1" (switch on drive)

Status for "Safe Torque Off"

The status of the function STO is displayed via r9772, r9872, r9773, and r9774. Alternatively, you can display the status of the function via the configurable message N01620 (configuration via p2118 and p2119).

Response time for the "Safe Torque Off" function

For the response times when the function is selected/deselected via input terminals, see the table in Section "Response times (Page 355)".

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

The function "internal armature short-circuit" can be configured together with the "STO" function.

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.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2810 SI Basic Functions - STO (Safe Torque Off), SS1 (Safe Stop 1)
- 2811 SI Basic Functions - STO (Safe Torque Off), safe pulse suppression

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9601 SI enable functions integrated in the drive (Control Unit)
- r9720 CO/BO: SI Motion drive-integrated control signals
- r9722 CO/BO: SI Motion drive-integrated status signals (Control Unit)
- r9772 CO/BO: SI Status (Control Unit)
- r9773 CO/BO: SI Status (Control Unit + Motor Module)
- r9774 CO/BO: SI Status (group STO)

4.1.1.1 Safe Torque Off (STO) for SINAMICS HLA

For the HLA module, safe torque off (STO) corresponds to shutting off a safety-relevant shutoff valve.

Special features of STO for HLA

- The shutoff valve controls the infeed to the hydraulic circuit. The shutoff valve is controlled via an F-DO of SINAMICS HLA.
- For Safety Integrated Functions, it is absolutely necessary that a shutoff valve is connected with the associated feedback signals.
- You configure the feedback signal contacts of the shutoff valve using parameter p9626.
- You can take into account the response times of the feedback signals using parameter p9625.
- The shutoff valve is safely closed by selecting STO. If the shutoff valve signals a safe state via the feedback signal(s), the "STO active/Power removed" state is displayed, and is output at the configured safety-related output (PROFIsafe feedback signal telegram, F-DO on TM54F).

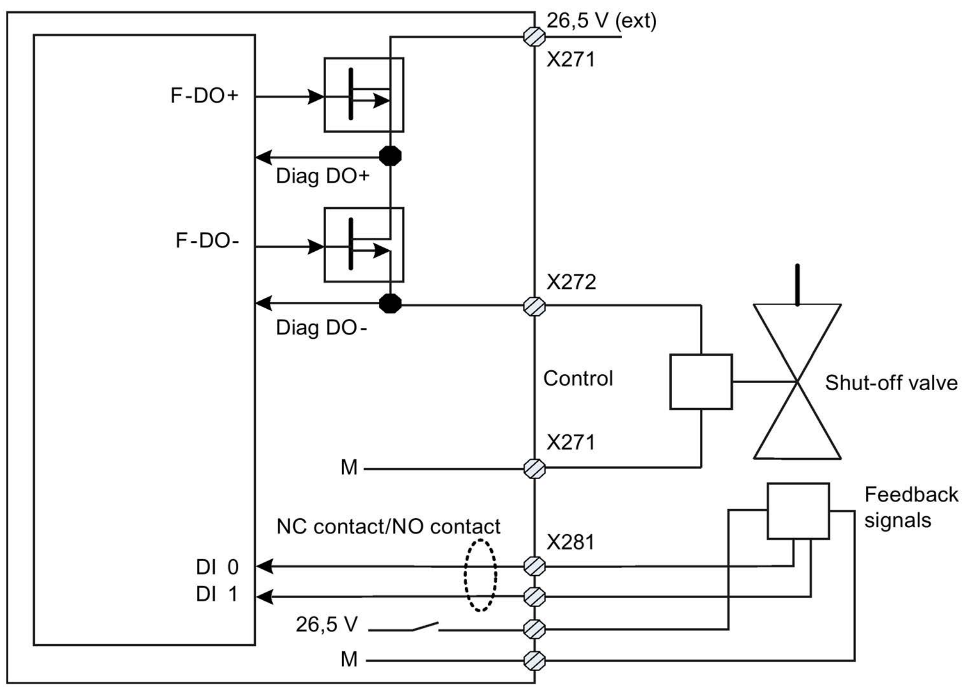


Figure 4-1 Interconnecting the shutoff valve (for an axis)

- F-DO is dynamized each time that STO is selected/deselected: "Diag DO+" and "Diag DO-" are checked when switching F-DO+ and F-DO-.
- This makes it unnecessary to select forced checking procedure (test stop) explicitly.
- If an error occurs in the forced checking procedure (test stop), the converter will issue fault F01632 or F30632.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2810 SI Basic Functions - STO (Safe Torque Off), SS1 (Safe Stop 1)
- 2811 SI Basic Functions - STO (Safe Torque Off), safe pulse cancellation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9625[0...1] SI HLA shutoff valve wait time (CU)
- p9626 SI HLA shutoff valve feedback contacts configuration (CU)
- r9773 CO/BO: SI Status (Control Unit + Hydraulic Module)
- r9774 CO/BO: SI Status (group STO)
- r9780 SI monitoring cycle (Control Unit)

4.1.2 Safe Stop 1 (SS1, time controlled)

4.1.2.1 SS1 with OFF3

The "Safe Stop 1" (SS1) function allows the drive to be stopped in accordance with EN 60204-1, Stop Category 1. The drive decelerates with the OFF3 ramp (p1135) once "Safe Stop 1" is selected and switches to "Safe Torque Off" (STO) once the delay time set in p9652 has elapsed.

Note

Selection via terminals

The selection of the "Safe Stop 1" (time-controlled) function via terminals is parameterized by setting a delay > 0 in p9652. In this case, the STO function can no longer be selected directly via terminals, i.e. either STO or SS1 can be selected via terminals.
If the "Safe Stop 1" (time-controlled) function has been selected by parameterizing a delay time in p9652, STO can no longer be selected directly via terminals.

Precondition

- The Basic Functions are enabled via terminals and/or PROFIsafe:
  - p9601 = 1, 8 or 9 (hex)
- Enabling Basic Functions via TM54F
  - p9601.6 = 1
- In order that the drive can brake down to a standstill even when selected through one channel, the time in p9652 must be shorter than the sum of the parameters for the data cross-check (p9650 and p9658). Otherwise the drive will coast down after the time p9650 + p9658 has elapsed.

Functional features of Safe Stop 1

SS1 is enabled by p9652 (delay time) ≠ 0.

- Setting parameter p9652 has the following effect:
  - p9652 = 0

    SS1 is not enabled. Only STO can be selected via TM54F, the onboard terminals and/or PROFIsafe.
  - p9652 > 0

    SS1 is enabled. Only SS1 can be selected via the onboard terminals; with PROFIsafe, a selection of SS1 and STO is possible.
- 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).

  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 deselected immediately.

  Note

  Setting the delay time

  So that the drive is able to travel down the OFF3 ramp completely and any motor holding brake present can be applied, before the pulses have been safely deleted, the delay time should be set as follows:

  - Motor holding brake parameterized: Delay time p9652 ≥ p1135 + p1228 + p1217
  - Motor holding brake not parameterized: Delay time p9652 ≥ p1135 + p1228
  - The setting of parameter p1135 must be oriented towards the actual braking capability of the drive.

- The timer (p9652) after whose expiration STO is activated, is implemented with two channels, although deceleration along the OFF3 ramp is only one channel.
- Effect on "Speed setpoint limit effective" (r9733[0...2]):

  If SS1 (≙ STOP B), setpoint 0 is specified in r9733[0...2].

Status of Safe Stop 1

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

As an alternative, the status of the function can be displayed using the configurable message N01621 (configured using p2118 and p2119).

4.1.2.2 SS1 with external stop

In drive line-ups (e.g. drives that are mechanically connected via the material), the drive-independent braking on the respective OFF3 ramp can cause problems. If the SS1E function is used, the safe delay time (p9652) is started when the function is selected, but no OFF3 is triggered. The higher-level controller still enters the setpoint. The controller receives the information that SS1E has been selected via the Safety Info Channel.

⚠WARNING
Any axis motion is possible
During the delay time (p9652), for "Safe Stop 1 (time-controlled) with external stop", any axis movements are possible.

Differences between "SS1 with OFF3" and "SS1 with external stop"

"SS1 with OFF3" and "SS1 with external stop" have the following differences:

- In order to activate "Safe Stop 1 with external stop", **additionally** set p9653 = 1.
- When SS1E is selected, the drive is **not** braked along the OFF3 ramp, but after the delay time has expired (p9652), only STO/SBC is automatically initiated.

See also

Safe Brake Control (SBC) (Page 78)

4.1.2.3 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2810 SI Basic Functions - STO (Safe Torque Off), SS1 (Safe Stop 1)
- 2811 SI Basic Functions - STO (Safe Torque Off), safe pulse cancellation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1135[0...n] OFF3 ramp-down time
- p1217 Motor holding brake closing time
- p1228 Pulse suppression delay time
- p9601 SI enable functions integrated in the drive (Control Unit)
- p9652 SI Safe Stop 1 delay time (Control Unit)
- r9772.0...23 CO/BO: SI Status (Control Unit)
- r9773.0...31 CO/BO: SI Status (Control Unit + Motor Module)
- r9774.0...31 CO/BO: SI Status (group STO)

Only for "Safe Stop 1 (time-controlled) with external stop"

- p9653 SI Safe Stop 1 drive-based braking response

4.1.3 Safe Brake Control (SBC)

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

The opening and closing of the brake is controlled by the Motor Module / Power Module. Terminals are available for this on the device in booksize format. A Safe Brake Relay is also required for the "Safe Brake Control" in the blocksize format. A Safe Brake Adapter is required in the chassis format (starting with article numbers ending with ...3). When the Power Module is configured automatically, the Safe Brake Relay is detected and the motor holding brake type is defaulted (p1278 = 0).

Brake activation via the brake connection on the Motor Module / Safe Brake Relay (SBR) / Safe Brake Adapter (SBA) involves a safe, two-channel method.

Note

No SBC for SINAMICS HLA

SINAMICS HLA does not support Safe Brake Control.

Note

Controlling the brake via a relay for "Safe Brake Control":

If you use the "Safe Brake Control (SBC)" function, the use of relays/contactors can cause faults in the brake control when brakes are switched. For this reason, this type of control is not generally permissible.

WARNING

Undesirable motor motion due to defective brake

"Safe Brake Control" does not detect mechanical defects of the brake.

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 and/or closes. In SINAMICS S120M, a cable break is only identified when opening the brake.

For devices in chassis format with connected Safe Brake Adapter, the connecting cable between the Safe Brake Adapter and the motor brake is not monitored for cable break or short-circuit.

The aforementioned defects may trigger unwanted motor motion, which may result in physical injury or death.

- In particular, ensure the brake is not powered from an external source. Information on this topic can be found in EN 61800-5-2, Appendix D.
- During commissioning, test the brake using the diagnostic function "Safe Brake Test (SBT)" (Extended Function): Additional information is provided in Chapter "Safe Brake Test (SBT) (Page 138)".

Functional features of "Safe Brake Control"

- SBC is executed when "Safe Torque Off" (STO) is selected.
- In contrast to conventional brake control, SBC is executed via two channels.
- SBC is executed regardless of the brake control or mode set in p1215. However, SBC does not make sense for p1215 = 0 or 3.
- The function must be enabled using parameters.
- When the state changes, electrical faults, such as a short-circuit in the brake winding or wire breakage can be detected.

Enabling the "Safe Brake Control" function

The "Safe Brake Control" function is enabled via parameter p9602.

The SBC function can be used only together with STO. The selection of SBC alone is not possible.

2-channel brake control

Note

Connecting the brake

The brake cannot be directly connected to the Motor Module in chassis format. A Safe Brake Adapter is also required.

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

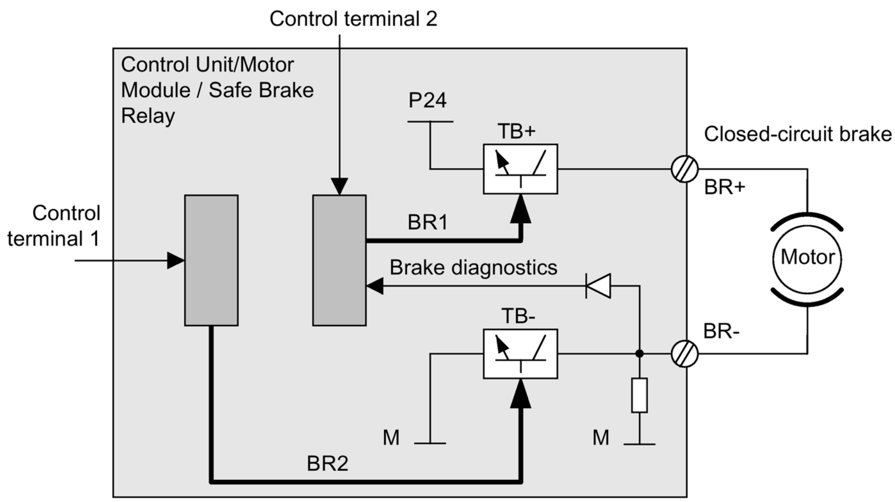


Figure 4-2 2-channel brake control, blocksize (example)

The Motor / Power Module carries out a check to ensure that the "Safe Brake Control" function is working properly and ensures that, if the Control Unit fails or is faulty, the brake current is interrupted and the brake applied.

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

If the Motor Module or Control Unit detects a fault, the brake current is switched off. The brake then closes and a safe state is reached.

4.1.3.1 SBC for Motor Modules in the chassis format

To be able to set higher power in the brakes of devices of this format, an additional Safe Brake Adapter (SBA) module is needed. For more information about connecting and wiring the Safe Brake Adapter, refer to the "SINAMICS G130/G150/S120 Chassis/S120 Cabinet Modules/S150 Safety Integrated" Function Manual.

Using parameter p9621, you can define via which digital input the relay (NO contacts) feedback signal of the Safe Brake Adapter is routed to the Control Unit.

To evaluate the feedback signal contacts, you must maintain the wait times caused by the SBA. Parameter p9622 is pre-assigned with the SBA-relay wait times:

- p9622[0] ≙ wait time, switching on
- p9622[1] ≙ wait time, switching off

Further functionality and the activation of the brake, i.e. reaching the safe status, are in this case the same as the above described procedure for booksize devices.

Safe Brake Control with power units in a parallel connection

Note

SBC for parallel connection of power units

Safe Brake Control with power units in a parallel connection is available if r9771.14 = 1.

If you wish to use SBC with SBA for chassis format power units connected in parallel, then it is only permissible that you connect precisely one SBA to a power unit in the parallel connection. The Safe Brake Adapter and therefore the brake are controlled via this power unit.

There are two options for registering this power unit with the system:

- Automatic brake identification when commissioning the system for the first time
  - Requirements:

    - No Safety Integrated functions enabled

    - p1215 = 0 (no motor holding brake available)
  - During the first commissioning, SINAMICS checks at which power unit an SBA is connected. If precisely one SBA is found, the number of the power unit is entered into parameter p7015.

    If several SBAs are found at the parallel-connected power units, message "F07935 drive: Motor holding brake configuration error" is output.
  - For devices in the chassis format, if the SBA feedback signal (SBA_DIAG) is read in via an input of the power unit, then in addition, this digital input is automatically entered into parameter p9621.
- Manually defining the power unit
  - Enter the component number of the power unit, to which the SBA is connected, into parameter p7015. If no SBA is connected to the power unit, faults are detected when controlling the motor holding brake and fault F01630 is output.
  - In parameter p9621 (p9621 = BICO interconnection to r9872.3), enter the digital input of the power unit to which the SBA is connected and via which the SBA feedback signal (SBA_DIAG) is read in.

Note

Disconnecting the brake cable for service purposes

As long as the brake is permanently released and not actuated, it is possible to briefly disconnect the brake cable, e.g. for service purposes, and not receive fault messages. In the case of a fault, message F07935 is only output when the brake is controlled.

4.1.3.2 Hardware required for SBC

- Safe Brake Relay

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

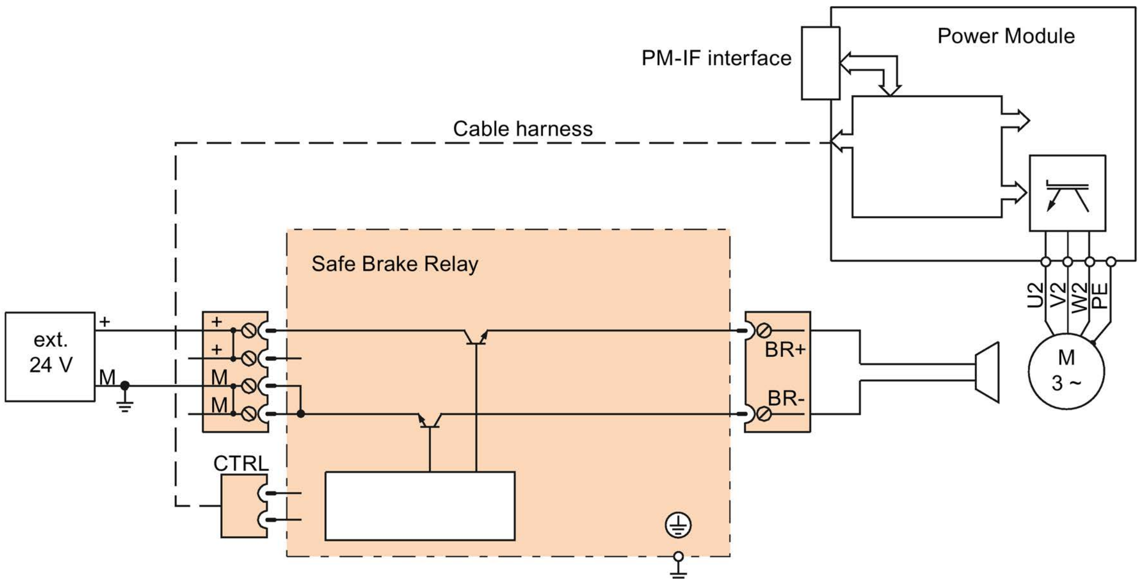


Figure 4-3 Interconnecting the Safe Brake Relay using Blocksize as an example

- Safe Brake Adapter

  The brake cannot be directly connected to the Motor Module in the chassis format. The connection terminals are only designed for 24 V DC with 150 mA; the Safe Brake Adapter is required for higher currents and voltages.

Note

Additionally required hardware for other formats

A Safe Brake Relay is also required for the "Safe Brake Control" in the blocksize format. With the chassis format (article numbers ending ...3 or higher), a Safe Brake Adapter is required. The Safe Brake Adapter is available for a 230 V AC brake control voltage.

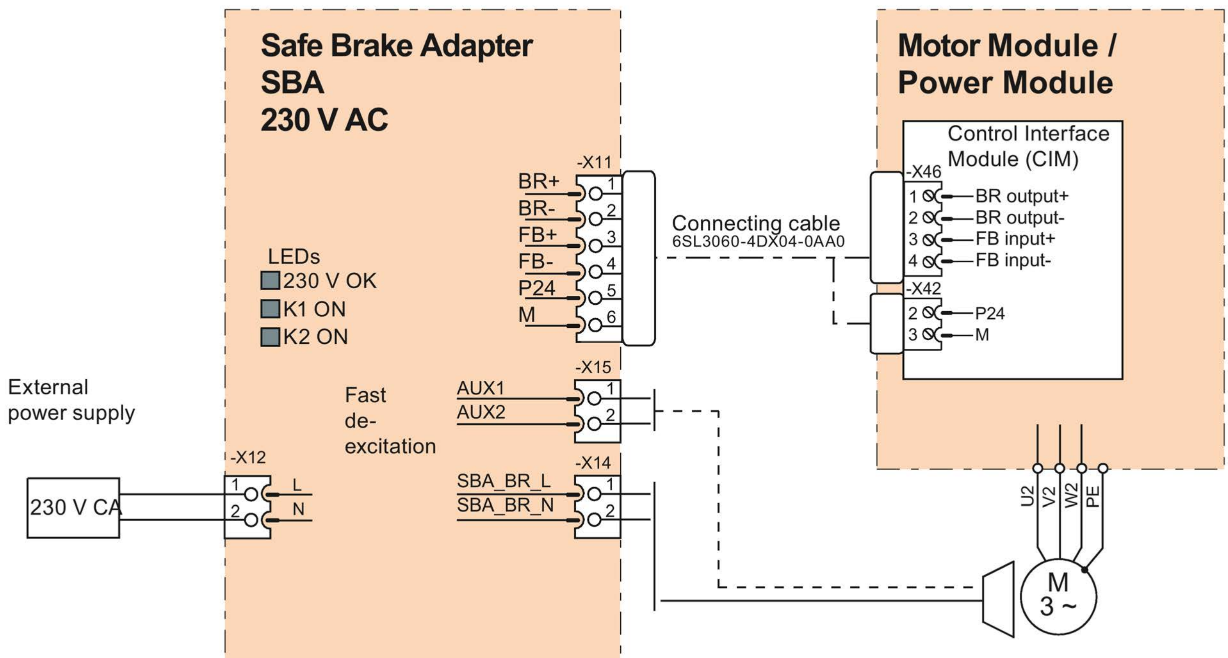


Figure 4-4 Interconnecting the Safe Brake Adapter

4.1.3.3 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2814 SI Basic Functions - SBC (Safe Brake Control), SBA (Safe Brake Adapter)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0799 CU inputs/outputs, sampling time
- p1215 Motor holding brake configuration
- p7015 Par_circuit holding brake power unit data set
- p9602 SI enable safe brake control (Control Unit)
- p9621 BI: SI Safe Brake Adapter signal source (Control Unit)
- p9622[0...1] SI SBA relay wait times (Control Unit)
- r9771.14 SI common functions (Control Unit): SBC supported for parallel connection
- r9780 SI monitoring cycle (Control Unit)

4.1.4 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. By contrast, the fault messages of the Safety Integrated Extended Functions are stored in a separate Safety message buffer (see Chapter "Message buffer (Page 382)").

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

Table 4- 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 acknowl-edged</td><td>For all Safety faults with pulse suppression that cannot be acknowledged.</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 rowspan="2">STOP A</td><td>For all acknowledgeable Safety faults
As a follow-up reaction of STOP F</td></tr>
<tr><td colspan="3">STOP A corresponds to Stop Category 0 in accordance with 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 rowspan="2">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 (factory set-ting without delay) if one of the safety functions is selected</td></tr>
<tr><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

Uncontrolled movement of the axis.

With a vertical axis or a pulling load, there is a danger of uncontrolled movement of the axis when STOP A/F if triggered.

This can cause serious injury or death to persons in the danger zone.

- If there is a hazard due to unwanted movement in your application, take measures to counter it, for example, by using a brake with safe monitoring. For additional information, see Chapter "Safe Brake Control (SBC) (Page 78)".

Acknowledging the Safety faults

There are several ways to acknowledge Safety faults:

- Acknowledgment through deselection of STO or SS1:
  - Remove the cause of the fault.
  - Deselect "Safe Torque Off" (STO) or "Safe Stop 1" (SS1).
  - Acknowledge the fault.

  If the Safety commissioning mode is exited when the Safety functions are switched off (p0010 ≠ 95 when p9601 = 0), all Safety faults can be acknowledged.

  Once safety commissioning mode has been selected again (p0010 = 95), all the faults that were previously present reappear.
- The higher-level controller sets the signal "Internal Event ACK" via the PROFIsafe telegram (STW bit 7). A falling edge in this signal resets the status "Internal Event" and so acknowledges the fault.
- Acknowledgment by switching the drive unit off/on

  Safety faults can also be acknowledged (as with 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

References

The faults and alarms for SINAMICS Safety Integrated Functions are described in the following document:

References: SINAMICS S120/S150 List Manual

4.1.5 Forced checking procedure (test stop)

Forced checking procedure or test of the switch-off signal paths (test stop) for Safety Integrated Basic Functions

The forced checking procedure (test stop) 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" (STO) or "Safe Stop 1" (SS1) 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 using the forced checking procedure (test stop), triggered either in the manual mode or by the automated process.

A timer ensures that forced checking procedure (test stop) is carried out in a timely fashion.

- p9659 SI forced checking procedure, timer.

A forced checking procedure (test stop) must be performed on the switch-off signal paths at least once during the time set in this parameter.

Once this time has elapsed, an alarm is output and remains active until forced checking procedure (test stop) is carried out.

The timer returns to the set value each time the STO/SS1 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. The user is therefore only informed that the forced checking procedure (test stop) is due in the form of an alarm, which requests the user to perform forced checking procedure (test stop) at the next possible opportunity. This alarm does not affect machine operation.

The user must set the time interval for carrying out forced checking procedure (test stop) to between 0.00 and 9000.00 hours depending on the application (factory setting: 8.00 hours).

Examples of when the forced checking procedure (test stop) must be performed:

- 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).
- The maximum time interval is one year (8760 hours).

Forced checking procedure (test stop) can be automatically executed at POWER ON.

- If the forced checking procedure (test stop) as well as the test of the F-DO for the CU310-2 are to be executed automatically, then set p9507.6 = 1. When testing the F-DO of the CU310-2, you must parameterize p10042 and activate the test in p10046.
- If the forced checking procedure (test stop) of the F-DI and F-DO of the TM54F is to be executed automatically, then set p10048 = 1.
- If you have parameterized the forced checking procedure (test stop) for POWER ON, you can still initiate a forced checking procedure (test stop) at any time as part of the engineered application.

- If the automatically initiated function cannot be correctly completed as a result of a problem (e.g. communication failure), then after the problem has been resolved, the function is automatically restarted.
- After the forced checking procedure (test stop) has been performed successfully, the converter goes into the "Ready" state.
- Timer p9659 is automatically reset as a result of the forced checking procedure (test stop).
- The automatic forced checking procedure (test stop) for POWER ON does not influence the Safety Integrated Functions.

Note

Resetting the timer of the Basic Functions

If when simultaneously using the Extended Functions, the forced checking procedure (test stop) is performed, then the timer of the Basic Functions is also reset.

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 checking procedure (test stop) of the Basic Functions must always be performed without the selection of STO or SS1 by the Extended Functions. It is otherwise not possible to verify the correct control through the terminals.

4.1.6 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2800 SI Basic Functions - Parameter manager
- 2802 SI Basic Functions - Monitoring functions and faults/alarms
- 2890 SI TM54F - Overview
- 2891 SI TM54F - Parameter manager
- 2900 SI TM54F - Basic Functions control interface (p9601.2/3 = 0, p9601.6 = 1)
- 2901 SI TM54F - Basic Functions Safe State selection
- 2902 SI TM54F - Basic Functions assignment (F-DO 0 ... F-DO 3)

4.2 Safety Integrated Extended Functions

Note

PFH values

The PFH values of the individual SINAMICS S120 safety components can be found at:

PFH values (https://support.industry.siemens.com/cs/ww/en/view/76254308)

4.2.1 License for Extended Functions or Advanced Functions

- **One** license is required for **each** axis that is operated with Safety Integrated Extended or Advanced Functions. You enter the associated license key with the "License Key" button in Startdrive. Then activate the license key via "Activate".

  As an alternative, you can enter the license key into parameter p9920 in the 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" or "SINAMICS Safety Integrated Advanced Functions" read the section "Licensing" in the SINAMICS S120 Function Manual. An insufficient license is indicated via the following fault and LED:
  - F13000 → licensing not sufficient
  - LED RDY → flashes red with 2 Hz
- When purchasing your drive, you can already decide to use Safety Integrated Functions, and you will then be provided with the required license(s) on the memory card supplied. In this case, you do not have to explicitly activate the licenses.
- A trial license is available for test purposes; this allows you to use Safety Integrated functions for a specific time without having a valid license.

  Details on the trial license can be found in the "SINAMICS S120 Function Manual Drive Functions", Chapter "Licensing".

4.2.2 Differences between Extended Functions "with encoder" and "without encoder"

If motors without a (safety-capable) encoder are being used, not all Safety Integrated Functions can be used. You will find general information on this distinction in Chapter "Drive monitoring with or without encoder (Page 36)."

Activation

For activation of the Safety Integrated Extended 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 Startdrive screen. To do this, in Startdrive, in the secondary navigation of the drive axis, select the "Drive functions > Safety Integrated > Function selection" menu item

- Operation with encoder
  p9506 = 0
  or
  p9506 = 2
- Operation without encoder
  p9506 = 1
  or
  p9506 = 3

Monitoring with an encoder

The Safety Integrated Functions with encoder are configured with p9506 = 0 (factory setting) or p9506 = 2 in the expert list or by selecting "with encoder" in the Safety screen.

- **If p9506 = 0:**

  Braking is monitored with the "Safe Acceleration Monitor" function.
- **If p9506 = 2:**

  Here, also for SS1, the monitoring function "Safe Brake Ramp" is active.

More detailed information on actual value acquisition with encoder can be found in Section "Notes regarding safe actual value sensing using an encoder system (Page 155)".

Monitoring without an encoder

The Safety Integrated Functions without encoder are configured in the expert list using p9506 = 1 or p9506 = 3 or by selecting "without encoder" in the Safety screen form.

- **For p9506 = 1, the following applies:**

  Here, also for SS1, the monitoring function "Safe Brake Ramp" is active.
- **For p9506 = 3, the following applies:**

  Braking is monitored with the "Safe Acceleration Monitor" function. The behavior corresponds to "monitoring with encoder".

Taking into account the slip of an induction motor

For Safety Integrated without encoder (depending on the drive load), as a result of slip (deviations between electrical and mechanical speed), deviations can occur between the safely determined electrical speed and the mechanical speed at the motor shaft.

Note

Sudden changes in the current and voltage curve (e.g. sudden change in the setpoint setting and load) and very small absolute values with a high proportion of noise generally result in faults of the safe encoderless actual value acquisition and must be avoided.

More detailed information on actual value acquisition without encoder can be found in Section "Notes regarding setting parameters for safe actual value sensing without encoder (Page 165)".

Note

Scope of functions

There are fewer Safety Integrated Extended Functions available "without encoder" than "with encoder" (see Section "Drive monitoring with or without encoder (Page 36)").

Note

Safety Integrated Functions "without encoder" for group drives

The Safety Integrated Functions "without encoder" are also permissible for group drives (multiple motors connected to one power unit).

"Parking" state for Safety Integrated Extended Functions with encoder

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Note

Extended Functions with encoder and "parking"

When a drive object, for which Safety Integrated Extended Functions with encoder are 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.

Basic Functions

- Basic Functions are available in all control modes with and without encoder for synchronous and induction motors without any restrictions.
- A safety-related encoder is not required for Basic Functions.
- The Safety Integrated Functions "without encoder" are also permitted for group drives (multiple motors connected to one power unit).

Extended Functions

Extended Functions SS1, SLS, SDI, and SSM "without encoder" do not require safety-related speed actual value sensing. If an encoder is used for the drive control, this has no influence on the sensorless safety functions. You can use Extended Functions "without encoder" with the following motor types:

- Induction motor in all control modes
- SIMOTICS A-1FU synchronous motors (previously: SIEMOSYN) with U/f control
- Synchronous-reluctance motors in vector control

The Safety Integrated Functions "without encoder" are also permitted for group drives (multiple motors connected to one power unit).

Note

The slip of an induction motor must be taken into account

For Safety Integrated without encoder (depending on the drive load), as a result of slip for induction motors (deviations between electrical and mechanical speed), deviations can occur between the safely determined electrical speed and the mechanical speed at the motor shaft.

When using Extended Functions, observe the following restrictions:

Synchronous reluctance motors with Safety Integrated Functions "without encoder"

SINAMICS S120 supports synchronous reluctance motors with Safety Integrated Functions "without encoder". Note the following information for this application case:

- Synchronous reluctance motors may only be operated with vector control.
- From the perspective of Safety Integrated, synchronous reluctance motors fall into the "asynchronous motor" category.
- Safety Integrated supported synchronous reluctance motors in the 0.55 to 98 kW range.

  Support of devices in "Chassis" format is intended for later firmware versions.
- Technical details:
  - Synchronous reluctance motors have no slip: The note "Slip of an induction motor must be taken into account" mentioned above does not apply to synchronous reluctance motors.
  - If you activate the function "Closed-loop controlled operation down to f = 0 Hz with test signal" (p1750.5 = 1), synchronous reluctance motors do not require current injection.
  - Compared to induction motors, synchronous reluctance motors require a shorter time for magnetization: This reduces the wait time when starting with active encoderless safety monitoring, e.g. for SLS.

Inadmissible operating modes for Safety Integrated Functions "without encoder"

- No operation with SINAMICS Hydraulic Drive (HLA)
- Current controller clock cycles 31.25 μs and 62.5 μs (for Double Motor Modules with two configured safety drives) are not permissible.
- For the independent setting of current controller clock cycle and pulse frequency in conjunction with Safety Integrated "without encoder", the following system clock cycles are not permitted:
  - Double Motor Module: < 125 μs
  - All other components: < 62.5 μs
  - p9589 must be set = 3300 to allow the current controller clock cycle and pulse frequency to be independently set.
- For all designs: Safety Integrated Functions "without encoder" only with parameter p1810 = factory setting, this includes:

  - No wobbling

  - No fine setting of the pulse frequency
- For chassis format devices, the following also applies:
  - For chassis format devices, operation without encoder is only permissible for induction motors, however **not** for synchronous motors.
  - No operation involving parallel connections
  - Optimized pulse patterns cannot be selected for SIMOTICS FD
- No "shaft generator" functionality
- Induction motors up to 1000 kW

  On very large machines, it may also be necessary to adjust the parameter p9585.

Critical operating modes for Safety Integrated Functions "without encoder"

When the safety functions are deactivated, the following technology functions are not negatively influenced.

Using the following operating modes with the Safety Integrated Functions activated without encoder can result in errors in the encoderless safe actual value sensing (see messages C01711, C30711 with fault values 1040 ff.).

Safe, encoderless actual value sensing is based on the measurement of current and voltage variables, which can influence the following functions. **This does not result in unsafe states.** However, this fault can be expected to have a negative impact on availability.

Note

Irregular operating states

Note that in irregular operating states (e.g. "stalled motor"), the converter can fail with safety faults. However, under no circumstances is an unsafe state reached.

- Current limiting of the power unit

  When the current limiting of the power unit responds, then it can be assumed that this will result in errors in the encoderless safe actual value sensing and in turn with an associated stop response.

  Note

  When engineering the drive and when the parameterizing the current and torque limits, it must be ensured that the power unit current limiting does not respond.

- Operation with pulling loads

  It is not permissible that the converter is forced into regenerative operation as a result of external forces.

  Note

  If a coupled drive comprises an electric drive that motors and one that regenerates (e.g. a test stand), and the speeds of both drives are safely monitored, safety functions without encoder can be used. This is because in the case of a fault, the motoring drive recognizes when a limit value is violated. If, in this example, the motoring drive is an internal combustion engine, which is not safely monitored, use of safety functions without an encoder for the braking drive is not permissible.

  Winders with a motoring and a braking drive can be assessed in the same way (both drives are monitored).

- Motor data identification

  When using the measuring functions (stationary and rotating measurement) to determine the motor data, then it can be assumed that the encoderless safe actual value sensing will have an error.

  Note

  The motor data identification should always be performed before commissioning the Safety Integrated Functions.

- Data set switchover

  The motor and drive data switchover can always be used for safety functions without encoder. It is not possible to switch over between induction and synchronous motors (this is interlocked). For several motor data sets it must be ensured that all motors have the same number of pole pairs. If the number of pole pairs in r0313 is not the same value that was taken into account when configuring the safe actual value sensing (gearbox), then the calculated, safe actual speed no longer corresponds to the mechanical speed of the shaft.

  When SLS is activated, the shaft can rotate faster than the configured limits.

- Alternating acceleration/deceleration

  For alternating acceleration and deceleration, it must be ensured that the following conditions are maintained.

  – Within 1 s, only one acceleration and one braking ramp are permitted.

    Therefore, for a cycle $0 \rightarrow +n_{set} \rightarrow -n_{set} \rightarrow 0$ – one period of at least 2 s is required.

- This also applies to positioning operation; it may be necessary that the position control settings and traversing profiles must be adapted so that no overshoots occur in the speed characteristic (e.g. reduce the dynamic response, use flatter braking ramps).
- Flying restart

  A flying restart should not be performed in operation with the Safety Integrated Functions active.

  Note

  If you must use this function, then before the flying restart, you can deactivate the Safety Integrated Functions, and then reactivate them again after the flying restart has been completed.

  In this case, the user must check as to whether it is permissible that the safety functions are deactivated during the flying restart.

  It is only permissible to activate and deactivate Safety Integrated Functions using failsafe signals.

- DC brake

  When using this function, DC current is impressed to brake the drive: This can result in an error in the encoderless, safe actual value sensing and in turn in an associated stop response.

  Note

  If you must use this function, then before braking, you can deactivate the Safety Integrated Functions, and then reactivate them again after braking has been completed.

  In this case, the user must check as to whether it is permissible that the safety functions are deactivated during braking.

  It is only permissible to activate and deactivate Safety Integrated Functions using failsafe signals.

- Closed-loop controlled operation down to f = 0 Hz with test signal (see corresponding chapter in the SINAMICS S120 Function Manual Drive Functions)

  If you use Safety Integrated without encoder simultaneously with the function "Closed-loop controlled operation up to f = 0 Hz with test signal", the drive may react with an undesired safety message and a stop reaction. In this case, you cannot use the combination described.

Recommendations for stable operation with active Extended Functions without encoder

The following preconditions must be fulfilled to avoid fault messages from the safe actual value sensing without encoder:

- The motor and the power unit are adequately dimensioned for this application.
- Motor and power unit should fulfill the following condition: The ratio between the rated power unit current (r0207[0]) and rated motor current (p0305) should be less than 5.

- Before commissioning the safety functions, we recommend that the motor data are identified at standstill and a rotating measurement is carried out.
- For the basic commissioning, i.e. before the safety commissioning, the closed-loop control should be optimally set. The following effects should be avoided:

  - speed overshoots

  - current peaks and/or discontinuous/unsteady current actual value over time

  - voltage peaks and/or discontinuous/unsteady voltage actual value over time

  - the lowest possible amount of noise in the current and voltage

Safety Integrated Extended Functions without encoder for Control Unit Adapter CUA31 and CUA32

In the case of the Control Unit Adapters CUA31 and CUA32, the Safety Integrated Extended Functions without encoder are available as follows:

Control Unit Adapter	Article number	Safety Integrated without encoder	
		Not available for	Available for
CUA31	6SL3040-0PA01-0AA1	Version (function states) A, B and C	**Version D or newer**
CUA32	6SL3040-0PA01-0AA0	Version (function states) A and B	**Version C or newer**

4.2.3 Safe Torque Off (STO)

For the control options and the functionality for "Safe Torque Off" (STO), see Section "Safe Torque Off (STO) (Page 70)".

4.2.4 Safe Stop 1 (SS1)

4.2.4.1 Safe Stop 1 with encoder

For function SS1 of the Extended Safety Functions, braking monitoring is included.

- **If p9506 = 0:**

  Braking is monitored with the "Safe Acceleration Monitor" function (see Chapter "Safe Acceleration Monitor (SAM) (Page 150)").

  In this case, we also talk about "SS1 (time and acceleration controlled)".

- **If p9506 = 2:**

  Here, also for SS1, the monitoring function "Safe Brake Ramp" is active (see Chapter "Safe Brake Ramp (SBR) (Page 152)").

  In this case, we also talk about "SS1 (speed controlled)".

The "Safe Stop 1" (SS1) 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" (STO) once the delay time has elapsed (p9556) or when the shutdown speed is fallen below (p9560).

Functional features of Safe Stop 1 with encoder

- The delay time starts after the function has been selected. If SS1 is deselected within this time, after the delay time has elapsed or after the velocity has fallen below the shutdown speed, the STO function is selected and deselected again immediately; i.e. the SS1 function is ended completely normally. It cannot be interrupted.
- Selection and monitoring of the acceleration (SAM) or the monitoring function "Safe Brake Ramp" are implemented in two channels, but braking along the OFF3 ramp is only implemented in one channel.

Note

Interrupting the ramp function with OFF2 by the higher-level controller

Activating SS1 can mean that the higher-level controller (PLC, motion controller), which specifies the speed setpoint, interrupts the ramp function (e.g. with OFF2). The device behaves in this way as a result of a fault reaction triggered by OFF3 activation. This fault reaction must be avoided by assigning appropriate parameters or configurations.

Note

No OFF2 with SS1 and EPOS

If you use SS1 together with EPOS, the fault reaction to F07490 (EPOS: enable withdrawn while traversing) OFF2 is not permitted. The response to this error message (OFF1, OFF2 or OFF3) can be configured via p2100/p2101.

- Effect on "Speed setpoint limit effective" (r9733[0...2]):

  If SS1 (≙ STOP B), setpoint 0 is specified in r9733[0...2].

Commissioning

The delay time (SS1 time) is set by entering parameter p9556. The wait time until safe pulse suppression (STO) can be shortened by specifying a shutdown speed in p9560.

To enable the drive to brake to standstill after selection, the time in p9556 must be selected to be large enough for the drive to be able to brake along the OFF3 ramp (p1135) from any speed of the work process to below the shutdown speed (p9560).

Note

Setting the delay time

To enable the drive to travel the entire OFF3 ramp and close any existing motor holding brake, you must set the delay time as follows:

- Motor holding brake parameterized: Delay time ≥ p1135 + p1228 + p1217
- Motor holding brake not parameterized: Delay time ≥ p1135 + p1228

The shutdown speed defined in p9560 must be set in such a way that coasting down (due to the subsequent STO function) does not represent any risk for man and machine.

Responses: System error

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

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 drive-integrated status signals, SS1 active
- r9722.0 CO/BO: SI Motion drive-integrated status signals, STO or safe pulse suppression active

4.2.4.2 Safe Stop 1 without encoder

Two encoderless Safe Stop 1 (SS1) monitoring functions can be set with parameter p9506:

- p9506 = 3: Safe monitoring of acceleration (SAM) / delay time

  The function is identical to "Safe Stop 1" with encoder, which was described in the previous section.

  In this case, we also talk about "SS1 (time and acceleration controlled)".

- p9506 = 1: Safe brake ramp monitoring (SBR)

  In this case, there is no SS1 delay time active. The transition from SS1 to STO depends entirely on the speed falling below the shutdown speed (p9560). You will find more information on the function "Safe Brake Ramp (SBR)" in Chapter "Safe Brake Ramp (SBR) (Page 152)." In this case, we also talk about "SS1 (speed controlled)".

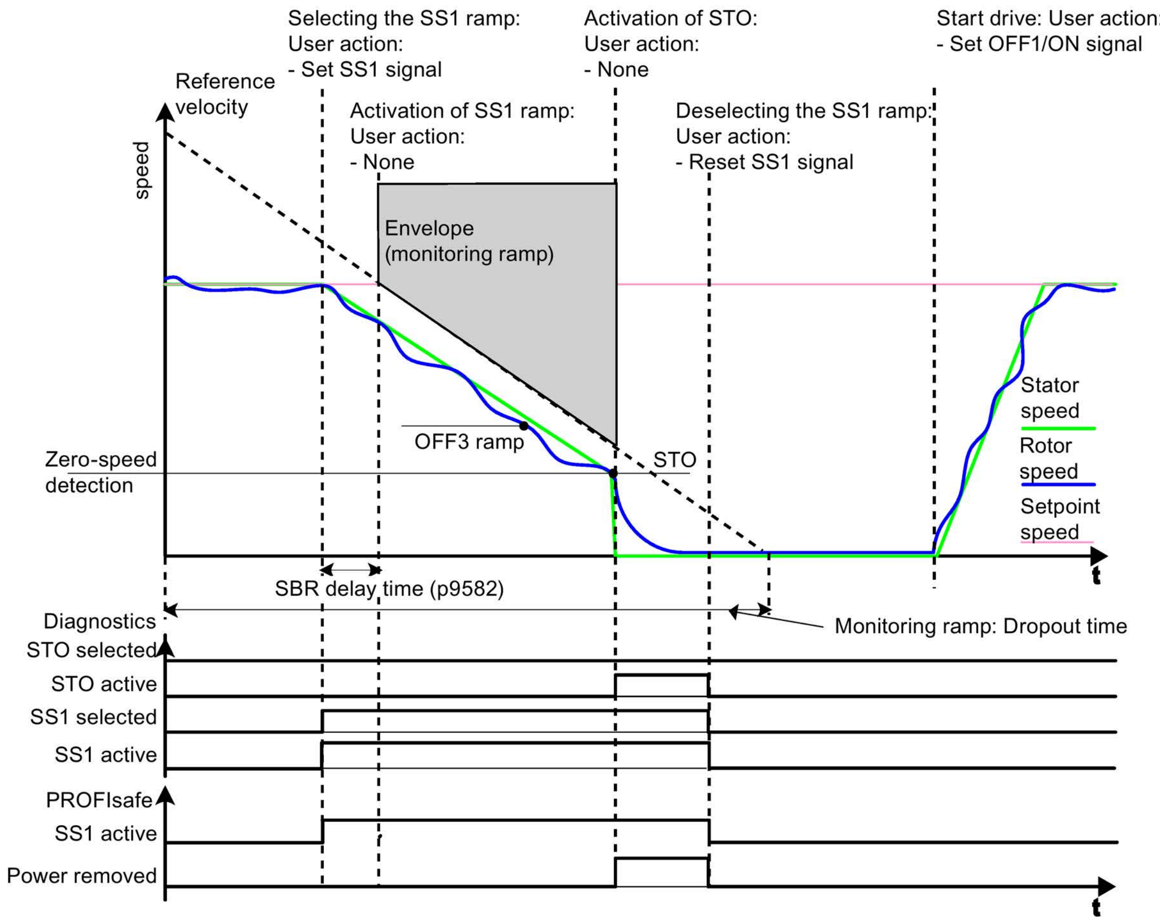


Figure 4-5 Sequence for "Safe Stop 1" without encoder with SBR monitoring (p9506 = 1)

Functional feature of Safe Stop 1 without encoder

- Selection and monitoring of the brake ramp (SBR) or the acceleration (SAM) are implemented in two channels, however braking at the OFF3 ramp is only through one channel.

4.2.4.3 Safe Stop 1 with external stop

General description

NOTICE
Any axis motion is possible
During the delay time (p9652), for "Safe Stop 1 (time-controlled) with external stop", any axis movements are possible. • If there is a hazard due to unwanted motion in your application, take measures to counter it, for example, by using a brake with safe monitoring. Further information can be found in Section "Safe Brake Control (Page 102)".

With external stop, "Safe Stop 1" basically works exactly as described in the previous Chapters "Safe Stop 1 with encoder (time and acceleration controlled)" and "Safe Stop 1 without encoder (speed controlled)." Note, however, the following differences:

Differences between "Safe Stop 1 with OFF3" and "SS1 with external stop"

- In order to activate "Safe Stop 1 with external stop", **additionally** set p9507.3 = 1.
- When SS1 with external stop is selected, the drive is **not** braked along the OFF3 ramp: You are responsible in applying suitable measures to brake the drive. After the delay time has expired (p9556), only STO/SBC are automatically initiated. 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 deselected immediately.
- The brake ramp (SBR) and the acceleration (SAM) are not monitored and there is no standstill detection.
- With this configuration, STO becomes active after the SS1 timer p9556 has expired; this also applies if SBR has been configured.
- For additional information, see Chapter "Stop responses (Page 375)".

4.2.4.4 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2819 SI Extended Functions - SS1, SS2, SOS, internal STOP B, C, D, F

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1135[0...n] OFF3 ramp-down time
- p9501 SI Motion enable safety functions (Control Unit)
- p9506 SI Motion function specification (Control Unit)
- p9560 SI Motion STO shutdown speed (Control Unit)
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals

Only for SS1 (Extended Functions) with external stop

- p9507 SI Motion function configuration (Control Unit)

4.2.5 Safe Brake Control (SBC)

For the control options and the functionality for "Safe Brake Control" (STO), see Section "Safe Brake Control (SBC) (Page 78)".

Note

No SBC for SINAMICS HLA

SINAMICS HLA does not support Safe Brake Control.

4.2.6 Safe Operating Stop (SOS)

This function serves for failsafe monitoring of the standstill position of a drive.

WARNING

Drive can be forced out of the SOS position by mechanical forces

A drive under position control can be forced out of the "Safe Operating Stop" (SOS) position by mechanical forces that are greater than the maximum torque of the drive. This unwanted drive movement then triggers a Category 1 Stop function according to EN 60204-1 (fault response function STOP B). The alarms for SS1 and STO must be observed.

- If there is a hazard due to unwanted motion in your application, take measures to counter it, for example, by using a brake with safe monitoring. For additional information, see Chapter "Safe Brake Control (SBC) (Page 78)".

Note

In particular, the motor is energized while the SOS function is performing position control.

- Ensure that the motor cannot be touched while it is in the SOS state.

- Drive stopping is monitored using an SOS tolerance window (p9530).
- Effect on "Speed setpoint limit effective" (r9733[0...2]):

  If SOS is selected, setpoint 0 is specified in r9733[0...2].

Note

Size of the tolerance window

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, based on the acquisition of the actual value for the safe motion monitoring functions.

STOP B is the stop response after the standstill tolerance window has been violated.

The SOS function comes into effect in the following cases:

- After SOS is selected and the delay time in 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 (corresponds to selection of SS2)
- As a consequence of STOP D (corresponds to selection of SOS)
- As a consequence of STOP E (corresponds to selecting SOS with additional activation of the standard "Extended stop and retract (ESR)" function)

Responses

- **Standstill tolerance violated in p9530**
  – STOP B with subsequent STOP A
  – Safety message C01707
- **System error**
  – STOP F
  – Safety message C01711

Note

Deactivating SOS during an external STOP A

If "Deactivating SOS/SLS during an external STOP A" (p9501.23 = 1) is released and SOS is selected, SOS is deactivated during a STOP A.

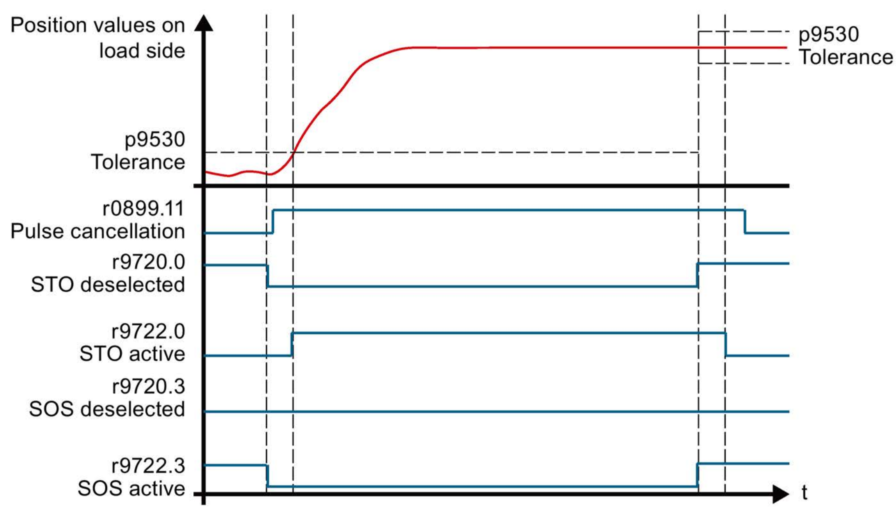


Figure 4-6 Signal flow: Deactivating SOS during an external STOP A

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2819 SI Extended Functions - SS1, SS2, SOS, internal STOP B, C, D, F

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9530 SI Motion standstill tolerance (Control Unit)
- p9551 SI Motion SLS(SG) switchover/SOS(SBH) delay time (CU)
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals
- r9731 SI Motion safe positioning accuracy

4.2.7 Safe Stop 2 (SS2)

Note

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

The safety function "Safe Stop 2" (SS2) is used to brake the motor of the OFF3 deceleration ramp (p1135) safely with transition after the delay time (p9552) has expired in to the SOS state (see Chapter "Safe Operating Stop (SOS) (Page 103)"). The delay time set must allow the drive to brake to a standstill from every speed of the operating process within this time. The standstill tolerance (p9530) may not be violated after this time.

After braking, the drives remain in speed control mode with the speed setpoint n = 0. The full torque is available.

The default setpoint (e.g. from the setpoint channel, or from a higher-level controller) remains inhibited as long as SS2 is selected.

During braking, one of the following functions is active:

- **If p9506 = 0:**

  Braking is monitored with the "Safe Acceleration Monitor" function (see Chapter "Safe Acceleration Monitor (SAM) (Page 150)").
- **If p9506 = 2:**

  Here, also for SS1, the monitoring function "Safe Brake Ramp" is active (see Chapter "Safe Brake Ramp (SBR) (Page 152)").

The selection and monitoring of the acceleration (SAM) are realized through two channels – however, braking along the OFF3 ramp, only through one channel.

- Effect on "Speed setpoint limit active" (r9733[0...2]):

  If SS2 (≙ STOP C), setpoint 0 is specified in r9733[0...2].

Interruption of the ramp function with OFF2

Activating SS2 can mean that the higher-level controller (PLC, motion controller) which specifies the speed setpoint, interrupts the ramp function (e.g. with OFF2). The device behaves in this way as a result of a fault reaction triggered by OFF3 activation. This fault reaction must be avoided by assigning appropriate parameters or configurations.

Responses

- **Speed limit violated (SAM):**
  - STOP A
  - Safety message C01706
- **Standstill tolerance violated in p9530 (SOS):**
  - STOP B with subsequent STOP A
  - Safety message C01707
- **System fault:**
  - STOP F with subsequent STOP A
  - Safety message C01711

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2814 SI Basic Functions - SBC (Safe Brake Control), SBA (Safe Brake Adapter)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1135[0...n] OFF3 ramp-down time
- p9501 SI Motion enable safety functions (Control Unit)
- p9530 SI Motion standstill tolerance (Control Unit)
- p9548 SI Motion SAM actual speed tolerance (Control Unit)
- p9552 SI Motion transition time STOP C to SOS (SBH) (Control Unit)[1)]
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals

[1)] STOP C corresponds to SS2.

See also

Safety Integrated and ESR (Page 274)

4.2.7.1 SS2 with external stop (SS2E)

⚠WARNING

Unexpected axis motion

When function "Safe Stop 2 with external stop" (SS2E) is active, during the delay time (p9553) the speed follows the setpoint issued from the higher-level control system. As a consequence, unexpected axis motion is possible, which can lead to severe injury and death.

- Prevent persons from entering the danger zone of the machine or plant during the delay time (p9553), for example, by keeping protective devices interlocked.

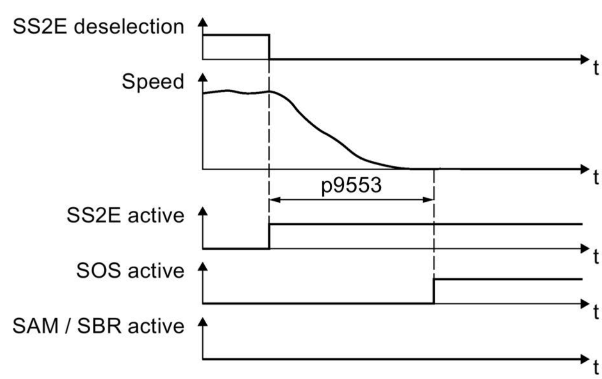


Figure 4-7 Selecting function SS2E

With external stop, "Safe Stop 2" functions in principle exactly the same way as described in the previous sections. Note, however, the following differences:

Differences between "Safe Stop 2 with OFF3" and "SS2 with external stop (SS2E)"

- If SS2 with external stop is selected, the drive does not brake the motor autonomously but follows the defined speed setpoint.
- During delay time p9553, the brake ramp (SBR) and the acceleration (SAM) are not monitored and there is no standstill detection.
- SOS becomes active after the delay time p9553 expires.

  When function SS2E is active, the higher-level control must issue the speed setpoint so that at the latest after delay time p9553 expires, the motor has come to a complete standstill.
- In order to activate "Safe Stop 2 with external stop", set p9501.18 = 1.
- The PROFIsafe control word S_STW2.28 selects the SS2E function. PROFIsafe S_STW2.28 is contained in telegrams 31, 901, 902, and 903.

- The PROFIsafe status word S_ZSW2.28 indicates whether the SS2E function is active. PROFIsafe status word S_ZSW2.28 is contained in telegrams 31, 901, 902 and 903. The associated diagnostics parameter is r9722.28.
  In the "Safety Info Channel", status word S_ZSW3B.11 indicates whether function SS2E is active. The associated diagnostics parameter is r10234.11.
  Diagnostic parameters p9722.28 and p10234.11 are also set during an internal STOP D.
- Effect on the "Setpoint speed limit effective" (r9733[0...2]):
  For SS2E (≙ STOP D), setpoint 0 is specified in r9733[0...2].

Deselecting function SS2E while SS2E is active

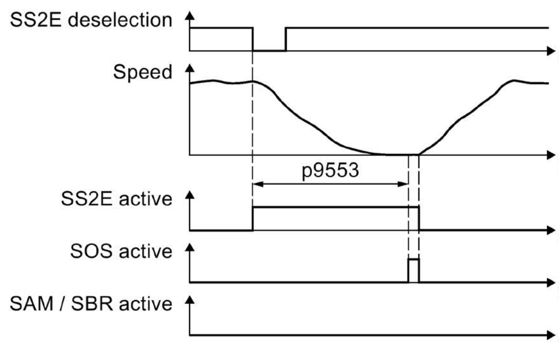


Figure 4-8 Deselecting function SS2E while SS2E is active

After the function has been selected, the delay time starts to expire - even if the function is deselected during this time. In this case, after the delay time has expired, the SOS function is briefly active. Afterwards, the drive may accelerate the motor back to the speed setpoint.

Interruption of the active SS2E function by functions SS1 and SS2

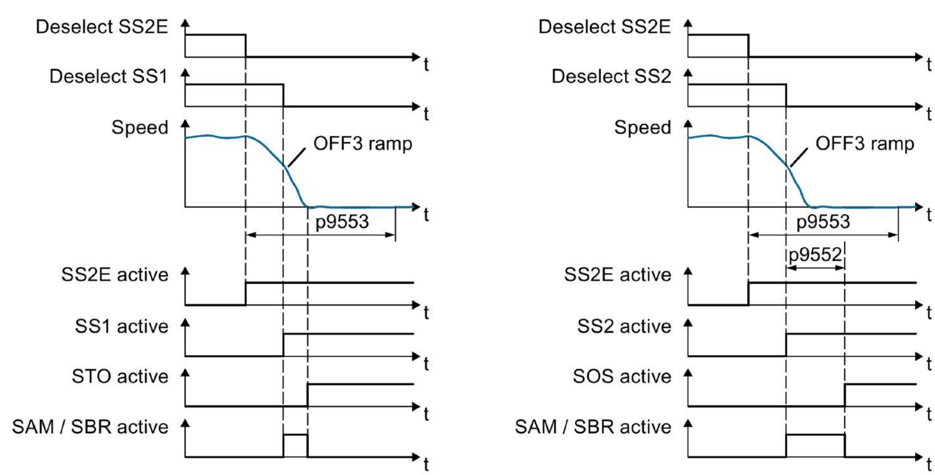


Figure 4-9 Interruption of function SS2E by functions SS1 (shown at the left) and SS2 (at the right)

When selecting SS1, the drive brakes the motor along the OFF3 ramp and monitors the speed using the SAM function. Function STO becomes active when the motor is at a standstill.
When selecting SS2, the drive also brakes the motor along the OFF3 ramp and monitors the speed using the SAM function. Function SOS becomes active after time p9552.

4.2.7.2 Safe Stop 2 Extended Stop and Retract (SS2ESR)

⚠WARNING

Unexpected axis motion

When function SS2ESR is active, during the delay time (p9554) the speed follows the setpoint issued from the higher-level control system. As a consequence, unexpected axis motion is possible, which can lead to severe injury and death.

- Prevent persons from entering the danger zone of the machine or system during the delay time (p9554), for example, by keeping protective devices closed and interlocked.

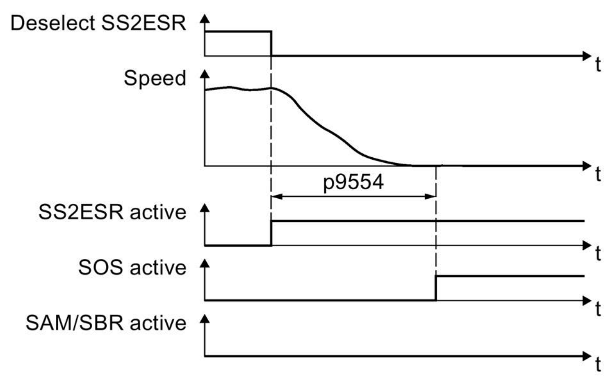


Figure 4-10 Selecting function SS2ESR

In principle, Safe Stop 2 Extended Stop and Retract (SS2ESR) functions in exactly the same way as SS2 described in the previous sections. Note, however, the following differences:

Differences between "Safe Stop 2 with OFF3" and SS2ESR

- If SS2ESR with external stop is selected, the drive does not brake the motor automatically, but instead follows the defined speed setpoint: This can also result in fast retraction motion.
- During the delay time p9554, the brake ramp (SBR) and the acceleration (SAM) are not monitored, and there is no standstill detection.
- SOS becomes active after the delay time p9554 has expired. If function SS2ESR is active, the higher-level control system must define the speed setpoint such that the motor is stopped no later than after the delay time p9554 has expired.
- To enable SS2ESR, set p9501.4 = 1.
- PROFIsafe control word S_STW2.29 selects function SS2ESR. PROFIsafe S_STW2.29 is contained in telegrams 31, 901, 902 and 903.
- PROFIsafe status word S_ZSW2.27 indicates whether function SS2ESR is active. PROFIsafe status word S_ZSW2.27 is contained in telegrams 31, 901, 902 and 903. The associated diagnostics parameter is r9722.27. In the "Safety Info Channel," status word S_ZSW3B.12 indicates whether the SS2ESR function is active. The associated diagnostics parameter is r10234.12.

- In addition, in the "Safety Info Channel", status word S_ZSW1B.14 = 1 is set. This bit corresponds to diagnostic parameter r9734.14.
- You can use p0890[1] to interconnect to an ESR integrated in the drive.
- SS2ESR has no effect on the "Setpoint speed limit effective" (r9733[0...2]). If SS2ESR is enabled in p9501.4, then also a STOP E has no effect on r9733[0...2].

Deselecting function SS2ESR while SS2ESR is active

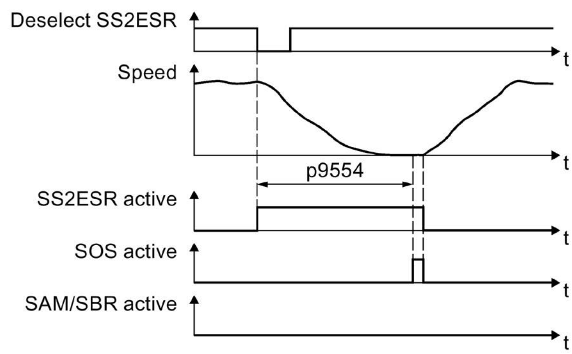


Figure 4-11 Deselecting function SS2ESR while SS2ESR is active

After the function has been selected, the delay time starts to expire - even if the function is deselected during this time. In this case, after the delay time has expired, the SOS function is briefly active. Afterwards, the drive may accelerate the motor back to the speed setpoint.

Interruption of the active SS2ESR function using functions SS1 and SS2

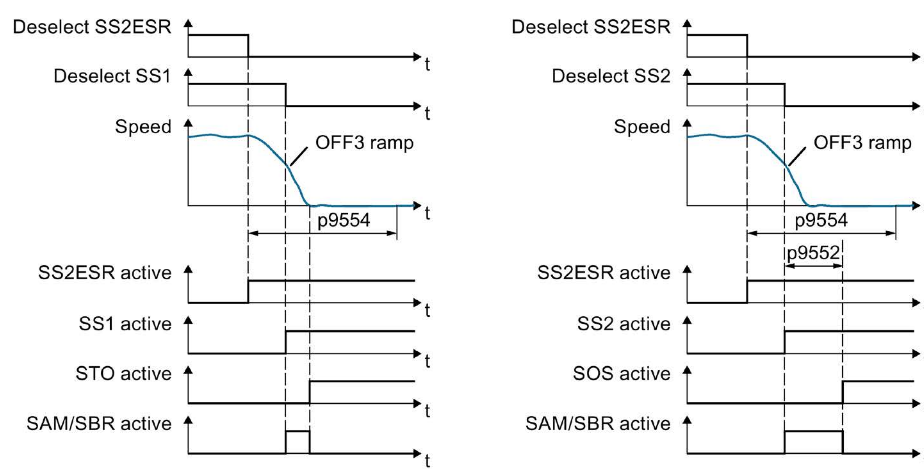


Figure 4-12 Interruption of function SS2ESR using functions SS1 (shown at the left) and SS2 (shown at the right)

When selecting SS1, the drive brakes the motor along the OFF3 ramp and monitors the speed using function SAM/SBR. Function STO becomes active when the motor is at a standstill.

When selecting SS2, the drive also brakes the motor along the OFF3 ramp and monitors the speed using the SAM function. Function SOS becomes active after time p9552.

4.2.7.3 Overview of important parameters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p2573 EPOS maximum delay
- p2594 CI: EPOS maximum speed, externally limited
- p2640 BI: EPOS intermediate stop (0 signal)
- p2645 CI: EPOS direct setpoint input/MDI, deceleration override
- p9551 SI Motion SLS(SG) switchover/SOS(SBH) delay time (CU)
- p9552 SI motion transition time STOP C to SOS (SBH) (Control Unit)
- p9553 SI motion transition time STOP D to SOS (SBH) (Control Unit)
- p9554 SI Motion transition time STOP E to SOS (SBH) (Control Unit)
- r9720.0...27 CO/BO: SI Motion drive-integrated control signals
- r9733[0...2] CO: SI Motion speed setpoint limit active

4.2.7.4 Interaction with EPOS

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) must then be entered in the delay time for SLS/SOS (p9551) with a safety margin: This ensures that the drive is at a standstill before SOS is active.

To do this, proceed as follows:

1. Connect the EPOS function "intermediate stop" (p2640) with the control signal "Deselect SOS" (r9720.3).
2. Enter the maximum necessary EPOS braking time (depending on the values set in p2573 and p2645) with a safety margin (approx. +5%) in the SOS delay time (p9551).

Since the STOP C stop response – 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 required braking time (from p2573 and p2645) must then be entered in the "Transition time STOP D to SOS" (p9553) with a small safety margin: This ensures that the drive is at a standstill before SOS is active.

To do this, proceed as follows:

1. Parameterize "STOP D" as stop response.
2. Connect the EPOS function "intermediate stop" (p2640) with the control signal "Deselect SOS" (r9720.3).
3. Enter the maximum required EPOS braking time (depending on the values set in p2573 and p2645) with a safety margin (approx. +5%) in the "Transition time STOP D to SOS" (p9553).

4.2.8 Safely-Limited Speed (SLS)

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 parameterized speed limit from being exceeded. Limits must be specified based on results of the risk analysis. Up to four different SLS speed limits can be parameterized using parameter p9531[0..3]; it is possible to switch between them even if the SLS is activated.

An override can also be added to SLS limit value 1. In operation, this override can be varied using a PROFIsafe telegram.

Note

Deviation of the displayed speed limit

The SLS speed limit displayed in r9714[2] can deviate slightly from the specified SLS speed limit. The reason for this is the internal resolution (r9732) of the speed values.

Note

Response in the event of a communication error

If p9580 ≠ 0 and SLS is active, in the event of communication failure, the parameterized ESR reaction is only realized if, as SLS response, a STOP with delayed pulse cancellation when the bus fails has been parameterized (p9563[0...3] ≥ 10).

Note

Setpoint speed limit and SLS

- It makes sense to configure the set velocity limit if SLS is also parameterized. This is done in a higher-level controller that evaluates the safety information channel, for example, or by wiring r9733[0/1] to the speed limits of the ramp-function generator (p1051/p1052).
- It does not make sense to use the positive and negative setpoint limiting for SLS in conjunction with standard telegram 105 and others: With this combination, the velocity setpoint of the standard telegram is only effective after the setpoint limiting.

Note

Deactivation of SLS during external STOP A

If "Deactivating SOS/SLS during an external STOP A" (p9501.23 = 1) is released and SLS is selected, SLS is deactivated during a STOP A.

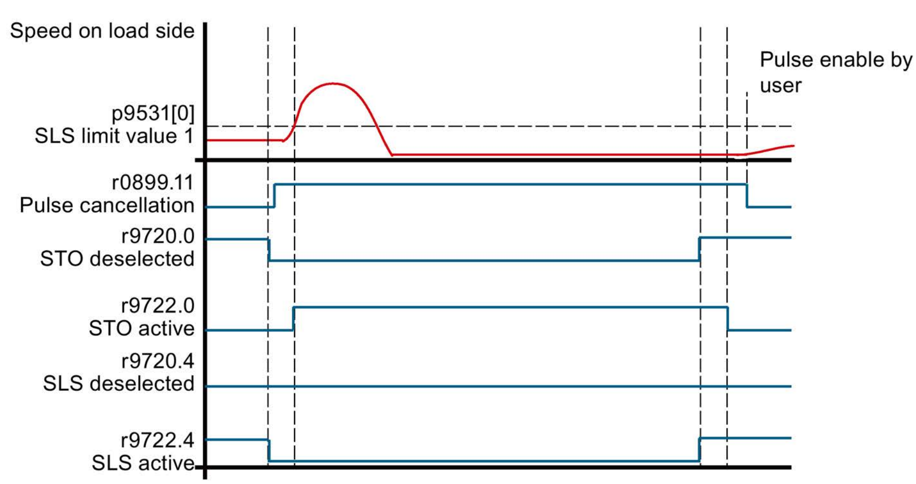


Figure 4-13 Signal flow: Deactivation of SLS during external STOP A

4.2.8.1 Safely Limited Speed (SLS)

Features

- When SLS is selected, the monitoring only takes effect after the configured delay time has expired (p9551). Within this time, the actual speed must be below the (selected) limit. The delay time is not effective when SLS is deselected.
- After switching to a lower limit value (p9531), the actual speed of the drive must have dropped below the new limit within the delay time (p9551). The existing limit remains active during the delay time. The lower limit value becomes active after the delay time expires. This also applies to a reduction of the limit value via PROFIsafe.
- If the actual speed of the drive is higher than the new Safely-Limited Speed limit after the delay time has elapsed, a message is generated with the parameterized stop response.
- The stop response (STOP A, STOP B, STOP C, STOP D or STOP E) is parameterized with p9563.
- During changeover to a higher limit value, the delay time is not active and the high limit value becomes immediately active. This also applies to increasing the limit value via PROFIsafe.
- 4 parameterizable limit values p9531[0...3]
- The first limit value can be entered via the PROFIsafe telegrams 901, 902 and 903 (for p9501.24 = 1)
- In parameter p9533 enter the weighting factor to determine the setpoint limit from the selected actual speed limit in percent. The active limit value is evaluated using this factor, and is provided as setpoint limit in r9733.
  - r9733[0] = p9531[x] · p9533 (converted from the load to the motor side)
  - r9733[1] = -p9531[x] · p9533 (converted from the load to the motor side)

    [x] = selected SLS stage

  Conversion factor from the motor to the load side:
  - Motor type = rotary and axis type = linear: p9522/(p9521 · p9520)
  - Otherwise: p9522/p9521
- Limit value
  - r9733[0] = p9531[x] · p9533; x = selected SLS limit value
  - r9733[1] = -p9531[x] · p9533; x = selected SLS limit value

  r9733 is used, for example, for transferring values to a higher-level controller, which can then, for example, adjust traversing speeds to the SLS levels or at the setpoint channel (p1051). r9733 is a part of the Safety Info Channel (SIC).
- The currently monitored limit value is displayed in parameter r9714[2].

Changeover of SLS limit values

The changeover is executed binary-coded via 2 F-DIs or 2 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 4- 2 Changeover of speed limits:

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

WARNING

Excessive speed during incorrect control of the Safely-Limited Speed limits via F-DI

For all control options except PROFIsafe, limit SLS1 is activated after 2 unacknowledged discrepancy errors. This means that, for the 2 F-DIs for selecting the speed levels, the value 0 is the "safe state" (failsafe value).

- Therefore parametrize the SLS limits in ascending order, i.e. with limit SLS1 as the lowest speed and limit SLS4 as the highest speed.

Responses

Speed limit value exceeded:

- Configured subsequent stop STOP A/B/C/D/E via p9563
- Safety message C01714

System fault:

- STOP F
- Safety messages C01711

Transferring the first limit value via PROFIsafe

SINAMICS offers the option of influencing the first SLS limit value via PROFIsafe:

- The transfer of the first SLS limit value via PROFIsafe is active if the speed level 1 in the PROFIsafe telegram is selected and the bit "Enable transfer SLS (SG) limit via PROFIsafe" (p9501.24) is set.
- S_SLS_LIMIT_A has the value range 1 ... 32767; the following applies:
  - 32767 ≙ 100 % of the 1st SLS level
  - The actually monitored limit value is calculated as follows:

    SLS limit value = (S_SLS_LIMIT_A/32767) · p9531[0]
- Also in this case, speed levels 2, 3 and 4 can be parameterized and selected.
- In operation, the selected delay time cannot be changed. If you require various delay times in your application, then you must realize this using a time-delayed transfer of the SLS limit value using your control system (F-CPU).
- If an incorrect SLS limit value is transferred, then the converter responds with the stop response of speed level 1 parameterized in p9563 and the safety message C01711(1041).

4.2.8.2 Safely Limited Speed without encoder

Functions

2 different encoderless Safely-Limited Speed monitoring functions can be set with parameter p9506:

- p9506 = 3: Safe monitoring of acceleration (SAM) / delay time

  The function is identical to "Safely-Limited Speed with encoder" which was described in the previous section.
- p9506 = 1: Safe brake ramp monitoring (SBR)

Note

Defaults

- For commissioning, also pay attention to the description in Chapter "Default settings for commissioning Safety Integrated functions without encoder (Page 278)."
- Information about setting the SBR monitoring function can be found in Chapter "Safe Brake Ramp (SBR) (Page 152)".

Monitoring the brake ramp

- If the speed setpoint limitation (r9733) was connected to the setpoint channel (p1051/p1052) and then SLS was selected – or if you change over to a lower SLS level – the motor is decelerated from the actual speed to below the value defined with r9733 along the OFF3 ramp. In this case, the drive may no longer follow the setpoint of the higher-level motion controller.
- Parameter p9582 is used to set the delay time for the braking ramp monitoring.
- Monitoring of the brake ramp is activated once the delay time in p9582 has elapsed. If the actual speed of the drive violates the brake ramp (SBR) during braking, safety message C01706 is output and the drive is stopped with STOP A.
- The newly selected SLS limit value is also taken over as the new limit speed, if either
  - The SBR ramp has reached the new SLS limit value, or
  - The actual speed of the drive was below the new SLS limit value for at least the time set in p9582.
- The "Safely-Limited Speed without encoder" function then monitors whether the actual speed remains below the newly selected SLS limit value.
- The parameterized stop response (p9563[x]) is triggered if the SLS limit value is exceeded.

Configuring the limits

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

Restart after OFF2/STO

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

1st case	• State after switching on	
		• SLS selected
		• STO selected
		• Pulse suppression active
	• Deselect STO	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	
2nd case	• Situation	
		• Traversing to standstill with SLS selected
		• OFF1 is initiated, pulse cancellation becomes active (internal selection STO)
	• Select STO	
	• Deselect STO STO activated internally via pulse suppression: This activation must be undone by selection/deselection.	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	
3rd case	• Situation	
		• Traversing to standstill with SLS selected
		• OFF1 is initiated, pulse cancellation becomes active (internal selection STO)
	• Deselect SLS STO activated internally via pulse suppression: This activation must be undone by selecting/deselecting SLS.	
	• Select SLS The drive enable must be issued with a positive edge at OFF1 within 5 seconds, otherwise STO is reactivated.	
4th case	• Situation	
		• All Safety Integrated functions are deselected.
	• After this the drive enable must be given by a positive edge at OFF1.	
	• In this case, the motor is not started safely.	

4.2.8.3 Safely-Limited Speed without selection

Differences between Safely-Limited Speed with and without selection

- As an alternative to controlling via terminals and/or PROFIsafe, there is also the option to parameterize the SLS function without selection (see Section "Motion monitoring without selection (Page 249)").
- The function "SLS without selection" is selected with p9512.4 = 1.
- For "SLS without selection", only one SLS limit value can be parameterized (p9531[0]).
- The stop response is parameterized with p9563[0].
- For Safely-Limited Speed without selection there is no delay time. The function is always active when operated with encoder. The function is always active at switch on when operated with encoder.

Switching the motor on and off (without encoder)

The time response and diagnostic options are as follows in this SLS version:

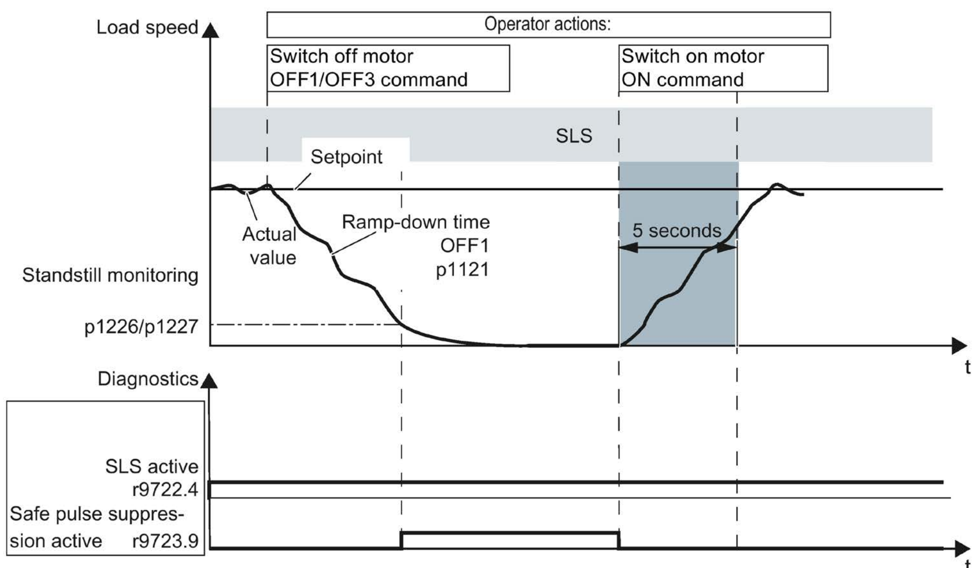


Figure 4-14 Time response of SLS without selection (example: Switching the motor on and off (without encoder))

"SLS without selection" behaves as follows when switching off and switching on again:

- After switch-off, the motor behaves in accordance with the removed signal (OFF1, OFF2 or OFF3).
- The "safe pulse cancellation" becomes active after the standstill limit is undershot. If a brake has been parameterized, it is also closed.
- After the ON command, the converter cancels the "safe pulse cancellation" state and the start procedure is initiated.
- If the minimum current has not been reached after 5 s, the converter returns into the "safe pulse suppression" state and initiates alarm C01711.

4.2.8.4 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2820 SI Extended Functions - SLS (Safely-Limited Speed)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501.0 SI Motion enable safety functions (Control Unit): Enable SOS/SLS (SBH/SG)
- p9512 Select SI Motion safety functions without selection (CU)
- p9531[0...3] SI Motion SLS (SG) limits (Control Unit)
- p9551 SI Motion SLS(SG) switchover/SOS(SBH) delay time (CU)
- p9563[0...3] SI Motion SLS (SG)-specific stop response (Control Unit)
- p9580 SI Motion STO delay bus failure (Control Unit)
- p9581 SI Motion braking ramp reference value (Control Unit)
- p9582 SI Motion braking ramp delay time (Control Unit)
- p9583 SI Motion braking ramp monitoring time (Control Unit)
- p9601 SI enable functions integrated in the drive (Control Unit)
- r9707[0...2] CO: SI Motion diagnostics actual position value GX_XIST1
- r9714[0...2] CO: SI motion diagnostics velocity
- r9720.0...27 CO/BO: SI Motion drive-integrated control signals
- r9721.0...15 CO/BO: SI Motion status signals (Control Unit)
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals (Control Unit)

4.2.8.5 EPOS and safe setpoint velocity limitation

If safe speed monitoring (SLS) or the safe direction motion monitoring (SDI) is also to be used at the same time as the EPOS positioning function, EPOS must be informed about the activated monitoring limits. Otherwise these speed monitoring limits can be violated by the EPOS setpoint input. By monitoring the limit value, if violated, the drive is stopped therefore exiting the intended motion sequence. In this case, the relevant safety faults are output first, and then the sequential faults created by EPOS.

Using parameter r9733, the safety functions offer EPOS setpoint limiting values, which when taken into account, prevent the safety limit value being violated.

In order to prevent a safety limit violation by the EPOS setpoint specification, you must transfer the setpoint limit value (r9733) as follows to the maximum speed setpoint of EPOS (p2594):

- r9733[0] = p2594[1]
- r9733[1] = p2594[2]

In this regard you must set the delay time for SLS/SOS (p9551), so that the relevant safety monitoring function only becomes active after the maximum required time for the speed to be reduced below the 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 (see SINAMICS S120/S150 List Manual)

- p2573 EPOS maximum delay
- p2574 EPOS jerk limitation
- p2593 CI: EPOS LU/revolution LU/mm
- p2594[0...2] CI: EPOS maximum speed, externally limited
- p9551 SI Motion SLS(SG) switchover/SOS(SBH) delay time (CU)
- r9733[0...2] CO: SI Motion speed setpoint limit active

4.2.9 Safe Speed Monitor (SSM)

The "Safe Speed Monitor" (SSM) function provides a reliable method for detecting when a speed limit has been fallen below (p9546) in both directions of rotation, e.g. for zero speed detection. A failsafe output signal is available for further processing.

The function is activated automatically as soon as the Safety Integrated Extended Functions are enabled with parameter p9501.0 = 1 and p9546 > 0. The SSM function is deactivated with setting p9546 = 0.

Note

Relationship between SSM and SAM

If you enter "0" for p9568 (SAM shutdown threshold), the speed limit of the SSM function (p9546) is simultaneously the lower limit for the Safe Acceleration Monitor function (SAM).

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

Note

Danger due to unwanted behavior of the STOP F on SSM

A STOP F is indicated by safety message C01711. STOP F only results in the subsequent response STOP B / STOP A if one of the Safety Integrated Functions is active. If only the SSM function without hysteresis (that is, p9501.16 = 0) is active, a STOP F cross-checking error does not result in a STOP B / STOP A follow-up response.

- SSM is only valid as an active monitoring function if "Hysteresis and filtering" is parameterized (p9501.16 = 1).

Note

Parameterization of hysteresis and actual value synchronization

You must carefully observe the following rules when parameterizing hysteresis and actual value synchronization:

- If "SSM hysteresis" has been enabled (p9501.16 = 1), you must set parameters p9546 and p9547 according to this rule:

  p9547 ≤ 0.75 · p9546
- If "Actual value synchronization" has been enabled (p9501.3 = 1), you must also observe this rule:

  p9549 ≤ p9547

Features

- Safe monitoring of the speed limit specified in p9546
- Parameterizable hysteresis via p9547
- Variable PT1 filter via p9545
- Safe output signal
- No stop response

4.2.9.1 Safe Speed Monitor with encoder

Functional features of "Safe Speed Monitor" with encoder

The parameter p9546 "SI Motion SSM (SGA n < nx) speed limit n_x" is used to set the speed 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 speed limit for the SSM feedback signal (n < n_x) is fallen below, the signal "Safe Speed Monitor feedback signal active" (SGA n < n_x) is set. When the set threshold value has been undershot, the "Safe Acceleration Monitor" (SAM) function is also deactivated (see p9568). If p9568 = 0, then p9546 (SSM feedback signal) is also used as a minimum threshold for the SAM monitoring.

A hysteresis can be configured for the SSM function via p9547. In this way, a more stable signal characteristic of SSM can be achieved at speeds close to the monitoring threshold (p9546).

When hysteresis is configured, then the velocity (or speed) determined by the two channels may not differ by more than the difference between p9546 and p9547. Otherwise it would be theoretically possible that one channel returns a HIGH signal and the other a LOW signal for SSM.

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

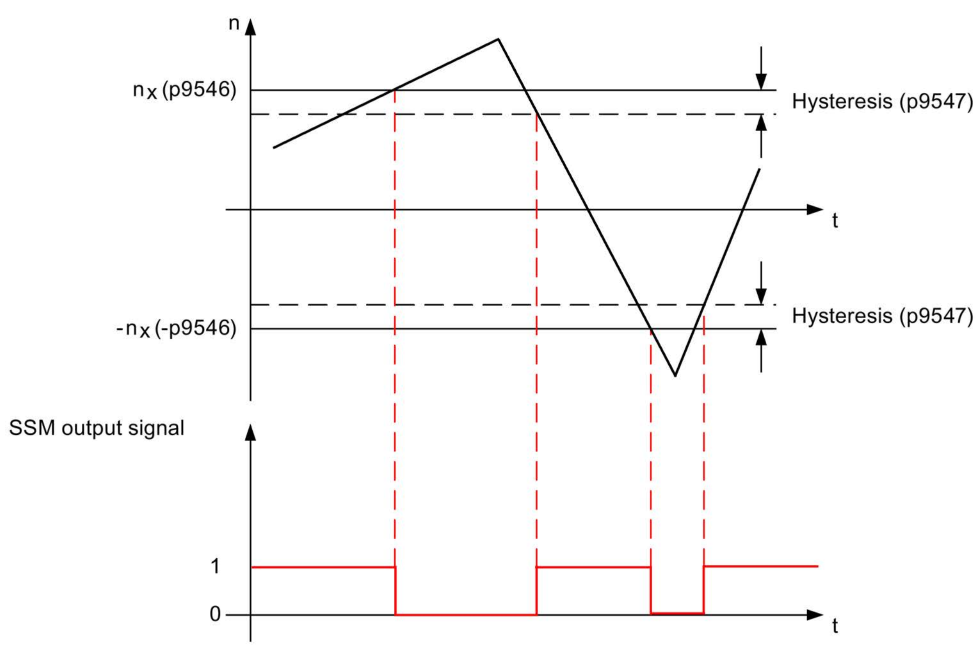


Figure 4-15 Safe output signal for SSM with hysteresis

The output signal for SSM is smoothed by setting a filter time with a PT1 filter (p9545).

During safe motion monitoring, the "hysteresis and filtering" functions can be activated or deactivated together using the enable bit p9501.16. In the default setting, the functions are deactivated (p9501.16 = 0).

Note

Exception: SSM as an active monitoring function

If the "hysteresis and filtering" function is enabled, the SSM function is evaluated as an active monitoring function and, after a STOP F, also results in a follow-up response STOP B/STOP A.

Note

Time-delayed SSM feedback

When "hysteresis and filtering" is activated with output signal SSM, a time-delayed SSM feedback signal occurs for the axes. This is a characteristic of the filter.

4.2.9.2 Safe Speed Monitor without encoder

Set p9506 = 1 or p9506 = 3 (factory setting = 0) to activate Safety Integrated Extended Functions without encoder. You can also make this setting by selecting "Without encoder" on the Safety screen in Startdrive.

Without an encoder, the "Safe Speed Monitor" essentially functions exactly the same as described in the previous section under "Safe Speed Monitor with encoder".

Note

Defaults

For commissioning, also pay attention to the description in Chapter "Default settings for commissioning Safety Integrated functions without encoder (Page 278)."

Note

Setting of the OFF1 or OFF3 ramp-down time

If the OFF1 or OFF3 ramp-down time is too short or the difference between the SSM limit speed and the shutdown speed is too small, the "speed below limit value" signal may not change to 1, because no actual speed value could be determined below the SSM limit before pulse suppression occurred. In this case, the OFF1 or OFF3 ramp-down time or the margin between SSM speed limit and shutdown speed should be increased.

Differences between Safe Speed Monitor with and without encoder

- For Safe Speed Monitor without encoder, after pulse suppression the drive is unable to determine the current speed. 2 responses can be selected for this operating state with parameter p9509.0:
  - p9509.0 = 1

    The status signal (SSM feedback signal) shows "0" (factory setting).
  - p9509.0 = 0

    The status signal (SSM feedback signal) is frozen. "Safe Torque Off" (STO) is selected internally.
- Due to the less precise speed recognition, "Safe Speed Monitor without encoder" requires a larger hysteresis (p9547) and, where applicable, a filter time (p9545) compared with the function with encoder.

Sequence diagram

The following diagram shows the signal characteristic for the case p9509.0 = 0.

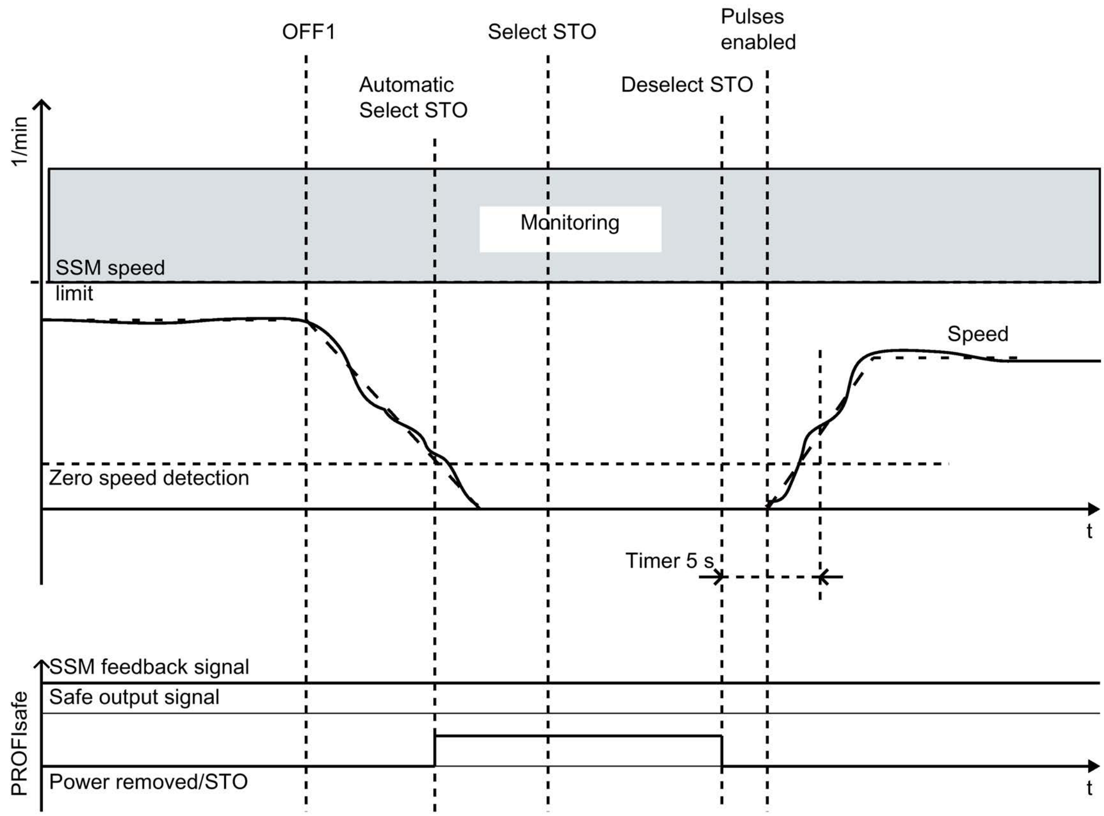


Figure 4-16 Safe Speed Monitor without encoder (p9509.0 = 0)

The speed remains below the limits of p9546 throughout the entire monitoring period. Therefore, the SSM feedback signal remains r9722.15 = 1. After the command for pulse suppression, the motor speed drops. The internal STO is set when the speed drops below the zero speed detection level.

In this case, the SSM feedback signal remains HIGH; it is frozen. The drive cannot accelerate again, due to the internal STO selection.

To restart the motor safely, the STO must be selected manually and deselected once more. After the STO has been deselected, a 5 second time window is opened. If the pulse enable takes place within this time window, the motor starts. If the pulse enable does not take place within this 5 second time window, the internal STO becomes active again.

If p9509.0 = 1, the SSM monitoring is ended after the pulse suppression. The feedback signal p9722.15 drops to 0. The SSM monitoring is only reactivated after a new pulse enable. In this case, STO must not be selected and deselected to start the drive.

Restart after pulse cancellation for p9509.0 = 0

If the drive pulses have been suppressed using OFF1/OFF2/STO, the following steps must be carried out for a restart:

1. Case	• State after switching on	
		• SSM active
		• STO selected
		• Pulse suppression active
	• Deselect STO	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	
2. Case	• Situation	
		• SSM active
		• Motor turning
		• OFF1 triggered, pulses are suppressed
	• Select STO	
	• Deselect STO STO activated internally via pulse suppression: This activation must be undone by selecting/deselecting STO.	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	

4.2.9.3 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2823 SI Extended Functions - SSM (Safe Speed Monitor)
- 2840 SI Extended Functions - SI Motion drive-integrated control signals/status signals
- 2905 SI TM54F - Extended Functions control interface (p9601.2 = 1 & p9601.3 = 0)
- 2907 SI TM54F - Extended Functions assignment (F-DO 0 ... F-DO 3)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9506 SI Motion function specification (Control Unit)
- p9509 SI Motion behavior during pulse suppression (Control Unit)
- p9545 SI Motion SSM (SGA n < nx) filter time (Control Unit)
- p9546 SI Motion SSM (SGA n < nx) speed limit (CU)
- p9547 SI Motion SSM (SGA n < nx) speed hysteresis n_x (CU)
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals (Control Unit)

4.2.10 Safe Direction (SDI)

Note

Response to bus failure

If p9580 ≠ 0 and SDI is active, in the event of a communication failure, the parameterized ESR reaction only occurs if a STOP with delayed pulse suppression when the bus fails has been parameterized as the SDI response (p9566 ≥ 10).

4.2.10.1 Safe Direction with encoder

The Safe Direction function (SDI) allows reliable monitoring of the direction of motion of the drive. If this function is activated, the drive can only move in the enabled direction.

Principle of operation

After SDI has been selected via terminals or PROFIsafe, the delay time p9565 is started. During this period, you have the option of ensuring that the drive is moving in the enabled direction. After this, the Safe Direction function is active and the direction of motion is monitored.

If the drive now moves more than the configured tolerance (p9564) in the disabled direction, message C01716 is output and the stop response defined in p9566 is initiated. To acknowledge the messages you must first deselect SDI, remove the fault cause and then safely acknowledge the messages. Only then can you reselect SDI.

Features

- Parameters r9720.12 and r9720.13 display whether the SDI function is selected.
- Parameters r9722.12 and r9722.13 display whether the SDI function is active.
- Parameter p9564 is used to set the tolerance within which a movement in a non-enabled (safe) direction is tolerated.
- Parameter p9566 defines the stop response in the case of a fault.
- For control via TM54F, parameters p10030 and p10031 are used to define the terminals for SDI.
- Parameters p10042 to p10045 are used to define whether the SDI status in the F-DO status display of theTM54F is taken into account.
- If "SDI positive" is selected, the following value is set automatically:
  - r9733[1] = 0 (setpoint limitation negative)
- If "SDI "negative" is selected, the following value is set automatically:
  - r9733[0] = 0 (setpoint limitation positive)
- The absolute setpoint speed limit is available in r9733[2].

Enabling the Safe Direction function

The "Safe Direction" function is enabled with p9501.17 = 1.

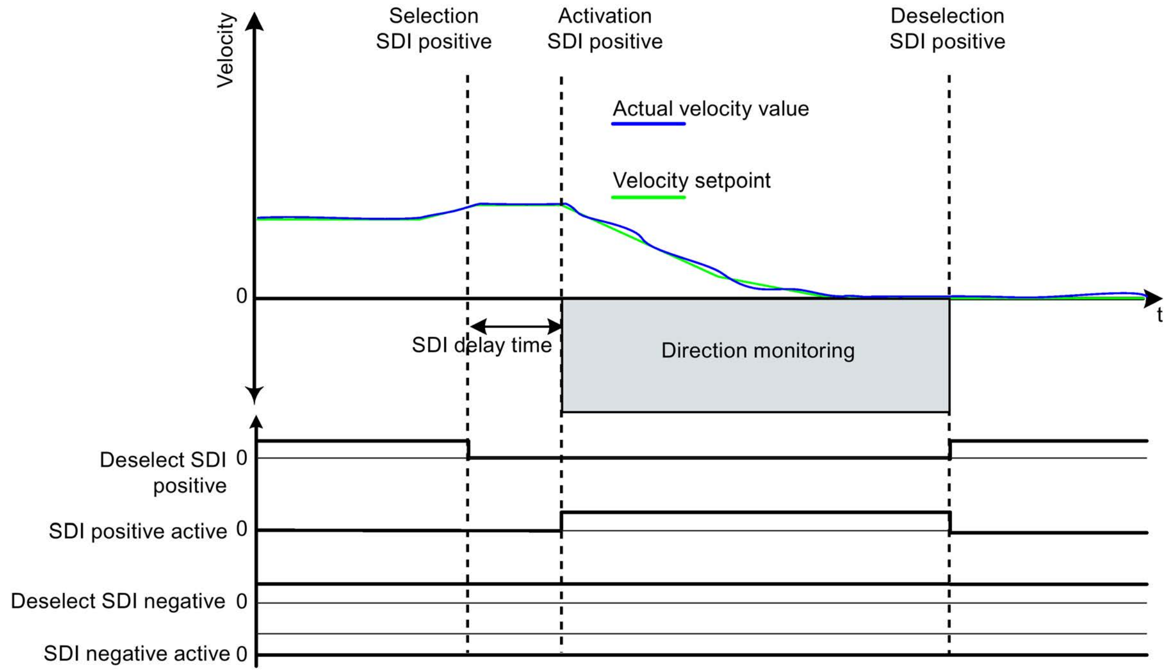


Figure 4-17 Functional principle SDI with encoder

4.2.10.2 Safe Direction without encoder

Set p9506 = 1 or p9506 = 3 (factory setting = 0) to activate Safety Integrated Extended Functions without encoder. You can also make this setting by selecting "Without encoder" on the Startdrive safety screen.

Note

Defaults

For commissioning, also pay attention to the description in Chapter "Default settings for commissioning Safety Integrated functions without encoder (Page 278)."

Differences between SDI with encoder and SDI without encoder

- For Safe Direction without encoder, after pulse suppression the drive is unable to determine the current speed. For this operating state, the behavior is defined in parameter p9509.8:
  - p9509.8 = 1

    The status signal displays "inactive".
  - p9509.8 = 0

    The status signal displays "active", and the drive takes on the state STO.
- Due to the less precise position recognition, "Safe Direction without encoder" requires a larger tolerance (p9564) compared with the function with encoder.

Note

No detection of a change in direction by means of p1820 or p1821

If the direction of rotation is reversed via p1820 or p1821, then safe monitoring is still possible: However, in this case, the setpoint limitation r9733 is calculated with the wrong direction of rotation. A reversal of the rotational direction with p1820 or p1821 therefore does not make sense.

Restart after pulse cancellation for p9509.8 = 0

If the drive has been switched off via OFF1/OFF2/STO etc., the following steps need to be carried out before a restart can be performed:

1. Case	• State after switching on	
		• SDI selected
		• STO selected
		• Pulse suppression active
	• Deselect STO	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	

2. Case	• Situation	
		• Traversing to standstill with SDI selected
		• Initiate OFF1
		• Pulses are canceled; internal selection STO becomes active
	• Select STO	
	• Deselect STO STO activated internally via pulse suppression: This activation must be undone by selecting/deselecting STO.	
	• The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	
3. Case	• Situation	
		• Traversing to standstill with SDI selected
		• Initiate OFF1
		• Pulses are canceled; internal selection STO becomes active
	• Deselect SDI STO activated internally via pulse suppression: This activation must be undone by deselecting SDI.	
	• Select SDI The drive enable must be issued within 5 seconds via a positive edge at OFF1, otherwise STO is reactivated.	
4. Case	• Situation	
		• All Safety Integrated functions are deselected.
	• After this the drive enable must be given by a positive edge at OFF1.	
	• In this case, the motor is not started safely.	

When acknowledging SDI with STOP C, you must maintain the following sequence:

1. Correct the incorrect setpoint input.
2. Deselect SDI.

   While the safety STOP is active, this ensures that the motor cannot travel in the direction that has not been enabled while the SDI function is deselected.
3. Select SDI again.

   The SDI limits are then set again.
4. Cancel the safety STOP as a result of "safe acknowledgment".

4.2.10.3 Safe Direction without selection

Differences between Safe Direction with and without selection

- As an alternative to controlling via terminals and/or PROFIsafe, there is also the option of parameterizing SDI without selection. In this case, SDI will be permanently active after POWER ON (with encoder) or will be active after switch-on (without encoder).
- The "SDI without selection" function is activated as follows:
  - p9512.12 = 1 (SDI positive (CU) statically selected)
  - p9512.13 = 1 (SDI negative (CU) statically selected)
- The stop response is parameterized with p9566[0].

Switching the motor on and off (without encoder)

The time response and diagnostic options are as follows in this SDI version:

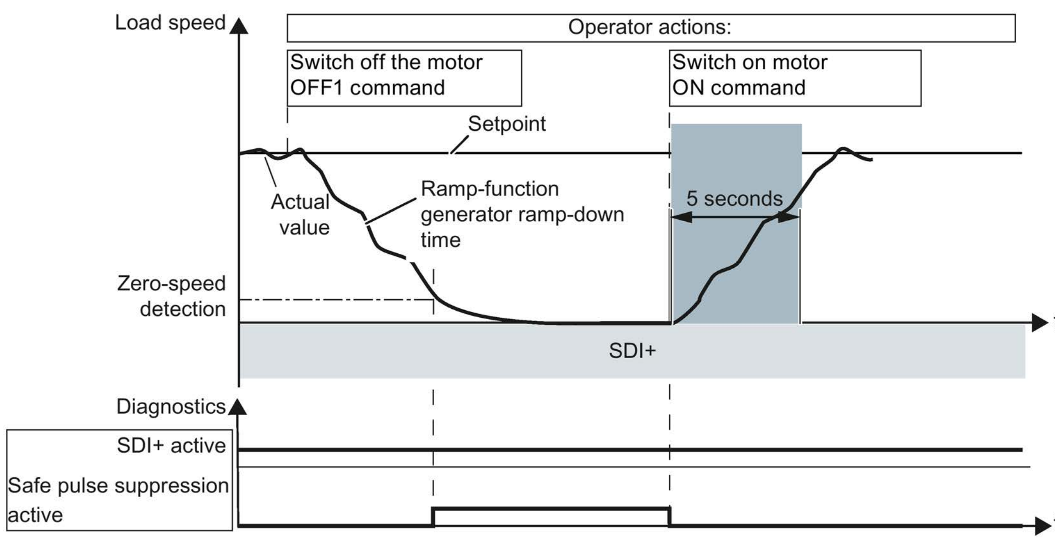


Figure 4-18 Time response of SDI without selection (example: Switching the motor on and off (without encoder))

"SDI without selection" behaves as follows when switching off and switching on again:

- After switch-off, the motor behaves in accordance with the canceled signal (OFF1, OFF2 or OFF3).
- STO (≙ safe pulse cancellation) becomes active after the standstill limit is undershot.
- After the ON command, the converter cancels the "safe pulse suppression" state and the start procedure is initiated.
- If the minimum current has not been reached after 5 seconds, the converter returns to the "safe pulse suppression" state and initiates the safety message C01711(1041).

4.2.10.4 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2824 SI Extended Functions - SDI (Safe Direction)
- 2840 SI Extended Functions - SI Motion drive-integrated control signals/status signals
- 2905 SI TM54F - Extended Functions control interface (p9601.2 = 1 & p9601.3 = 0)
- 2906 SI TM54F - Extended Functions Safe State selection
- 2907 SI TM54F - Extended Functions assignment (F-DO 0 ... F-DO 3)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1820[0...n] Reverse the output phase sequence
- p1821[0...n] Direction of rotation
- p9501.17 SI Motion enable safety functions (Control Unit): Enable SDI
- p9506 SI Motion function specification (Control Unit)
- p9509 SI Motion behavior during pulse suppression (Control Unit)
- p9564 SI Motion SDI tolerance (Control Unit)
- p9565 SI Motion SDI delay time (Control Unit)
- p9566 SI Motion SDI stop response (Control Unit)
- p9580 SI Motion STO delay bus failure (Control Unit)
- r9720.0...27 CO/BO: SI Motion drive-integrated control signals
- r9722.0...31 CO/BO: SI Motion drive-integrated status signals (Control Unit)
- r9733[0...2] CO: SI Motion speed setpoint limit active
- p10017 SI Motion digital inputs debounce time (CPU 1)
- p10030[0...3] SI TM54F SDI positive input terminal (CPU 1)
- p10031[0...3] SI TM54F SDI negative input terminal (CPU 1)
- p10039[0...3] SI TM54F Safe State signal selection (CPU 1)
- p10042[0...5] SI TM54F F-DO signal sources (CPU 1)
- p10043[0...5] SI TM54F F-DO 1 signal sources
- p10044[0...5] SI TM54F F-DO 2 signal sources
- p10045[0...5] SI TM54F F-DO 3 signal sources

4.2.11 Safely Limited Acceleration (SLA)

Function "Safely-Limited Acceleration" (SLA) monitors that the motor does not violate the defined acceleration limit (e.g. in the setup mode). SLA detects early on whether the speed is increasing at an inadmissible rate (the drive accelerates uncontrollably) and initiates the stop response.

SLA is effective when accelerating, however, not when braking.

Note

Safety function "Safely-Limited Acceleration" (SLA) can only be used with an encoder.

Note

Safety function "Safely-Limited Acceleration" (SLA) can only be used for 1-encoder systems.

Enabling SLA

- You enable the SLA function with p9501.20 = 1.

Selecting SLA

Select the SLA function using the PROFIsafe control word S_STW1.8 or S_STW2.8. Which control word you use depends on the PROFIsafe telegram that you configured.

Once selected, the SLA function becomes immediately active without any delay.

You can use telegrams 30, 31, 901, 902 and 903 for SLA. These telegrams contain the control words S_STW1.8 and S_STW2.8 and status words S_ZSW1.8 and S_ZSW2.8 for SLA.

Acceleration limit

- You define the acceleration limit to be monitored using parameter p9578. This limit value is applicable for both the positive and negative directions of rotation.
- When setting p9578, the following rule must be complied with:
  - p9578 ≥ 10 · r9790[1]
- The possible acceleration resolution is shown by the drive in r9790:
  - r9790[0] = resolution, coarse
  - r9790[1] = resolution, fine

  The actual accuracy of the acceleration detection depends on the type of actual value acquisition, the gear ratios as well as the quality of the encoder being used.
- The drive indicates the velocity limit corresponding to the actual acceleration in r9714[3].
- r9789 allows the diagnosis of the finer resolution acceleration monitoring offered Index 0 indicates the actual acceleration determined. Index 1 and 2 indicate the current limit values of the SLA monitoring.

Filter time

If the determination of the acceleration leads to very noisy signals, the drive cannot reasonably monitor the acceleration.

Remedy

- In this case, increase the "SLA filter time" (p9576).

  Note that SLA reacts with a delay when you increase the filter time.

Stop response

If the SLA subsequently detects violation of the acceleration limit, the drive initiates the stop response configured using p9579.

Principle of operation

The following diagram shows the principle of operation of SLA:

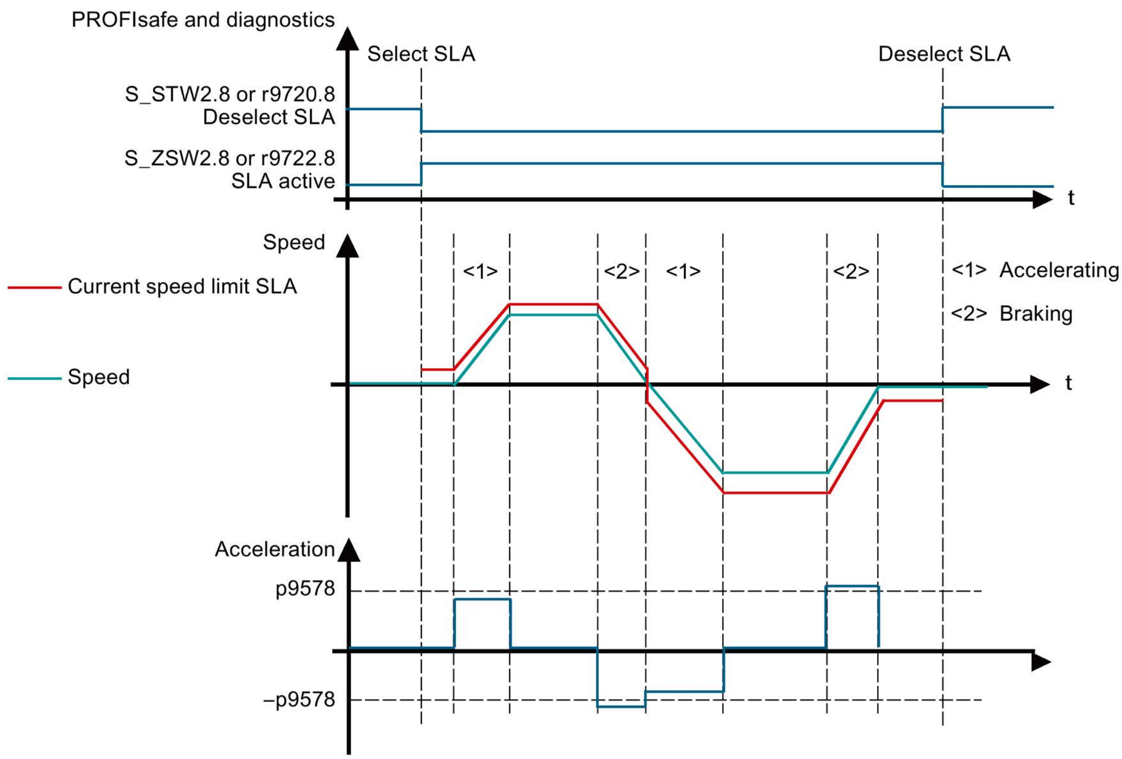


Figure 4-19 Safely-Limited Acceleration (SLA): Principle

Transmission via PROFIsafe

Once SLA has been parameterized and selected, the monitoring results are transmitted in status words S_ZSW1.8 or S_ZSW2.8 (see Chapter "Process data (Page 217)").

Note

Response to bus failure

If p9580 ≠ 0 and SLA is active, in the event of a communication failure, the parameterized ESR reaction only occurs if a STOP with delayed pulse suppression when the bus fails has been parameterized as the SLA response (p9579 ≥ 10).

Transfer via SIC

Once SLA has been parameterized and selected, the monitoring results are also transmitted in SIC in status word S_ZSW1B.8 (Chapter "Safety Info Channel and Safety Control Channel (Page 251)"). You will find this status word in telegrams 700 and 701.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2838 SLA (Safely-Limited Acceleration)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9576 SI Motion SLA filter time (CU)
- p9578 SI Motion SLA acceleration limit (CU)
- p9579 SI Motion SLA stop response (Control Unit)
- r9714[3] CO: SI Motion diagnostics velocity: Actual SLA velocity limit on the Control Unit
- r9719.17 CO/BO: SI Motion control signals 2: Deselect SLA
- r9720.8 CO/BO: SI Motion drive-integrated control signals: Deselect SLA
- r9721.11 CO/BO: SI Motion status signals (Control Unit): SLA active
- r9722.8 CO/BO: SI Motion drive-integrated status signals (Control Unit): SLA active
- r9789 CO: SI Motion SLA acceleration acceleration diagnostics
- r9790 SI Motion acceleration resolution

4.2.12 Safe Brake Test (SBT)

Note

SBT only with encoder

The "Safe Brake Test" (SBT) diagnostic function can only be used with an encoder.

The diagnostic function "Safe Brake Test" function (SBT) checks the holding torque of a brake (operating or holding brake). The drive purposely generates a configurable torque against the applied brake. If the brake is operating correctly, the axis motion remains within a parameterized tolerance. However, if larger axis motion is identified from the encoder actual values, the brake is not in a position to provide the specified holding torque. The brake must now be serviced or replaced.

Features

The Safe Brake Test function has the following properties:

- The parameters of the "SBT" function are protected by the safety password, and can only be changed in the safety commissioning mode.
- Using this function, brakes can be tested that are directly connected to SINAMICS S120 (integrated brake control), but also externally controlled brakes (e.g. via a PLC).
- A maximum of 2 brakes can be tested:
  - A motor holding brake, controlled by the integrated brake control of the SINAMICS, and in addition, an externally controlled brake.
  - 2 externally controlled brakes
  - A motor holding brake, controlled by the integrated brake control of the SINAMICS.
  - One externally controlled brake

- The following options are available to control the SBT function:
  - BICO interconnection; this setting uses digital signals (e.g. DIs) to operate the "SBT" function.
  - Safety Control Channel (SCC) via PROFIBUS or PROFINET

    Using SCC, the SBT function can be directly controlled from a higher-level control system. You can find additional information about SCC and SIC data in Chapter "Safety Info Channel and Safety Control Channel (Page 251)".
  - The brake test can be automatically executed when the forced checking procedure (test stop) is selected. With this setting, no additional signals are required for the control. However, the test possibilities are restricted.
- The "Safe Brake Test" (SBT) diagnostic function is suitable for safety functions up to Category 2 according to ISO 13849-1.

  Safe Brake Test (SBT) is suitable as diagnostics function for a brake that is controlled in a safety-relevant fashion (e.g. via SBC). With one brake in a Category 2 application and with 2 brakes in a Category 3 application, a Performance Level of up to Category PL d can be achieved with an adequate test rate.

  You will find an application example of the calculation at this address (https://support.industry.siemens.com/cs/ww/en/view/69870640).

Preconditions

The following preconditions must be satisfied when using the "Safe Brake Test" function:

- The Safety Integrated Extended Functions must be enabled; also available for the Safety Integrated Extended Functions without selection.

  To acknowledge errors when exiting the brake test, "Extended Functions without selection and Basic Functions via onboard terminals" must be activated (p9601 = 0025 hex).
- Safety Integrated Extended Functions with encoder have been enabled

  You can find information about possible encoder concepts in Chapter "Notes regarding safe actual value sensing using an encoder system (Page 155)".
- Speed control with encoder (p1300 = 21).

  SBT is not possible with encoderless speed control (e.g. vector V/f control) and torque control. In this case, alarm A01784 is output.

Note

SBT and SBC

The Safe Brake Control (SBC) function must be activated to control a motor holding brake in a safety-relevant fashion.

However, this is not necessary to perform the brake test.

Enabling the SBT function

To enable the Safe Brake Test function, proceed as follows:

1. Enable the Safe Brake Control (SBC) function: p9602 = 1.
2. Select the SBT selection type with parameter p10203:
   – = 0
     Selection of SBT via SCC
   – = 1
     Selection of SBT via BICO
   – = 2
     Selection of SBT for forced checking procedure (test stop)
3. Check the motor type; the following settings must apply: p10204 = r0108.12

Parameterizing the test sequences

For testing brake 1 [index 0] or 2 [index 1], initially enter those values which apply to both test sequences:

- Brake type (p10202[0,1])
  – = 0 (≙ block)
    Make this setting if one of the brakes is either not available or is not to be tested.
  – = 1 (≙ test motor holding brake)
    For this setting, set p1215 = 1 in addition.
  – = 2 (≙ test external brake)
- You define the holding torque of brakes using p10209.
- Test torque ramp time p10208[0,1]

  Within this time, before starting the test sequence, the test torque is ramped up. And at the end of the sequence, it is ramped down again within this time.

  Note

  When testing an external brake, whose mechanical design exhibits backlash (e.g. if there is a gearbox located between the motor and external brake), it can make sense to extend the ramp time (p10208) when ramping up and ramping down the test torque.

- The parameters for the telegram extension relevant for SCC/SIC can be performed automatically by setting p60122 = 701. However, the telegram extension must have been previously created. More detailed information on this can be found in Chapter "Safety Info Channel and Safety Control Channel (Page 251)".

- If you control the brake test using BICO signals (p10203 = 1), set the following parameters in addition:

p10230.0	Signal for selecting the brake test
p10230.1	Signal for starting the test sequence
p10230.2	Signal for selecting the brake to be tested (= 0: Brake 1; = 1: Brake 2)
p10230.3	Signal for selecting the sign of the test torque (= 0: positive; = 1: negative)
p10230.4	Signal to select the test sequence (= 0: sequence 1; = 1: sequence 2)
p10230.5	Feedback signal for the state of the external brake (= 0: external brake open; = 1: external brake closed)

You can parameterize 2 test sequences for each brake. Each test sequence is characterized by the following setting values:

- Brake test sequence 1

p10210[0,1]	Test torque to be generated in % of the brake holding torque
p10211[0,1]	Test duration in ms
p10212[0,1]	Positional deviation to be tolerated in mm/degrees during the test

- Brake test sequence 2

p10220[0,1]	Test torque to be generated in % of the brake holding torque
p10221[0,1]	Test duration in ms
p10222[0,1]	Positional deviation to be tolerated in mm/degrees during the test

- Perform a POWER ON after commissioning

NOTICE

Damage to the motor holding brake as a result of an incorrect setting

Brake wear increases if the motor holding brake is incorrectly set. This can damage the brake.

- Correctly adjust the opening and closing times of the motor holding brake.
- If you use an external brake, you are only permitted to close it when requested by signal r10234.6 = 1. Following this, you are permitted to set the signal p10230.5 = 1 ("External brake closed").
- If you use an internal brake, set the switching times in parameters p1216 ("Motor holding brake opening time") and p1217 ("motor holding brake closing time"). Further information can be found in the SINAMICS S120 Function Manual Drive Functions.
  – Note that you must set the times p1216 and p1217 exactly according to the physical behavior of the brake.
  – In DRIVE-CLiQ motors, the values are preassigned automatically. Do not change these default values.

Note

SBT and EPOS

If EPOS is activated, you must activate "follow-up mode" (r2683.0) before you perform the brake test so that the position monitoring does not react during the brake test.

Note

SBT and DSC

If you use SBT with SIMOTION, evaluate parameter r10234 (S_ZSW3B) and activate Safety Control Channel control word 3B (S_STW3B). In SIMOTION, r10234.1 specifies that no position monitoring or traversing may be active during the brake test.

Note

SBT and HLA

The "Safe Brake Test" (SBT) function is not available for SINAMICS HLA.

Starting SBT

1. Selection

   You have the following options for the selection of the Safe Brake Test:

   – Selection via BICO using a 0/1 signal edge at DI for p10230[0]

   – Selected via fieldbus (SCC):

     Select the brake test sequence with a 0/1 edge in S_STW3B bit 0

   – Selected using forced checking procedure (test stop) of the Extended Functions:

     Selection by signal at the intended DI

     After the 0/1 edge at the digital input for p9705 or in S_STW1B bit 8, the drive initially executes SBT automatically. Forced checking procedure (test stop) is then performed.

   Note

   When selected via DI (BICO) and selected via fieldbus (SCC, S_STW3B bit 0), then the sequence of the subsequently described steps 2 to 5 must be carefully observed.

   Note

   Only brake 1 when selecting via forced checking procedure (test stop)

   When selecting using forced checking procedure (test stop), only the internal motor holding brake parameterized as brake 1 is tested with test sequence 1 in the direction parameterized in p10218.

   It is not possible to use the brake test together with the "Automatic test stop when powering up" function.

   The pulses must be enabled when SBT is selected. When selected, the speed actual value must not exceed 1 % of the maximum speed (p1082) - and over the complete course of the SBT, it must not exceed a value of 10 % of the maximum speed.

   The brake(s) must be open.

2. Wait for feedback signal, r10231[0] = 1

3. Select brake and test sequence

   Make the following decisions before starting the brake test sequence:

   – The brake to be tested using DI for p10230[2] or S_STW3B bit 2

   – Positive or negative direction of the test torque using DI for p10230[3] or S_STW3B bit 3

   – Brake test sequence 1 or 2 using DI for p10230[4] or S_STW3B bit 4.

4. Start brake test

   Start the brake test sequence using a 0/1 edge at the DI for p10230[1] or in S_STW3B bit 1.

5. Exit brake test

   Note

   Observe the sequence when exiting

   When you exit the brake test, you must observe the following sequence.

   – Withdraw "Begin brake test" via 1/0 edge at the digital input for p10230[1] or in S_STW3B Bit 1.
   – Wait for at least one monitoring cycle (p9500).
   – Withdraw "Select brake test" via 1/0 edge at the digital input for p10230[0] or in S_STW3B Bit 0.

Note

Observe the sequence when exiting

Please also note that the following actions may only be initiated after the message "Brake test selected" (r10234.0 = S_ZSW3B.0 = 1):

- Withdraw pulse enable (OFF1)
- Select STO

Sequence

SBT has the following basic sequence:

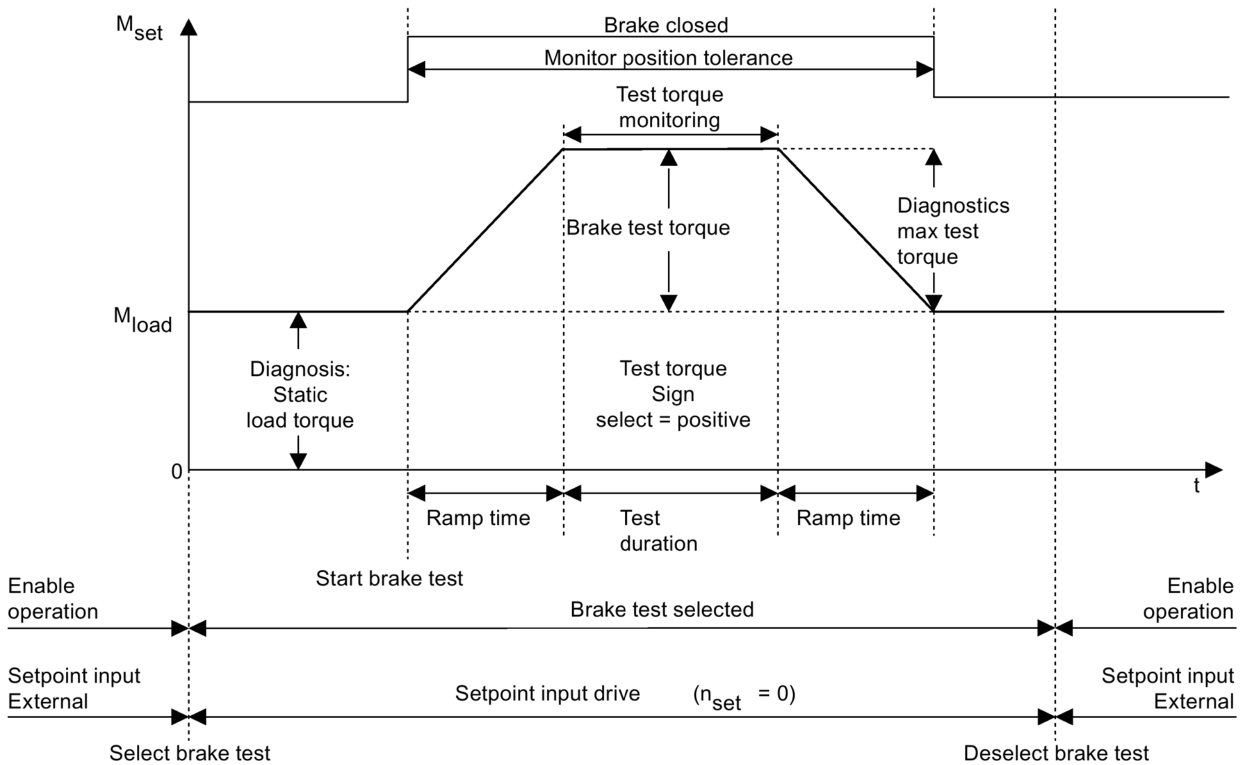


Figure 4-20 SBT: Time sequence

- After you have selected the brake test (0/1 edge in r10231.0), the drive determines the static suspended load. This is the reason that all brakes must be open and the pulses enabled when the brake test is selected.
  - When testing a motor holding brake, which is directly controlled from the drive, the dive automatically opens when the pulses are enabled and p1215 = 1.
  - When testing an external brake, via p10234.6 or for SIC/SCC, via S_ZSW3B.6, a value of 0 indicates that the external brake must be opened. Open the brake within 11 s, otherwise the drive aborts the test and outputs a fault.
- Then select the brake, the test sequence and the test direction.
- Start the brake test/test sequence (0/1 edge in r10231.1):
  - This activates the brake test.
  - The drive closes the motor holding brake or requests closing of the external brake. The request to close the brake is again indicated via p10234.6 = 1 or S_ZSW3B.6 = 1. Also in this case, only a maximum of 11 seconds must elapse, otherwise the drive outputs a fault.
- The test torque is specified during the SBT. When n = 0 is entered, the controller builds up an appropriate test torque against the closed brake. The test torque is built up along a ramp. The ramp is defined by the time of p10208.

- At the end of the test sequence, the brake is opened or there is a prompt to open the brake.
- After deselection of the test sequence (test sequence is switched off), another test sequence can be started, e.g. with a different brake in a different direction, assuming that the brake test is still selected.
- When the test sequence is active, the brake that is not being tested must remain open.
- After deselection of the SBT, the original speed setpoint takes effect again.

Cancel

A 1/0 edge of signal r10231.1 "Start brake test", interrupts the brake test. The converter issues alarm A01782 after the brake test has been interrupted. You can then deselect the brake test using a 1/0 signal edge of signal r10231.0.

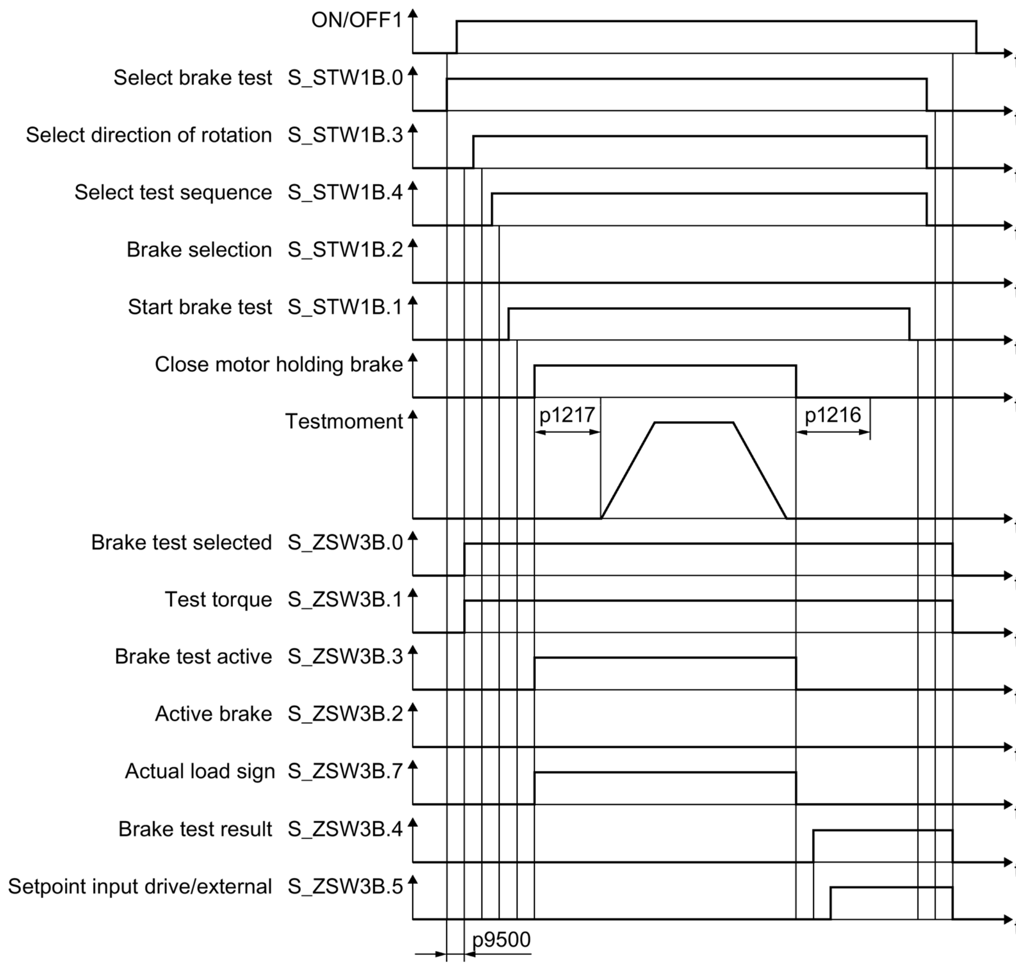
Acknowledging alarms

You can only **safely acknowledge** the alarms relevant for the brake test (Failsafe Acknowledge, e.g. using TM54F), and under certain circumstances, only acknowledge them when the brake test is deselected. For "motion monitoring without selection," a POWER ON is required – or STO/SS1 must be selected/deselected (if extended message acknowledgment is configured).

4.2.12.1 Communication via SIC/SCC

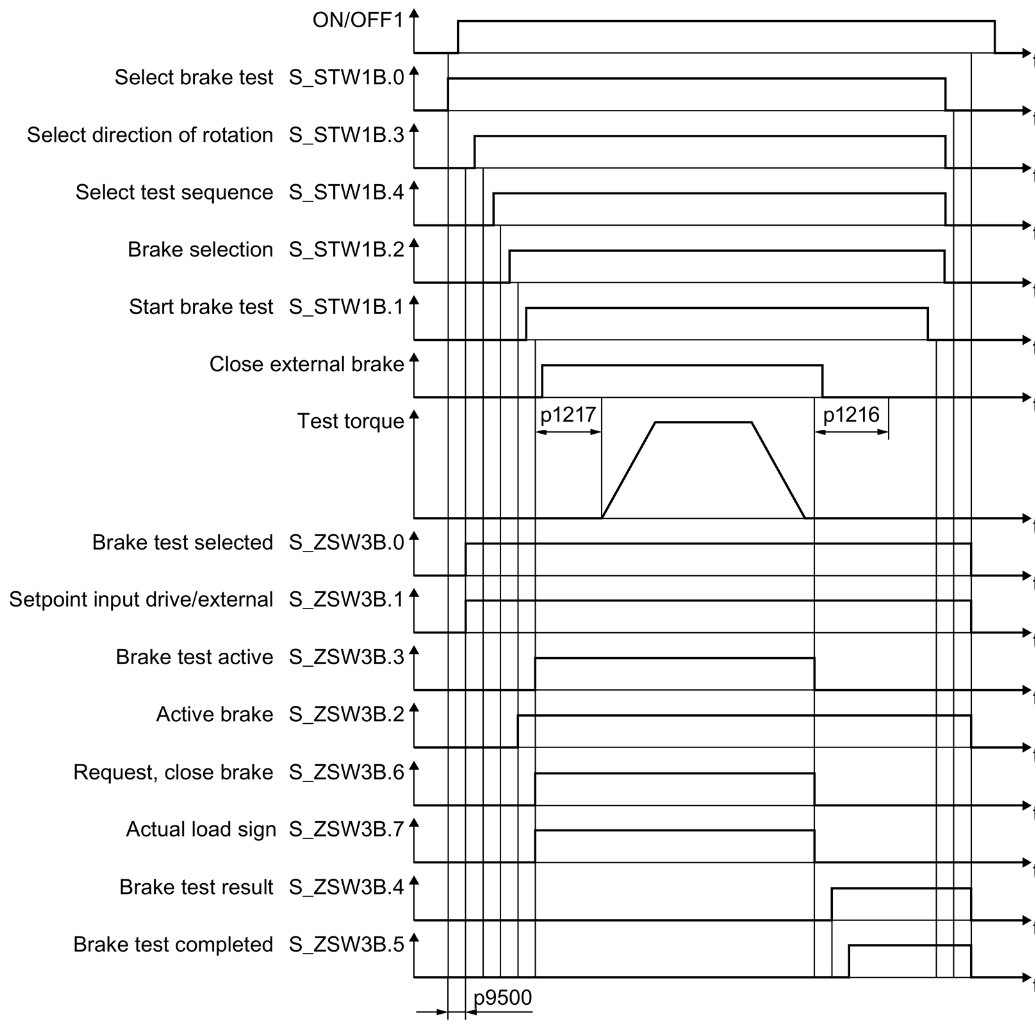
Test of a motor holding brake

The following figure shows the communication via SIC and SCC during the test of a motor holding brake:



Test of an external brake

The following figure shows the communication via SIC and SCC during the test of an external brake:



4.2.12.2 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2836 SI Extended Functions - SBT (Safe Brake Test)
- 2837 SI Extended Functions – Selection of active control word

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1215 Motor holding brake configuration
- p1216 Motor holding brake opening time
- p1217 Motor holding brake closing time
- p9501 SI Motion enable safety functions (Control Unit)
- p9601 SI enable functions integrated in the drive (Control Unit)
- p9602 SI enable safe brake control (Control Unit)
- p10201 SI Motion SBT enable
- p10202[0...1] SI Motion SBT brake selection
- p10203 SI Motion SBT control selection
- p10204 SI Motion SBT motor type
- p10208[0...1] SI Motion SBT test torque ramp time
- p10209[0...1] SI Motion SBT brake holding torque
- p10210[0...1] SI Motion SBT test torque factor sequence 1
- p10211[0...1] SI Motion SBT test duration sequence 1
- p10212[0...1] SI Motion SBT position tolerance sequence 1
- p10218 SI Motion SBT test torque sign
- p10220[0...1] SI Motion SBT test torque factor sequence 2
- p10221[0...1] SI Motion SBT test duration sequence 2
- p10222[0...1] SI Motion SBT position tolerance sequence 2
- p10230[0...5] BI: SI Motion SBT control word
- r10231 SI Motion SBT control word diagnostics
- r10234.0...15 CO/BO: SI Safety Info Channel status word S_ZSW3B
- p10235 CI: SI Safety Control Channel control word S_STW3B
- r10240 SI Motion SBT test torque diagnostics
- r10241 SI Motion SBT load torque diagnostics
- p60122 IF1 PROFIdrive SIC/SCC telegram selection

4.2.13 Safe Acceleration Monitor (SAM)

The "Safe Acceleration Monitor" (SAM) function is used to safety monitor braking along the OFF3 ramp. The function is active for SS1, SS2 or STOP B and STOP C.

Features

As long as the speed is less, the converter continuously adds the adjustable tolerance p9548 to the actual speed so that the monitoring tracks the speed. If the speed is temporarily higher, the monitoring remains at the last value. The converter reduces the monitoring threshold until the "Shutdown speed" has been reached.

SAM recognizes if the drive accelerates beyond the tolerance defined in p9548 during the ramp-down phase, and generates a STOP A. The monitoring is performed as follows:

- Monitoring with SAM is activated for SS1 (or STOP B) and SS2 (or STOP C).
- The SAM limit value is frozen after the speed limit in p9568 is undershot.
- SAM monitoring continues until the transition time to SOS/STO expires.

Note

Relationship between SSM and SAM

If 0 is entered for p9568, the speed limit of the SSM function (p9546) is also used as minimum limit value for the SAM function (safe acceleration monitoring). If the speed is below this limit, SAM no longer triggers a response from the drive.

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

Note

No direct selection of SAM

SAM is part of the Safety Integrated Extended Functions SS1 and SS2 or STOP B and STOP C. SAM cannot be individually selected.

Calculating the SAM tolerance of the actual speed

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

  Actual velocity for SAM = acceleration · acceleration duration

  The following setup rule is derived thereof:
  - For a linear axis:
    SAM tolerance [mm/min] = a [m/s^2] · MC [s] · 1000 [mm/m] · 60 [s/min]
  - For a rotary axis:
    SAM tolerance [rpm] = a [rev/s^2] · MC [s] · 60 [s/min]
- Recommendation

  The SAM tolerance value entered should be approx. 20% higher than the calculated value.
- You set the tolerance such that the "overshoot" is tolerated that necessarily occurs when standstill is reached after braking along the OFF3 ramp. However, it cannot be calculated as to just how high this is.

Note

First monitoring cycle

For SAM, in the first "SI Motion monitoring cycle" (p9500) a higher SAM tolerance is taken into account in order to compensate for possible settling operations without resulting in an incorrect initiation. The increase factor is calculated as follows:
SI Motion monitoring cycle (p9500) / SI Motion actual value acquisition cycle (p9511)

Example:
SI Motion monitoring cycle (p9500) = 12 ms
SI Motion actual value acquisition cycle (p9511) = 1 ms
SAM tolerance (p9548) = 300 rpm
Actual speed = 250
Rotary axis

In the first cycle after activation of the monitoring, the SAM limit value is therefore:

Actual speed + SAM tolerance · (12 ms/1 ms) =
250 rpm + 300 rpm · 12 =
approx. 3850 rpm

Responses

- **Speed limit violated (SAM):**
  - STOP A
  - Safety message C01706
- **System fault:**
  - STOP F with subsequent STOP A
  - Safety message C01711

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9546 SI Motion SSM (SGA n < nx) speed limit (CU)
- p9548 SI Motion SAM actual speed tolerance (Control Unit)
- p9568 SI Motion SAM speed limit (Control Unit)

4.2.14 Safe Brake Ramp (SBR)

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 with the functions "SS1 with/without encoder," "SLS without encoder," SS2 and STOP B / STOP C (for Safety with encoder). For SLS, you must connect the setpoint limitation of the Safety Integrated Functions (r9733) to the ramp-function generator (p1051/p1052).

Features

The motor is decelerated with the OFF3 ramp as soon as SS1, SS2, or SLS is triggered. Monitoring of the brake ramp is activated once the delay time in p9582 has elapsed. The drive monitors the motor to ensure that it does not exceed the set braking ramp (SBR) when braking. The safe monitoring of the brake ramp is deactivated

- For SS1:
  - As soon as the speed drops below the shutdown speed (p9560).

    Or:
  - As soon as the delay time (p9556) has elapsed.
- For SS2:

  As soon as the SS2 delay time (p9552) has elapsed.
- For SLS:
  - As soon as the set brake ramp has reached the new SLS level

    Or:
  - As soon as the actual speed drops below the newly selected SLS level and has remained there for the time parameterized in p9582.

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

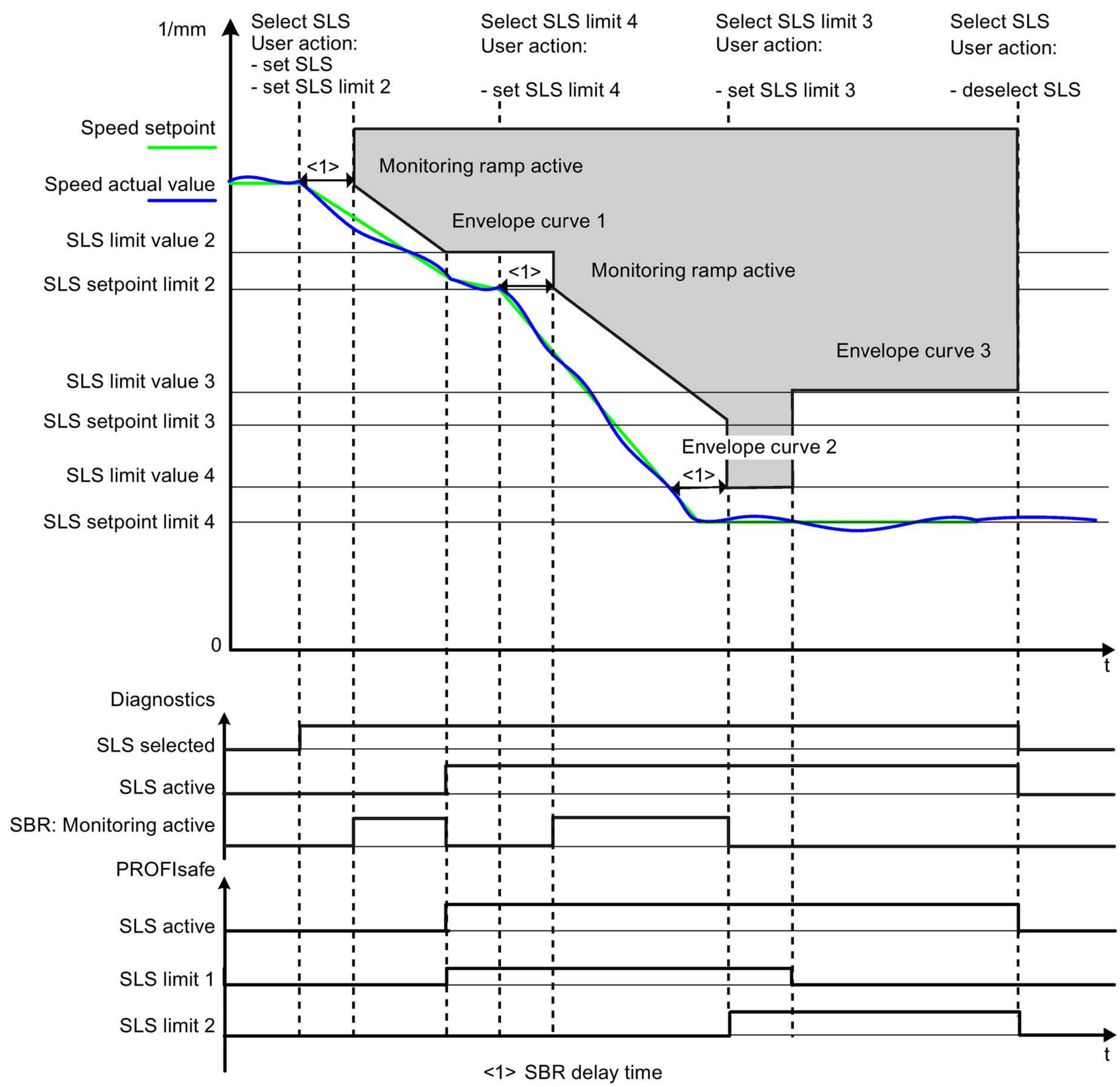


Figure 4-21 Safe Brake Ramp without encoder (for SLS)

Parameterization of the brake ramp

p9581 (SI Motion braking ramp reference value) and p9583 (SI Motion brake ramp monitoring time) are used to set the gradient of the brake ramp. Parameter p9581 determine the reference speed and parameter p9583 define the ramp-down time. Parameter p9582 is used to set the time which passes after the triggering of SS1, selection of SLS or SLS level changeover and the start of brake ramp monitoring.

Note

SBR and OFF3 curve

The SBR curve should be aligned to the OFF3 curve. In addition, you should check that under every load condition, the drive can follow this OFF3 ramp.

Note

Limitation of the SBR delay time

The SBR delay time (p9582) is limited to a minimum value of two SI Motion monitoring cycles (2 · p9500), i.e. even if a value less than 2 · p9500 is parameterized for the delay time (p9582), SBR only takes effect two safety cycles after an active SS1.

If a value greater than 2 · p9500 is parameterized for the delay time (p9582), SBR takes effect after active SS1 after the time p9582. Ensure that you round off the SBR delay time to an integer multiple of the safety cycle (p9500).

Responses to brake ramp violations (SBR)

- Safety message C01706 (SI Motion: SAM/SBR limit exceeded)
- Drive stopped with STOP A
- With p9516.4 = 1 ("No STOP A after encoder error with 1-encoder safety"), set the following response:
  - After an encoder error in the 1-encoder system, the drive triggers a STOP F, but not an immediate STOP A.
  - If safety functions are selected, the STOP F is followed by a time-controlled subsequent stop STOP B or STOP A - i.e. **without** monitoring with SBR or SAM.

  You can use this behavior if, after an encoder error, coasting down would be harmful and you should instead use the switchover to encoderless operation with encoderless braking.

Features

- Part of the “SS1 with/without encoder”, “SS2 with encoder”, “SLS without encoder” and “STOP B/STOP C (for safety with encoder)” functions.
- Parameterizable safe brake ramp

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9516 SI Motion encoder configuration safety functions (Control Unit)
- p9560 SI Motion STO shutdown speed (Control Unit)
- p9581 SI Motion braking ramp reference value (Control Unit)
- p9582 SI Motion braking ramp delay time (Control Unit)
- p9583 SI Motion braking ramp monitoring time (Control Unit)

4.2.15 Safe actual value acquisition

4.2.15.1 Notes regarding safe actual value sensing using an encoder system

Supported encoder systems

The following encoder systems can in principle be used for safety-relevant speed/position acquisition:

- Single-encoder systems

  or

- 2-encoder systems

Note

Rules for connecting an encoder

Note when connecting an encoder the valid rules: See SINAMICS S120 Drive Functions Function Manual.

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 suitable (see encoder types). The actual values are generated in a safety-relevant fashion either directly in the encoder or in the Sensor Module and are transferred to the Control Unit via DRIVE-CLiQ.

For motors without a DRIVE-CLiQ interface, the connection is made using additional Sensor Modules.

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.

Note

No monitoring of the braking ramp with SAM or SBR in the case of encoder error in the 1-encoder system

With p9516.4 = 1 ("No STOP A after encoder error with 1-encoder safety"), set the following behavior:

- After an encoder error in the 1-encoder system, the drive triggers a STOP F, but not an immediate STOP A.
- If safety functions are selected, the STOP F is followed in this case by a time-controlled subsequent stop STOP B[1)]; i.e. a stop response **without** monitoring with SBR or SAM.

You can use this behavior if, after an encoder error, coasting down would be harmful and you want instead to use the switchover to encoderless operation with encoderless braking.

[1)] If you have selected one of the Basic Functions contained in the Extended Function, the subsequent stop is STOP A.

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.

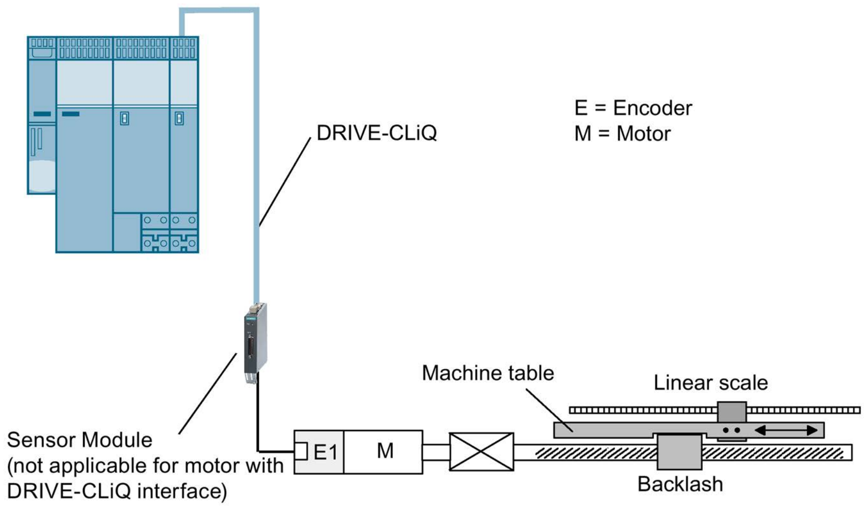


Figure 4-22 Example of a single-encoder system

2-encoder system

The failsafe actual values for a drive are provided by two separate encoders. The actual values are transferred to the Control Unit via DRIVE-CLiQ.

For motors without a DRIVE-CLiQ interface, the connection is made using additional Sensor Modules (see encoder types).

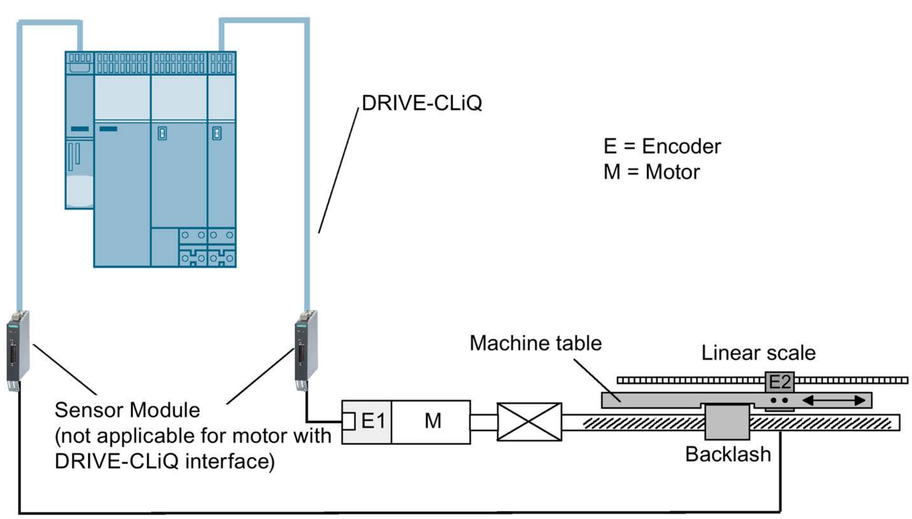


Figure 4-23 Example of a 2-encoder system on a linear axis via a ball screw

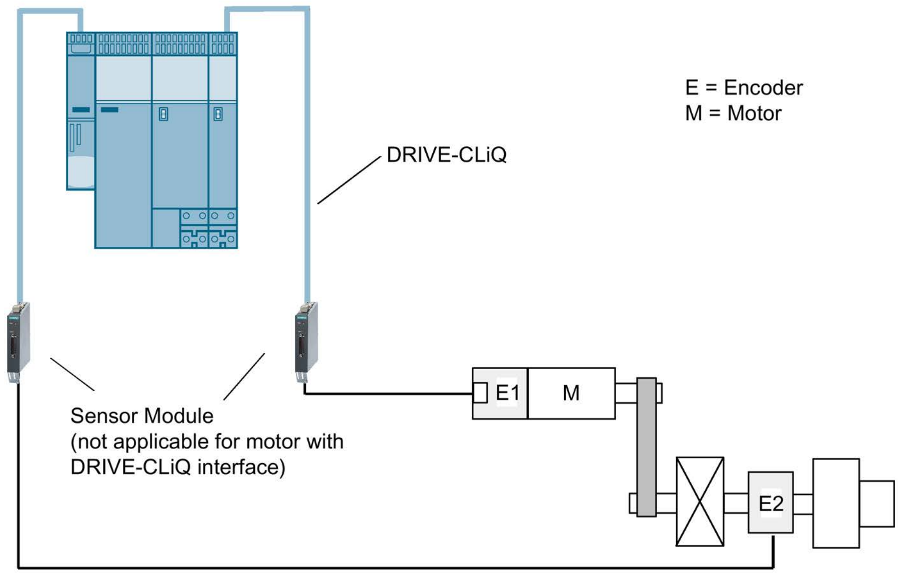


Figure 4-24 Example of a 2-encoder system on a rotary axis

When parameterizing a 2-encoder system with Safety Integrated, you must align parameters p9315 to p9329 with parameters r0401 to r0474.

Note

Assignment of the encoder parameters

Parameters p95xx are assigned to the 1st encoder; parameters p93xx to the 2nd encoder.

Note

Transfer of the values from the encoder commissioning

To accept the values from the parameters filled during the encoder commissioning to the safety parameterization, set parameter p9700 = 46 (2E hex). This copy function is only possible if you are connected online with the drive unit.

Table 4- 3 Encoder parameters and corresponding safety parameters for 2-encoder systems

Safety parameters	Designation	Encoder parameters
p9315/p9515 SI Motion coarse position value configuration		
p9315.0/p9515.0	Up-counter	r0474[x].0
p9315.1/p9515.1	Encoder CRC, least significant byte first	r0474[x].1
p9315.2/p9515.2	Redundant coarse position value, most significant bit left-justified	r0474[x].2
p9315.16/p9515.16	DRIVE-CLiQ encoder	p0404[x].10
p9316/p9516 SI Motion encoder configuration, safety functions		
p9316.0/p9516.0	Motor encoder, rotary/linear	p0404[x].0
p9316.1/p9516.1	Actual position value, sign change	p0410[x]
p9317/p9517	SI Motion linear scale grid division	p0407
p9318/p9518	SI Motion encoder pulses per revolution	p0408
p9319/p9519	SI Motion fine resolution G1_XIST1	p0418
p9320/p9520	SI Motion leadscrew pitch	Startdrive encoder parameterization dialog
p9321/p9521	SI Motion gearbox encoder	Startdrive encoder parameterization dialog
p9322/p9522	SI Motion gearbox encoder	Startdrive encoder parameterization dialog
p9323/p9523	SI Motion redundant coarse position value valid bits	r0470
p9324/p9524	SI Motion redundant coarse position value fine resolution bits	r0471
p9325/p9525	SI Motion redundant coarse position value relevant bits	r0472
p9326/p9526	SI Motion encoder assignment	Startdrive encoder parameterization dialog
p9328/p9528	SI Motion Sensor Module node identifier	–
p9329/p9529	SI Motion Gx_XIST1 coarse position safety most significant bit	For DRIVE-CLiQ encoders: p0415 = r0470 – r0471
		For SMx modules: p0415 = 14

Encoder types for single and 2-encoder systems

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

The absolute position values can be transferred via the serial EnDat interface or an SSI interface to the controller. However, these are not evaluated by the safety functions.

In systems with encoders with SINAMICS Safety Integrated (single and 2-encoder systems), the following encoders are permitted for safe actual value acquisition:

- Encoders with sin/cos 1 Vpp signals
  - 1 and 2-encoder systems
  - Connected to the SINAMICS SME20/25, SME120/125 and SMC20 Sensor Modules
  - 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").
- HTL/TTL encoders
  - Can only be used for 2-encoder systems. In this case, one encoder must be an HTL/TTL encoder. The other encoder can be a sin/cos encoder or an HTL/TTL encoder.
  - Connected to an SMC30 Sensor Module Cabinet or to the onboard interface of the C U310-2, CUA32, SINAMICS HLA or SINAMICS S120 Combi.
  - An HTL/TTL encoder connected to the onboard interface of CU310-2, CUA32, SINAMICS HLA or SINAMICS S120 Combi must not be operated as first encoder.
  - Note the lowest possible velocity resolution (r9732[1]) for an HTL/TTL encoder system.
  - When using 2 HTL/TTL encoders, these must be connected to separate power supplies.
- EnDat-2.2 encoder with SMC40
  - 1 and 2-encoder systems
- DRIVE-CLiQ encoder
  - 1 and 2-encoder systems

Note

Encoders with integrated DRIVE-CLiQ interface

These encoders must be certified at least according to IEC 61800-5-2 (SIL2) or ISO 13849-1 (Performance Level d / Category 3).

A Failure Mode Effects Analysis (FMEA) for securing the encoder on the motor shaft or on the linear drive must be performed. The result must be that the risk of the encoder mounting loosening is defined as a fault that can be ruled out (see DIN EN 61800-5-2, 2008, Table D.16). The encoder would no longer correctly map the motion if its mounting were to become loose.

You can implement failsafe detection of slip on the encoder shaft or a broken motor-encoder shaft by checking the plausibility of the acquired safety-relevant actual value with respect to the expected setpoint. If the actual value does not lie within a configurable tolerance bandwidth around the setpoint within a defined time, then it can be assumed that there is either slip - or that there is a broken connection between the encoder and the motor. You must ensure this monitoring functionality in the safety user program according to SIL 2 or PL d.

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.

Siemens motors with and without DRIVE-CLiQ connection, which can be used for Safety Integrated functions, are listed under:

Siemens motors for Safety Integrated (https://support.industry.siemens.com/cs/ww/en/view/33512621)

For these motors, the encoder mounting on the motor shaft can be considered to be safety relevant, and faults associated with an encoder becoming loose ruled out.

Note

Basic absolute encoders with EnDat interface and additional sin/cos tracks

Basic absolute encoders (e.g. EQI) that offer an EnDat interface with additional sin/cos tracks, but operate according to an inductive measuring principle internally, are not permitted for SINAMICS Safety Integrated.

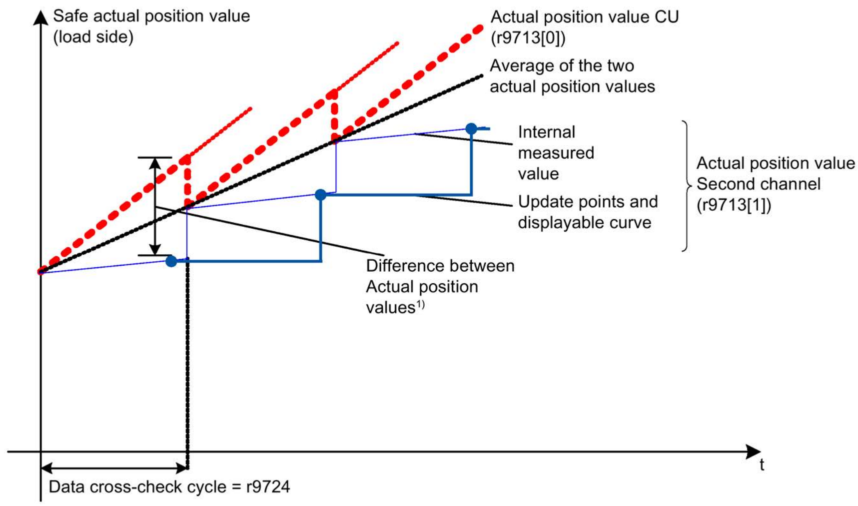
Note

Encoder types for SINAMICS HLA

The following encoder types are permissible for SINAMICS HLA:

- Single-encoder systems
  - DRIVE-CLiQ encoder with safety capability
  - sin/cos encoder connected via SME20/25, SME120/125 or SMC20 (1 V_{PP}, pure analog signal processing)
- 2-encoder systems
  - Encoders with DRIVE-CLiQ connection
  - sin/cos encoder connected via SME20/25, SME120/125 or SMC20 (1 V_{PP}, pure analog signal processing)
  - HTL/TTL encoder connected via SMC30 (not in connection with SINUMERIK)
  - TTL encoder connected via the onboard interface of the HLA module (not in connection with SINUMERIK)

Actual value synchronization



1) This deviation cannot be larger than the position difference that can arise at maximum slip (p9549) during a cross-check cycle (r9724).

Figure 4-25 Example diagram of actual value synchronization

The mean value of the actual values of both channels is calculated cyclically after actual value synchronization (p9501.3 = 1) has been activated, for example, for systems or machines with slip. The maximum slip defined in p9549 is monitored in the cross-check cycle (r9724). The maximum slip defined in p9549 is monitored once per cross-check cycle (r9724).

If "Actual value synchronization" is not enabled, the value parameterized in p9542 is used as tolerance value for the cross-checking.

Safe motion monitoring

The properties of the actual value acquisition determine not only the encoders used, but also the values for safe motion monitoring that can be achieved in the best case.

- Safe maximum speed (r9730)

  The maximum speed (load side) that is permissible due to the acquisition of actual values for safe motion monitoring functions is indicated in r9730. This parameter shows the load velocity up to which the safety-relevant encoder actual values (redundant coarse encoder position) can still be correctly sensed as a result of the particular encoder parameterization.

  The actual value acquisition clock (p9511) determines the frequency at which the actual values are acquired. The longer the clock cycle, the higher the "safe maximum velocity." On the other hand, a longer actual value acquisition clock cycle places a greater load on the Control Unit. You must consider this circumstance when setting the optimum for your application.

  For SINAMICS S120M, only the values 2 and 0 ms are allowed for the actual value acquisition cycle clock (p9511). In both cases, the frequency converter calculates with an actual value acquisition cycle clock of 2 ms regardless of the PROFIBUS DP/PN cycle clock.

- Safe positioning accuracy (r9731)

  This positioning accuracy can be achieved in the best case by acquiring the actual values. If a 2-encoder system is used, the accuracy of the poorer encoder is indicated based on the number of encoder pulses.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501.3 SI Motion enable safety-related functions Enable actual value synchronization
- p9502 SI Motion axis type (Control Unit)
- p9511 SI Motion actual value acquisition clock (Control Unit)
- p9515 SI Motion encoder coarse position value configuration (Control Unit)
- p9516 SI Motion encoder configuration safety functions (Control Unit)
- p9517 SI Motion linear encoder grid division (Control Unit)
- p9518 SI Motion encoder pulses per revolution (Control Unit)
- p9519 SI Motion fine resolution G1_XIST1 (Control Unit)
- p9520 SI Motion leadscrew pitch (Control Unit)
- p9521[0...7] SI Motion gearbox encoder (motor)/load denominator (Control Unit)
- p9522[0...7] SI Motion gearbox encoder (motor)/load numerator (Control Unit)
- p9523 SI Motion redundant coarse position value valid bits (Control Unit)
- p9524 SI Motion redundant coarse position value fine resolution bits (CU)
- p9525 SI Motion redundant coarse position value relevant bits (CU)
- p9526 SI Motion encoder assignment second channel
- p9542 SI Motion actual value comparison tolerance (crosswise) (Control Unit)
- p9549 SI Motion slip velocity tolerance (Control Unit)
- p9700 SI Motion copy function
- r9713[0...5] CO: SI Motion diagnostics actual position value load side
- r9714[0...2] CO: SI Motion diagnostics velocity
- r9724 SI Motion, cross-check cycle
- r9730 SI Motion safe maximum speed
- r9731 SI Motion safe positioning accuracy
- r9732[0...1] SI Motion velocity resolution

4.2.15.2 Notes regarding setting parameters for safe actual value sensing without encoder

Parameters p9585, p9586, p9588 and p9589 are available to guarantee safe motion monitoring for Safety Extended Functions without encoder depending on the situation in your specific application. In most cases, you can work with the default values.

- If, during the start phase, the actual value acquisition is still not operating correctly, the converter outputs messages; however these still do not represent any safety problems. In order to avoid this, increase this value of parameter **Delay time of the evaluation encoderless** (p9586). In this way, you determine the "Evaluation delay time without encoder" (p9586):
  - To determine the minimum delay time of p9586, record the starting behavior of the drive system (with motor and the intended load). The trace function allows the value for p9586 to be determined.
  - In order to avoid fault responses, deselect the "SDI without encoder" and "SLS without encoder" functions.
  - Activate the trace function using the "OFF2 → inactive" trigger, and the following as the signals to be recorded: At least one motor current phase and OFF2. After the ON command, record this motor phase current until I_{rated} is reached. Enter the time required to reach I_{min} (+ 10% reserve) in p9586.
  - Perform application-specific startup characteristics for the drive. Establish from the trace recording the time after which the peak current of the induction or reluctance motor or the pulse pattern of the rotor position identification finishes, and the current of p9588 which exceeds the "Minimum current actual value acquisition without encoder".
  - Enter the measured time + approx. 10 % into p9586.
  - Activate the "SDI without encoder" and "SLS without encoder" functions. Restart the machine, and keep the trace function activated.

    Now it is no longer permissible that messages are output.
  - Alternatively, you can change the value of p9586 in small steps and then monitor the system response. You have found a suitable value if unnecessary messages/signals no longer occur.

- Using parameter **Fault tolerance actual value acquisition encoderless** (p9585), you can set the tolerance of the plausibility monitoring of current and voltage angle.
  - For synchronous motors, p9585 = 4 must be parameterized.
  - Reducing this value can have a negative impact on the actual value acquisition and the plausibility check.
  - Increasing the value results in a longer evaluation delay.
  - For devices in the chassis format, Safety Integrated without encoder can be used with induction motors up to a maximum of 1000 kW: For very large motors, it may be necessary to increase the value in parameter p9585. For chassis format devices, parameter p9585 is preassigned a value of "2".
  - For the factory setting (= -1), for synchronous motors, the calculation automatically uses the value 4, for asynchronous or reluctance motors, the value 0.
  - The diagnostics parameter r9786[0...2] shows you the values of the plausibility angle, voltage angle and current angle currently measured by the converter. These values allow you to optimize what you enter into p9585.
- The field **Voltage tolerance acceleration** (p9589) is used to suppress acceleration peaks. An increase in this percentage value means that voltage peaks must have a greater amplitude during acceleration to avoid influencing the actual value acquisition.

Note

Settings for reluctance motors

When operating a reluctance motor, the controller settings selected are usually more dynamic. If in this case - for a factory setting of p9589 - the drive issues message C01711 with fault value 1043, then you can apply the following remedy:

- Increase p9589.

  Experience has shown that a value between 500 % and 1000 % provides robust behavior in this case.

- Set the value of **voltage tolerance acceleration** (p9589) as follows:
  - The diagnostics parameter r9784[0...1] shows the parameterized and the actual measured acceleration value. These values allow you to optimize what you enter into p9589.
  - Record the following parameters with the trace function in the current controller cycle:

    - r9784[0]: Target acceleration value

    - r9784[1]: Actual acceleration value

    - r9714[0]: load side actual velocity value on the Control Unit

    - r0063: Actual speed value
  - Accelerate the motor, if possible until it reaches the rated speed.
  - Check whether r9714[0] and r0063 match in the range 0 … rated speed.

– Set p9589 such that r9784[1] touches r9784[0] a maximum of twice per second in the range 0 … rated speed.

  - If message C01711 with fault value 1043 occurs, you have to increase p9589.

  - The value must be decreased if acceleration has resulted in an excessive safety actual speed.

– Check once again whether r9714[0] and r0063 match in the range 0 … rated speed.

If you change one of the following parameters, you have to check and set the encoderless actual value acquisition once again:

– PROFIdrive isochronous mode asynchronous participation:

  p2049 = 1

– Current controller sampling time for servo control:

  p0115[0] = 187.5 µs, 150 µs, 100 µs, 93.75 µs, 75 µs, 50.0 µs or 37.5 µs

– Current controller sampling time for vector control:

  p0115[0] = 375 µs, 312.5 µs, 218.75 µs, 200 µs, 187.5 µs, 175 µs, 156.25 µs, 150 µs or 137.5 µs

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9585 SI Motion actual value acquisition without encoder fault tolerance (CU)
- p9586 SI Motion actual value acquisition without encoder delay time (CU)
- p9587 SI Motion actual value acquisition without encoder filter time (CU)
- p9588 SI Motion actual value acquisition without encoder minimum current (CU)
- p9589 SI Motion actual value acquisition without encoder acceleration limit (CU)
- p9700 SI Motion copy function
- r9732[0...1] SI Motion velocity resolution

4.2.16 Safe gearbox stage switchover

"Safe gearbox switchover" allows you to switch between 8 gearbox ratios in operation. Switchover between gearbox ratios is only possible via PROFIsafe (p9601.3 = 1).

Parameterization

Before you can use "Safe gearbox switchover", you must parameterize the following values:

- Gear ratios

  You can set up to 8 different gearbox ratios using parameter p9521 (denominator) and p9522 (numerator).
- Direction of rotation reversal

  Using parameter p9539, you can set as to whether a direction of rotation reversal is involved for the particular gearbox.
- Position tolerance

  As a result of the motion that can possibly occur when switching over the gearbox, it may be necessary to increase the tolerance threshold for the duration of the switchover operation. Using parameter p9539, you set how the tolerance is calculated when switching over the gearbox:
  - Without actual value synchronization: p9542 · p9543
  - With actual value synchronization: p9549 · p9543

Selection

Proceed as follows to enable the "Safe gearbox switchover" function:

1. Set p9501.26 = 1
   - If control via PROFIsafe is not parameterized, then the converter outputs fault F01681 with the appropriate fault value.
   - If you activate the "Safe gearbox switchover" function on a converter, which does not support the function, then the converter outputs fault F01682 with fault value 39.
2. Switch off the drive unit and then on again (POWER ON).

Gearbox switchover without increased position tolerance

In order to switch over the gearbox stage, where no increased tolerance is required for the crosswise comparison of the actual positions, proceed as follows:

1. Set the new gearbox stage using bits 0 to 2 in byte 3 of S_STW2.
2. The actual values are then synchronized once automatically. This synchronization is used to compensate any possible difference that occurs between the position actual values of the two monitoring channels as a result of the switchover operation.

   The new gearbox stage is then active.

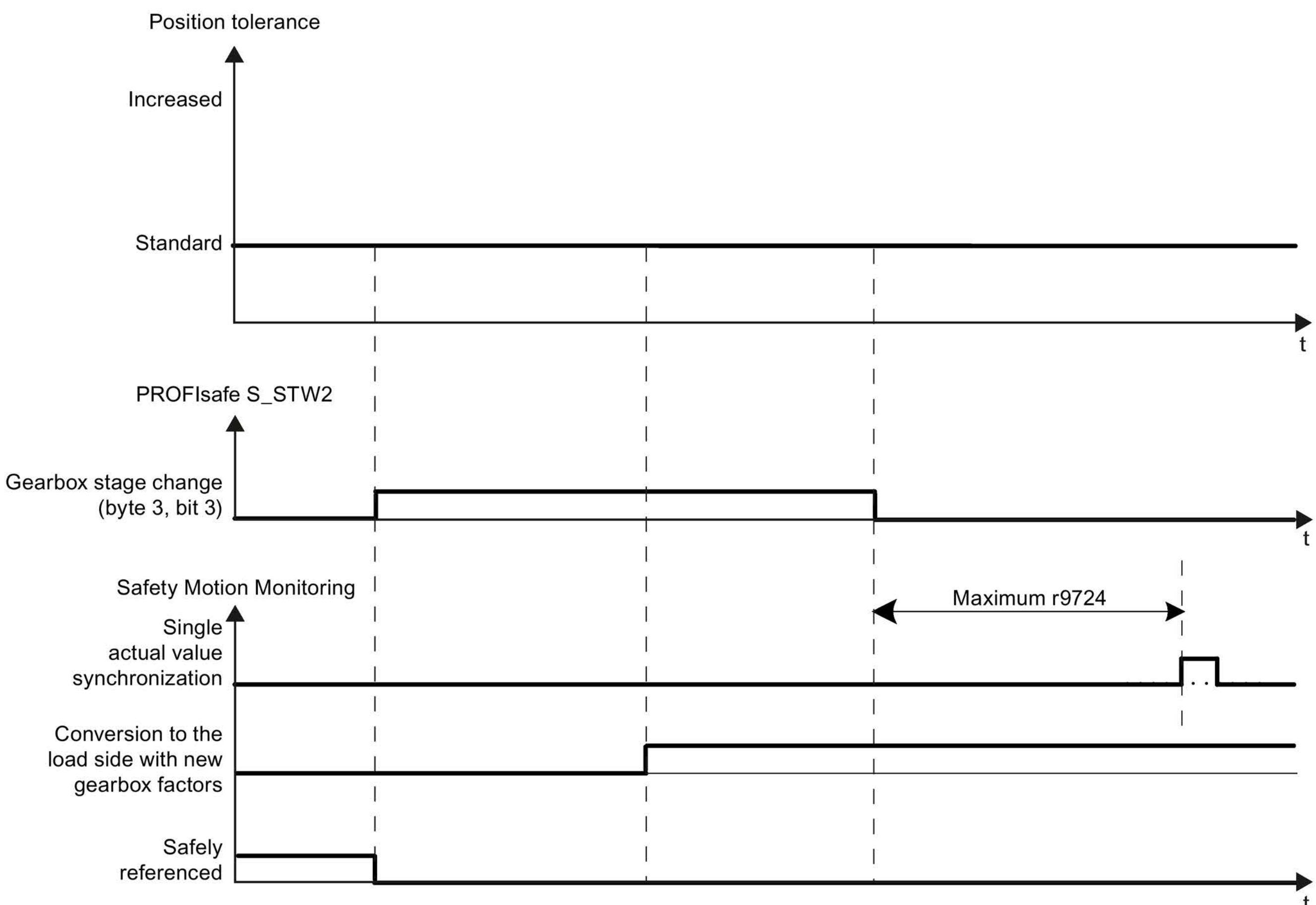


Figure 4-26 Gearbox switchover from stage "0" to "1" without increased position tolerance

Gearbox switchover with increased position tolerance

In order to switch over the gearbox stage, where increased tolerance is required for the crosswise comparison of the actual positions, proceed as follows:

Note

Maximum duration of the increased position tolerance

It is not permissible that the increased position tolerance is set for longer than 2 min. If this time is exceeded, the converter outputs message C01711 with fault value 1015 (≙ STOP F).

---

1. Set the increased position tolerance using bit 3 (= 1) in byte 3 of S_STW2.
2. Set the new gearbox stage using bits 0 to 2 in byte 3 of S_STW2.
3. Set the position tolerance back to the normal value using bit 3 (= 0) in byte 3 of S_STW2.
4. The actual values are then synchronized once automatically. This synchronization is used to compensate any possible difference that occurs between the position actual values of the two monitoring channels as a result of the switchover operation.

   The new gearbox stage is then active.

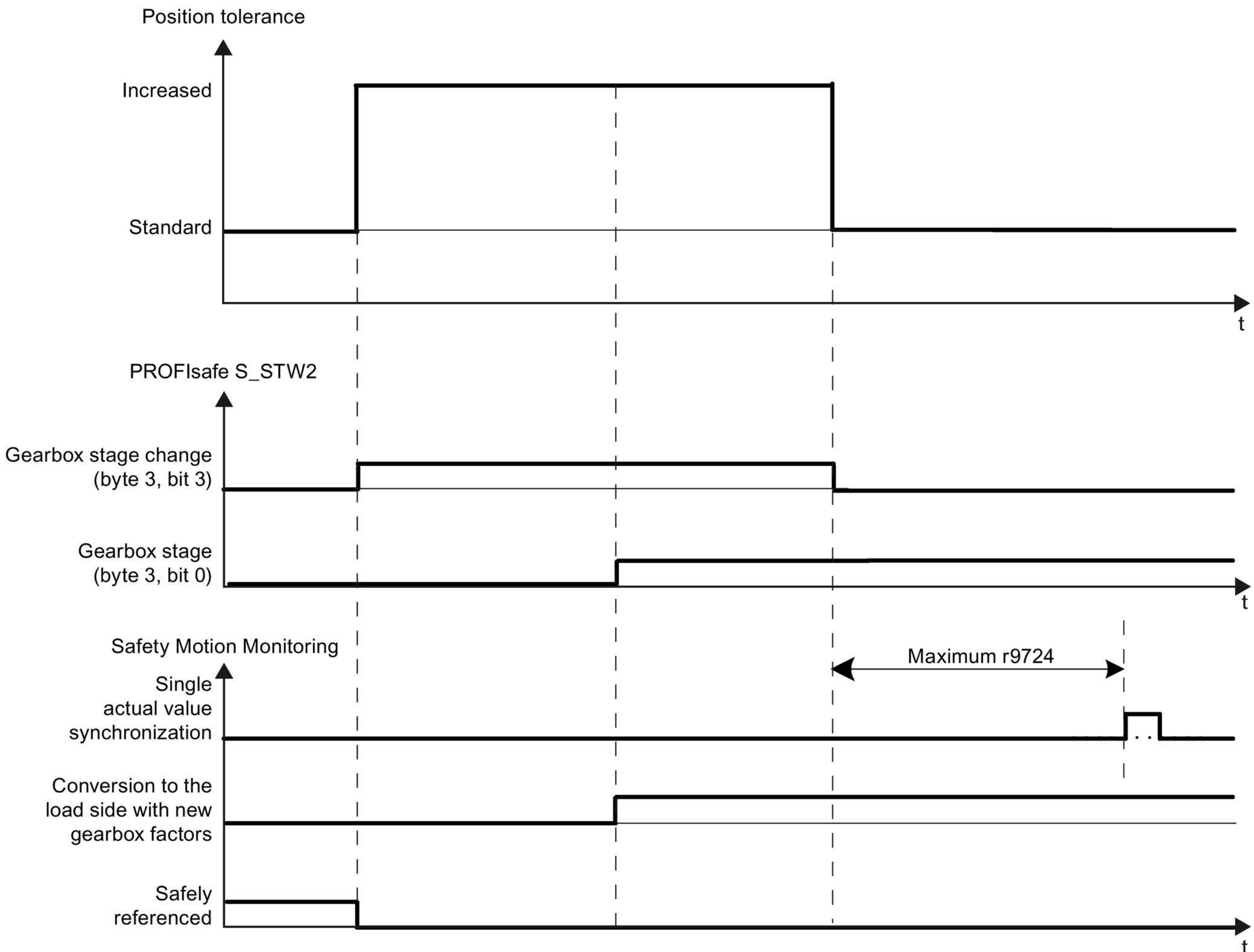


Figure 4-27 Gearbox switchover with increased position tolerance

Diagnostics

The selected gearbox stage is displayed for diagnostic purposes in parameter r9720, bits 24 to 26.

The selected gearbox stage is displayed for diagnostic purposes in parameter r9720, bit 27.

"Safe gearbox switchover" and referencing

The gearbox stage switchover means that the reference position and the user agreement are lost. This means that after a gearbox switchover, initial referencing is required, to return to the "safely referenced" state (see Chapter "Safe referencing (Page 190)").

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501.26 SI Motion enable safety functions (Control Unit): Enable reliable gearbox switchover
- p9521[0...7] SI Motion gearbox encoder (motor)/load denominator (Control Unit)
- p9522[0...7] SI Motion gearbox encoder (motor)/load numerator (Control Unit)
- p9539[0...7] SI Motion gearbox direction of rotation reversal (Control Unit)
- p9542 SI Motion actual value comparison tolerance (crosswise) (Control Unit)
- p9543 SI Motion gearbox switching position tolerance factor (CU)
- p9549 SI Motion slip velocity tolerance (Control Unit)
- r9720.0...27 CO/BO: SI Motion drive-integrated control signals

4.2.17 Forced checking procedure (test stop)

Forced checking procedure (test stop) and function test

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 the forced checking procedure (test stop) for Basic and Extended/Advanced Functions is 8760 hours; i.e. the forced checking procedure (test stop) must be performed at least once per year.

This functionality must be implemented by initiating forced checking procedure (test stop) cyclically either manually or as part of an automated process.

The test stop cycle is monitored. When the parameterized timer expires (also after POWER ON / warm restart), 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.

Executing a forced checking procedure (test stop)

Forced checking procedure (test stop) can be executed at the following points in time:

1. Forced checking procedure (test stop) can be initiated application-specifically and can therefore be executed at a time that 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 (Control Unit) - or to a bit of any arbitrary PZD.

   In addition, it is possible to select the test stop via the Safety Control Channel (see Chapter "Safety Info Channel and Safety Control Channel (Page 251)").

   – p9559 SI Motion Forced checking procedure timer (Control Unit)
   – p9705 BI: SI Motion test stop signal source
   – r9723.0 CO/BO: SI Motion diagnostics signals integrated in the drive

   If the test stop is executed as described, the action does not require a POWER ON. The acknowledgment is set by canceling the test stop request.

2. Forced checking procedure (test stop) can be automatically executed at POWER ON.

   – To perform an automatic test stop of the Safety Integrated Extended/Advanced Functions as well as an automatic test of the F-DO for the CU310-2, set p9507.6 = 1.

     When testing the F-DO of the CU310-2, you must parameterize p10042 and activate the test in p10046.

     Note

     Automatic forced checking procedure (test stop) and SBT

     Automatic forced checking procedure (test stop) of the Safety Integrated Extended/Advanced Functions is possible together with the "Brake test for test stop selection" function (p10203 = 2).

   – To perform automatic forced checking procedure (test stop) of the F-DI and F-DO of the TM54F, set p10048 = 1.
   – Even if you have parameterized forced checking procedure (test stop) for POWER ON, you can still initiate a test stop at any time through the application.
   – If the automatically initiated function cannot be correctly completed as a result of a problem (e.g. communication failure), the function will be automatically restarted after the problem has been resolved.
   – After the forced checking procedure (test stop) has been performed successfully, the converter goes into the "Ready" state.
   – Timer p9559 is reset as a result of the automatic forced checking procedure (test stop).
   – The automatic forced checking procedure (test stop) for POWER ON does not influence the Safety Integrated Functions.

In all cases, the scope of forced checking procedure (test stop) function is identical.

Safety devices

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. The user is therefore only informed that the forced checking procedure (test stop) is due in the form of an alarm, which requests the user to perform forced checking procedure (test stop) at the next possible opportunity.

Examples of when the forced checking procedure (test stop) must be performed:

- 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

Preconditions

STO is triggered when a test stop is carried out for the Safety functions. It is not permissible that STO is selected before selecting the test stop.

When blocksize Power Modules are used, the test stop must be triggered under controlled standstill conditions (speed setpoint setting of 0, current is flowing through the motor).

Forced checking procedure (test stop) F-DI/F-DO of TM54F

An automatic test stop function is available for the forced checking procedure (test stop) to test the F-DI/F-DO.

To ensure that the test stop function of the TM54F can be used, the F-DIs that are used must be interconnected according to the following wiring example. The digital inputs of F-DI 0 to F-DI 4 must connected to the "L1+" power supply. The digital inputs of F-DI 5 to F-DI 9 must connected to the "L2+" power supply.

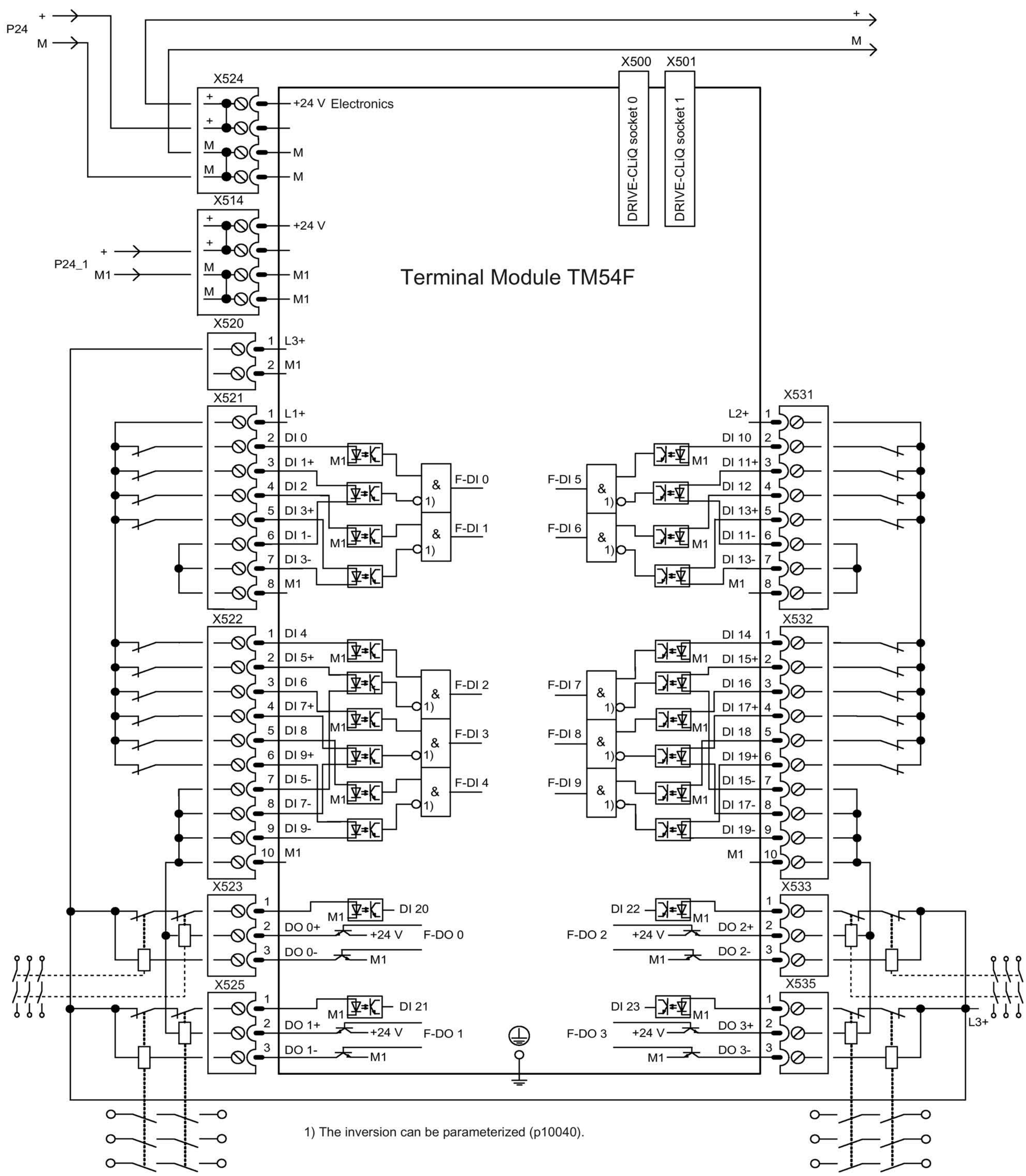


Figure 4-28   Connection example for TM54F

The F-DIs must be registered for the test stop using p10041.

Note

F-DI not operational during the test

The F-DI states are frozen for the duration of the test!

- Ensure that the states of the F-DIs are not evaluated during the test.

The associated F-DOs must be registered for the test stop using p10046.

Note

F-DOs during the time period of the test stop

F-DOs, which are not registered for evaluation using p10046, are set to "0" for the duration of the test stop ("failsafe values").

Maximum test stop time period is: $T_{\text{Test stop}} = T_{\text{FDIs}} + T_{\text{FDOs}}$

- Testing F-DIs: $T_{\text{FDIs}} = 3 \cdot \text{r10015} + 3 \cdot X$ ms

  (X = 20 ms or r10015 or p10017 - the greatest time value of the 3 values determines the waiting time X)
- Test of the F-DOs: $T_{\text{FDOs}} = 8 \cdot \text{r10015} + 6 \cdot Y$ ms

  (Y = p10001 or r10015 or p10017 - the longest time of the 3 values determines the wait time Y)

The Safety Integrated Functions of the TM54F are executed in the sampling time displayed in r10015. This sampling time corresponds to the lowest value of the communication sampling time entered in p10000[0..5].

Note

Manual dynamization required for specific F-DIs or F-DOs

It is possible that this test stop function cannot be used for certain F-DIs or F-DOs because of the devices that are connected.

- Ensure dynamic operation of the affected F-DIs/F-DOs by other means, e.g. switch operation or triggering certain machine functions.

- The test stop should be executed at a suitable point in time. This is the reason that it must be initiated by the application or carried out at POWER ON. This functionality is implemented using parameter p10007, which can be wired via BICO either to an input terminal on the drive unit (CU), or to a bit of any arbitrary PZD.

- Forced checking procedure (test stop) can be automatically executed at POWER ON.
  - If an automatic test stop of F-DI and F-DO of the TM54F is to be executed, then set p10048 = 1.
  - Even if you have parameterized the test stop for POWER ON, you can still initiate a test stop at any time through the application.
  - If the automatically initiated function cannot be correctly completed as a result of a problem (e.g. communication failure), then after the problem has been resolved, the function is automatically restarted.
  - After forced checking procedure (test stop) has been successfully executed, the TM54F goes into the "Ready" state.
  - Timer p9559 is reset as a result of the automatic forced checking procedure (test stop).
  - The automatic test stop for POWER ON does not influence the Safety Integrated Functions.

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

- p10001 SI wait time for test stop at F-DO 0 ... 3
- p10003 SI Motion forced checking procedure timer
- p10007 BI: SI Motion forced checking procedure F-DO signal source
- p10041 SI TM54F F-DI enable for test
- p10046 SI Motion F-DO feedback signal input activation

Forced checking procedure (test stop) does not require a POWER ON, but it can be automatically performed at POWER ON: The acknowledgment is set by canceling the test stop request.

Note

Forced checking procedure (test stop) of the CU310-2

The description applies analogously to forced checking procedure (test stop) of the F-DO on the CU310-2. You will find more instructions for carrying out test stops in Section "Forced checking procedure (test stop) of the CU310-2 (Page 306)".

Note

Manual checking of F-DIs and/or F-DOs

If there are F-DIs and/or F-DOs that you do not wish to have checked automatically, or that cannot be checked automatically (e.g. F-DIs of the CU310-2), the correct function of the connected sensor/actuator and its response should be checked at suitable intervals by actuating it.

Additional instructions for performing the test stops are provided in Chapters:

- Forced checking procedure (test stop) of the CU310-2 (Page 306)
- Forced checking procedure (test stop) of the TM54F (Page 313)

4.3 Safety Integrated Advanced Functions

4.3.1 Note regarding PFH values

Note

PFH values

The PFH values of the individual SINAMICS S120 safety components can be found at:

PFH values (https://support.industry.siemens.com/cs/ww/en/view/76254308)

4.3.2 License for Extended Functions or Advanced Functions

- **One** license is required for **each** axis that is operated with Safety Integrated Extended or Advanced Functions. You enter the associated license key with the "License Key" button in Startdrive. Then activate the license key via "Activate".

  As an alternative, you can enter the license key into parameter p9920 in the 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" or "SINAMICS Safety Integrated Advanced Functions" read the section "Licensing" in the SINAMICS S120 Function Manual. An insufficient license is indicated via the following fault and LED:
  - F13000 → licensing not sufficient
  - LED RDY → flashes red with 2 Hz
- When purchasing your drive, you can already decide to use Safety Integrated Functions, and you will then be provided with the required license(s) on the memory card supplied. In this case, you do not have to explicitly activate the licenses.
- A trial license is available for test purposes; this allows you to use Safety Integrated functions for a specific time without having a valid license.

  Details on the trial license can be found in the "SINAMICS S120 Function Manual Drive Functions", Chapter "Licensing".

4.3.3 Safely-Limited Position (SLP)

The Safely-Limited Position function (SLP) is used to safely monitor the limits of two traversing or positioning ranges which can be switched over by a safe signal.

Preconditions

For the Safely-Limited Position function, the following requirements must be met:

- The use of one or two suitable encoders for the extended safety functions with encoder (see also Section "Notes regarding safe actual value sensing using an encoder system (Page 155)").
- Determining the absolute position of the drive by referencing during commissioning and after all actions after which a safe absolute reference can no longer be guaranteed (POWER ON, parking)

A description of safe referencing is provided in Section "Safe referencing (Page 190)".

Principle of operation

As soon as SLP is active, maintaining the limits of the active positioning range is safely monitored. With a safety signal you can switch between 2 position ranges. Each position range is limited by its previously defined limit switch pair. When passing the position of one of the two limit switches, a parameterizable stop response (STOP A, STOP B, STOP C, STOP D or STOP E) is triggered and safety message C01715 is output.

To acknowledge this fault, you can either switch over to a range whose limits have not been violated, or you can deselect the SLP function. After acknowledgment, the drive can then be traversed again in the permissible range.

Traversing in the permissible range can be realized in a safety-related fashion using the "Retract" function (available for TM54F) (see Chapter "Retraction (Page 182)").

Features

- Selection via safe terminals (TM54F or onboard F-DI) or PROFIsafe
- Definition of the position range using 2 limit switch pairs (p9534 and p9535)
- Safe switchover between 2 different position ranges (not available for PROFIsafe telegram 30)
- Adjustable stop response (p9562)

Enabling the Safely-Limited Position function

- The "Safely-Limited Position" function is enabled with p9501.1 = 1.
- After the enable, POWER ON at the converter.

Note

No actual value synchronization for SLP

It is not permissible to simultaneously enable the SLP function and the actual value synchronization (p9501.3 = 1). In this case, the drive outputs fault F01688.

Control and status signals from the SLP

Selecting SLP and switching over between the position ranges is realized via an F-DI or a PROFIsafe control bit. SLP selection can be checked using parameter r9720.6. The selected position range can be checked using parameter r9720.19. Status bit r9722.6 is set if SLP is active. The active position range is displayed by r9722.19. Maintaining the upper or lower active SLP limit can be checked using r9722.30 and r9722.31.

Note

Jumps in the display

There is no hysteresis available for r9722.30 and r9722.31. Small fluctuations in the area around the range limit can result in the display jumping back and forth.

Controlling the Safely-Limited Position function

You have 2 options to select/deselect the Safely-Limited Position function and to switch over the range limits:

- PROFIsafe
  - SLP is selected/deselected using control words S_STW1.6 or S_STW2.6.
  - Switchover between the two limit switch pairs using control word S_STW2.19.
  - S_ZSW2.23 indicates whether the actual position is "safe"; for instance, the bit is only set after the axis was "safely referenced".
  - Whether SLP is active is indicated in bit 6 of the status words S_ZSW1.6 or S_ZSW2.6. The bit is not set until SLP is selected and the axis is in the "safely referenced" state.
  - Which SLP limit switch pair is active is indicated in status word S_ZSW2.19. This indication is only valid if SLP is itself active.
  - S_ZSW2.30 and S_ZSW2.31 indicate whether the upper or lower limit of the active position range is maintained.

Note

Extended Functions via PROFIsafe

The status signal "SLP active" (S_ZSW1.6 or S_ZSW2.6) is not the same as the diagnostic signal "SLP active" (r9722.6), but is the AND logic operation of "SLP active" (r9722.6) and "safely referenced" (r9722.23).

The other SLP status signals S_ZSW2.19 "SLP active position range", S_ZSW2.30 "upper SLP limit maintained" and S_ZSW2.31 "lower SLP limit maintained" match the corresponding bits in r9722.

Note

Restrictions for PROFIsafe telegram 30

The use of PROFIsafe telegram 30 (with the 16-bit words S_STW1 and S_ZSW1) has the following restrictions:

- Only position range 1 is available.
- A switchover to position range 2 is not possible.
- The status feedback signals "safely referenced", "active position range", "upper SLP limit maintained" and "lower SLP limit maintained" are not available.

- F-DI

  The function can be selected via the F-DI of the TM54F or via onboard F-DI (CU310-2):

  – Parameter p10032 is used to predefine the terminal for the SLP selection.

  – The terminals to select the SLP position range are defined in parameter p10033.

  – The status signal "SLP active" can be used directly as signal source, or linked via the safe state signal (p10039) with an F-DO (p10042).

Note

Extended Functions via TM54F or onboard terminals

The safe status signal "SLP active" is not the same as the diagnostic signal "SLP active" (r9722.6), but is the AND logic operation of "SLP active" (r9722.6) and "safely referenced" (r9722.23).

On the other hand, the status signal "Active SLP area" corresponds to the signal "SLP active position range" (r9722.19).

Note

Response to bus failure

If p9580 ≠ 0 and SLP is active, in the event of communication failure the parameterized ESR reaction is only realized if, as an SLP response, a STOP with delayed pulse suppression when the bus fails has been parameterized (p9562[0...1] ≥ 10).

4.3.3.1 Retraction

After a limit of the active traversing range has been exceeded, the drive must be brought back to the permissible range. A safety acknowledgment would, in this case, only retrigger the safety messages; the drive would be prevented from moving. If a switchover to the other traversing range doesn't come into question, then the only thing that remains is to deselect SLP. However, this would have the disadvantage that it is not monitored as to whether the drive is moving in the direction of the permissible traversing range.

Therefore, it is recommended that a retract function is implemented as follows:

Safety commissioning

1. Completely parameterize SLP.
2. Completely parameterize SDI.
3. Perform an acceptance test for both functions.

The next steps differ depending on the control type.

Control via PROFIsafe

- Implement a user program in your F-CPU with the following steps to implement a retract function:
  - Select SDI positive in the case that the lower SLP limit is violated, or SDI negative if the upper SLP limit is violated
  - Wait until the selected SDI is active, then deselect SLP
  - Safe acknowledgment of the limit violation
  - Movement of the drive with suitable setpoint inputs into the range that has been enabled
  - Select SLP
  - Wait until SLP is active, then deselect SDI
- Proceed as follows for an SLP limit violation:
  - Activate this program for retraction, for example, using an F-DI of the F-CPU

Note

FAQ retraction

You will find a description of how retraction can be implemented via a fail-safe control and PROFIsafe communication in the Internet at:

Retraction (https://support.industry.siemens.com/cs/ww/en/view/65128501)

Control via F-DI (TM54F or onboard terminals)

1. Using parameters p10009, parameterize an F-DI, with which you can select/deselect the internal retract logic function.
2. Parameterize two F-DIs for the selection/deselection of the SDI positive and SDI negative functions in an independent acceptance test.
3. Proceed as follows for an SLP limit violation:
   – Switch the signal at the F-DI "retract" from 0 to 1 (the signal edge is evaluated). The retract function is active at all drives that are safely referenced and where presently a limit value has been violated. When the retract function is active, SLP is inactive and depending on which limit which has been violated, either SDI positive or SDI negative is selected.
   – Safe acknowledgment of the limit violation
   – Move the drive into the range that has been enabled using the appropriate setpoint inputs.
   – Switch the signal at the F-DI "retract" from 1 to 0 (the signal edge is evaluated): As a consequence, SDI is again deselected and SLP is active again.

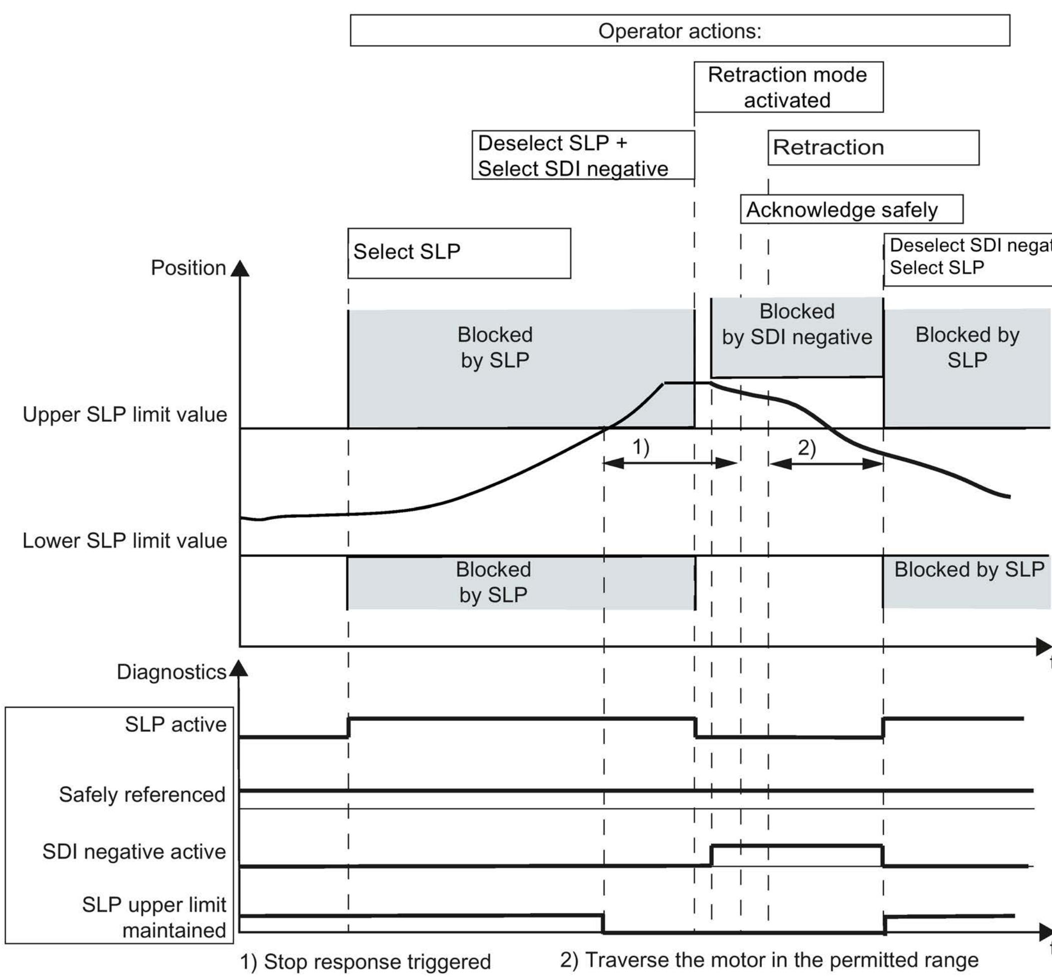


Figure 4-29 Time behavior of SLP and retraction

4.3.3.2 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2822 SI functions - SLP (Safely-Limited Position)
- 2840 SI functions - SI Motion drive-integrated control signals/status signals
- 2893 SI TM54F - Failsafe digital inputs (F-DI 0 ... F-DI 4)
- 2894 SI TM54F - Failsafe digital inputs (F-DI 5 ... F-DI 9)
- 2895 SI TM54F - Failsafe digital outputs (F-DO 0 ... 3), digital inputs (DI 20 ... 23)
- 2905 SI TM54F - control interface (p9601.2 = 1 & p9601.3 = 0)
- 2906 SI TM54F - safe state selection
- 2907 SI TM54F assignment (F-DO0 ... F-DO3)
- 2870 SI functions - CU310-2 (F-DI 0 ... F-DI 2)
- 2873 SI functions CU310-2 failsafe digital output (F-DO 0)
- 2875 SI functions - CU310-2 control interface
- 2876 SI functions - CU310-2 safe state selection
- 2877 SI functions, CU310-2 assignment (F-DO 0)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9534[0...1] SI Motion SLP (SE) upper limit values (Control Unit)
- p9535[0...1] SI Motion SLP (SE) lower limit values (Control Unit)
- p9544 SI Motion actual value comparison tolerance (referencing) (CU)
- p9562[0...1] SI Motion SLP (SE) stop response (Control Unit)
- p10009 SI Motion SLP retraction F-DI (CPU 1)
- p10032[0...3] SI TM54F SLP input terminal (CPU 1)
- p10033[0...3] SI TM54F SLP position range input terminal (CPU 1)
- p10039[0...3] SI TM54F Safe State signal selection (CPU 1)
- p10109 SI Motion SLP retraction F-DI (CPU 2)
- p10132 SI Motion SLP input terminal (CPU 2)
- p10133 SI Motion SLP position range input terminal (CPU 2)
- p10139 SI Motion Safe State signal selection (CPU 2)

4.3.4 Transferring safe position values (SP)

4.3.4.1 Transferring safe position values

The function "Transfer safe position values (SP)" enables you to transfer a safe position (i.e. absolute or relative position) to the higher-level controller via PROFIsafe. Transfer of the safe relative position (Safe Position SP) can be used to calculate the safe speed in a higher-level controller. Its use for safe position monitoring is only permissible if the reference to the absolute position was established at the controller level. In this case, the "safely referenced" bit of SINAMICS S120 (r9722.23) cannot be used.

Enabling the "Transfer safe position values" function

The following steps are required to enable the "Transfer safe position values" function:

- Enabling Safety Integrated functions
  - p9601 = 12 = C hex (≙ Extended Functions via PROFIsafe)

    or
  - p9601 = 13 = D hex (≙ Extended Functions via PROFIsafe and Basic Functions via onboard terminals)
- Enable "Transfer the safe absolute position with the possibility of calculating the velocity by the controller"
  - Select one of the PROFIsafe telegrams 901 or 902 (p60022, p9611, p9811)
  - p9501.2 = 1 (≙ enable absolute position)
  - p9501.25 = 1 (≙ enable transfer of safe position via PROFIsafe)

Note

No actual value synchronization when SP is enabled

If the transfer safe position value function is used, it is not permissible to enable actual value synchronization (p9501.3 = 1): In this case, the drive outputs fault F01688.

- Enable the "Transfer safe relative position" only to calculate the speed by the controller
  - Select one of the PROFIsafe telegrams 901 or 902
  - p9501.25 = 1
- After the enable, POWER ON the converter.

Principle of operation

After parameter assignment, release and POWER ON, the function is automatically selected and the values transferred. Please observe the following:

- Transfer of safe absolute position values
  - If the transfer of the safe relative position has been enabled through p9501.25 = 1 and p9501.2 = 0, the validity of the safe relative position is displayed by the set bit S_ZSW2.22.
  - If the transfer of the safe absolute position has been enabled using p9501.25 = 1 and p9501.2 = 1, S_ZSW2.22 is only set when the drive has also been safely referenced.
- Transfer of safe relative position values (e.g. for calculating the velocity)
  - Only S_ZSW2.22 (r9722.22, actual position value valid) must be set to calculate the speed.

Setting the modulo value for rotary axes

- P9505 is used to define the modulo range of a safety rotary axis (p9502 = 1) when the transfer of a safe absolute position (p9501.2 = 1 and p9501.25 = 1) is enabled.

  Parameterizing the modulo value can result in a jump in the position actual value if the range that can be represented overflows. p9505 must therefore only be parameterized in steps of $2^n \times 360°$ (n = 1, 2, 3, …). In all other cases, the converter issues alarm A01794. This alarm can be hidden in the case that the possible jump in the position actual value can be tolerated in the particular application – or this does not present a problem.
- The modulo function is deactivated if p9505 = 0. This parameter has no relevance for a safety linear axis (p9502 = 0) or when the transfer of a safe relative position (p9501.2 = 0 and p9501.25 = 1) is enabled.
- If SLP is also enabled (p9501.1 = 1), the modulo function must be deactivated (p9505 = 0).

Transfer formats and value range

- 32-bit

  The values are transferred in telegram 902 as 32-bit values with the following value ranges:

Table 4- 4 Value range and resolution (32 bits)

	Linear axis	Rotary axis
Position values	±737280000	±737280000
Unit	1 µm	0.001 °
Comment	Monitoring ±737.280 m with an accuracy of 1 µm	≙ 2048 revolutions

- 16-bit

  To transfer the position values in telegram 901 in the 16-bit format, you must scale the values using p9574. In this case, you must select the scaling factor so that the value of the actual position value does not exceed the 16-bit format. If the actual position value exceeds the range that can be displayed with 16 bits (±32767), a STOP F is initiated and message C01711 is output with fault value 7001. Depending on the scaling factor, this means that ranges with different sizes can be monitored with varying accuracy. Example:

– Scaling factor: 1000
– Unit: 1 µm (linear axis)
– Position value: ±32767 mm

It may therefore be precisely monitored in a range of ±32.767 m to an accuracy of 1 mm.

Note

Scaling to 16 bits

The scaling is performed by dividing the mean value of r9708[0] and r9708[1] with this scaling factor.

Example: For a position of -29.999 mm signaled in r9708[0] and r9708[1] and a scaling factor of p9574 = 1000, a numerical value of -29 is signaled to the controller.

Value range r9708

The diagnostics information in parameter r9708 is displayed with the following properties:

Table 4- 5 Value range and resolution (32 bits)

	Linear axis	Rotary axis
Position values	±737280000	±737280000
Unit	1 µm	0.001 °
Comment	Monitoring ±737.280 m with an accuracy of 1 µm	≙ 2048 revolutions

What is shown in parameter r9713 is identical to the values of r9708; however, in SINAMICS-internal calculation units.

Speed calculation

The control must calculate the speed from the position change:

- `Pos diff = Pos new - Pos old`
- `Cycle diff = cycle counter new - cycle counter old`
- `Timediff = Cyclediff · Safetycycle`
  (If `Cyclediff` = 0, the speed that was last calculated must be used.)
- `v = Pos diff/time diff`
- `Format v`

Acceptance test

An acceptance test is not required for the "Transfer safe position values" function, but the function that was implemented with the aid of SP must be accepted in the higher-level controller.

4.3.4.2 Synchronous transfer of safe position values

For axes that have to transfer their position values synchronously due to their application, proceed as follows:

Selection and enabling

1. For all axes that must transfer their position synchronously at the same time, parameterize the following:
   - Activating synchronous position transmission: p9501.29 = 1
   - Enabling SP via PROFIsafe: p9501.25 = 1
2. Set the same fieldbus cycle (DP/PN cycle) and the same SI Motion monitoring cycle (t_{SI}) for all relevant axes.

   The DP/PN cycle must be an even multiple of the SI Motion monitoring cycle. Example for setting the cycles:

Current controller cycle (p115[0])	= 0.125 ms
SI Motion actual value acquisition cycle (p9511)	= 1.0 ms
SI Motion monitoring cycle (p9500)	= 2.0 ms
Fieldbus-cycle (DP/PN cycle)	= 4.0 ms

- Activate clock synchronized PROFIdrive communication for all affected axes.

Note

Acceptance test required

If you change the fieldbus cycle after safety acceptance has already taken place, you must carry out a new safety acceptance test.

Activation

The synchronous transmission of safe positions function is always active after release. An selection/deselection, e.g. via the cyclic PROFIsafe control word, is not necessary.

Status feedback

The drive gives a cyclic status feedback "SP valid" in the status word S_ZSW2.22.

This bit is also cleared during parameterization of the synchronous position transfer if the position cannot be synchronous to the other axes.

F-Host safety program checks

The following points must be checked by the safety program of the F-Host:

- Synchronism of the counters (S_CYCLE_COUNT) of all axes involved in the cycle pattern used
- Correct adjustment of the counters of the individual axes in the cycle pattern used

4.3.4.3 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2840 SI Motion drive-integrated control signals / status signals

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9505 SI Motion SP modulo value (Control Unit)
- p9542 SI Motion actual value comparison tolerance (crosswise) (Control Unit)
- p9601 SI enable functions integrated in the drive (Control Unit)
- r9708[0...5] SI Motion diagnostics safe position
- r9713[0...5] CO: SI Motion diagnostics actual position value load side

4.3.5 Safe referencing

The "safe referencing" function allows a safe absolute position to be defined. This safe position is used for the following functions:

- Safely-Limited Position (SLP) (Page 178)
- Transferring safe position values (SP) (Page 185)
- Safe Cam (SCA) (Page 192)

General description

In most cases, an external control performs referencing to an absolute position. The converter only performs this task in special cases (for example, EPOS).

- Referencing using an external control

  Requirement: No movement of the drive

  The reference position determined by the control is entered into parameter p9572 and is declared to be valid using p9573 = 89.
- Referencing by EPOS

  The SINAMICS EPOS function transfers, when referencing, the determined position directly to Safety Integrated. This can also take place during motion.
- User agreement

  The user agreement must be set (p9726 = p9740 = AC hex) within a certain time interval (see below) after referencing.

Safety Integrated only evaluates the reference position if this is required by a function that has been enabled (e.g. SLP). Using diagnostics bit r9723.17, Safety Integrated indicates whether the drive has been referenced. Safety Integrated indicates the position of the drive in diagnostic parameters r9708 and r9713. Bit r9722.23 is set when the axis is safely referenced.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2821 SI functions - safe referencing

Value range r9708

The diagnostics information in parameter r9708 is displayed with the following properties:

Table 4- 6 Value range and resolution (32 bits)

	Linear axis	Rotary axis
Position values	±737280000	±737280000
Unit	1 µm	0.001 °
Comment	Monitoring ±737.280 m with an accuracy of 1 µm	≙ 2048 revolutions

What is shown in parameter r9713 is identical to the values of r9708; however, in SINAMICS-internal calculation units.

Referencing types

SINAMICS distinguishes between 2 types of referencing:

- Initial referencing

  For initial safe referencing, or in the event of a fault during a subsequent referencing, the following steps are necessary:

  – The reference position determined by the controller is entered in parameter p9572 and is declared to be valid with p9573 = 89. This step is not required for closed-loop position control with EPOS.

  – Referencing has been correctly implemented (r9723.17 = 1)

  – Confirm the actual position value: Within 4 s, set parameters p9726 = p9740 = AC hex

    - If you do not set p9740 = AC hex within 4 s after setting p9726 = AC hex, the converter outputs messages C01711 (value: 1002), C30711(value: 0) and any subsequent messages. User confirmation is cleared in safety channels.

    - If you do not set p9726 = AC hex within 4 s after setting p9740 = AC hex, the converter outputs messages C01711 (value: 0), C30711(value: 1002) and any subsequent messages. User confirmation is cleared in safety channels.

    After correctly setting this "user agreement", the drive is "safely referenced" (r9722.23 = 1)

    Note

    No automatic user agreement permitted

    Please note that the operator must be capable of assigning the determined position to the real position of the axis before setting the user agreement. This can be performed, for example, by a visual inspection of the axis position. Under no circumstances must these parameters ever be set fully automatically by a control system without agreement by the user. This would only be permissible if the reference position can be safely sensed by means of a safe sensor.

- Subsequent referencing

  Subsequent referencing involves referencing with a safety-relevant history (i.e. with an internally buffered user agreement) after a POWER ON or after deselecting "parking axis".

  – The position determined by the controller is entered in parameter p9572 and is declared to be valid with p9573 = 89. This step is not required for closed-loop position control with EPOS and use of an absolute encoder.

  – After the drive has been referenced, Safety Integrated automatically performs a plausibility check.

  – If the deviation between the actual absolute position and the previous standstill position saved from Safety Integrated in the NVRAM is within the tolerance p9544, then the drive goes into the state "safely referenced" (r9722.23 = 1).

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9572 SI Motion reference position (Control Unit)
- p9573 Accept SI Motion reference position (Control Unit)
- r9708[0...5] SI Motion diagnostics safe position
- r9713[0...5] CO: SI Motion diagnostics actual position value load side
- r9722.0...31 CO/BO: SI Motion drive integrated status signals (Control Unit)
- r9723.0...17 CO/BO: SI Motion diagnostics signals integrated in the drive
- p9726 SI motion, user agreement, select/deselect
- p9740 SI motion, user agreement, select/deselect MM

4.3.6 Safe Cam (SCA)

With the "Safe Cam" function (SCA), you implement safe electronic cams, safe zone sensing, or a working area limitation/protection zone delimitation for a specific axis, to replace a hardware-based solution. You parameterize up to 30 output cams for each axis. You enable each output cam individually.

Note

The "Safe Cam" (SCA) safety function can only be used with an encoder.

Defining the output cam positions

- You define the output cam positions to be monitored using the parameters p9536[x] and p9537[x] (where x = 0 ... 29).

  Note that the defined output cams must have a certain minimum length: p9536[x] - p9537[x] ≥ p9540 + p9542

  If you violate this rule, the drive will output the message F01686 ("SI Motion: Cam position parameterization not permissible").

- Owing to variations in the cycle and signal propagation times, the output cam signals of the two monitoring channels do not switch simultaneously and not precisely at the same position. For this reason, enter a tolerance band for all output cam types via parameter p9540. Within this tolerance band, the monitoring channels can have different signal states for the same output cam:

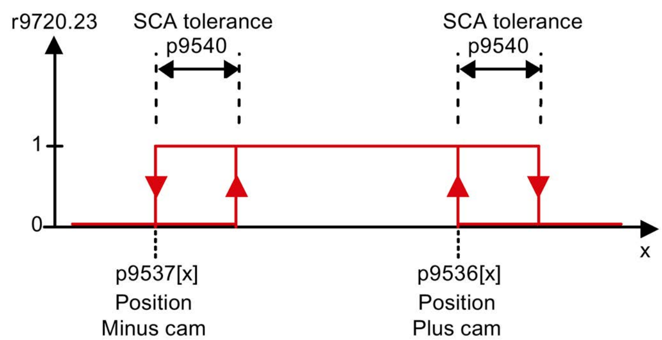


Figure 4-30 Parameterize output cam and tolerance

Note

The smallest possible tolerance range should be selected for the SCA function (< 5 ... 10 mm). It makes sense to parameterize the cam tolerance to be greater than or equal to the actual value tolerance.

- Reference the axis using the "Safe referencing (Page 190)" function.

Enabling SCA

- You enable the SCA function with p9501.28 = 1.
- You enable each output cam individually with p9503.x = 1 (where x = 0 ... 29).

⚠ WARNING

Safe referencing

The enabled output cam signals are output immediately after POWER ON. However, this output only safe after safe referencing has been performed. The cams are only considered as being safe if they were safely referenced.

- Reference the axis using the "Safe referencing (Page 190)" function.

Select SCA

Select the SCA function using the PROFIsafe control word S_STW2.23. For SCA, you must use telegram 903, in which control word S_STW2 and status word S_ZSW_CAM1 are available for SCA.

Cam synchronization

For transmission of the output cam status word via PROFIsafe to the F host, the output cam signals of the two monitoring channels are synchronized. Monitoring is also performed as to whether a different output cam signal from the second channel is plausible. If the drive detects an error, it outputs the message C01711 with the fault value 1014.

As the position tolerance for monitoring the output cam positions, the tolerance for the cross-check of the actual position between the two monitoring channels in p9542 ("Actual value comparison tolerance") is used.

Transmission via PROFIsafe

After SCA has been parameterized and selected, the monitoring results are transmitted in status word S_ZSW_CAM1 (see Chapter "Additional process data (Page 226)").

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2826 SCA (Safe Cam)
- 2844 S_ZSW_CAM1 Safety status word Safe Cam 1

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501 SI Motion enable safety functions (Control Unit)
- p9503 SI Motion SCA (SN) enable (Control Unit)
- p9505 SI Motion SP modulo value (Control Unit)
- p9536[0...29] SI Motion SCA (SN) plus cam position (Control Unit)
- p9537[0...29] SI Motion SCA (SN) minus cam position (Control Unit)
- p9540 SI Motion SCA (SN) tolerance (Control Unit)
- p9542 SI Motion actual value comparison tolerance (crosswise) (Control Unit)
- r9703.0...31 CO/BO: SI Motion SCA status signal (Control Unit)
- r9708[0...5] SI Motion diagnostics safe position
- r9720.23 CO/BO: SI Motion drive-integrated control signals: Deselect SCA
- r9727 SI Motion user agreement inside the drive
- r9771.22 SI shared functions: SCA supported

4.3.7 Forced checking procedure (test stop)

Forced checking procedure (test stop) and function test

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 the forced checking procedure (test stop) for Basic and Extended/Advanced Functions is 8760 hours; i.e. the forced checking procedure (test stop) must be performed at least once per year.

This functionality must be implemented by initiating forced checking procedure (test stop) cyclically either manually or as part of an automated process.

The test stop cycle is monitored. When the parameterized timer expires (also after POWER ON / warm restart), 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.

Executing a forced checking procedure (test stop)

Forced checking procedure (test stop) can be executed at the following points in time:

1. Forced checking procedure (test stop) can be initiated application-specifically and can therefore be executed at a time that 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 (Control Unit) - or to a bit of any arbitrary PZD.

   In addition, it is possible to select the test stop via the Safety Control Channel (see Chapter "Safety Info Channel and Safety Control Channel (Page 251)").

   – p9559 SI Motion Forced checking procedure timer (Control Unit)
   – p9705 BI: SI Motion test stop signal source
   – r9723.0 CO/BO: SI Motion diagnostics signals integrated in the drive

   If the test stop is executed as described, the action does not require a POWER ON. The acknowledgment is set by canceling the test stop request.

2. Forced checking procedure (test stop) can be automatically executed at POWER ON.

   – To perform an automatic test stop of the Safety Integrated Extended/Advanced Functions as well as an automatic test of the F-DO for the CU310-2, set p9507.6 = 1.

     When testing the F-DO of the CU310-2, you must parameterize p10042 and activate the test in p10046.

     Note

     Automatic forced checking procedure (test stop) and SBT

     Automatic forced checking procedure (test stop) of the Safety Integrated Extended/Advanced Functions is possible together with the "Brake test for test stop selection" function (p10203 = 2).

   – To perform automatic forced checking procedure (test stop) of the F-DI and F-DO of the TM54F, set p10048 = 1.
   – Even if you have parameterized forced checking procedure (test stop) for POWER ON, you can still initiate a test stop at any time through the application.
   – If the automatically initiated function cannot be correctly completed as a result of a problem (e.g. communication failure), the function will be automatically restarted after the problem has been resolved.
   – After the forced checking procedure (test stop) has been performed successfully, the converter goes into the "Ready" state.
   – Timer p9559 is reset as a result of the automatic forced checking procedure (test stop).
   – The automatic forced checking procedure (test stop) for POWER ON does not influence the Safety Integrated Functions.

In all cases, the scope of forced checking procedure (test stop) function is identical.

Safety devices

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. The user is therefore only informed that the forced checking procedure (test stop) is due in the form of an alarm, which requests the user to perform forced checking procedure (test stop) at the next possible opportunity.

Examples of when the forced checking procedure (test stop) must be performed:

- 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

Preconditions

STO is triggered when a test stop is carried out for the Safety functions. It is not permissible that STO is selected before selecting the test stop.

When blocksize Power Modules are used, the test stop must be triggered under controlled standstill conditions (speed setpoint setting of 0, current is flowing through the motor).

Forced checking procedure (test stop) F-DI/F-DO of TM54F

An automatic test stop function is available for the forced checking procedure (test stop) to test the F-DI/F-DO.

To ensure that the test stop function of the TM54F can be used, the F-DIs that are used must be interconnected according to the following wiring example. The digital inputs of F-DI 0 to F-DI 4 must connected to the "L1+" power supply. The digital inputs of F-DI 5 to F-DI 9 must connected to the "L2+" power supply.

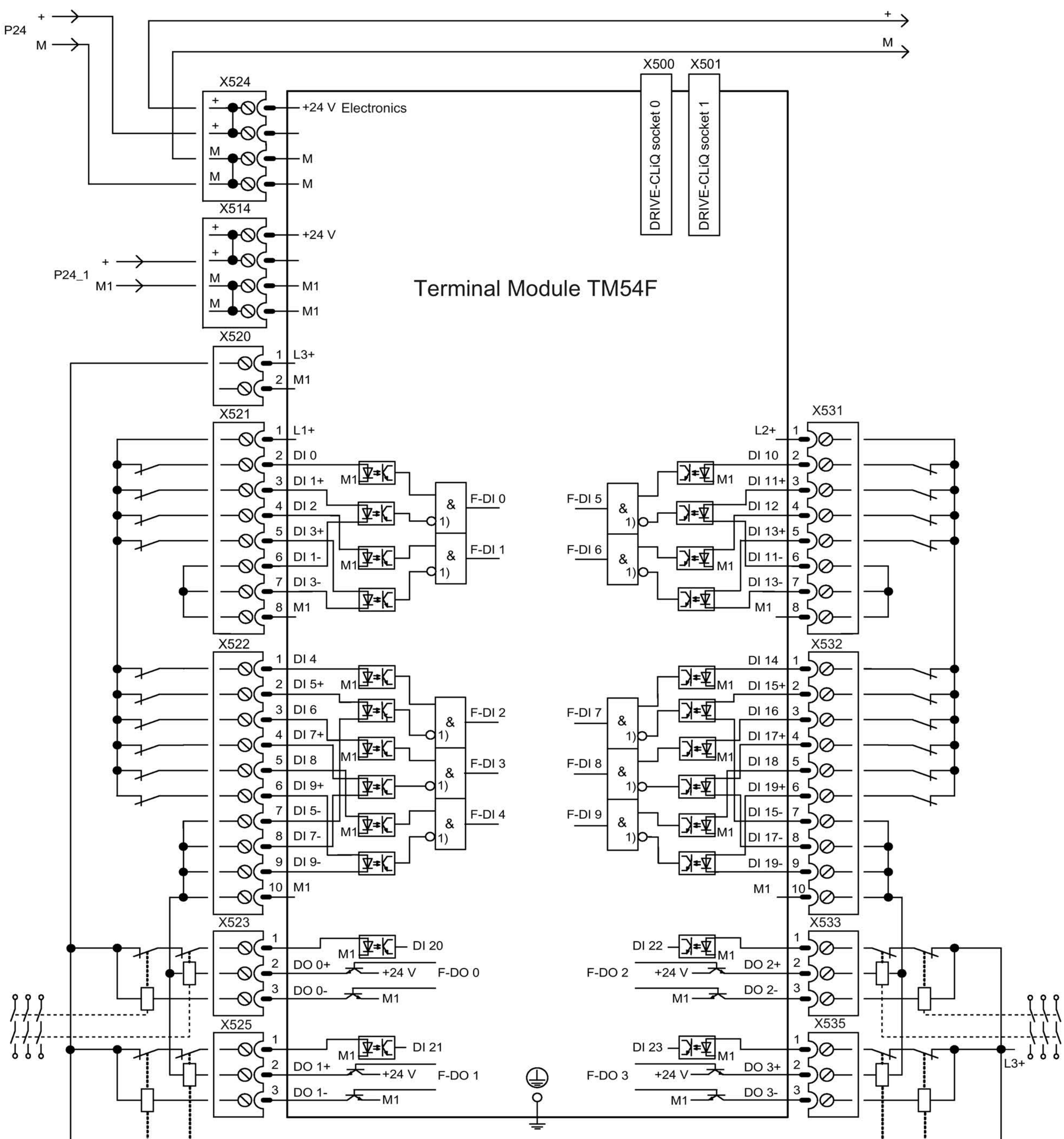


Figure 4-31 Connection example for TM54F

The F-DIs must be registered for the test stop using p10041.

Note

F-DI not operational during the test

The F-DI states are frozen for the duration of the test!

- Ensure that the states of the F-DIs are not evaluated during the test.

The associated F-DOs must be registered for the test stop using p10046.

Note

F-DOs during the time period of the test stop

F-DOs, which are not registered for evaluation using p10046, are set to "0" for the duration of the test stop ("failsafe values").

Maximum test stop time period is: $T_{\text{Test stop}} = T_{\text{FDIs}} + T_{\text{FDOs}}$

- Testing F-DIs: $T_{\text{FDIs}} = 3 \cdot \text{r10015} + 3 \cdot X$ ms

  (X = 20 ms or r10015 or p10017 - the greatest time value of the 3 values determines the waiting time X)
- Test of the F-DOs: $T_{\text{FDOs}} = 8 \cdot \text{r10015} + 6 \cdot Y$ ms

  (Y = p10001 or r10015 or p10017 - the longest time of the 3 values determines the wait time Y)

The Safety Integrated Functions of the TM54F are executed in the sampling time displayed in r10015. This sampling time corresponds to the lowest value of the communication sampling time entered in p10000[0..5].

Note

Manual dynamization required for specific F-DIs or F-DOs

It is possible that this test stop function cannot be used for certain F-DIs or F-DOs because of the devices that are connected.

- Ensure dynamic operation of the affected F-DIs/F-DOs by other means, e.g. switch operation or triggering certain machine functions.

- The test stop should be executed at a suitable point in time. This is the reason that it must be initiated by the application or carried out at POWER ON. This functionality is implemented using parameter p10007, which can be wired via BICO either to an input terminal on the drive unit (CU), or to a bit of any arbitrary PZD.

- Forced checking procedure (test stop) can be automatically executed at POWER ON.
  - If an automatic test stop of F-DI and F-DO of the TM54F is to be executed, then set p10048 = 1.
  - Even if you have parameterized the test stop for POWER ON, you can still initiate a test stop at any time through the application.
  - If the automatically initiated function cannot be correctly completed as a result of a problem (e.g. communication failure), then after the problem has been resolved, the function is automatically restarted.
  - After forced checking procedure (test stop) has been successfully executed, the TM54F goes into the "Ready" state.
  - Timer p9559 is reset as a result of the automatic forced checking procedure (test stop).
  - The automatic test stop for POWER ON does not influence the Safety Integrated Functions.

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

- p10001 SI wait time for test stop at F-DO 0 ... 3
- p10003 SI Motion forced checking procedure timer
- p10007 BI: SI Motion forced checking procedure F-DO signal source
- p10041 SI TM54F F-DI enable for test
- p10046 SI Motion F-DO feedback signal input activation

Forced checking procedure (test stop) does not require a POWER ON, but it can be automatically performed at POWER ON: The acknowledgment is set by canceling the test stop request.

Note

Forced checking procedure (test stop) of the CU310-2

The description applies analogously to forced checking procedure (test stop) of the F-DO on the CU310-2. You will find more instructions for carrying out test stops in Section "Forced checking procedure (test stop) of the CU310-2 (Page 306)".

Note

Manual checking of F-DIs and/or F-DOs

If there are F-DIs and/or F-DOs that you do not wish to have checked automatically, or that cannot be checked automatically (e.g. F-DIs of the CU310-2), the correct function of the connected sensor/actuator and its response should be checked at suitable intervals by actuating it.

Additional instructions for performing the test stops are provided in Chapters:

- Forced checking procedure (test stop) of the CU310-2 (Page 306)
- Forced checking procedure (test stop) of the TM54F (Page 313)

Control of the safety functions 5

5.1 Control possibilities

The following options for controlling Safety Integrated Functions are available:

Control via:	Basic	Extended	Advanced
Terminals (on the Control Unit and Motor/Power Module)	x	-	-
PROFIsafe based on PROFIBUS or PROFINET	x	x	x
TM54F	x	x	x
Control without selection	-	SLS, SDI	-
Onboard F-DI/F-DO (CU310-2)	x[1)]	x	x

1) Only the F-DI 0 can be used for the control. The F-DO is not available.

Note

PROFIsafe or TM54F

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

The safety-oriented input and output terminals (F-DI and F-DO) act as an interface between the SINAMICS S120 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.

An F-DO (Fail-safe Digital Output, safety-oriented digital output = safe output terminal pair) delivers a dual-channel signal representing feedback from the safety functions.

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.

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

Features

- Only for the Basic Functions
- Two-channel structure via two digital inputs (e.g. 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 test signals. The filter times are set using parameter p9651.
- Different terminal blocks depending on the format
- Automatic ANDing of up to eight digital inputs (p9620[0...7]) on the Control Unit for chassis format power units connected in parallel
- The F-DI 0 is available on the CU310-2

Overview of the safety function terminals for SINAMICS S120

The different power unit formats of SINAMICS S120 have different terminal designations for the inputs of the safety functions. These are shown in the following table.

Table 5- 1 Inputs for safety functions

Module	1st switch-off signal path (p9620[0])	2nd switch-off signal path (EP terminals)
Control Unit CU320-2	X122.1....6/X132.1…6 DI 0...7/16/17/20/21	–
Single Motor Module Booksize/Booksize Compact	(see CU320-2)	X21.3 and X21.4 (on the Motor Module)
Single Motor Module/ Power Module Chassis	(see CU320-2)	X41.1 and X41.2
Double Motor Module Booksize/Booksize Compact	(see CU320-2)	X21.3 and X21.4 (motor connection X1) X22.3 and X22.4 (motor connection X2) (on the Motor Module)
Power Module Blocksize with CUA31/CUA32	(see CU320-2)	X210.3 and X210.4 (on the CUA31/CUA32)
Control Unit CU310-2	X120.3 X121.1...4	X120.4 and X120.5[1)]
Power Module Chassis with CU310-2	(see CU310-2)	X41.1 and X41.2
Power Module blocksize with CU310-2	(see CU310-2)	STO_A and STO_B (for additional information, see Chapter "STO via terminals of the Power Modules Blocksize (CU310-2) (Page 209)")
Controller Extension SIMOTION CX32-2	X122.1...6 DI 0...3/16/17	–

1) Please note: On the CU310-2, you must use the EP terminal (DI 17) as a switch-off signal path.
Use any free digital input (DI) as the 2nd switch-off signal path.
See the equipment manuals for additional information about the terminals.

Note

Function of the EP terminals

The EP terminals are only evaluated if the Safety Integrated Basic Functions are released via onboard terminals.

Description of the two-channel structure

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

- Switch-off signal path, Control Unit (CU310-2/CU320-2)

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

- Switch-off signal path, Motor Module / Power Module (with CUA3x or CU310-2)

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

Both terminals must be energized within the tolerance time p9650, otherwise a fault will be output.

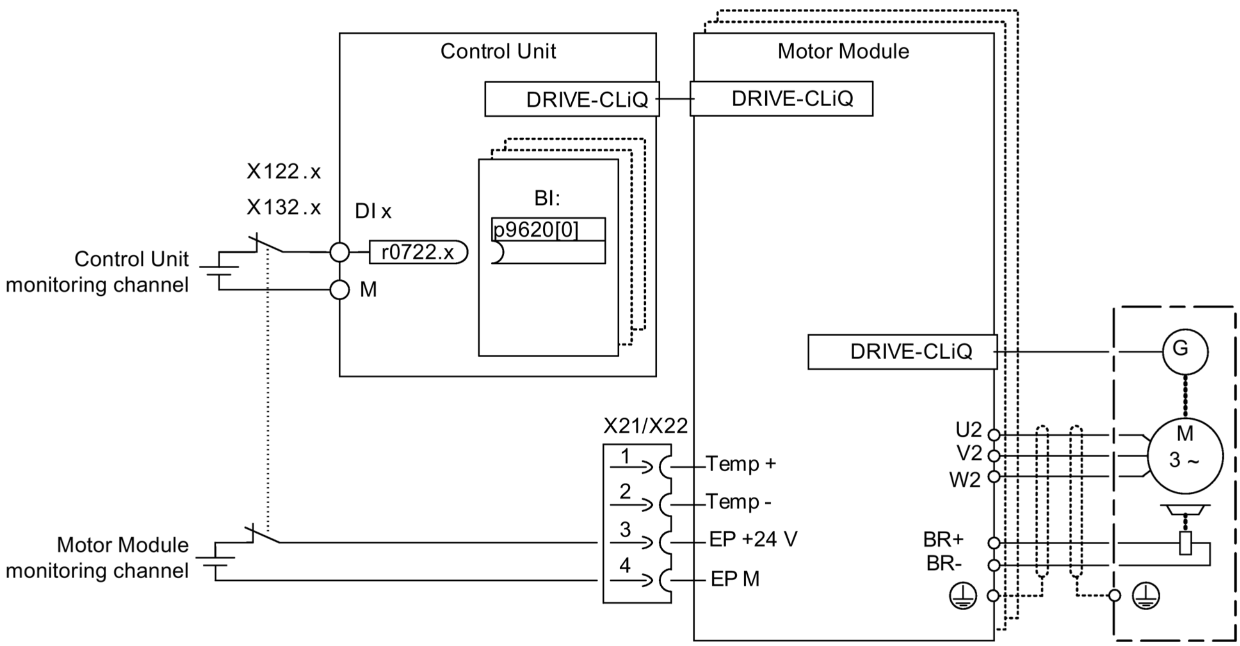


Figure 5-1 Example: Terminals for "Safe Torque Off": Example of Motor Modules Booksize and CU320-2

Grouping drives (not for CU310-2)

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

   Connect the p9620 parameters of all drives that belong to a group with a single DI (r0722.x) of the CU320-2.

2. Switch-off signal path (Motor Module / Power Module with CUA3x)

   Wire the terminals for the individual Motor Modules / Power Modules, belonging to the group, with CUA31/CUA32.

Note

Parameterization of the grouping

The grouping must be configured (DI on Control Unit) and wired (EP terminals) identically in both monitoring channels.

Note

Response of STO for grouping

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 (drives 1 and 2) and group 2 (drives 3 and 4). For this purpose, the same grouping for "Safe Torque Off" must be realized both for the Control Unit and the Motor Modules.

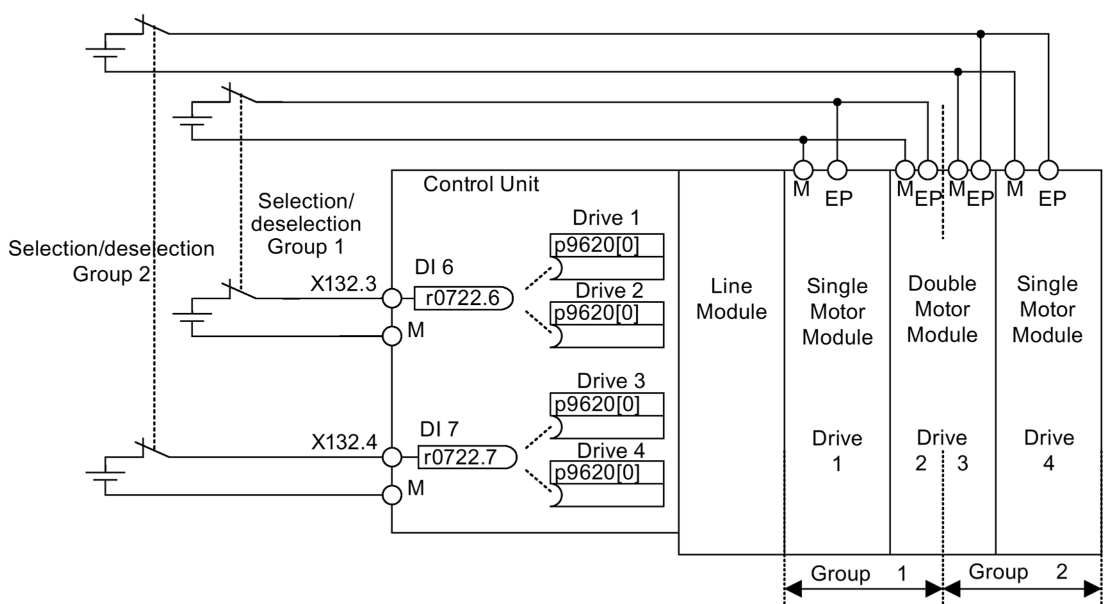


Figure 5-2 Example: Grouping terminals with Motor Modules Booksize and CU320-2

Information on the parallel connection of chassis type Motor Modules

When chassis type 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.

5.2.1 Simultaneity and tolerance time of the two monitoring channels

The monitoring functions must be selected/deselected simultaneously in both monitoring channels via the input terminals and only have an effect on the associated drive.

- 1 signal: Deselecting the function
- 0 signal: Selecting the function

The time delay that is unavoidable due to mechanical switching, for example, can be adapted via parameters. The tolerance time, within which selection/deselection of the two monitoring channels must occur if they are to be considered "simultaneous," is set in the following parameters:

- p9650 (Basic Functions)
- p10002 (Extended/Advanced Functions)

Note

Parameterization of the tolerance time

In order to avoid that faults are incorrectly initiated, at these inputs the tolerance time must always be set shorter than the shortest time between two switching events (ON/OFF, OFF/ON).

- If the monitoring functions are not selected/deselected within the tolerance time, this is detected by the cross-check, and the following fault (STOP F) is output.
  - F01611 (Basic Functions)
  - C01770 (Extended/Advanced Functions)

  For STO: In this case, the pulses have already been canceled as a result of the selection of "Safe Torque Off" on one channel.

  Note

  Timing between the switching operations in the Basic Functions

  Message F01611 with fault value 1000 is output if switching operations occur too frequently. The cause depends on the type of control:

  - Persistent signal changes occurred at the F-DI.
  - STO was permanently triggered via PROFIsafe (also as subsequent response).

  Within the time 5 · p9650, there must be at least two switching operations at the terminals or via PROFIsafe with a minimum time between them of p9650.

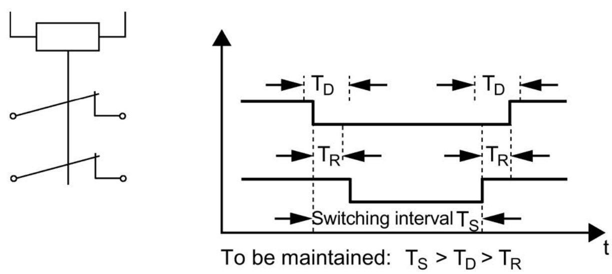
- If the "Safe Stop 1" of the Basic Functions is not selected within the tolerance time in two channels, this is detected by the cross-check, and fault F01611 (STOP F) is output. After the set "SI Safe Stop 1 delay time" (p9652), the pulses are suppressed.

Note

In order that the drive can brake down to a standstill even when selected through one channel, the time in p9652 must be shorter than the sum of the parameters for the data cross-check (p9650 and p9658). Otherwise, the drive will coast down after the time p9650 + p9658 has elapsed.

Further notes for setting the discrepancy time (also see the following diagram "Discrepancy time") are provided in the "SINAMICS S120/S150 List Manual" for the following message:

- F01611 (Basic Functions)
- C01770 (Extended/Advanced Functions)



T_S Switching interval
T_D Discrepancy time
T_R Response time

Figure 5-3 Discrepancy time

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9650 SI SGE switchover discrepancy time (Control Unit)
- p9652 SI Safe Stop 1 delay time (Control Unit)
- p9658 SI transition time STOP F to STOP A (Control Unit)
- p10002 SI Motion F-DI switchover discrepancy time (CPU 1)

5.2.2 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 (on/off tests), in order to identify faults due to either short-circuit or cross-circuit faults. 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.

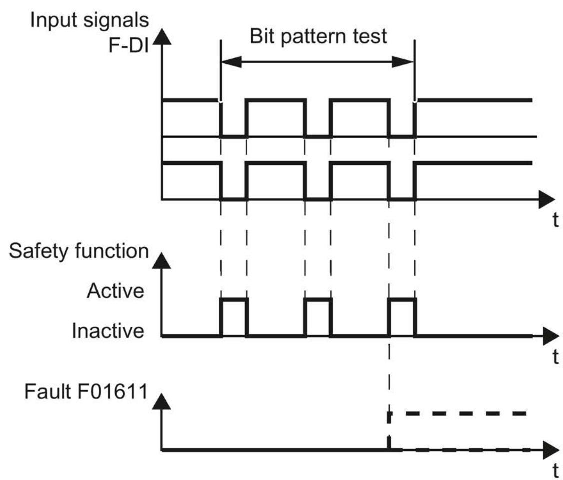


Figure 5-4 Converter response to a bit pattern test

Note

Debounce time for unwanted triggering of Safety Integrated functions

If the test pulses cause an unwanted triggering of the Safety Integrated functions, these test pulses can be suppressed using the F-DI input filter (p9651 for Basic Functions or p10017 for Extended/Advanced Functions). To do this, a value must be entered in p9651 or p10017 that is greater than the duration of a test pulse.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9651 SI STO/SBC/SS1 debounce time (Control Unit)
- p10017 SI Motion digital inputs debounce time (CPU 1)

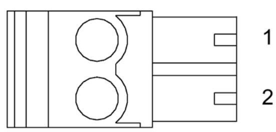
5.2.3 STO via terminals of the Power Modules Blocksize (CU310-2)

PM240-2 FSD, FSE and FSF Power Modules

The Safe Torque Off (STO) safety function is used to safely disconnect the power feed to the motor that generates the torque.

Using PM terminals - STO_A and STO_B - as well as 2 DIP switches, the "Safe Torque Off" (STO) function can be used independent of a Control Unit using the Power Module hardware. This hardware-based STO can be used up to PL e according to EN 13849-1 and SIL3 according to IEC 61508 with the appropriate application engineering.

Table 5- 2 Terminals STO_A/STO_B for the safety function "Safe Torque Off"

	Terminal	Signal name	Technical data
Terminal: 	1	STO_A/STO_B	Voltage: 24 V DC (20.4 … 28.8 V) Current consumption: max. 1.0 A
	2	M	Ground
Type: screw-type terminal 2 (see Manual SINAMICS S120 AC Drive, Section "Screw terminals") Max. connectable conductor cross-section: 2.5 mm²			

Note

Using the "STO" safety function via the Power Module terminals

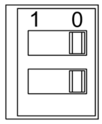
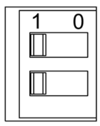
With enabled Safety Integrated functions of the CU310, a **simultaneously active** STO function via Power Module terminals results in fault messages being output.

Note

Insulated signal cables

Signal cables that are routed in the cable duct with 600 V power cables must be insulated.

Table 5- 3 DIP switches for the safety function "Safe Torque Off" via terminals of the Power Module

DIP switch	Application
	To use Safety Integrated of the CU310, deactivate the function "STO via Power Module terminals" by setting both the DIP switches for the interface STO_A/STO_B into the "0" position.
	To enable the "Safe Torque Off" safety function via Power Module terminals, you must set **both** DIP switches to the "1" position.

Note

Diagnostics

The state of the switch-off signal paths can be monitored using 2 digital outputs of the Control Unit. You can find additional information in the SINAMICS S120/S150 List Manual.

Note

Conformity with SIL3

To satisfy the requirements of SIL3, you must regularly check the STO functionality – as a minimum every 4 weeks. The check must be made on the plant/system side.

5.3 Activation via PROFIsafe

As an alternative to controlling Safety Integrated Functions via terminals, TM54F or on-board terminals on the CU310-2, they can also be controlled via PROFIsafe. For communication via PROFIBUS and PROFINET, use one of the following PROFIsafe telegrams: 30, 31, 901, 902 and 903

Control via PROFIsafe is available for both Safety Integrated Basic Functions, Safety Integrated Extended Functions and the Safety Integrated Advanced Functions.

Note

Timing between the switching operations

Message F01611 with fault value 1000 is output if switching operations occur too frequently. The cause depends on the type of control:

- Persistent signal changes occurred at the F-DI.
- STO was permanently triggered via PROFIsafe (also as subsequent response).

Within the time 5 · p9650, there must be at least two switching operations at the terminals or via PROFIsafe with a minimum time between them of p9650.

5.3.1 Assigning Safety Integrated Functions to PROFIsafe

The following table provides you with an overview of which Safety Integrated functions you can control with which PROFIsafe telegram.

Table 5- 4 Assigning Safety Integrated functions to PROFIsafe telegrams

Safety function	PROFIsafe telegram				
	30	31	901	902	903
STO	x	x	x	x	x
SS1	x	x	x	x	x
SOS	x	x	x	x	x
SS2	x	x	x	x	x
SS2E	-	x	x	x	x
SLS	x	x	x	x	x
SSM[1)]	x	x	x	x	x
SDI	x	x	x	x	x
SLP	x[2)]	x	x	x	x
SCA	-	-	-	-	x
SLA	x	x	x	x	x
SP	-	-	x	x	-
Safe gearbox stage switchover	-	x	x	x	x

1) As feedback signal in S_ZSW1 and S_ZSW2

2) Without safety-related switchover between 2 different position ranges

5.3.2 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 or F device) with a fail-safe communication to the F host via PROFIBUS or PROFINET and is assigned its own PROFIsafe telegram.

In this case, a PROFIsafe channel, known as a safety slot, is created using the Startdrive commissioning tool and transferred to HW Config (alternatively, this safety slot can be created by the SIMATIC Manager Step 7 using HW Config). The Safety Integrated Functions can then be additionally controlled via the PROFIsafe telegrams 30, 31, 901, 902 and 903. The structure of the associated control and status words is described below (see Section "Telegram format (Page 215)"). The selected PROFIsafe telegrams for Safety Integrated are 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:

- Basic Functions: p9601 = 8 hex or 9 hex
- Extended/Advanced Functions: p9601 = C hex or D hex

Note

License requirement for Safety Integrated Functions via PROFIsafe

No license is required to use Basic Functions. This also applies for control via PROFIsafe. However, for Extended Functions or Advanced 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 telegram configuration is performed in the hardware configuration in the F-host (see Sections "PROFIsafe via PROFIBUS (Page 321)" and "PROFIsafe via PROFINET (Page 322)").

Safety Integrated Basic Functions via PROFIsafe and via terminals

Control of the Basic Functions via terminals on the Control Unit and on the Motor/Power Module (parameters p9601.0 = 1) may be enabled in parallel. In order to be able to select SS1, an SS1 delay time p9652 > 0 must be configured. With PROFIsafe, both SS1 and STO can be selected. Only SS1 is available for control via terminal.

STO takes priority over SS1, i.e. STO becomes active if SS1 and STO are simultaneously selected.

Note

Double Motor Module in the case of PROFIsafe and a sampling time of 62.5 µs

In the case of a Double Motor Module, the converter issues message F01625 "Sign-of-life error in safety data" if you also select the following options:

- Control of the Safety Integrated Basic Functions via PROFIsafe
- "Sampling times for internal control loops" p0115[0] = 62.5 µs
- "Current controller dynamic response higher" (p1810.11 = 1)

In addition, message F30802 "Power unit: Time slice overflow" may occur.

The following options are available to you to remedy this problem:

- Use a Single Motor Module
- Deactivate "Current controller dynamic response higher" (p1810.11 = 0)
- Increase the "Sampling times for internal control loops" (p0115[0]).
- Control the Safety Integrated Basic Functions via terminals.

5.3.3 Selecting a PROFIsafe telegram

Proceed as follows to define the PROFIsafe telegram:

1. In parameter p60022 select the required telegram.
2. In parameter p9611, select the same telegram number.

Note

Compatibility mode

If you set p9611 = 998 for p60022 = 0 (for instance, if you have upgraded the safety project to firmware V4.5), then the PROFIsafe telegram 30 is also set as for p60022 = 30 and p9611 = 30.

PROFIsafe configuration

The PROFIsafe address is required for control of the safety functions via PROFIsafe.

Note

You can only change communication parameters in Startdrive in the setting dialog.

---

1. Click the icon "Telegram configuration"

   The properties of the PROFINET interface are displayed in the Inspector window. The "Cyclic data traffic" setting range is active. Here you define the telegrams for the drive objects.
2. Click the <Add telegram> entry in the telegram configuration of "Drive axis_x".
3. Select the "Add safety telegram" option in the drop-down list of the entry:

   Startdrive then inserts the "Safe actual value" and "Safe setpoint" lines. The relevant PROFIsafe telegrams are preassigned.
4. Open the new "Safe setpoint" screen form (for Drive axis_x) in the Inspector window.
5. Correct the PROFIsafe address of the drive in the "F-address" field.
6. In the function view, switch back to the "control" screen form.

   The value of the F-address is displayed in the "PROFIsafe address" (p9610) field. A preassigned PROFIsafe telegram is displayed in the "PROFIsafe telegram no." drop-down list.
7. Click "Accept values" to transfer the telegram from the default settings into the Safety programming.
8. Select the desired stop response for a failure of the PROFIsafe communication in the "PROFIsafe failure response" (p9612) drop-down list.

Note

Unique PROFIsafe addresses

You must ensure the unique assignment of the PROFIsafe address throughout the network and the CPU.

- The failsafe I/O of PROFIsafe address type 1 is addressed clearly by its failsafe destination address.
- The failsafe destination address of the failsafe I/O (drive units in this case) must be unique for the entire failsafe I/O throughout the network and the CPU (system-wide). The failsafe I/O of PROFIsafe address type 2, e.g. modules of the ET 200SP type, must also be taken into account.
- Note also the corresponding documentation in the TIA Portal online help in Section "SIMATIC Safety - Configuration and programming". (SDR001)

5.3.4 Telegram format

The PROFIsafe telegram received at the Control Unit is displayed in r9768, and the PROFIsafe telegram to be sent, in parameter r9769.

Structure of telegram 30

Telegram 30 transfers safety control word 1 (S_STW1) and safety status word 1 (S_ZSW1) as user data. It is structured as follows:

	Output data	Input data
PZD1	S_STW1	S_ZSW1

Structure of telegram 31

Telegram 31 transfers safety control word 2 (S_STW2) and safety status word 2 (S_ZSW2) as user data. It is structured as follows:

<table>
<tr><th></th><th>Output data</th><th>Input data</th></tr>
<tr><td>PZD1</td><td rowspan="2">S_STW2</td><td rowspan="2">S_ZSW2</td></tr>
<tr><td>PZD2</td></tr>
</table>

Structure of telegram 901

Telegram 901 transfers the S_STW2, the variable SLS limit (S_SLS_LIMIT_A), the S_ZSW2, the active SLS value of level 1 (S_SLS_LIMIT_A_ACTIVE), a counter value (S_CYCLE_COUNT) and the safe position value in 16-bit format (S_XIST16) as user data. It is structured as follows:

<table>
<tr><th></th><th>Output data</th><th>Input data</th></tr>
<tr><td>PZD1</td><td rowspan="2">S_STW2</td><td rowspan="2">S_ZSW2</td></tr>
<tr><td>PZD2</td></tr>
<tr><td>PZD3</td><td>S_SLS_LIMIT_A</td><td>S_SLS_LIMIT_A_ACTIVE</td></tr>
<tr><td>PZD4</td><td>–</td><td>S_CYCLE_COUNT</td></tr>
<tr><td>PZD5</td><td>–</td><td>S_XIST16</td></tr>
</table>

Structure of telegram 902

Telegram 902 transfers the following user data:

- S_STW2
- Variable SLS limit (S_SLS_LIMIT_A)
- S_ZSW2
- Active SLS value of level 1 (S_SLS_LIMIT_A_ACTIVE)
- One count value (S_CYCLE_COUNT)
- The safe position value in 32-bit format (S_XIST32).

Telegram 902 is structured as follows:

	Output data	Input data
PZD1	S_STW2	S_ZSW2
PZD2		
PZD3	S_SLS_LIMIT_A	S_SLS_LIMIT_A_ACTIVE
PZD4	–	S_CYCLE_COUNT
PZD5	–	S_XIST32
PZD6		

Telegram 902 can only be used, if the higher-level controller (F-host) can process 32-bit values.

Note

Telegram 902 for SIEMENS products

STEP7 Safety in the TIA Portal can process this value. However, Distributed Safety in older STEP 7 version cannot do this.

Structure of telegram 903

Telegram 903 transmits the following user data: S_STW2, S_SLS_LIMIT_A, S_ZSW2, S_ZSW_CAM1 and S_SLS_LIMIT_A_ACTIVE.

Telegram 903 is structured as follows:

	Output data	Input data
PZD1	S_STW2	S_ZSW2
PZD2		
PZD3	S_SLS_LIMIT_A	S_ZSW_CAM1
PZD4	–	
PZD5	–	S_SLS_LIMIT_A_ACTIVE

5.3.5 Process data

5.3.5.1 S_STW1 and S_ZSW1 (Basic Functions)

Safety control word 1 (S_STW1)

S_STW1, output signals
see function chart [2806].

Table 5- 5 Description of safety-control word1 (S_STW1)

Byte	Bit	Meaning	Remarks	
0	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	SLP	0	–[1]
	7	Internal Event ACK	1/0	Acknowledgment
			0	No acknowledgment
1	0	SLA	0	–[1]
	1	Select SLS bit 0	0	–[1]
	2	Select SLS bit 1	0	
	3	Reserved	–	–
	4	SDI positive	0	–[1]
	5	SDI negative	0	
	6, 7	Reserved	–	–

[1] Signals not relevant for Basic Functions: Should be set to "0".

Safety status word 1 (S_ZSW1)

S_ZSW1, input signals
see function diagram [2806].

Table 5- 6 Description of safety status word 1 (S_ZSW1)

Byte	Bit	Meaning	Remarks	
0	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	SLP active	0	–[1]
	7	Internal Event	1	Internal event
			0	No internal event
1	0	SLA active	0	–[1]
	1	Active SLS level bit 0	0	–[1]
	2	Active SLS level bit 1	0	
	3	SOS selected	0	–[1]
	4	SDI positive active	0	–[1]
	5	SDI negative active	0	–[1]
	6	Reserved	–	–
	7	SSM (speed below limit value)	0	–[1]

[1] Signals not relevant for Basic Functions: It is not permissible that they are evaluated.

5.3.5.2 S_STW2 and S_ZSW2 (Basic Functions)

Safety control word 2 (S_STW2)

S_STW2, output signals
see function diagram [2806].

Table 5- 7 Description of safety-control word 2 (S_STW2)

Byte	Bit	Meaning	Remarks	
0	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	SLP	0	–[1)]
	7	Internal Event ACK	1/0	Acknowledgment
			0	No acknowledgment
1	0	SLA active	0	–[1)]
	1	Select SLS bit 0	0	–[1)]
	2	Select SLS bit 1	0	
	3	Reserved	–	–
	4	SDI positive	0	–[1)]
	5	SDI negative	0	–[1)]
	6, 7	Reserved	–	–
2	0 ... 2	Reserved	–	–
	3	Select SLP position range	0	–[1)]
	4 ... 6	Reserved	–	–
	7	SCA	0	–[1)]
3	0	Select gearbox stage, bit 0	0	–[1)]
	1	Select gearbox stage, bit 1	0	–[1)]
	2	Select gearbox stage, bit 2	0	–[1)]
	3	Gearbox stage switchover	0	–[1)]
	4	SS2E	0	–[1)]
	5, 6, 7	Reserved	–	–

[1)] Signals not relevant to Basic Functions should be set to "0".

Safety status word 2 (S_ZSW2)

S_ZSW2, input signals
see function diagram [2806].

Table 5- 8 Description of safety status word 2 (S_ZSW2)

Byte	Bit	Meaning	Remarks	
0	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	SLP active	0	–1)
	7	Internal Event	1	Internal event
			0	No internal event
1	0	SLA active	0	–1)
	1	Active SLS level, bit 0	0	–1)
	2	Active SLS level, bit 1	0	
	3	Reserved	–	–
	4	SDI positive active	0	–1)
	5	SDI negative active	0	–1)
	6, 7	Reserved	–	–
	7	SSM (speed)	0	–1)
2	0 ... 2	Reserved	–	–
	3	SLP active position range	0	–1)
	4, 5	Reserved	–	–
	6	Safe position valid	0	–1)
	7	Safely referenced	0	–1)
3	0 ... 2	F-DI 0 ... 22)	0	–1)
	3	Reserved	–	–
	4	SS2E active	0	–1)
	5	SOS selected	0	–1)
	6	SLP upper limit maintained	0	–1)
	7	SLP lower limit maintained	0	–1)

1) Signals not relevant for Basic Functions: It is not permissible that they are evaluated.

2) Only valid for CU310-2.

5.3.5.3 S_STW1 and S_ZSW1 (Extended/Advanced Functions)

Safety control word 1 (S_STW1)

S_STW1, output signals
see function chart [2842].

Table 5- 9 Description of safety-control word1 (S_STW1)

Byte	Bit	Meaning	Remarks	
0	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	SLP[1)]	1	Deselect SLP
			0	Select SLP
	7	Internal Event ACK	1/0	Acknowledgment
			0	No acknowledgment
1	0	SLA	1	Deselect SLA
			0	Select SLA
	1	Select SLS bit 0	–	Select speed limit for SLS (2 bits)
	2	Select SLS bit 1	–	
	3	Reserved	–	–
	4	SDI positive	1	Deselect SDI positive
			0	Select SDI positive
	5	SDI negative	1	Deselect SDI negative
			0	Select SDI negative
	6, 7	Reserved	–	–

[1)] Signals not relevant for Extended Functions: It is not permissible that they are evaluated.

Safety status word 1 (S_ZSW1)

S_ZSW1, input signals
see function diagram [2842].

Table 5- 10 Description of safety status word 1 (S_ZSW1)

Byte	Bit	Meaning	Remarks	
0	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	SLP active[1)]	1	SLP active
			0	SLP not active
			–	The status signal "SLP active" is not the same as the diagnostic signal "SLP active" (r9722.6), but is the AND logic operation of "SLP active" (r9722.6) and "safely referenced" (r9722.23).
	7	Internal Event	1	Internal event
			0	No internal event
1	0	SLA active	1	SLA active
			0	SLA not active
	1	Active SLS level bit 0	–	Display of the speed limit for SLS (2 bits)
	2	Active SLS level bit 1	–	
	3	SOS selected	1	SOS selected
			0	SOS deselected
	4	SDI positive active	1	SDI positive active
			0	SDI positive not active
	5	SDI negative active	1	SDI negative active
			0	SDI negative not active
	6	Reserved	–	–
	7	SSM (speed)	1	SSM (speed below limit value)
			0	SSM (speed higher than/equal to limit)

1) Signals not relevant for Extended Functions: It is not permissible that they are evaluated.

5.3.5.4 S_STW2 and S_ZSW2 (Extended/Advanced Functions)

Safety control word 2 (S_STW2)

S_STW2, output signals
see function diagram [2843].

Table 5- 11 Description of safety-control word 2 (S_STW2)

Byte	Bit	Meaning	Remarks	
0	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	SLP[1]	1	Deselect SLP
			0	Select SLP
	7	Internal Event ACK	1/0	Acknowledgment
			0	No acknowledgment
1	0	SLA	1	Deselect SLA
			0	Select SLA
	1	Select SLS bit 0	–	Select speed limit for SLS (2 bits)
	2	Select SLS bit 1	–	
	3	Reserved	–	–
	4	SDI positive	1	Deselect SDI positive
			0	Select SDI positive
	5	SDI negative	1	Deselect SDI negative
			0	Select SDI negative
	6, 7	Reserved	–	–
2	0 ... 2	Reserved	–	–
	3	Select SLP position range[1)]	1	Select SLP area 2 (SLP2)
			0	Select SLP area 1 (SLP1)
	4 ... 6	Reserved	–	–
	7	SCA[1)]	1	Deselect SCA
			0	Select SCA

Byte	Bit	Meaning	Remarks	
3	0	Select gearbox stage, bit 0	–	Select gearbox stage (3 bits)
	1	Select gearbox stage, bit 1	–	
	2	Select gearbox stage, bit 2	–	
	3	Gearbox stage switchover	1	With increased position tolerance
			0	Without increased position tolerance
	4	SS2E	1	Deselect SS2E
			0	Select SS2E
	5	SS2ESR	1	Deselect SS2ESR
			0	Select SS2ESR
	6, 7	Reserved	–	–

1) Signals not relevant for Extended Functions: It is not permissible that they are evaluated.

Safety status word 2 (S_ZSW2)

S_ZSW2, input signals; see function diagram [2843].

Table 5- 12 Description of safety status word 2 (S_ZSW2)

Byte	Bit	Meaning	Remarks	
0	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	SLP active[1]	1	SLP active
			0	SLP not active
			–	The status signal "SLP active" is not the same as the diagnostic signal "SLP active" (r9722.6), but is the AND logic operation of "SLP active" (r9722.6) and "safely referenced" (r9722.23).
	7	Internal Event	1	Internal event
			0	No internal event
1	0	SLA active	1	SLA active
			0	SLA not active
	1	Active SLS level bit 0	–	Display of the speed limit for SLS (2 bits)
	2	Active SLS level bit 1	–	
	3	Reserved	–	–
	4	SDI positive active	1	SDI positive active

Byte	Bit	Meaning	Remarks	
			0	SDI positive not active
	5	SDI negative active	1	SDI negative active
			0	SDI negative not active
	6	Reserved	–	–
	7	SSM (speed)	1	SSM (speed below limit value)
			0	SSM (speed higher than/equal to limit)
2	0 ... 2	Reserved	–	–
	3	SLP active position range[1)]	1	SLP area 2 (SLP2) active
			0	SLP area 1 (SLP1) active
			-	The status signal "SLP active position range" always corresponds to the diagnostic signal "SLP active position range" (r9722.19).
	4, 5	Reserved	-	-
	6	Safe position valid	1	Safe position valid
			0	Safe position invalid
	7	Safely referenced	1	Safe position is applicable as "safely referenced"
			0	Safe position is not applicable as "safely referenced"
3	0	F-DI 0[2)]	1	F-DI 0 inactive
			0	F-DI 0 active
	1	F-DI 1[2)]	1	F-DI 1 inactive
			0	F-DI 1 active
	2	F-DI 2[2)]	1	F-DI 2 inactive
			0	F-DI 2 active
	3	SS2ESR	1	SS2ESR active
			0	SS2ESR not active
	4	SS2E active	1	SS2E active
			0	SS2E not active
	5	SOS selected	1	SOS selected
			0	SOS deselected
	6	SLP upper limit maintained[1)]	1	SLP: Upper limit maintained
			0	SLP: Upper limit not maintained
			–	The status signal "upper SLP limit maintained" always corresponds to the diagnostic signal "upper SLP limit maintained" (r9722.30).
	7	SLP lower limit maintained[1)]	1	SLP: Lower limit maintained
			0	SLP: Lower limit not maintained
			–	The status signal "lower SLP limit maintained" always corresponds to the diagnostic signal "lower SLP limit maintained" (r9722.31).

[1)] Signals not relevant for Extended Functions: It is not permissible that they are evaluated.

[2)] Only valid for CU310-2.

5.3.5.5 Additional process data

S_SLS_LIMIT_A

- PZD3 in telegrams 901, 902 and 903, output signals
- SLS limit value input
- Value range 1 ... 32767; 32767 ≙ 100% of the 1st SLS level

S_SLS_LIMIT_A_ACTIVE

- PZD3 in telegrams 901, 902 and 903, output signals
- Active SLS limit value
- Value range 1 ... 32767; 32767 ≙ 100%
- Must only be evaluated if SLS 1 active and p9501.24 = 1.

S_CYCLE_COUNT

- PZD4 in telegrams 901 and 902, input signals
- Counter for the safety cycle
- Value range -32768 ... +32767
- May only be evaluated if the transfer of safe position values is active (p9501.25 = 1) and the position value is valid (r9722.22 = r9722.23 = 1).

S_XIST16

- PZD5 in telegram 901, input signals
- Current actual position value (16 bits)
- Value range ±32767
- Scaling using p9574

Note

Scaling

It is not permissible that the position value transferred in S_XIST16 exceeds the value range that can be represented. This is the reason that the safe position value of the drive (r9713[0]) can be allocated a scaling factor. The position value is divided by this factor before transfer. As a consequence, a wider value range can be transferred with a reduced accuracy.

Example: For a position of -29.999 mm signaled in r9708[0] and r9708[1] and a scaling factor of p9x74 = 1000, a numerical value of -29 is signaled to the controller.

- S_XIST16 must only be evaluated if the transfer of safe position values is active (p9501.25 = 1) and the position value is valid (r9722.22 = r9722.23 = 1).

S_XIST32

- PZD5 and PZD6 in telegram 902, input signals
- Current actual position value (32 bits)
- Value range ±737280000
- Unit: 1 µm (linear axis), 0.001 ° (rotary axis)
- S_XIST32 must only be evaluated if the transfer of safe position values is active (p9501.25 = 1) and the position value is valid (r9722.22 = r9722.23 = 1).

S_ZSW_CAM1

S_ZSW_CAM1, Safe Cam
see function diagram [2844].

Table 5- 13 Description of Safety status word Safe Cam (S_ZSW_CAM1)

Byte	Bit	Meaning	Remarks	
0	0	Position at cam 1	1	Position is at cam 1
			0	Position is not at cam 1
	1	Position at cam 2	1	Position is at cam 2
			0	Position is not at cam 2
	2	Position at cam 3	1	Position is at cam 3
			0	Position is not at cam 3
	3	Position at cam 4	1	Position is at cam 4
			0	Position is not at cam 4
	4	Position at cam 5	1	Position is at cam 5
			0	Position is not at cam 5
	5	Position at cam 6	1	Position is at cam 6
			0	Position is not at cam 6
	6	Position at cam 7	1	Position is at cam 7
			0	Position is not at cam 7
	7	Position at cam 8	1	Position is at cam 8
			0	Position is not at cam 8
1	0	Position at cam 9	1	Position is at cam 9
			0	Position is not at cam 9
	1	Position at cam 10	1	Position is at cam 10
			0	Position is not at cam 10
	2	Position at cam 11	1	Position is at cam 11
			0	Position is not at cam 11
	3	Position at cam 12	1	Position is at cam 12
			0	Position is not at cam 12
	4	Position at cam 13	1	Position is at cam 13
			0	Position is not at cam 13
	5	Position at cam 14	1	Position is at cam 14

Byte	Bit	Meaning	Remarks	
			0	Position is not at cam 14
	6	Position at cam 15	1	Position is at cam 15
			0	Position is not at cam 15
	7	Position at cam 16	1	Position is at cam 16
			0	Position is not at cam 16
2	0	Position at cam 17	1	Position is at cam 17
			0	Position is not at cam 17
	1	Position at cam 18	1	Position is at cam 18
			0	Position is not at cam 18
	2	Position at cam 19	1	Position is at cam 19
			0	Position is not at cam 19
	3	Position at cam 20	1	Position is at cam 20
			0	Position is not at cam 20
	4	Position at cam 21	1	Position is at cam 21
			0	Position is not at cam 21
	5	Position at cam 22	1	Position is at cam 22
			0	Position is not at cam 22
	6	Position at cam 23	1	Position is at cam 23
			0	Position is not at cam 23
	7	Position at cam 24	1	Position is at cam 24
			0	Position is not at cam 24
3	0	Position at cam 25	1	Position is at cam 25
			0	Position is not at cam 25
	1	Position at cam 26	1	Position is at cam 26
			0	Position is not at cam 26
	2	Position at cam 27	1	Position is at cam 27
			0	Position is not at cam 27
	3	Position at cam 28	1	Position is at cam 28
			0	Position is not at cam 28
	4	Position at cam 29	1	Position is at cam 29
			0	Position is not at cam 29
	5	Position at cam 30	1	Position is at cam 30
			0	Position is not at cam 30
	6	SCA active	1	SCA is active
			0	SCA is not active
	7	Validity of the values from SCA	1	Values from SCA are valid
			0	Values from SCA are not valid

5.3.6 Function diagrams and parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2840 SI functions - SI Motion drive-integrated control signals/status signals
- 2858 SI functions, control via PROFIsafe (p9601.2 = p9601.3 = 1)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9562[0...1] SI Motion SLP (SE) stop response (Control Unit)
- p9563[0...3] SI Motion SLS (SG)-specific stop response (Control Unit)
- p9566 SI Motion SDI stop response (Control Unit)
- p9580 SI Motion stop response delay bus failure (Control Unit)
- p9601 SI enable functions integrated in the drive (Control Unit)
- p9610 SI PROFIsafe address (Control Unit)
- p9611 SI PROFIsafe telegram selection (Control Unit)
- p9612 SI PROFIsafe failure response (Control Unit)
- p60022 Selecting a PROFIsafe telegram

5.4 Control via TM54F

Note

Commissioning TM54F

- TM54F is not yet available in Startdrive.
- You can find information on commissioning with STARTER in older editions of this manual.

The TM54F is a terminal expansion module for snapping onto a DIN EN 60715 mounting rail: The TM54F features failsafe digital inputs and outputs for controlling and signaling the states of the Safety Integrated Basic, Extended and Advanced Functions.

Note

DRIVE-CLiQ line of the TM54F

- A TM54F must be connected directly to a Control Unit via DRIVE-CLiQ.
- Each Control Unit can be assigned only one TM54F which is connected via DRIVE-CLiQ.
- Additional DRIVE-CLiQ nodes can be operated at the TM54F, such as Sensor Modules and Terminal Modules (excluding an additional TM54F). It is not permissible that Motor Modules and Line Modules are connected to a TM54F.
- In the case of a CU310-2 Control Unit, it is not possible to connect the TM54F to the DRIVE-CLiQ line of a Power Module. The TM54F can only be connected to the sole DRIVE-CLiQ X100 socket of the Control Unit.

Table 5- 14 Overview of the TM54F interfaces

Type	Number
Failsafe digital outputs (F-DO)	4
Failsafe 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 for the forced checking procedure (test stop)	4

1) Sensors: Failsafe devices for command operations and sensing (e.g. Emergency Stop pushbuttons, safety door locks, position switches, and light arrays / light curtains).

2) Dynamic response: The sensor power supply is switched on and off by the TM54F when the forced checking procedure (test stop) is active for the sensors, cable routing, and the evaluation electronics.

The TM54F provides four failsafe digital outputs and ten failsafe digital inputs. A failsafe digital output consists of a 24 VDC switching output, an output switching to ground and a digital input for reading back the switching state. A failsafe digital input is made up of 2 digital inputs.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2890 SI TM54F - overview

5.4.1 Assigning Safety Integrated Functions to the F-DI/TM54F

The following table provides you with an overview of which Safety Integrated functions you can control with which F-DI/F-DO (onboard or TM54F).

Table 5- 15 Assigning Safety Integrated functions to F-DI/F-DO (onboard or TM54F)

Safety function	Onboard F-DI/F-DO	TM54F F-DI/F-DO
STO	x	x
SS1	x	x
SOS	x	x
SS2	x	x
SS2E	-	-
SLS	x	x
SSM[1)]	x	x
SDI	x	x
SLP	x	x
SCA	-	-
SLA	-	-
SP	-	-
Safe gearbox stage switchover	-	-

1) As feedback signal in S_ZSW1 and S_ZSW2

5.4.2 Fault acknowledgment

You have the following options of acknowledging TM54F faults after troubleshooting:

- POWER ON
- Falling edge of the signal "Internal Event ACK" with subsequent acknowledgment on the Control Unit ("fail-safe acknowledgment")

5.4.3 Overview of the F-DIs

Description

Failsafe digital inputs (F-DI) consist of 2 digital inputs. At the 2nd digital input, the cathode (M) of the optocoupler is additionally brought out to enable connection of an output of a failsafe controller grounded through a switch. (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 each DI can be read at parameter r10051. The bits of both drive objects are logically AND'ed and return the status of the relevant F-DI.

Test signals from F-DOs and interference pulses can be filtered out using the input filter (p10017), so that they do not cause any faults.

Explanation of terms:

NC contact / NC contact: To select the safety function, a "zero level" must be present at both inputs.

NC contact / NO contact: To select the safety function, a "zero level" must be present at input 1 and a "1 level" at input 2.

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.

To enable the forced checking procedure (test stop), connect the digital inputs of F-DI 0 ... 4 of the TM54F to the dynamic voltage supply L1+ and the digital inputs to F-DI 5 ... 9 to L2+. Additional information for the forced checking procedure (test stop) is provided in Chapter "Forced checking procedure (test stop) (Page 172)".

Table 5- 16 Overview of the failsafe inputs in the SINAMICS S120/S150 List Manual:

Module	Function diagram	Inputs
TM54F	2893	F-DI 0 ... 4
	2894	F-DI 5 ... 9

F-DI features

- Failsafe configuration with 2 digital inputs per F-DI
- Input filter to block test signals with an adjustable suppression time (p10017), see Chapter "Bit pattern test (Page 208)".
- Configurable connection of NC/NC or NC/NO contacts by means of p10040
- Status parameter r10051
- Adjustable time window for monitoring discrepancy at both digital inputs by means of parameter p10002 for all F-DIs

---

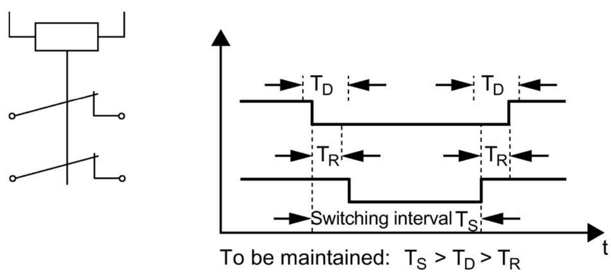
Note

Discrepancy time

To avoid that fault messages are incorrectly triggered ("nuisance tripping"), at these inputs the discrepancy time must always be set less than the shortest time between 2 switching events (ON/OFF, OFF/ON) (see also the following diagram "Discrepancy time").

Further notes for setting the discrepancy time are contained in the "SINAMICS S120/S150 List Manual" for the following messages:

- F01611 (Basic Functions)
- C01770 (Extended/Advanced Functions)



T_S Switching interval

T_D Discrepancy time

T_R Response time

Figure 5-5 Discrepancy time

- Second digital input with additional tap of the optocoupler cathode for connecting a ground-switching output of a failsafe controller.
- The signal states of the two digital inputs of the F-DIs are frozen at logical 0 (safety function selected) when different signal states are present within a failsafe F-DI until a safe acknowledgment has been carried out by means of an F-DI via parameter p10006 (SI acknowledgment internal event input terminal).
- 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 associated 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 acknowledgment.

WARNING

Unwanted movement due to incorrect signal states as a result of diagnostic currents in the switched-off state (logical state "0" or "OFF")

Unlike mechanical switching contacts, e.g. emergency stop switches, diagnostic currents can also flow when the semiconductor is in the switched-off state. If interconnection with digital inputs is faulty, the diagnostic currents can result in incorrect switching states. Incorrect signal states of digital inputs can cause unwanted movements of machine parts and result in serious injury or death.

- Observe the conditions of digital inputs and digital outputs specified in the relevant manufacturer documentation.
- Check the conditions of the digital inputs and digital outputs with regard to currents in the "OFF" state and if necessary connect the digital inputs to suitably dimensioned, external resistors to protect against the reference potential of the digital inputs.

More information on this topic is available on the Internet at: Parameterizing and configuring safety hardware (https://support.industry.siemens.com/cs/ww/en/view/39700013)

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2893 SI TM54F - Failsafe digital inputs (F-DI 0 ... F-DI 4)
- 2894 SI TM54F - Failsafe digital inputs (F-DI 5 ... F-DI 9)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p10002 SI TM54F F-DI switchover discrepancy time
- p10017 SI TM54F digital inputs debounce time
- p10040 SI TM54F F-DI input mode
- r10051.0...9 CO/BO: SI TM54F digital inputs, status

5.4.4 Overview of the F-DOs

Failsafe digital outputs (F-DO) consist of 2 digital outputs and 1 digital input that checks the switching state for forced checking procedure (test stop). The 1st digital output switches 24 V DC, and the 2nd switches the ground of the power supply of X514 (TM54F).

The status of each F-DO can be read at parameter r10052. The status of the associated DI can be read at parameter r10053 (only available for TM54F_SL (TM54F Slave Module)).

The actuator connected to the F-DO can also be tested under specific conditions as part of forced checking procedure (test stop). See Section "Forced checking procedure (test stop) of the TM54F (Page 313)".

Table 5- 17 Overview of the failsafe outputs in the SINAMICS S120/S150 List Manual:

Module	Function diagram	Outputs	Associated checking inputs
TM54F	2895	F-DO 0 ... 3	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
- SS1 active
- SS2 active
- SOS active
- SLS active
- SSM feedback active
- Safe State
- SOS selected
- Active SLS level bit 0
- Active SLS level bit 1
- SDI positive active
- SDI negative active
- SLP active
- Active SLP area
- Internal event

The following (safe state) signals can be requested via p10039[0...3] for each drive group (index 0 corresponds with drive group 1 etc.):

- STO active (power removed/pulses suppressed)
- SS1 active
- SS2 active
- SOS active
- SLS active
- SLP active
- SDI positive active
- SDI negative active

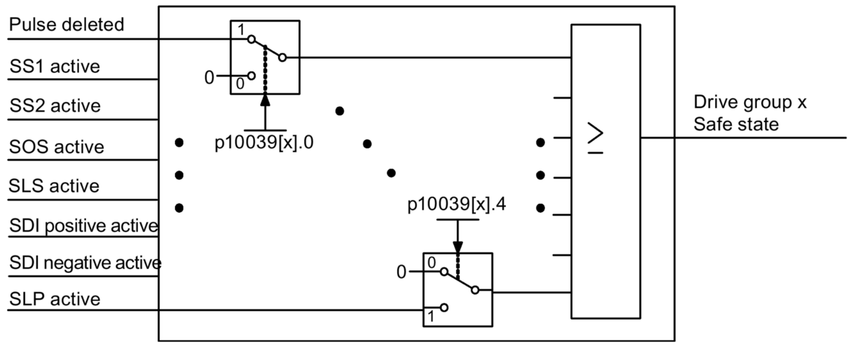


Figure 5-6 Safe state selection (example Extended/Advanced Functions)

The same signals (high-active) of each drive or drive group are logically linked by means of AND operation. The different signals selected via p10039 are logically OR'ed. Result of these logic operations is the "Safe State" for each drive group. You will find details in the SINAMICS S120/S150 List Manual in function diagrams 2901 (Basic Functions) and 2906 (Extended/Advanced Functions).

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.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2893 SI TM54F - Failsafe digital inputs (F-DI 0 ... F-DI 4)
- 2894 SI TM54F - Failsafe digital inputs (F-DI 5 ... F-DI 9)
- 2895 SI TM54F - Failsafe digital outputs (F-DO 0 ... 3), digital inputs (DI 20 ... 23)
- 2900 SI TM54F - Basic Functions control interface (p9601.2/3 = 0, p9601.6 = 1)
- 2901 SI TM54F - Basic Functions Safe State selection
- 2902 SI TM54F - Basic Functions assignment (F-DO 0 ... F-DO 3)
- 2905 SI TM54F - Extended/Advanced Functions control interface (p9601.2 = 1 & p9601.3 = 0)
- 2906 SI TM54F - Extended/Advanced Functions safe state selection
- 2907 SI TM54F - Extended/Advanced Functions assignment (F-DO 0 ... F-DO 3)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p10039[0...3] SI TM54F Safe State signal selection
- p10042[0...5] SI TM54F F-DO 0 signal sources
- p10043[0...5] SI TM54F F-DO 1 signal sources
- p10044[0...5] SI TM54F F-DO 2 signal sources
- p10045[0...5] SI TM54F F-DO 3 signal sources
- r10051.0...9 CO/BO: SI TM54F digital inputs, status
- r10052.0...3 CO/BO: SI TM54F digital outputs, status
- r10053.0...3 CO/BO: SI TM54F digital inputs 20 ... 23, status

5.5 Communication failure via PROFIsafe or with TM54F

Factory setting for the response to communication failure

In the following cases, the drive responds with a STOP A.

- PROFIsafe communication to the higher-level control has failed.
- DRIVE-CLiQ communication with the TM54F has failed.

5.5.1 STOP B as response to communication failure with PROFIsafe control

If, for a communication failure, the axis coasting down can result in subsequent damage, as response to the communication failure, instead of a STOP A, you can select that the axis is stopped along a ramp.

Requirement

You have released the Safety Integrated Extended or Advanced Functions.

Communication failure

In this context, communication failure can mean the following:

- Interruption or disturbance in PROFIsafe communication
- The higher-level controller (F-CPU) is in the STOP state

Drive response

Parameter p9612 defines the drive stop response when PROFIsafe communication fails:

- p9612 = 0: STOP A
- p9612 = 1: STOP B

Note

For the selected STOP B stop response, in order to ensure that the OFF3 ramp is actually maintained, when just using the Safety Basic Functions, the following must be carefully observed:

- The selected transition time from STOP F to STOP A (p9658) must be greater than or equal to the SS1 delay time (p9652).
- If a higher-level control system responds to the drive fault by withdrawing the controller enable signals, for faults F01611 and F30611, the message type must be changed to alarm (p2118, p2119).

5.5.2 Initiating ESR for a communication failure

If, braking the axis along the braking ramp for a communication failure can result in subsequent damage, the braking operation can be delayed by a maximum of 800 ms. During this delay time, the converter can suitably stop the axis using the "Extended stop and retract (ESR)" function.

If communication with the higher-level motion control is working (for example, if the TM54F fails or the SIMATIC F-CPU with separate motion control fails), retraction can also be performed during the delay time by the controller. This assumes that retraction is configured on the controller side, see, S_ZSW1B, bit 14 (r9734.14) "ESR retract requested".

Preconditions

The following preconditions apply to the drive response subsequently described:

- You have released the Safety Integrated Basic/Extended/Advanced Functions.
- Function module "Extended stop and retract" is activated and enabled.

Communication failure

In this context, communication failure can mean the following:

- Interruption or disturbance in PROFIsafe communication
- The higher-level controller (SIMATIC F-CPU) is in the STOP state
- Interruption of disturbance in the DRIVE-CLiQ communication for control via TM54F

Drive response

For a communication failure, the converter responds corresponding to the settings of the ESR function module.

For communication failure, a maximum delay time of (p9580) 800 ms can be set. After this time has elapsed, the frequency converter activates the "Safe Torque Off" function.

Depending on the setting, either stop responses or safety functions can prevent the ESR response. You must set the safety functions as follows in order that you do not influence the ESR response:

Function	Precondition for the ESR response after communication failure	Setting
SLP	As SLP response, a STOP is parameterized with delayed pulse cancellation when the bus fails	p9562[0...1] ≥ 10
SLS	As SLS response, a STOP is parameterized with delayed pulse cancellation when the bus fails	p9563[0...3] ≥ 10
SDI	As SDI response, a STOP is parameterized with delayed pulse cancellation when the bus fails	p9566 ≥ 10
SLA	As SLA response, a STOP is parameterized with delayed pulse cancellation when the bus fails	p9579 ≥ 10
---	Adequate STOP F to STOP B transition time if additional faults occur when the communication fails	p9555 ≥ p9580
---	Adequate STOP F to STOP A transition time if additional faults occur when communication fails.	p9658 ≥ p9580
---	Check whether the effective setpoint speed limiting (CO: r9733) is set to zero when STOP F is active.	p9507.1

5.6 Control of the Extended/Advanced Functions via F-DI (for CU310-2)

The following terminals are provided on the CU310-2:

Table 5- 18 Interface overview of the CU310-2

Type	Number
Failsafe digital outputs (F-DO)	1
Failsafe digital inputs (F-DI)	3
Sensor[1] power supply, no dynamic response	1
Digital input for checking the F-DO for the forced checking procedure (test stop)	1

[1] Sensors: Failsafe devices for command operations and sensing (e.g. Emergency Stop pushbuttons, safety door locks, position switches, and light arrays / light curtains).

The CU310-2 has 1 failsafe digital output and 3 failsafe digital inputs. A failsafe digital output consists of a 24 VDC switching output, an output switching to ground and a digital input for reading back the switching state. A failsafe digital input is made up of 2 digital inputs.

Note

Fault acknowledgment

You have the following options of acknowledging CU310-2 faults after removing the fault:

- POWER ON
- Falling edge of the signal "Internal Event ACK" with subsequent acknowledgment on the Control Unit ("failsafe acknowledgment").

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 failsafe F-DI, until a safe acknowledgment has been performed through an F-DI via parameter p10006 (SI acknowledgment internal event input terminal) or the extended message acknowledgment has been performed.

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. The signal states at the two related digital inputs (F-DI) will need to have the same state within this monitoring time or fault C01770/C30770 will be triggered, "discrepancy error" (CU310-2). This requires safe acknowledgment.

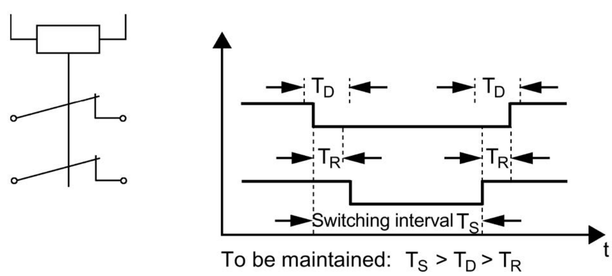
Note

Discrepancy time

The discrepancy time must be set so that it is always less than the smallest expected switching interval of the signal at this F-DI (see also the following diagram "Discrepancy time").

Further notes for setting the discrepancy time are contained in the "SINAMICS S120/S150 List Manual" for the following messages:

- F01611 (Basic Functions)
- C01770 (Extended/Advanced Functions)



T_S Switching interval

T_D Discrepancy time

T_R Response time

Figure 5-7 Discrepancy time

5.6.1 Assigning Safety Integrated Functions to the F-DI/TM54F

The following table provides you with an overview of which Safety Integrated functions you can control with which F-DI/F-DO (onboard or TM54F).

Table 5- 19 Assigning Safety Integrated functions to F-DI/F-DO (onboard or TM54F)

Safety function	Onboard F-DI/F-DO	TM54F F-DI/F-DO
STO	x	x
SS1	x	x
SOS	x	x
SS2	x	x
SS2E	-	-
SLS	x	x
SSM[1)]	x	x
SDI	x	x
SLP	x	x
SCA	-	-
SLA	-	-
SP	-	-
Safe gearbox stage switchover	-	-

1) As feedback signal in S_ZSW1 and S_ZSW2

5.6.2 Overview of the F-DIs

Description

Failsafe digital inputs (F-DI) consist of 2 digital inputs. At the 2nd digital input, the cathode (M) of the optocoupler is additionally brought out to enable connection of an output of an failsafe control grounded through a switch. (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 each DI can be read at parameter r10051. 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 F-DOs and interference pulses can be filtered out using the input filter (p10017), so that they do not cause any faults.

Explanation of terms:

NC contact / NC contact: To select the safety function, a "zero level" must be present at both inputs.

NC contact / NO contact: To select the safety function, a "zero level" must be present at input 1 and a "1 level" at input 2.

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.

The digital inputs of the CU310-2 cannot be dynamized by a test stop.

Table 5- 20 Overview of the failsafe inputs in the SINAMICS S120/S150 List Manual:

Module	Function diagram	Inputs
CU310-2	2870	F-DI 0 ... 2

F-DI features

- Failsafe configuration with 2 digital inputs per F-DI
- Input filter to block test signals with an adjustable suppression time (p10017), see Chapter "Bit pattern test (Page 208)".
- 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

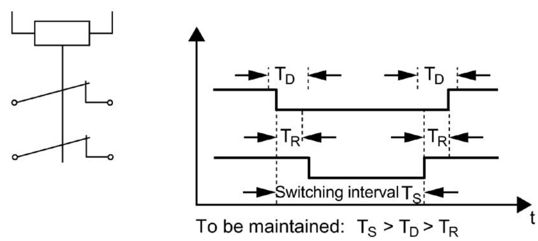
Discrepancy time

To avoid incorrect triggering of fault messages, at these inputs the discrepancy time must always be set less than the shortest time between 2 switching events (ON/OFF, OFF/ON).

Further notes for setting the discrepancy time (also see the following diagram "Discrepancy time") are provided in the "SINAMICS S120/S150 List Manual" for the following message:

– F01611 (Basic Functions)

– C01770 (Extended/Advanced Functions)



T_S Switching interval

T_D Discrepancy time

T_R Response time

Figure 5-8 Discrepancy time

- 2nd digital input with additional tap of the optocoupler cathode for connecting an output of a failsafe control grounded through a switch.

WARNING

Unwanted movement due to incorrect signal states as a result of diagnostic currents in the switched-off state (logical state "0" or "OFF")

Unlike mechanical switching contacts, e.g. emergency stop switches, diagnostic currents can also flow when the semiconductor is in the switched-off state. If interconnection with digital inputs is faulty, the diagnostic currents can result in incorrect switching states. Incorrect signal states of digital inputs can cause unwanted movements of machine parts and result in serious injury or death.

- Observe the conditions of digital inputs and digital outputs specified in the relevant manufacturer documentation.
- Check the conditions of the digital inputs and digital outputs with regard to currents in the "OFF" state and if necessary connect the digital inputs to suitably dimensioned, external resistors to protect against the reference potential of the digital inputs.

More information on this topic is available on the Internet at:

Parameterizing and configuring safety hardware (https://support.industry.siemens.com/cs/ww/en/view/39700013)

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2870 SI functions - CU310-2 (F-DI 0 ... F-DI 2)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p10002 SI Motion F-DI switchover discrepancy time (CPU 1)
- p10017 SI Motion digital inputs debounce time (CPU 1)
- p10040 SI Motion, F-DI input mode (CPU 1)
- r10051.0...2 CO/BO: SI Motion digital inputs status (CPU 1)

5.6.3 Function of the F-DO

Description

The failsafe digital output (F-DO) comprises 2 digital outputs plus one digital input that checks the switching state for forced checking procedure (test stop). The 1st digital output switches 24 V DC, and the 2nd switches M of the X130 (CU310-2) voltage supply.

The status of each F-DO can be read at parameter r10052. The status of the associated DI22 can be read using parameter r0722.22.

The actuator connected to the F-DO can also be tested under specific conditions as part of forced checking procedure (test stop). See Section "Forced checking procedure (test stop) of the CU310-2 (Page 306)".

Table 5- 21 Overview of the failsafe outputs in the SINAMICS S120/S150 List Manual:

Module	Function diagram	Outputs	Associated checking inputs
CU310-2	2873	F-DO 0	DI 22

Signal sources for the F-DO

For the CU310-2, the following signals are available for interconnecting (p10042, ..., p10045) on the F-DO:

- STO active
- SS1 active
- SS2 active
- SOS active
- SLS active
- SSM feedback active

- Safe State
- SOS selected
- Internal event
- Active SLS level bit 0
- Active SLS level bit 1
- SDI positive active
- SDI negative active
- SLP active
- Active SLP area

For the F-DO, up to 6 signals can be interconnected via indexes (p10042[0...5]); these are then output AND'ed.

Safe state signal selection

For the CU310-2, the following (Safe State) signals can be requested via p10039[0...3]:

- STO active (power removed/pulses suppressed)
- SS1 active
- SS2 active
- SOS active
- SLS active
- SDI positive active
- SDI negative active
- SLP active

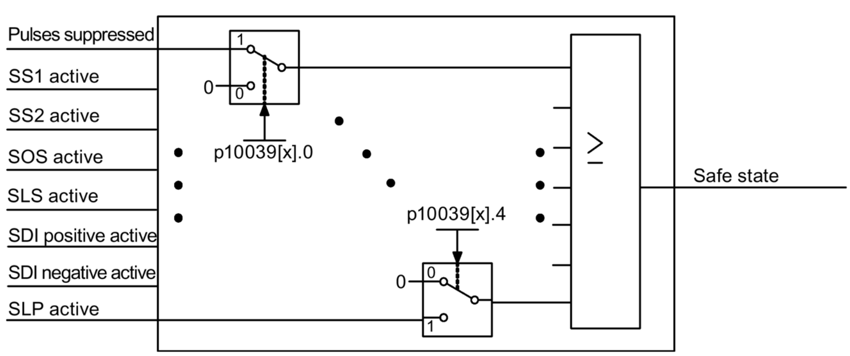


Figure 5-9 Safe state selection

The same signals (high-active) are logically AND'ed. The different signals selected via p10039 are logically OR'ed. Result of these logic operations is the "Safe State". Details can be found in function block diagram 2876, see SINAMICS S120/S150 List Manual.

F-DO features

- Each F-DO with failsafe configuration consisting of 2 digital outputs plus one digital input for checking the switching state for the forced checking procedure (test stop)
- Status parameters r10051/r10052

Note

Display using r0747.16

If digital outputs DO16+ and DO16- act as F-DO, parameter r0747 "CU, digital outputs status", bit 16 "DO 16 (- / X130.7, 8)" does not display the level defined by Safety Integrated. Instead, it displays the ineffective setpoint state according to BICO signal source p0746 "BI: CU signal source for terminal DO 16".

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2870 SI functions - CU310-2 (F-DI 0 ... F-DI 2)
- 2873 SI functions CU310-2 failsafe digital output (F-DO 0)
- 2875 SI functions - CU310-2 control interface
- 2876 SI functions - CU310-2 safe state selection
- 2877 SI functions, CU310-2 assignment (F-DO 0)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p10039 SI Safe State signal selection (CPU 1)
- p10042[0...5] SI F-DO 0 signal sources
- r10051.0...2 CO/BO: SI Digital inputs status (CPU 1)
- r10052.0 CO/BO: SI Digital output status (CPU 1)

5.7 Motion monitoring without selection

As an alternative to controlling via terminals and/or PROFIsafe, there is also the option to parameterize several Safety functions without selection. For this mode, after parameterization and a POWER ON, these functions are permanently selected.

Example

"SLS without selection" can be used to monitor the maximum velocity, for example. This monitoring function prevents the drive from exceeding a mechanical speed limit. When using the "without selection" function, you do not have to use an F-DI and you do not have to use an F-CPU.

Features

- The function "Motion monitoring without selection" is available in the following versions:

p9601	Meaning	Scope of functions	Comment
0024 hex	Drive-integrated motion monitoring functions without selection are enabled	• SLS • SDI	• p9501.0 = 1 • p9501.17 = 1
0025 hex	Drive-integrated motion monitoring functions without selection with STO via terminals are enabled	• SLS • SDI • STO • SS1 • SBC	• p9501.0 = 1 • p9501.17 = 1 • Basic Functions • Basic Functions • Basic Functions

- The functions "SLS without selection" and "SDI without selection positive/negative" are selected with p9512.
- The functions without selection are available in the versions "with encoder" and "without encoder" (selection via p9506).
- The functions without selection are parameterized and enabled in the same way as the versions with control via PROFIsafe/terminals.

Acknowledging safety faults

Carefully observe the following cases for acknowledging Safety faults:

- Motion monitoring functions without selection integrated in the drive

  Acknowledging Safety faults is only possible with POWER ON.
- Motion monitoring functions without selection integrated in the drive and Basic Functions via onboard terminals

  Acknowledging safety faults is possible with POWER ON or selecting/deselecting STO SS1 (see "Extended acknowledgment" in Chapter "Safe Torque Off (STO) (Page 70)").

Differences

Differences in the response of the functions to the versions with control via PROFIsafe/terminals are described in the sections for commissioning the individual functions:

- "Safely-Limited Speed (SLS) (Page 112)"
- "Safe Direction (SDI) (Page 128)"

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9501.0 SI Motion enable safety functions (Control Unit)
- p9512 Select SI Motion safety functions without selection (CU)
- p9601 SI enable functions integrated in the drive (Control Unit)

5.8 Safety Info Channel and Safety Control Channel

5.8.1 Safety Info Channel (SIC)

The Safety Info Channel (SIC) enables Safety Integrated functionality status information of the drive (S_ZSW1B, S_ZSW2B, S_ZSW3B, and S_V_LIMIT_B) to be transmitted to the higher-level controller.

5.8.2 Safety Control Channel (SCC)

Using the Safety Control Channel (SCC), control information (S_STW1B and S_STW3B) can be sent from the higher-level control to the Safety functions of the drive.

5.8.3 Possible telegram configuration (700, 701)

The predefined PROFIdrive telegrams 700 and 701 are available for the transfer of the SIC and the SCC:

Telegram 700

The predefined PROFIdrive telegram 700 is available for the transfer of the SIC:

Table 5- 22 Structure of telegram 700

	Receive data	Send data	Parameter
PZD1	–	S_ZSW1B	r9734
PZD2	–	S_V_LIMIT_B	r9733[2]
PZD3	–		

You can find further information on communication via PROFIdrive in the Manual "SINAMICS S120 Drive Functions Function Manual", Section "Communication according to PROFIdrive".

Telegram 701

The predefined PROFIdrive telegram 701 is available for the transfer of the SIC and the SCC:

Table 5- 23 Structure of telegram 701

<table>
<tr><th></th><th>Receive data</th><th>Parameter</th><th>Send data</th><th>Parameter</th></tr>
<tr><td>PZD1</td><td>S_STW1B</td><td>p10250</td><td>S_ZSW1B</td><td>r9734</td></tr>
<tr><td>PZD2</td><td>S_STW3B</td><td>p10235</td><td>S_ZSW2B</td><td>r9743</td></tr>
<tr><td>PZD3</td><td>–</td><td>–</td><td rowspan="2">S_V_LIMIT_B</td><td rowspan="2">r9733[2]</td></tr>
<tr><td>PZD4</td><td>–</td><td>–</td></tr>
<tr><td>PZD5</td><td>–</td><td>–</td><td>S_ZSW3B</td><td>r10234</td></tr>
</table>

Note

Update of the send data

The send data S_ZSW2B and S_ZSW3B are only updated if the Safety Integrated Extended/Advanced Functions are enabled.

You will find further information on communication via PROFIdrive in the Manual "SINAMICS S120 Drive Functions Function Manual," Chapter "Communication according to PROFIdrive."

5.8.4 Configuring

The following diagram shows the principle when configuring for telegrams 700 and 701:

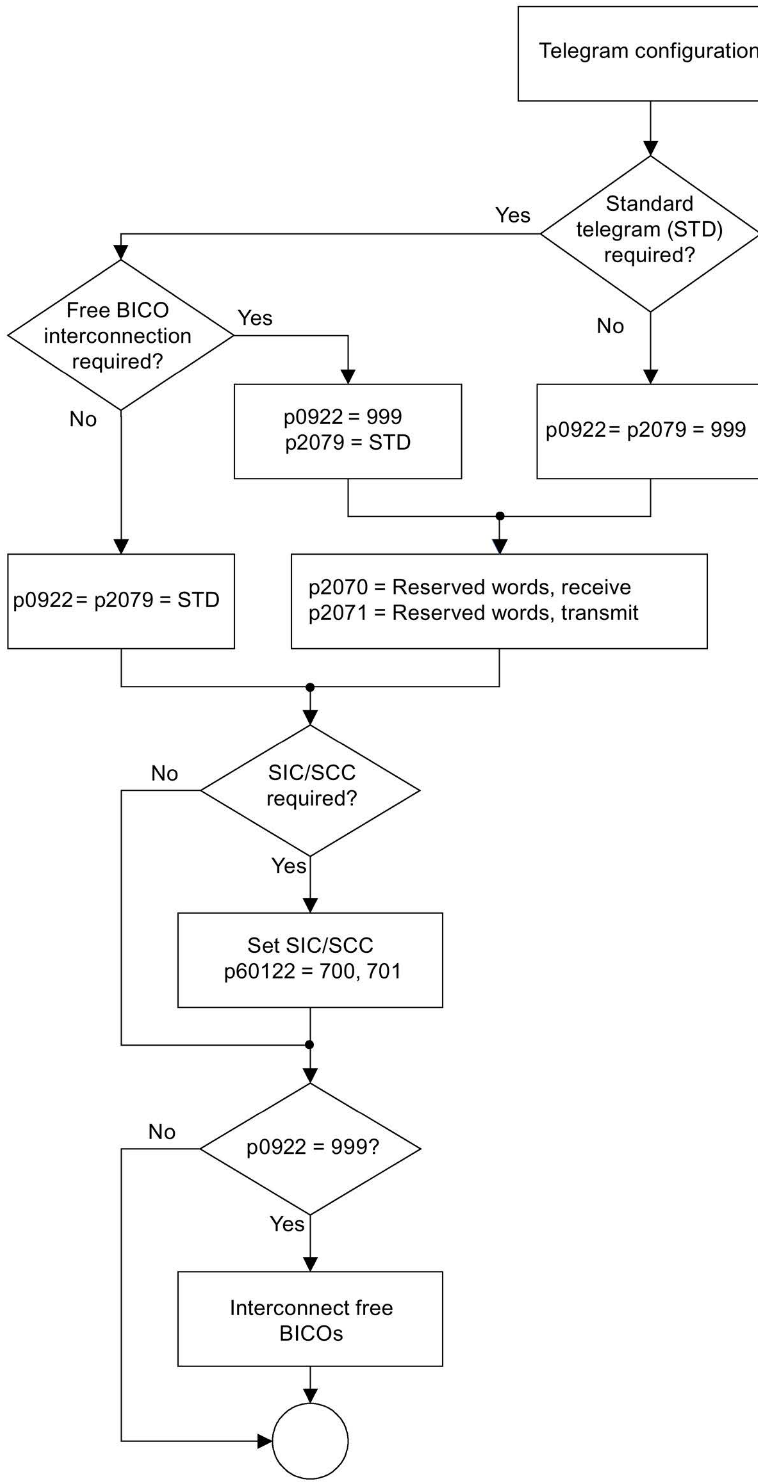


Figure 5-10 Telegram configuration procedure

- Parameter p2070 is used to define at which location (after how many words) the SCC starts in receive words r2050/r2060.
- Parameter p2071 is used to define at which location (after how many words) the SIC starts in send words p2051/p2061.
- If, using p0922 = 999 and p2079 = x, a fixed telegram is to be parameterized with PZD extension, then you can appropriately adapt p2070 and p2071.
- For p0922 = p2079 = x, p2070 and p2071 are locked to prevent changes being made.
- When writing to parameter p0922 or p2079, parameters p2070 and p2071 are appropriately preassigned (with the length of the standard telegram). All BICO interconnections in r2050[...]/r2060[...] and p2051[...]/p2061[...] are deleted and reassigned to telegram x. In so doing, p60122 is also set = 999.
- When changing from a fixed telegram (p0922 = p2079 = x) to a free telegram (p0922 = 999), p2070 and p2071 remain unchanged, however they are released so that they can be changed. The value of p60122 is kept.
- If p10235 and p10250 are manually changed, fault F01786 is output without any drive response. This fault can be acknowledged by the standard message acknowledgment.

Note

Effects in r2050[...]/r2060[...] and p2051[...]/p2061[...] when changes are made to p2070, p2071 and p60122

- If you change p2070 and p2071, all BICO interconnections in r2050[...]/r2060[...] and p2051[...]/p2061[...] will be deleted (starting with the end of the currently set standard telegram). In so doing, p60122 is also set = 999.
- If you change p60122 to a value ≠ 999, then (starting with the indices set in p2070 or p2071) all BICO interconnections are deleted in r2050[...]/r2060[...] and p2051[...]/p2061[...] and the new telegram set for SIC/SCC.

5.8.5 Applications

You can attach the telegrams 700 and 701 as an extension to your telegram. You can only select one of the two telegrams.To do this, proceed as follows:

<table>
<tr><th>Application</th><th>Action by the user</th><th>Effect</th></tr>
<tr><td rowspan="3">Standard telegram + SIC/SCC</td><td>

- Specify standard telegram; e.g. p0922 = 106

</td><td>

- p2079 = p0922 = 106
- r2050 and p2051 are appropriately preassigned and completely locked so that changes cannot be made.
- In p2070 and p2071, the number of transmit/receive words are occupied and cannot be changed (e.g: p2070 = 11 and p2071 = 15).

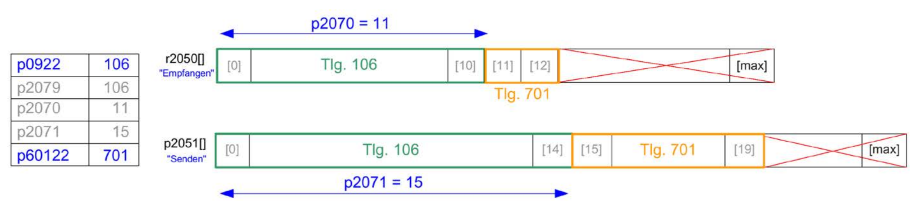
</td></tr>
<tr><td>

- Select SIC/SCC; e.g. p60122 = 701

</td><td>

- The telegram extension for SCC/SIC is directly attached to the standard telegram in r2050 and p2051.

</td></tr>
<tr><td colspan="2">



</td></tr>
<tr><td rowspan="4">Standard telegram + free telegram configuration with BICO + SIC/SCC</td><td>

- Define standard telegrams with possible telegram extension; e.g. p0922 = 999 and p2079 = 106

</td><td>

- r2050 and p2051 are appropriately preassigned. Areas that are not preassigned, can be freely interconnected.
- p2070 = 11, p2071 = 15 are preassigned corresponding to p0922 and cannot be changed.

</td></tr>
<tr><td>

- Reserve space for the telegram extension with free BICO wiring, e.g. 2 words in the receive direction and 1 word in the send direction:
  - p2070 = 11 + 2 = 13
  - p2071 = 15 + 1 = 16

</td><td>

- Words r2050[11...12] and p2051[15] are reserved for the telegram extension and can be freely interconnected.

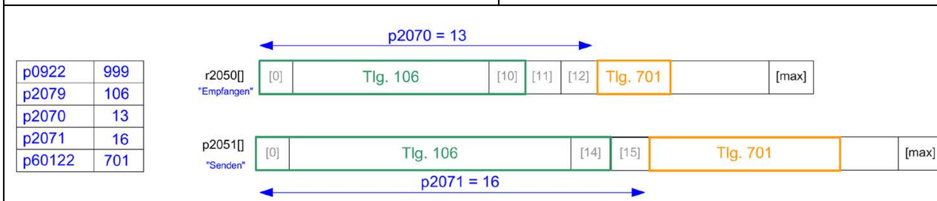
</td></tr>
<tr><td>

- Select SIC/SCC; e.g. p60122 = 701

</td><td>

- The telegram extension for SIC/SCC is inserted from r2050[13…] and p2051[16…].
- In r2050 and p2051, the words for SIC/SCC are preassigned accordingly and locked. The other words can be freely connected.

</td></tr>
<tr><td colspan="2">



</td></tr>
</table>

Changing the standard telegram (without free telegram configuration)	• Specify a new telegram; e.g. p0922 = 105	• r2050 and p2051 are deleted and reassigned accordingly.
	• Select SIC/SCC; e.g. p60122 = 701	• The telegram extension for SCC is added after the standard telegram. • r2050 and p2051 are preassigned corresponding to p0922 and SIC/SCC are completely locked so that they cannot be changed.
Changing the standard telegram (with free telegram configuration)	• Change standard telegram (see above) • Now continue as described in the "Standard telegram + free telegram configuration with BICO + SIC/SCC"	–
Change of the SIC/SCC telegram	• Change SIC/SCC; now, e.g. p60122 = 700	• Starting with the indices set in p2070 or p2071, all BICO interconnections are deleted in r2050[...] and p2051[...]. • The telegram extension for SIC is inserted into parameter p2071 according to p2051.
Adding further "Free telegram configuration with BICO" words	• Change the values in p2070 or p2071.	• When changing from a fixed telegram (p0922 = p2079 = x) to a free telegram (p0922 = 999), p2070 and p2071 remain unchanged, however they are released so that they can be changed. The value of p60122 is kept.
	• Select SIC/SCC; e.g. p60122 = 701	• SIC/SCC is reconfigured.
	• Now specify the new free telegram configuration (see above).	–

Note

Parameter interdependencies

- Values for p2070 or p2071, which fall below the length of the standard telegram, will be rejected and cannot be entered.
- Write access in p60122 is rejected if excessively high values are set in p2070 or p2071 so that attaching a SCC/SIC telegram would mean that the maximum permissible PZD lengths would be exceeded.

5.8.6 Send data for SIC and SCC

S_ZSW1B

SI Motion Safety Info Channel status word

Table 5- 24 Description S_ZSW1B

Bit	Meaning	Remarks		Parameter
0	STO active	1	STO active	r9734.0
		0	STO not active	
1	SS1 active	1	SS1 active	r9734.1
		0	SS1 not active	
2	SS2 active	1	SS2 active	r9734.2
		0	SS2 not active	
3	SOS active	1	SOS active	r9734.3
		0	SOS not active	
4	SLS active	1	SLS active	r9734.4
		0	SLS not active	
5	SOS selected	1	SOS selected	r9734.5
		0	SOS deselected	
6	SLS selected	1	SLS selected	r9734.6
		0	SLS deselected	
7	Internal event	1	Internal event	r9734.7
		0	No internal event	
8	SLA active	1	SLA active	r9734.8
		0	SLA not active	
9	Active SLS level bit 0	–	Display of the speed limit for SLS (2 bits)	r9734.9
10	Active SLS level bit 1	–		r9734.10
11	Reserved	–	–	–
12	SDI positive selected	1	SDI positive selected	r9734.12
		0	SDI positive deselected	
13	SDI negative selected	1	SDI negative selected	r9734.13
		0	SDI negative deselected	
14	ESR retract requested	1	ESR retract requested	r9734.14
		0	ESR retract not requested	
15	Safety message active	1	Safety message active	r9734.15
		0	No safety message active	

S_ZSW2B

Safety Info Channel status word 2

Table 5- 25 Description of S_ZSW2B

Bit	Meaning	Remarks		Parameter
0...3	Reserved	–	–	–
4	SLP selected position range	1	SLP area 2 selected	r9743.4
		0	SLP area 1 selected	
5, 6	Reserved	–	–	–
7	SLP selected and user agreement	1	SLP selected and user agreement set	r9743.7
		0	SLP selected or user agreement not set	
8	SDI positive	1	SDI positive selected	r9743.8
		0	SDI positive deselected	
9	SDI negative	1	SDI negative selected	r9743.9
		0	SDI negative deselected	
10, 11	Reserved	–	–	–
12	Test stop active	1	Test stop active	r9743.12
		0	Test stop not active	
13	Test stop required	1	Test stop required	r9743.13
		0	Test stop not required	
14	Reference position required	1	Reference position required	r9743.14
		0	Reference position not required	
15	Reference trigger command identified or reference position valid	1	Reference trigger command identified or reference position valid	r9743.15
		0	No reference trigger command identified or reference position invalid	

S_ZSW3B

Safety Info Channel status word 3

Table 5- 26 Description of S_ZSW3B

Bit	Meaning	Remarks		Parameter
0	Brake test	1	Brake test selected	r10234.0
		0	Brake test deselected	
1	Setpoint input, drive/external[1)]	1	Setpoint specification for the drive	r10234.1
		0	Setpoint specification, external (controller)	
2	Active brake	1	Test brake 2 active	r10234.2
		0	Test brake 1 active	
3	Brake test active	1	Test active	r10234.3
		0	Test inactive	
4	Brake test result	1	Test successful	r10234.4
		0	Test error	
5	Brake test completed	1	Test run	r10234.5
		0	Test incomplete	
6	External brake request	1	Close brake	r10234.6
		0	Open brake	
7	Current load sign	1	Negative sign	r10234.7
		0	Positive sign	
8...10	Reserved	–	–	–
11	SS2E	1	SS2E active	r10234.11
		0	SS2E not active	
12	SS2ESR	1	SS2ESR active	r10234.12
		0	SS2ESR not active	
13	Reserved	–	–	–
14	Acceptance test SLP (SE) selected	1	Acceptance test SLP (SE) selected	r10234.14
		0	Acceptance test SLP (SE) deselected	
15	Acceptance test mode selected	1	Acceptance test mode selected	r10234.15
		0	Acceptance test mode deselected	

1) Setpoint input for the drive: The speed setpoint is entered by the function SBT.
External setpoint input (open-loop control): The "normal" speed setpoint is effective.

S_V_LIMIT_B

SLS speed limit with 32-bit resolution and sign bit.

- The SLS speed limit is available in r9733[2].
- The SLS speed limit is standardized via p2000.

  S_V_LIMIT_B = 4000 0000 hex ≙ speed in p2000

5.8.7 Receive data for SCC

S_STW1B

Safety Control Channel control word 1

Table 5- 27 Description of S_STW1B

Bit	Meaning	Remarks		Parameter
0...7	Reserved	–	–	–
8	Extended/Advanced Functions forced checking procedure (test stop)	1	Extended/Advanced Functions forced checking procedure (test stop)	r10251.8
		0	Extended/Advanced Functions forced checking procedure (test stop)	
9...15	Reserved	–	–	–

S_STW3B

Safety Control Channel control word 3

Table 5- 28 Description of S_STW3B

Bit	Meaning	Remarks		Parameter
0	Select brake test	1	Brake test selected	r10231.0
		0	Brake test deselected	
1	Start brake test	1	Start brake test requested	r10231.1
		0	Start brake test not requested	
2	Brake selection	1	Test brake 2 selected	r10231.2
		0	Test brake 1 selected	
3	Select direction of rotation	1	Negative direction selected	r10231.3
		0	Positive direction selected	
4	Select test sequence	1	Test sequence 2 selected	r10231.4
		0	Test sequence 1 selected	
5	Status of external brake	1	External brake closed	r10231.5
		0	External brake open	
6...15	Reserved	–	–	–

5.8.8 Overview of important parameters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r9733[0...2] CO: SI Motion setpoint speed limit effective
- r9734.0...15 CO/BO: SI Safety Info Channel status word S_ZSW1B
- r9743.4...15 CO/BO: SI Safety Info Channel status word S_ZSW2B
- r10231 SI Motion SBT control word diagnostics
- r10234.0...15 CO/BO: SI Safety Info Channel status word S_ZSW3B
- p10235 CI: SI Safety Control Channel control word S_STW3B
- p10250 CI: SI Safety Control Channel control word S_STW1B
- r10251.8...12 CO/BO: SI Safety Control Channel control word S_STW1B diagnostics
- p60122 IF1 PROFIdrive SIC/SCC telegram selection

Commissioning 6

6.1 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 Module each have separate version IDs. 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 information can be read for the Extended/Advanced 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)

    or

    r0148[0...n] for DQI encoders
  - r10090[0...3] SI TM54F version

Basic Functions and Extended/Advanced Functions

For Basic and/or Extended or Advanced Functions that have been enabled, a check is made to see 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.

Otherwise, the message F01664 (SI CU: No automatic firmware update) is output.

In the acceptance test of the Safety Integrated Basic Functions, the Safety Firmware Versions (r9770, r9870) must be read out and recorded.

In the acceptance test of the Safety Integrated Extended/Advanced Functions, the Safety Firmware Versions of the Motor Modules (r9590, r9390), the Sensor Modules (r9890 or r0148[0...n] for DQI encoders), and, if necessary, the Terminal Module TM54F (r10090) participating in the safety functions must be read out and recorded.

6.2 Parameters, checksum, version

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.
- The safety parameterization is password-protected against accidental or unauthorized changes.
- Factory settings for safety parameters
  - The drive-specific reset of the Safety parameters to the factory setting with p3900 and p0010 = 30, is only possible if the safety functions are not enabled (p9501 = p9601 = p10010 = 0).
  - Safety parameters can be reset to the factory setting with p0970 = 5. To do so, the Safety Integrated password must be set. If Safety Integrated has been enabled, this can result in error messages that require an acceptance test to be performed. Then save the parameters and carry out a POWER ON.
  - 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 p9501 = p9601 = p10010 ≠ 0).

Note

You will find more detailed information on this password in Chapter "Handling the Safety password (Page 266)."

Note

Safety parameters that are not protected

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 speed setpoint limitation
- p9783 SI Motion synchronous motor current injection without encoder

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Note

The password protection is only available online.

Checking the checksum

For each monitoring channel, the Safety parameters include 2 parameters for the reference and 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 reference checksum. This can be done for all checksums of a drive object at the same time using parameter p9701 or using the corresponding Startdrive functionality.

- Basic Functions

• r9798	SI actual checksum SI parameters (Control Unit)
• p9799	SI reference checksum SI parameters (Control Unit)
• r9898	SI actual checksum SI parameters (Motor Module)
• p9899	SI reference checksum SI parameters (Motor Module)

- Extended/Advanced Functions (also contain the following checksum parameters)

• r9398[0...1]	SI Motion actual checksum SI parameters (Motor Module)
• p9399[0...1]	SI Motion reference checksum SI parameters (Motor Module)
• r9728[0...2]	SI Motion actual checksum SI parameters
• p9729[0...2]	SI Motion reference checksum SI parameters

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

If the actual and reference checksums are different, fault F01650/F30650 or F01680/F30680 is output.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2818 SI Extended/Advanced Functions - parameter manager

6.3 Handling the Safety password

The safety password protects safety parameters against maloperation. Always assign a strong password, to enable protection.

Note

The safety password does not have the equivalent quality of a password (protection against unauthorized access, e.g. by an attacker), but rather that of write protection (e.g. protection against maloperation).

Note

The password protection is only available online.

Password reset

- You require a valid password to reset the password to the factory setting by resetting the safety parameters.
- Please note that when the factory setting is reset throughout the complete device, then the safety password is also deleted.

Details on handling the safety password

If a password is set, 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. In addition to the specified parameters, a corresponding functionality is available in Startdrive!

- When Safety Integrated is commissioned for the first time, the following applies:
  - Default of p10061 = 0 (SI password entry TM54F)
  - Default of p9761 = 0 (SI password entry drive)

  This means:
  You do not need to enter a safety password during the 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 Startdrive 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".
  - p0977 = 1; "Copy from RAM to ROM"
  - 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"
  - p0977 = 1; "Copy from RAM to ROM"
  - The new and acknowledged safety password is valid immediately.
- Changing the password with Startdrive
  - Click "Enter password" in the Startdrive secondary navigation.
  - Enter the current password.
  - Enter the new password.
  - Enter the new password again.
  - Click "Change password" to accept the new password.
- Resetting the password with Startdrive
  - Click "Enter password" in the Startdrive secondary navigation.
  - In the subsequent dialog, first enter the old password.
  - Set the new password = 0.
  - Click "Change password" to accept the new password.
  - SINAMICS S120 responds with the message "Please change the password!"
  - Close the message.
  - In the "Change password" dialog box, then click the "Cancel" button.
  - The password has now been reset to the default "0."
- If the safety password is no longer available, you can no longer change the safety configuration. You then have the following options:
  - To commission the SINAMICS S120 completely as new:

    - Restore the factory settings of the entire drive (Control Unit with all connected drives/components).

    - Commission the drive unit and the drives afresh.

    - Commission Safety Integrated as new.
  - To load another project into the drive (without a Safety password or with a known Safety password). This is possible without a password because this operation is the same as complete new commissioning.
  - If neither option is acceptable to you, please contact "Technical Support" (see "Preface (Page 3)").

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2818 SI Extended/Advanced Functions - parameter manager

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9761 SI password input
- p9762 SI password new
- p9763 SI password acknowledgment
- p10061 SI TM54F password entry
- p10062 SI TM54F password new
- p10063 SI TM54F password confirmation

6.4 DRIVE-CLiQ rules for Safety Integrated Functions

Note

General DRIVE-CLiQ rules

For the Safety Integrated Functions (Basic, Extended and Advanced Functions) the general DRIVE-CLiQ rules apply as a basic principle. You will find these rules in Section "Rules for connection with DRIVE-CLiQ" in the following manual:
References: SINAMICS S120 Drive Functions Function Manual
This specification also lists the exceptions for Safety Integrated components depending on the firmware version.

Note

Effect of the Safety monitoring clock cycle (p9500)

If you select a value of <12 ms for the Safety monitoring clock cycle, you can operate fewer than the specified number of maximum axes at one Control Unit if you have demanding configurations.

- The following rule also applies particularly for Safety Integrated Basic Functions:
  - Maximum of four drives per DRIVE-CLiQ line for control via PROFIsafe
- The following rules are also valid particularly for the Safety Integrated Extended/Advanced Functions:
  - Maximum of 6 servo axes for default clock cycle settings (Safety monitoring clock cycle = 12 ms; current controller cycle = 125 µs); of which a maximum of 4 servo axes are in one DRIVE-CLiQ line
  - Maximum of six vector axes for the following cycle settings (Safety monitoring cycle = 12 ms; current controller cycle = 500 µs)
  - One Double Motor Module corresponds to 2 DRIVE-CLiQ nodes.
  - On Double Motor Modules, on the drive objects, different values for p9511 are not permitted, even if the values in p0115[0] are different.
  - A maximum of 4 Motor Modules with Safety Extended/Advanced Functions may be operated on one DRIVE-CLiQ line (for current controller cycle T_{IReg} = 125 µs on all axes). No further DRIVE-CLiQ components other than a Line Module and Sensor Modules may be operated on this DRIVE-CLiQ line.

    Exception: For SINAMICS S120M, a maximum of 6 S120M with Safety Extended/Advanced Functions can be operated on one DRIVE-CLiQ line.

- For "V/f control (vector control)", the following rules[1)] apply:

Safety functionality	Number of V/f axes
Basic Functions	12
Basic Functions via TM54F	6
Extended/Advanced Functions via PROFIsafe	11
Extended/Advanced Functions via TM54F	6
Motion monitoring without selection	12[2)]

1) The values specified in the table apply to Extended/Advanced Functions with and without encoder and also for group drives connected in parallel.

2) All axes V/f control, 500 µs, Safety Integrated with encoder

- TM54F
  - The TM54F connection must be established via the DRIVE-CLiQ directly at a Control Unit. Only one TM54F Terminal Module can be assigned to each Control Unit.
  - Additional DRIVE-CLiQ nodes can be operated at the TM54F, such as Sensor Modules and Terminal Modules (excluding an additional TM54F). It is not permissible that Motor Modules and Line Modules are connected to a TM54F.
  - In the case of a CU310-2 Control Unit, it is not possible to connect the TM54F to the DRIVE-CLiQ line of a Power Module. The TM54F can only be connected to the sole DRIVE-CLiQ X100 socket of the Control Unit.

6.5 Forced dormant error detection (test stop)

To fulfill the requirements of standards DIN EN ISO 13849-1 and IEC 61508 regarding timely error detection, the converter must regularly test its safety-relevant circuits to ensure that they function correctly – this must be performed at least once every year. The converter monitors the regular testing of its safety-related circuits, which monitor the speed of the motor and which safely interrupt the torque-generating energy supply to the motor by means of safe pulse suppression.

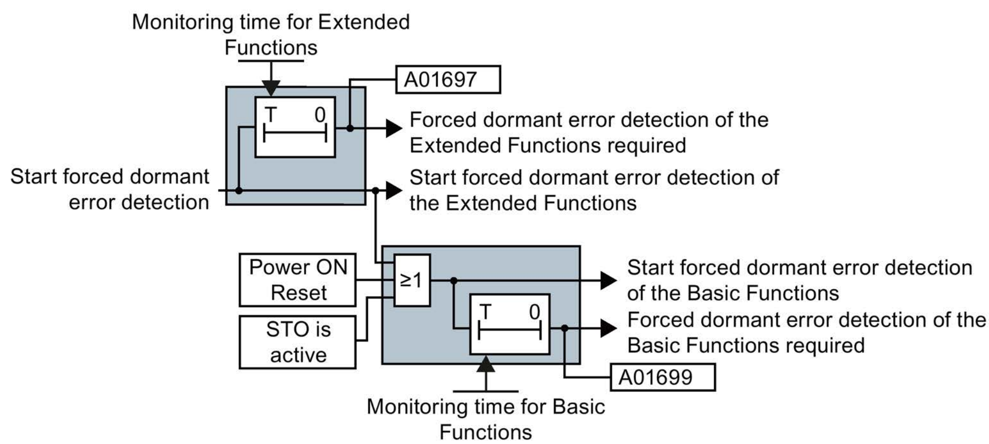


Figure 6-1 Monitoring the regular forced checking procedure (test stop) in the converter

Table 6- 1 Monitoring the forced checking procedure (test stop)

Extended/Advanced Functions	Basic Functions
r9765 contains the remaining monitoring time.	r9660 contains the remaining monitoring time.
The converter signals that the monitoring time has come to an end with alarm A01697.	The converter signals that the monitoring time has come to an end with alarm A01699.

Setting the forced checking procedure (test stop)

If you only use the "Basic Functions", you must take the following steps during commissioning:

1. Set monitoring time p9659 to a value to match your application.
2. Evaluate the warning A01699 in your higher-level control, e.g. r9773.31 with a digital output or a bit in the status word of the field bus.

The circuits of "Basic Functions" are part of the circuits of "Extended/Advanced Functions". If you use the "Extended/Advanced Functions", you must take the following steps during commissioning:

1. Set monitoring time p9559 to a value to match your application.
2. Set the monitoring time p9659 to the maximum value.
3. Evaluate alarm A01697 in your higher-level controller, for example by interconnecting the output of the time monitoring (r9723.0) with a digital output or a bit in the status word of the fieldbus.

Executing the forced checking procedure (test stop)

If the converter signals alarm A01699 or A01697, you must initiate the forced checking procedure (test stop) at the next opportunity.

These alarms do not affect the operation of your machine. You should shut down the drive before performing the forced checking procedure (test stop).

Note

Internal selection of STO

Controlling the forced checking procedure (test stop) causes STO to be selected internally. In this case, drives that were previously not stopped, or that do not have a holding brake, coast down.

Initiating the forced checking procedure (test stop)

- Extended/Advanced Functions
  - You define the signal with which the converter tests its circuits for speed monitoring. Alternatively, the test can be performed automatically every time the power supply is switched on (POWER ON).
  - To ensure that the forced checking procedure (test stop) is performed without error, it is not permissible that STO is active.
  - If you select the forced checking procedure (test stop), the converter checks the Extended/Advanced Functions and Basic Functions circuits.
- Basic Functions

  The converter checks its circuits for interruption of the torque-generating energy feed to the motor for one of the following conditions:
  - After the power supply has been connected (POWER ON).
  - Each time after selecting the function STO or SS1.
  - For the forced checking procedure (test stop) of the Extended Functions.

Note

Additional information

- You will find detailed information on forced checking procedure (test stop), in Chapter "Forced checking procedure (test stop) (Page 172)."
- You will find a description of the forced checking procedure (test stop) of the TM54F in Section "Forced checking procedure (test stop) of the TM54F (Page 313)."

Examples for the instants in time that the forced checking procedure (test stop) is performed

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

Note

Test stop of a CU310-2

The pulses must be enabled when conducting a test stop at a CU310-2: Here, the drive should be switched on with N_{set} = 0.

6.6 Safety Integrated and ESR

The following table lists the options that SINAMICS Safety Integrated offers for ESR. There are 3 variants in which the converter triggers ESR:

1. STOP E

   Internal response to a limit value violation + SLS, SDI, SLP, SLA with subsequent response

2. STOP F

   Defect in a monitoring channel + programmed subsequent response with STOP B → STOP A

3. Communication breakdown

   Cable, CPU STOP, ...

	Variant	Basic Functions	Extended/Advanced Functions
ESR integrated in the drive ("internal" ESR)	1	• STOP E: NOT POSSIBLE → SS1 immediately responds with STOP B	• STOP E (internal response to a limit value violation + SLS, SDI, SLP, SLA with subsequent response) • Is initiated when a limit value is violated, for example • For these functions, the following value is monitored: p0890[1] = r9721.15 (Safety Integrated STOP E)
	2	• STOP F (defect in a monitoring channel + programmed subsequent response with STOP B → STOP A) • E. g. for a discrepancy at the input terminals • Basic Functions, set r9734.14 • p0890[4] = r9734.14	• STOP F (defect in a monitoring channel + programmed subsequent response with STOP B → STOP A) • In the transition time from STOP F to STOP B, you can request an ESR. • p0890[2] = r9723.1 (Safety Integrated STOP F)
	3	• Communication breakdown: NOT POSSIBLE	• Communication error (cable, CPU STOP, ...) • During the "Delay for bus failure" (p9580) from STOP F to STOP B, you can request an ESR. • p0890[3] = r9723.2 (Safety Integrated communication failure) • NOTE: As p9580 delays the initiation of STO, you must explicitly select a safety function with delay. For this function, parameterize a STOP with delayed STO when the bus fails (e.g. p9563 for SLS).

<table>
<tr><th></th><th>Variant</th><th>Basic Functions</th><th>Extended/Advanced Functions</th></tr>
<tr><td rowspan="3">ESR via a control system ("external" ESR)</td><td>1</td><td>STOP E: NOT POSSIBLE → SS1 immediately responds with STOP B</td><td>STOP E (internal response to a limit value violation + SLS, SDI, SLP, SLA with subsequent response)
SS2ESR: STOP E explicitly requested by control unit; S_STW2.29 and S_ZSW3B.12
ESR integrated in the drive (p0890, …), is not enabled when using the external ESR.
ESR is requested via r9734.14.
The motion control evaluates r9734.14 (SIC).
Bit r9734.14 is used as trigger for the external CPU, to initiate the external ESR. In addition, bit r10234.12 (S_ZSW3B) is set if the request was received via S_STW2.29. This allows a distinction to be made between cases where ESR was triggered by a limit value being violated. The external CPU then specifies the setpoint.</td></tr>
<tr><td>2</td><td>STOP F (defect in a monitoring channel + programmed subsequent response with STOP B → STOP A)
ESR integrated in the drive (p0890, …), is not enabled when using the external ESR.
ESR is requested via r9734.14.
The motion control evaluates r9734.14 (SIC).
Bit r9734.14 is used as trigger for the external CPU, to initiate the external ESR. The external CPU then specifies the setpoint.</td><td>STOP F (defect in a monitoring channel + programmed subsequent response with STOP B → STOP A)
You can request an ESR in the time from STOP F to STOP B.
ESR integrated in the drive (p0890, …), is not enabled when using the external ESR.
ESR is requested via r9734.14.
The motion control evaluates r9734.14 (SIC).
Bit r9734.14 is used as trigger for the external CPU, to initiate the external ESR. The external CPU then specifies the setpoint.</td></tr>
<tr><td>3</td><td>Communication breakdown: NOT POSSIBLE</td><td>Communication breakdown: NOT POSSIBLE</td></tr>
</table>

6.7 Commissioning Safety Integrated functions

6.7.1 General information

1. In the Startdrive secondary navigation select "<Drive axis> > Drive functions > Safety Integrated > Function selection".
2. To commission Safety Integrated Basic Functions, you can select the following settings in the "Function selection" screen form. You can also simultaneously select the control version of the safety functions:
   – Basic Functions via onboard terminals
   – Basic Functions via PROFIsafe
   – Basic Functions via PROFIsafe and onboard terminals
3. To commission Safety Integrated Extended Functions, you can select the following settings in the "Function selection" screen form. You can also simultaneously select the control version of the safety functions – as well as a possible combination with the Basic Functions:
   – Extended Functions via PROFIsafe
   – Extended Functions via PROFIsafe and Basic Functions via onboard terminals
   – Extended Functions without selection
   – Extended Functions without selection and Basic Functions via onboard terminals

Note

Commissioning TM54F and CU310-2

TM54F, CU310-2 and PROFIBUS are not yet available in Startdrive.

Note

Configuration in Startdrive

- You can find examples for configuring the Safety Integrated Functions in the chapters "Basic Functions (Page 288)" and "Extended Functions (Page 293)".
- You can find detailed information on configuring in Startdrive in the online help.

Safety slot

A safety slot must first be created in order to be able to control the Safety Integrated Functions via PROFINET. The procedure for this is described in the following sections:

- "PROFIsafe via PROFINET (Page 322)"

Parameter view

You can parameterize the Safety Integrated Functions in Startdrive via the parameter view, but making settings via the dialogs is more convenient and less prone to error.

Note

Password for the factory setting

The password "0" is set by default.

See also

PROFIsafe via PROFIBUS (Page 321)

Note

Incompatible version in the Motor Module

If there is no compatible version in the Motor Module, the Control Unit will respond as follows on transition to Safety commissioning mode (p0010 = 95):

- The Control Unit indicates the fault F01655 (SI CU: Aligning the monitoring functions). The fault initiates fault response OFF2.
- The Control Unit triggers safe pulse suppression via its own Safety switch-off signal path.
- If parameterized (p1215, p9602), the motor holding brake is closed.
- The fault can only be acknowledged after the Safety functions have been blocked (p9601).

Note

Duplicate the parameters for the 2nd channel

When parameterizing the Safety Integrated Functions using Startdrive screen forms (online and offline), you only set the values of one channel. Information on how you can copy the parameters for the 2nd channel is provided in Chapter "Accepting the settings in the drive (Page 286)".

Note

Behavior when copying

For the encoder parameters (p9515 to p9529), which are used for safe motion monitoring, the following procedure applies when copying:

- The following applies to safety-related functions that have not been enabled (p9501 = 0):

  The parameters are automatically set during startup in the same way as the corresponding encoder parameters (e.g. p0410, p0474, ...).
- The following applies to safety-related functions that have been enabled (p9501 > 0):

  The parameters are checked against their corresponding encoder parameters (e.g. p0410, p0474, ...).

Further information can be found in the parameter descriptions in the SINAMICS S120/S150 List Manual.

Note

Copying a drive with enabled Safety Integrated Functions

If a drive with enabled Safety Integrated Functions is copied offline, fault F01656 can occur when the project is downloaded. This behavior occurs whenever component numbers change during copying (e.g. different DO number or hardware).

Take care to observe these limitations or perform Safety commissioning again.

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. In this case, a drive message (A01693 or A30693) will inform you.

6.7.2 Prerequisites for commissioning the Safety Integrated functions

- Commissioning of the drives must be complete.
- It is not permissible that the drive, on which the safety functions are to be commissioned online, is in the "Operation" state.
- To commission the "Safe Brake Control" (SBC) function, the following also applies:

  A motor with motor holding brake must be connected to the appropriate connection of the Motor Module or to Safe Brake Relay/Safe Brake Adapter (SBR/SBA).

6.7.3 Default settings for commissioning Safety Integrated functions without encoder

Additional default settings are required before commissioning Safety Integrated Functions without an encoder. The parameterization of the ramp-function generator is necessary, so that in encoderless operation stepped signals do not occur.

1. The ramp-function generator is automatically created if a vector drive is configured. Continue with point 3.
2. If a servo drive has been configured, activate the ramp-function generator as follows: Activate the "Extended setpoint channel" function module.
3. Open the ramp-function generator and click the button showing the ramp.
4. Here, enter the data to define the ramp-function generator ramp.
5. Subsequently carry out a "motor data identification" to determine the motor data and to improve the torque accuracy: Start with static measurements and then take rotating measurements. You will find details in the relevant chapters on "Motor data identification" in the "Function manual SINAMICS S120 drive functions."

Activating Safety Integrated

1. Open the Safety Integrated selection window and select the required safety control type.
2. In the drop-down list below that, select "[1] Safety without encoder and brake ramp (SBR)" or "[3] Safety without encoder with acc_monitoring (SAM)/delay time."
3. Set the actual value acquisition cycle (p9511) to the value of the current controller cycle (p0115[0]) (e.g. 125 µs).
4. Then click in the "Configuration" dialog on "Mechanical system configuration": Set the actual value tolerance (p9542) to a higher value (e.g. 1 mm or 12 °).

   When configuring the gearbox ratio, take into account the pole pair number of the motor.

   Note

   Interrelationship between the electrical ↔ mechanical speed

   The encoderless safe actual value sensing calculates the electric speed of the drive. The pole pair number (r0313) specifies the factor with which the electrical speed must be multiplied in order to obtain the mechanical speed at the motor shaft.

   ---

5. Open SS1, and set the shutdown velocity > 0 (p9560). This is only absolutely necessary if "Safety without encoder with braking ramp (SBR)" was selected.
6. Open SLS/SDI, and switch over all of the stop responses to "[0] STOP A" or "[1] STOP B" (p9563[0...3], p9566) and then close the window.
7. You can now carry out the user-specific safety settings.
8. Using p9585, define the value for the "SI Motion fault tolerance actual value acquisition - sensorless" (see Section "Notes regarding setting parameters for safe actual value sensing without encoder (Page 165)").
9. Click the "Copy parameters" button.
10. Click the "Activate settings" button.
11. Switch the drive off and back on again to accept the changes.

Note

Response to message C01711/C30711

If during acceleration or deceleration, the drive outputs the message C01711/C30711 (message value 1041 to 1043), this indicates problems, for example, with values too high for acceleration/deceleration. 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 p9586, p9587, p9588, p9589 and p9783 (see the specifications in the SINAMICS S120/S150 List Manual).

6.7.4 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 in the **monitoring cycle** (p9500) and the TM54F is executed with the **sampling time** displayed in r10015. This sampling time corresponds to the lowest value of the communication sampling time entered in p10000[0..5]. For Basic Functions, the cycle is displayed in r9780.

Communication via PROFIBUS is performed cyclically via the **communication cycle.**

During the PROFIsafe scan cycle, the PROFIsafe telegrams issued by the master are evaluated.

Rules

- The monitoring cycle (p9500) can be set between 500 µs to 25 ms.

Note

Setting an identical monitoring cycle

The monitoring cycle must be the same on all drives and the TM54F.

However, the calculation time required for the Extended/Advanced Functions in the Control Unit depends on the monitoring cycle, that is, shorter cycles extend the calculation time. The availability of a specific monitoring cycle therefore depends on calculation time resources of the Control Unit.

CPU time resources on the Control Unit are influenced primarily by the number of drives, the number of drives with enabled Extended/Advanced Functions, the connected DRIVE-CLiQ components, the selected DRIVE-CLiQ topology, the use of a CBE20 and by the selected technological functions. You can determine the number of axes that can be controlled (closed loop) using the "SIZER" tool.

Note

Influence of deactivated drives on the required CPU time

Please note that the deactivated drives also affect the required CPU time. In the case of utilization limits being reached, it is sufficient to deactivate one drive. This drive must then be deleted.

- PROFIsafe (via PROFIBUS/PROFINET)
  - The monitoring cycle (p9500) must be an integer multiple of the actual value update cycle. p9511 is generally used for the cycle time for actual value acquisition. If p9511 = 0 in *isochronous operation* the isochronous PROFIBUS communication cycle is used, in *non-isochronous* operation the actual update cycle in this case is 1 ms.
  - Actual value acquisition cycle ≥ 4 · current controller cycle

    Recommendation: Actual value acquisition cycle ≥ 8 · current controller cycle.

    Note

    Actual value sensing cycle for safety functions without encoder

    This is not applicable when using safety functions without encoder: In this case, the actual value sensing cycle must be configured to be the same as the current controller cycle.

    Note

    Actual value acquisition cycle clock for SINAMICS S120M

    SINAMICS S120M only allows a fixed actual value acquisition cycle clock of 2 ms: For SINAMICS S120M, only 2 ms or 0 will be accepted for p9511 (in the latter case, 2 ms is accepted internally – regardless of the PROFIBUS DP-/PN cycle clock).

  - Depending on the set sampling time of the current controller (p0115[0]), the maximum number of controllable drives will vary (see SINAMICS S120 Function Manual drive functions, Chapter "System control, sampling times, and DRIVE-CLiQ wiring").
- TM54F

  The sampling time of the TM54F must be set the same as the monitoring cycle of the Safety Integrated function used (p10000[0..5] = p9500 or r9780).

  Note

  Relationship between the monitoring cycle and the PROFIsafe scan cycle

  The safety functions are carried out in the monitoring cycle (r9780 for Basic Functions or p9500 for Extended/Advanced Functions). PROFIsafe telegrams are evaluated in the PROFIsafe scan cycle, which corresponds to twice the monitoring cycle.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9500 SI Motion monitoring clock cycle (Control Unit) (Extended and Advanced Functions)
- p9511 SI Motion actual value acquisition clock (Control Unit)
- r9780 SI monitoring cycle (Control Unit)
- p10000[0..5] SI TM54F communication clock

6.8 Commissioning: Basic procedure

6.8.1 Making basic settings

6.8.1.1 Starting the safety commissioning

Requirement

For safety reasons, you can only set the safety-relevant parameters of the 1st channel offline for Startdrive. To set the safety-relevant parameters of the 2nd channel, the drive must be online. The settings are protected by a password.

Icon	Description
	Startdrive is not online.
	Startdrive is online. The processing mode is not activated yet.
	Startdrive is online. The processing mode is active. In addition to the safety marking, a "pin"  is displayed in the secondary navigation.

Activating safety settings

1. Click the "Go online" icon.
2. Click the  icon in the toolbar of the parameterization editor.

   The dialog for the password input opens.
3. Enter the password.

   You only have to enter a new password at the first start to replace the default password.
4. Click "OK" to accept the settings.

   The safety commissioning is activated.

6.8.1.2 Making basic safety settings

□ "Drive axis > Parameter > Safety Integrated > Function selection"

Selecting the safety functionality

Note

You can select the safety functionality offline. The selection can be made online with active Safety commissioning (processing mode).

1. Select the required functionality in the first drop-down list:
   - No Safety Integrated Function
   - Basic Functions
   - Extended / Advanced Functions

   If you select Basic Functions or Extended / Advanced Functions, a screen form with additional setting options is displayed.

   Note

   Call of the Extended Functions and the Advanced Functions is identical. Startdrive shows the functions for which you have purchased a license.

   If you have a license for Advanced Functions, the Extended Functions are also automatically included. If you have a license for Extended Functions only, only these functions will be displayed.

Making the basic settings for the Safety Integrated Basic Functions

1. Select the setting "Basic Functions" in the first drop-down list:

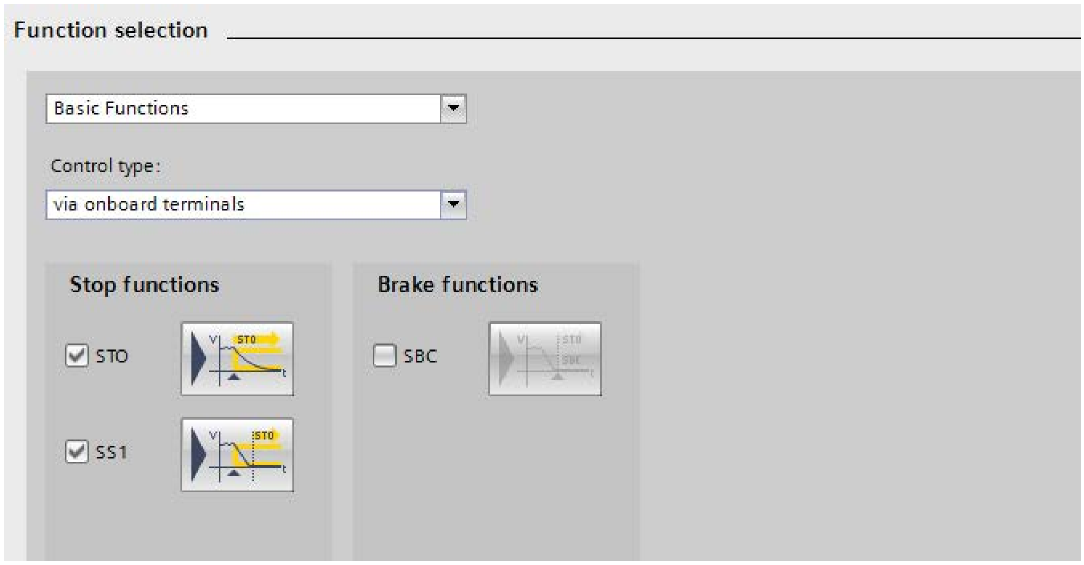


Figure 6-2 Basic Functions

2. Select one of the following settings in the "Control type" drop-down list:
   - via PROFIsafe

     The "Basic functions via onboard terminals" option is automatically active.
   - via onboard terminals

   In the lower part of the screen form the corresponding functions are active.
3. Click the button for the required function.

   The corresponding screen form is displayed.
4. Parameterize the function (see Chapter "Basic Functions (Page 288)").

Making the basic settings for the Safety Integrated Extended/Advanced Functions

1. Select the setting "Extended/Advanced Functions" in the first drop-down list.

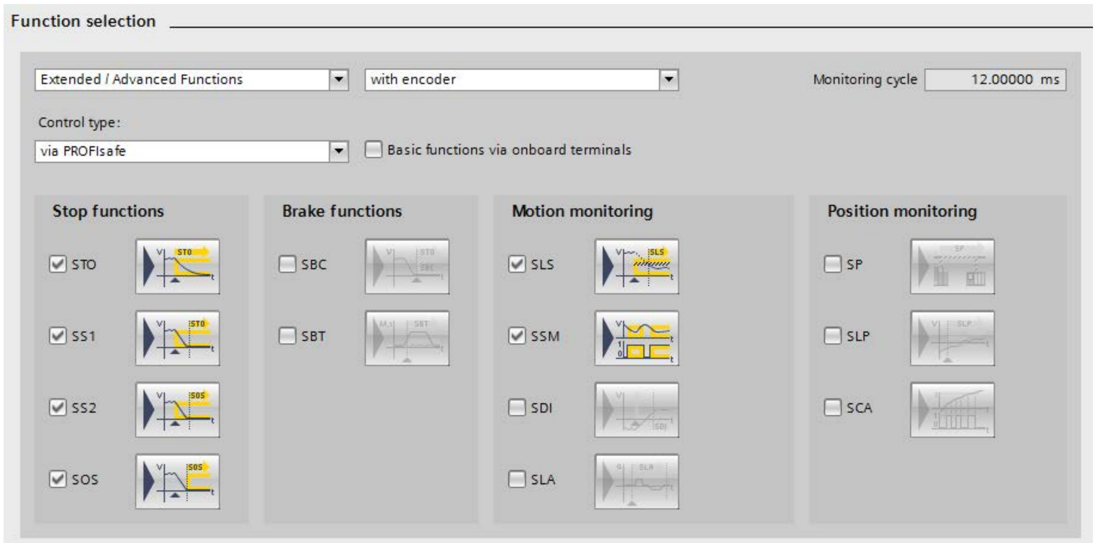


Figure 6-3 Extended Functions

2. In the second drop-down list, select whether a safety-capable encoder is used:
   – with encoder
   – without encoder
3. Select one of the following settings in the "Control type" drop-down list:
   – via PROFIsafe

     The "Basic functions via onboard terminals" option is automatically active.
   – without selection

     Only for SBC, SBT, SDI and SLS. SBT only for Extended / Advanced Functions with an encoder.
4. Activate or deactivate the "Basic functions via onboard terminals" option.

   The associated Safety Integrated Functions are then active in the lower part of the screen form:
   – Stop functions
   – Braking functions
   – Motion monitoring
   – Position monitoring (= Advanced Functions)
5. Click the button for the required Safety Integrated Function.

   Parameterize the function (see Chapter "Extended and Advanced Functions (Page 293)").

6.8.1.3 Accepting the settings in the drive

After you have parameterized all safety functions, the drive must accept the settings.

Note

To accept the settings in the drive, it must be online.

---

1. To accept the settings and deactivate the safety functions, click the icon in the toolbar.

   The following steps are executed:

   – The parameter settings are copied from CPU 1 to CPU 2.

   – Copy RAM to ROM is offered.

   – Safety mode is deactivated, the icon now has a yellow border.

2. Go offline with the drive.

   You can now continue with the further settings of the parameterization. The dialogs are no longer deactivated.

6.8.1.4 Changing the safety password

❒ "Drive axis > Parameter > Safety Integrated > Enter password"

The safety password protects safety parameters against maloperation. Always assign a strong password, to enable protection. To reset the password to the factory setting, you require the valid password.

Note

The safety password does not have the equivalent quality of a password (protection against unauthorized access, e.g. by an attacker), but rather that of write protection (e.g. protection against maloperation).

Requirement

- The drive axis is ONLINE.

  The safety password can only be read or changed in online mode.

Procedure

To change the safety password, proceed as follows:

1. Enter the current password at the top.

Figure 6-4 Entering the password

2. Enter the new password at the bottom.
3. Enter the new password again at the bottom.
4. Click "Change password" to accept the new password.

6.8.2 Basic Functions

6.8.2.1 Commissioning with Startdrive

Configuring Safety Functions

Proceed as follows to configure the Safety Integrated Functions STO, SS1 and SBC:

1. Call the "STO/SS1/SBC" safety functions.

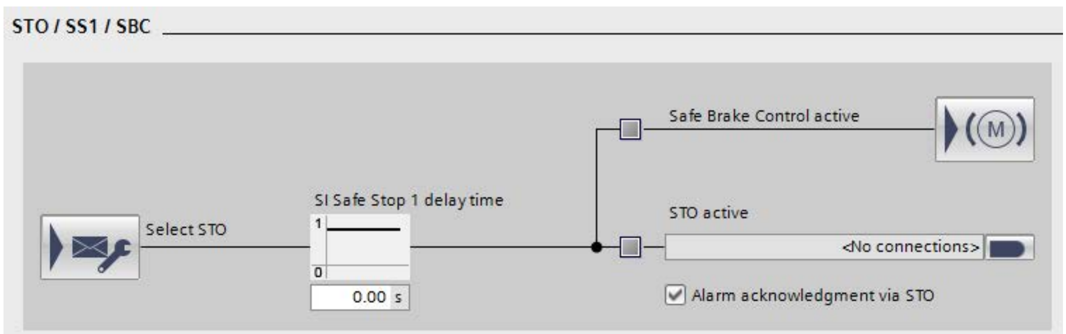


Figure 6-5 Safety Integrated Basic Functions STO, SS1 and SBC

2. Click the  button ("Select STO") to configure the STO function.

   The "Control" screen form opens. The display of the screen form depends on the basic settings of the Safety Integrated Basic Functions.

3. In this screen form, configure the controls via the fail-safe inputs and outputs and/or PROFIsafe.

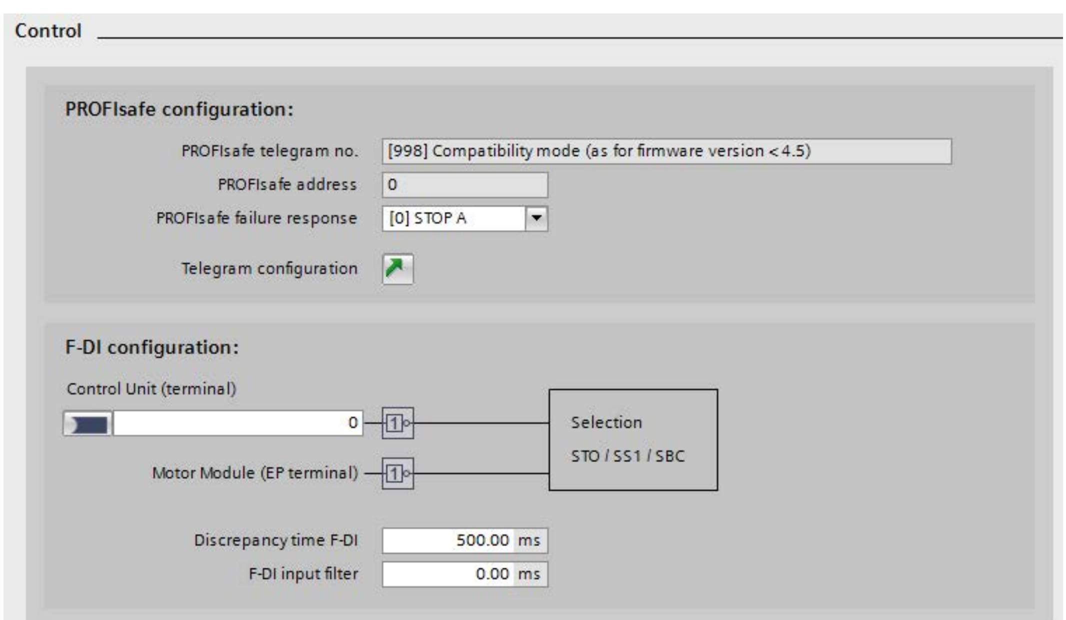


Figure 6-6 Example: Control of STO

4. Call "STO/SS1/SBC" again.
5. To configure the "SS1" function, set the delay time until the start of "STO" in the "Safe stop 1 delay time" field.
6. Then connect the signal source r9773.1 for the "STO active in the drive" function.
7. Click the  button (brake control) to configure the "SBC" function.

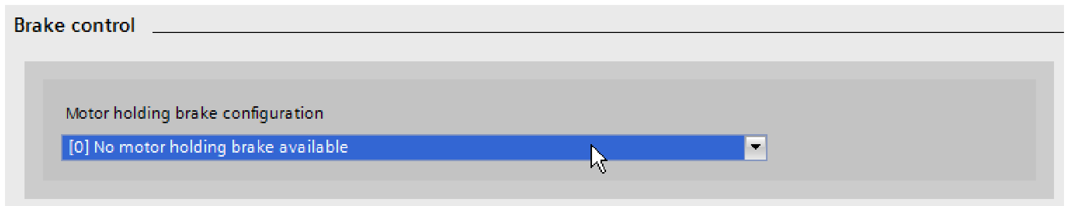


Figure 6-7 Example: Brake control without motor holding brake

8. Click "Save project" in the toolbar to save the changes in the project.
9. Accept these settings in the drive: Chapter "Accepting the settings in the drive (Page 286)"

Result

You have configured the Safety Integrated Basic Functions.

6.8.2.2 Commissioning via direct parameter access

To commission the Basic Functions "STO", "SBC" and "SS1" via terminals, proceed as follows:

Table 6- 2 Commissioning the "STO", "SBC" and "SS1" Basic Functions

No.	Parameter	Description/comments
1	p0010 = 95	Setting **Safety Integrated 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 Integrated parameters exist for the Motor Module). – F30650 (SI MM: Acceptance test required) with fault value = 130 (no Safety Integrated parameters exist for the Motor Module). Acceptance test and test certificate, see step 17. • The pulses are safely suppressed. • 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 Integrated parameter is changed for the first time. This behavior applies for the entire duration of Safety Integrated commissioning, that means, the "STO" function cannot be selected/deselected while Safety Integrated commissioning mode is active because this would constantly force safe pulse suppression.
2	p9761 = "Value"	**Entering Safety Integrated password.** When Safety Integrated is commissioned for the first time, the following applies: • Safety Integrated password = 0 • Default setting for p9761 = 0 This means that the Safety Integrated password does not need to be set during first commissioning.
3	p9601.0 = 1	**Enabling "Safe Torque Off" function (STO).**
4	p9602 = 1	**Enabling "Safe Brake Control" function (SBC).** • SBC cannot be used alone, but only in conjunction with one of the STO and SS1 functions.
5	p9652 > 0	**Enabling "Safe Stop 1" function (SS1).** • The "Safe Stop 1" function is not activated until at least one Safety Integrated monitoring function has been enabled (i.e. p9601 ≠ 0).

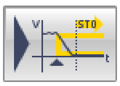
No.	Parameter	Description/comments
6	p9620 = "fast DI on CU" Terminal "EP"	**Set terminals for "Safe Torque Off (STO)".** Wire terminal "EP" (enable pulses) on the Motor Module. • Control Unit monitoring channel: By appropriately interconnecting BI: p9620 for the individual drives, the following is possible: – Selecting/deselecting the STO – Grouping the terminals for STO • Motor Module monitoring channel: By wiring the "EP" terminal accordingly on the individual Motor 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.
7	p9650 = "Value"	**Set F-DI changeover tolerance time.** F-DI changeover tolerance time on Control Unit • The parameter is not changed until Safety Integrated 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 is not subject to a data cross-check during this tolerance time.
8	p9651 = "Value"	**Debounce time for the failsafe digital inputs** to control STO/SBC/SS1
9	p9658 = "Value"	**Set transition period from STOP F to STOP A.** • 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 initiates "No stop response" as default setting. • After the parameterized time has expired, STOP A (immediate Safety Integrated pulse inhibit) is triggered by the fault F01600 or F30600 (SI: STOP A triggered). The default setting for p9658 is 0 (i.e. STOP F immediately results in STOP A).
10	p9659 = "Value"	**Time for carrying out forced checking procedure and testing the Safety Integrated shutdown 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/deselect STO). • The commissioning engineer can change the time required for carrying out the forced checking procedure and testing the Safety Integrated shutdown paths.

No.	Parameter	Description/comments
11	 p9762 = "Value" p9763 = "Value"	**Setting a new Safety Integrated 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 to change Safety Integrated parameters. • Changing the Safety Integrated password does not mean that you have to change the checksums.
12	 p9621 = "value" p9622[0...1] = "value"	**Parameterizing Safe Brake Adapter.** • Set with p9621 the signal source for the Safe Brake Adapter. • Set with p9622 the wait times for switching on and switching off the Safe Brake Adapter relay.
13	 p9700 = 57 hex p9701 = DC hex	**Saving and copying the Safety Integrated Functions parameters.** After setting the specific parameters of the Safety Integrated Functions, they must be copied from the Control Unit into the Motor/Power Module and then activated: • p9700 SI Motion copy function • p9701 SI Motion confirm data change
14	p0010 = 0	**Exiting Safety Integrated commissioning mode.** • The checksums are checked if at least one Safety Integrated monitoring function is enabled (p9601 ≠ 0): 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 Integrated commissioning mode. If the target checksum on Motor 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 Integrated commissioning mode. • If a Safety Integrated monitoring function has not been enabled (p9601 = 0), the Safety Integrated commissioning mode is exited without the checksums being checked. When the Safety Integrated commissioning mode is exited, the following is carried out: • A POWER ON must be performed after the initial commissioning. This is indicated with the A01693 message.
15	p0971 = 1 p0977 = 1	All drive parameters (entire drive group or only single axis) must be manually saved from RAM to ROM. This data is not saved automatically!
16	POWER ON	**Carry out POWER ON**. After commissioning, a reset must be carried out with POWER ON.
17	-	**Carry out acceptance test and create test certificate**. Once Safety Integrated commissioning is complete, the commissioning engineer must carry out an acceptance test for the enabled Safety Integrated monitoring functions. The results of the acceptance test must be documented in an acceptance certificate.

6.8.3 Extended and Advanced Functions

The following is a description of how you commission the Safety Integrated Extended Functions in Startdrive, using SS1 as an example. The screen forms shown here are examples from the offline commissioning. To complete commissioning, you must subsequently establish an online connection between Startdrive and the drive.

6.8.3.1 SS1 (Extended Functions)



Make the settings for the motor deceleration in the "SS1" screen form. The "SS1" function brakes the motor, monitors the magnitude of the motor deceleration within specified limits, and after a delay time or violation of a speed threshold, triggers the "STO" function.

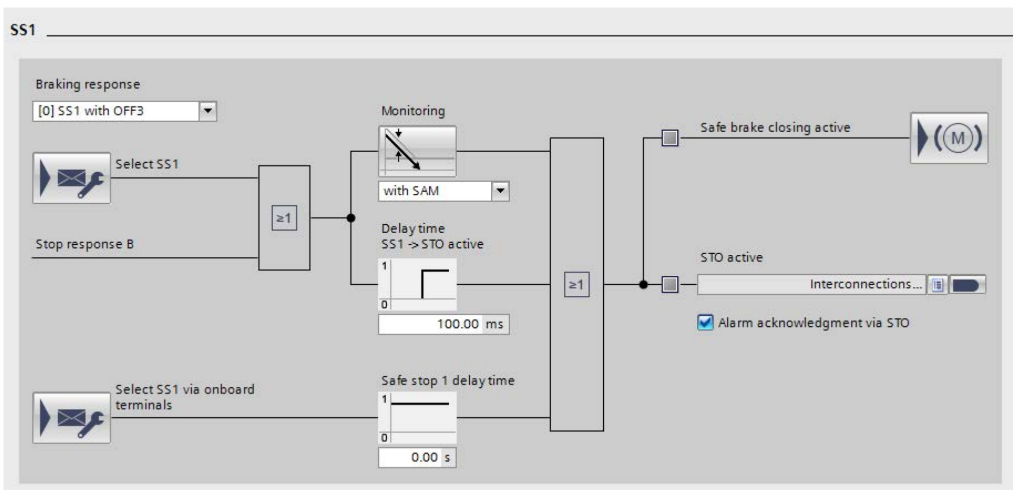


Figure 6-8 Safe Stop 1 (example)

Configuring the motor deceleration with internal braking response (OFF 3)

1. Select the "[0] SS1 with OFF 3" setting from the "Braking response" drop-down list.

   The screen form is structured accordingly.
2. Select the monitoring type in the "Monitoring" drop-down list:
   – with SAM
   – with SBR
3. Click "Monitoring" and parameterize the alternative brake monitoring functions "SAM" and "SBR" in the dialog.
4. Enter the required delay time in the "Delay time SS1 -> STO active" (p9556) input field.
5. Enter the required delay time in the "Safe stop 1 delay time" (p9652) input field.
6. Interconnect the signal source "STO active in the drive" (r9773.1).
7. If you want to receive an alarm acknowledgment via STO, activate the option with the same name.
8. Click "Save project" in the toolbar to save the changes in the project.

Configuring the motor deceleration with external stop

> ⚠ WARNING
>
> **Any axis motion is possible**
>
> During the delay time (p9652), for "Safe Stop 1 (time-controlled) with external stop", any axis movements are possible.

1. Select the "[1] SS1E external stop" setting from the "Braking response" drop-down list.

   The screen form is structured accordingly.
2. Enter the required delay time in the "Delay time SS1 -> STO active" (p9556) input field.
3. Enter the required delay time in the "Safe stop 1 delay time" (p9652) input field.
4. Interconnect the signal sink "STO active in the drive" (r9773.1).
5. If you want to receive an alarm acknowledgment via STO, activate the option with the same name.
6. Click "Save project" in the toolbar to save the changes in the project.

Completing parameter assignment

- Parameterize all the functions you have selected in a similar way.
- Accept these settings in the drive: Chapter "Accepting the settings in the drive (Page 286)"

6.8.4 General settings

6.8.4.1 Parameterizing the actual value acquisition / mechanical system

The actual value acquisition / mechanical system can only be parameterized for the Extended Functions.

For parameterization of the actual value acquisition, only the parameters required for your configuration are offered:

	Para-meter	Required for the configuration: - Encoder system - Motor type - Axis type						
		①	②	③	④	⑤	⑥	⑦
Axis type Select the "Linear axis" or "Rotary axis / spindle" axis type.	p9502	x	x	x	x	x	x	x
Topology Select whether you are using a "1-encoder system" or a "2-encoder system."	p9526	x	x	x	x	x	–	–
Modulo range - only for rotary axis / spindle Set the modulo value in degrees for rotary axes for the "Safe Position" function here. This modulo value is taken into account for safe homing and for the transfer of the safe position via PROFIsafe when absolute position is enabled.	p9505	x	x	x	–	–	–	–
The safety functions are executed in the sampling time displayed in the "Monitoring cycle".	p9500	x	x	x	x	x	x	x
The actual value acquisition cycle defines the cycle time in which the actual values for Safety Integrated are acquired. • A slower cycle time 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 the safe actual value acquisition, is displayed in r9730. Setting criteria if the motion monitoring functions are executed without an encoder: • The actual value acquisition cycle must be set the same as the current controller cycle (p0115).	p9511	x	x	x	x	x	x	x
The "Accept encoder data" button is available online and allows you to update the safety parameters. Depending on whether the configuration is a 1-encoder or 2-encoder system, the appropriate encoder parameters are copied from the basic system to the corresponding safety parameters.	–	x	x	x	x	x	x	x
Direction of rotation reversal Here, you can set whether a direction of rotation reversal is involved for the particular gearbox.	p9539[0]	x	x	x	–	–	–	–

	Parameter	Required for the configuration: - Encoder system - Motor type - Axis type						
		①	②	③	④	⑤	⑥	⑦
Pulse number This field shows the number of pulses of the encoder used.	p9518	x	x	x	x	x	–	–
Fine resolution This field shows the number of bits of the encoder control word used.	p9519	x	x	x	x	x	–	–
Load revolutions / encoder revolutions In this section you can parameterize a gear ratio for the encoders used. The gear ratio is the ratio of encoder revolutions to revolutions of the drive shaft (load revolutions). • "Number of load revolutions" allows you to enter the number of load revolutions. • "Number of encoder revolutions" allows you to enter the number of encoder revolutions.	p9521 p9522	x	x	x	–	–	x	x
Gear ratio Sets the denominator and numerator for the gearbox between the encoder (or motor for encoderless monitoring functions) and load.	p9321 p9322	x	–	–	–	–	–	–
Here, you parameterize the number of encoder pulses for the encoder that is used for safe motion monitoring on the Motor Module.	p9318	x	–	x	–	x	–	–
Here, you parameterize the fine resolution for the encoder that is used for safe motion monitoring on the Motor Module.	p9319	x	–	x	–	x	–	–
The mean value of the actual values of both channels is calculated cyclically after actual value synchronization has been activated, for example, for systems or machines with slip. The maximum slip defined in p9549 is monitored once per cross-check cycle (r9724). If "Actual value synchronization" is not enabled, the value parameterized in p9542 is used as tolerance value for the cross-checking.	p9501.3	x	–	x	–	x	–	–
Actual value tolerance Here, you set the tolerance for the crosswise comparison of the actual position between the two monitoring channels	p9542	x	–	x	–	x	x	x
Velocity tolerance Here, you set the maximum tolerance for the crosswise comparison of the actual velocity (only if actual value synchronization has been activated).	p9549	x	–	x	–	x	–	–

	Para-meter	Required for the configuration: - Encoder system - Motor type - Axis type						
		①	②	③	④	⑤	⑥	⑦
Leadscrew pitch Here, you set the transmission ratio between the encoder and load in mm (linear axis with rotary encoder) (only available for linear axis).	p9520	–	–	–	–	–	x	–
Pole pair number The safe actual value acquisition without encoder calculates the electric speed of the drive. The pole pair number specifies the factor with which the electrical speed must be multiplied in order to obtain the mechanical speed at the motor shaft.	p0313	–	–	–	–	–	x	x

Legend for table header:

① 2-encoder, rotary, rotary
② 1-encoder, rotary, linear
③ 2-encoder, rotary, linear
④ 1-encoder, linear, linear
⑤ 2-encoder, linear, linear
⑥ Without encoder, linear
⑦ Without encoder, rotary

6.8.4.2 Configuring the control of the safety functions

❒ "Drive axis > Parameter > Safety Integrated > Control"

In the "Control" screen form, you can parameterize the settings of the SINAMICS S120 for the fail-safe inputs and outputs or the control via PROFIsafe.

In this screen form, Startdrive shows only those parameters that you have to take into account for the selected control mode.

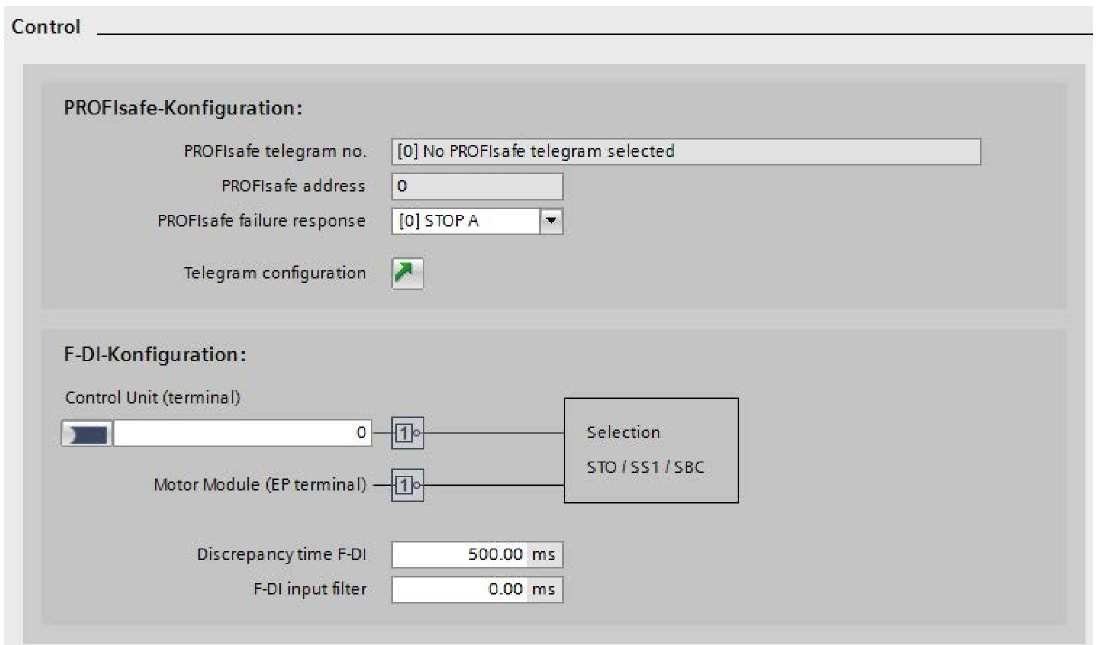


Figure 6-9 Example: Control via PROFIsafe and F-DI

F-DI configuration

The signal states on the two terminals of an F-DI are then monitored whether they attain the same logical signal state within the discrepancy time.

For example, the unavoidable delay caused by mechanical switching operation can be adapted via parameters. The time within which the selection or deselection must be performed in both monitoring channels in order to qualify as "simultaneous", is specified with p9650.

For internal faults or limit value violations, the drive-internal safety functions issues safety faults.

1. Interconnect signal source p9620 for STO, SS1 or SBC to the Control Unit.

   Only the fixed zero and digital inputs DI 0 ... 7, 16, 17, 20 and 21 are permissible as signal sources.
2. Enter a discrepancy time in the "Discrepancy time" (p9650) field.
3. Enter a time for the input filter (debounce time) in the "F-DI input filter" (p9651) field.

   The debounce time is rounded off to whole ms and then accepted. This debounce time applies for the F-DIs and the readback input for the forced checking procedure. The debounce time specifies the maximum time an interference pulse can be present at F-DIs before being interpreted as a switching operation.

PROFIsafe configuration

The PROFIsafe address is required for control of the safety functions via PROFIsafe.

1. Click the icon "Telegram configuration"

   The properties of the PROFINET interface are displayed in the Inspector window. The "Cyclic data traffic" setting range is active. Here you define the telegrams for the drive objects.
2. Click the <Add telegram> entry in the telegram configuration of "Drive axis_x".
3. Select the "Add safety telegram" option in the drop-down list of the entry:

   Startdrive then inserts the "Safe actual value" and "Safe setpoint" lines. The relevant PROFIsafe telegrams are preassigned.
4. Open the new "Safe setpoint" screen form (for Drive axis_x) in the Inspector window.
5. Correct the PROFIsafe address of the drive in the "F-address" field.
6. In the function view, switch back to the "control" screen form.

   The value of the F-address is displayed in the "PROFIsafe address" (p9610) field. A preassigned PROFIsafe telegram is displayed in the "PROFIsafe telegram no." drop-down list.
7. Click "Accept values" to transfer the telegram from the default settings into the Safety programming.
8. Select the desired stop response for a failure of the PROFIsafe communication in the "PROFIsafe failure response" (p9612) drop-down list.

Note

Unique PROFIsafe addresses

You must ensure the unique assignment of the PROFIsafe address throughout the network and the CPU.

- The fail-safe I/O of PROFIsafe address type 1 is addressed clearly by its fail-safe destination address.
- The fail-safe destination address of the fail-safe I/O (drive units in this case) must be unique for the entire fail-safe I/O throughout the network and the CPU (system-wide). The fail-safe I/O of PROFIsafe address type 2, e.g. modules of the ET 200SP type, must also be taken into account.
- Note also the corresponding documentation in the TIA Portal online help in Section "SIMATIC Safety - Configuration and programming". (SDR001)

Without selection - configuration

As an alternative to controlling via terminals and/or PROFIsafe, there is also the option to parameterize the "SDI" or the "SLS" functions without selection. In this case, the SDI function is permanently active after POWER ON (with encoder) or becomes active after switching on (without encoder) (see SDI (Extended Functions) (Page 59)). With the "SLS" function without selection, there is no delay time and the function is permanently active after POWER ON (with encoder), or it becomes active when switched on (without encoder) (see SLS (Extended Functions) (Page 51)).

1. Select whether SLS or SDI should be selected permanently in the respective drop-down list.

6.8.4.3 Forced checking procedure (test stop)

❒ "Drive axis > Parameter > Safety Integrated > Test stop"

Parameterize the settings for the forced checking procedure (test stop) in the "Test stop" screen form.

To meet the requirements of the DIN EN ISO 13849-1 and IEC 61508 standards in terms of timely fault detection, the converter must test its safety-related circuits regularly - at least once a year - for correct functioning. The converter monitors the regular test of its safety-related circuits that monitor the speed of the motor, and to safely interrupt the torque-generating energy supply to the motor through the safe pulse suppression.

Test stop for Basic Functions

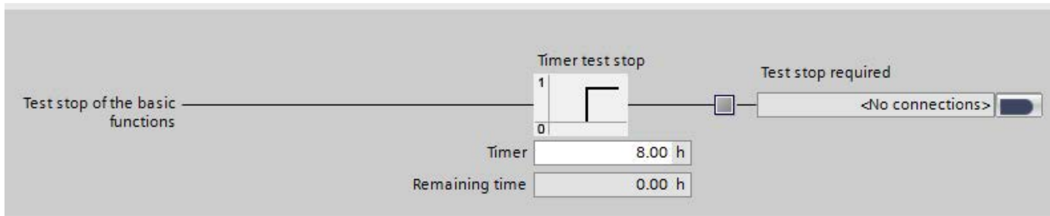


Figure 6-10 Example: Basic Functions

To parameterize the forced checking procedure (test stop) for the Basic Functions, proceed as follows:

1. Enter the interval for performing dynamization and testing the safety shutdown paths in the "Timer" (p9659) field.

   Within the parameterized time, the "STO" function must be selected and deselected at least once. The monitoring time is reset at every STO deselection.

2. Connect the "Test stop required" (r9773.31) signal sink to a digital output or to a bit in the status word of the fieldbus.

Note

Resetting the timer of the Basic Functions

If the associated forced checking procedure (test stop) is performed, while simultaneously using the Extended/Advanced Functions, the Basic Functions timer is also reset.

While STO is selected via the Extended/Advanced Functions, the terminals for the selection of the Basic Functions are not checked for discrepancy. This means that the forced checking procedure (test stop) of the Basic Functions must always be performed without the selection of STO or SS1 via the Extended/Advanced Functions. It is otherwise not possible to verify the correct control through the terminals.

Extended/Advanced Functions test stop

Note

If the "Basic functions via onboard terminals" option is active for the Extended/Advanced Functions, you must make the test stop settings for the Basic Functions as well as for the Extended/Advanced Functions.

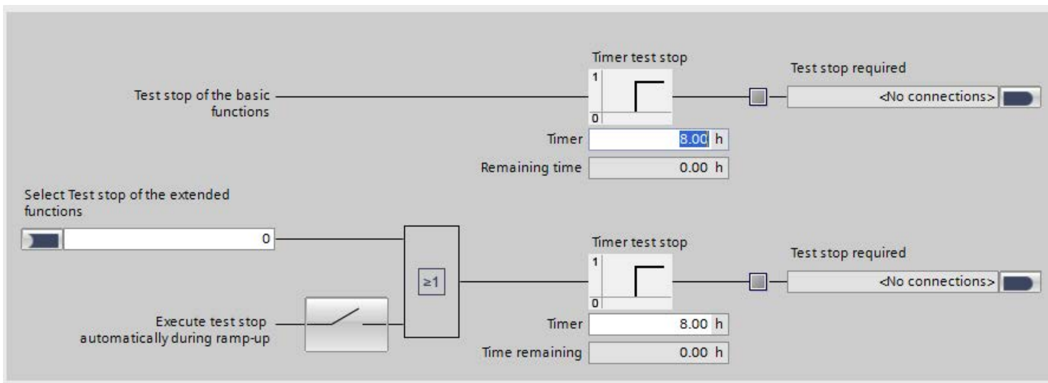


Figure 6-11 Example: Extended and Advanced Functions

To parameterize the forced checking procedure (test stop) for the Extended Functions, proceed as follows:

1. If the test stop is to be executed during ramp-up, establish a connection for "Execute test stop automatically during ramp-up". The line in the button must be continuous.

   - Or -

   If the test stop is not to be executed automatically during ramp-up, select the signal (p9705) that is to trigger the forced checking procedure. Make sure that the connection for "Execute test stop automatically during ramp-up" is interrupted.
2. Enter the interval for performing the forced checking procedure and testing the safety shutdown paths in the "Timer" (p9559) field.

   Within the parameterized time, the "STO" function must be selected and deselected at least once. The monitoring time is reset at every STO deselection.
3. Connect the "Test stop required" (r9723.0) signal sink to a digital output or to a bit in the status word of the fieldbus.

Status display

The following elements show the current status of the forced checking procedure:

- Time remaining:

  Shows the time remaining until the forced checking procedure and the test of the safety shutdown paths are performed (r9660 for the Basic Functions, r9765 for the Extended Functions).

- Test stop required:

  Shows that a forced checking procedure (test stop) must be performed on the drive. Evaluate alarm A01699 in your higher-level controller, for example, by connecting r9773.31 or r9723.0 to a digital output or a bit in the fieldbus status word (r9773.31 for the Basic Functions, r9723.0 for the Extended/Advanced Functions).

6.8.4.4 Function status of the Safety Integrated settings

❒ "Drive axis > Parameter > Safety Integrated > Function status"

The "Function Status" screen form displays a list of all Safety Integrated functions on the left.

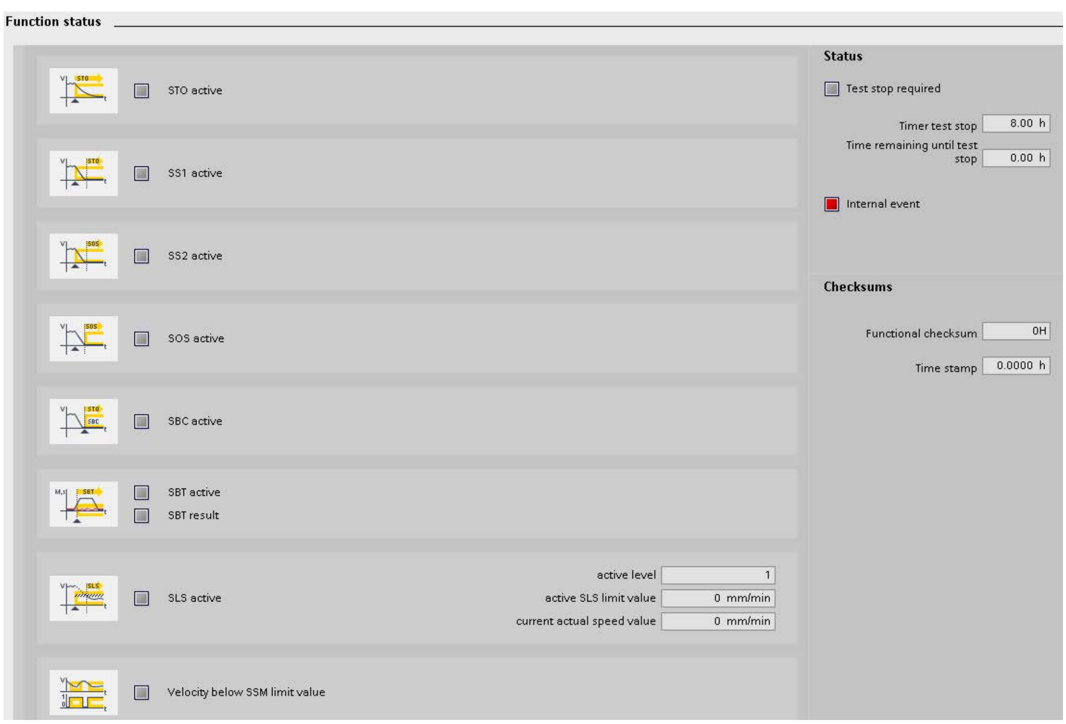


Figure 6-12 Example: Safety Integrated Function status

All Safety Integrated functions activated in Startdrive are identified by a green LED.

In addition, the most important information of the selected Safety Integrated functions is displayed.

The status information is displayed on the right-hand side of the screen form for:

- Test stop required

  Indicates that a forced checking procedure (test stop) is required.

  – "Timer test stop" (p9659): Time interval for performing the forced checking procedure and testing the safety shutdown paths. Within the parameterized time, the STO must be selected and deselected at least once. The monitoring time is reset at every STO deselection.

  – "Remaining time" (r9660 for the Basic Functions, r9765 for the Extended Functions) shows the time remaining until the forced checking procedure and the test of the safety shutdown paths are performed.

- Internal event

  Is set when the first safety message occurs.

- Communication failure

  The communication (PROFIsafe) has failed.

6.9 Commissioning CU310-2

6.9.1 Basic sequence of commissioning

The following preconditions must be met to configure Safety Integrated on the CU310-2:

- Concluded initial commissioning of all drives
- Connect the sensors to the F-DIs and an actuator to the F-DO (if used)

Configuration sequence

1. Configuring Safety functions of the CU310-2
2. Configuring inputs (if used)
3. Configuring outputs (if used)
4. Copy parameters to the 2nd drive object
5. Change the safety password
6. Activate the configuration by selecting "Activate settings"
7. Save the entire project to Startdrive
8. Save the project in the drive by selecting "Copy RAM to ROM"
9. Execute POWER ON
10. Acceptance test

Note

Commissioning CU310-2

- The CU310-2 is still not available in Startdrive.
- You can find information on commissioning with STARTER in older editions of this manual.

6.9.2 Forced checking procedure (test stop) of the CU310-2

Testing failsafe inputs and outputs

Failsafe inputs and outputs must be tested for fail-safety at defined time intervals (forced checking procedure or test stop). For this purpose, the CU310-2 contains a function block that executes this forced checking procedure (test stop) for the failsafe output when selected via a BICO source. Each time a forced forced checking procedure (test stop) is performed without error, a timer is started to monitor the time until the next required test. After this time interval (p10003) has elapsed and every time the Control Unit is switched on, the user is informed by the message A01774 that a forced checking procedure (test stop) must be performed.

- 3 modes can be selected for testing the output (see following chapter).

Note

Testing the sensors for the CU310-2

Unlike TM54F, the sensors connected to the F-DI of the CU310-2 cannot be tested as part of the forced checking procedure (test stop). The user must cyclically test sensors connected to the F-DIs. Then it is sufficient to actuate the particular sensor and to check the corresponding function selection.

Execution

When parameterizing, proceed as follows:

1. Derive the suitable mode from the circuit used in your application (see figures in the following chapters).
2. Use parameter p10047 to set the mode that is to be used.
3. Use parameter p10046 to define whether the digital output F-DO 0 is to be tested.
4. Use parameter p10001 to set the time within which the digital output signals to the corresponding digital inputs or DIAG inputs must be recognized.
5. With parameter p10003, set the interval within which the forced checking procedure (test stop) is to be performed. After this interval has elapsed, the user is informed by the message A01774 that the forced checking procedure (test stop) must be performed for the F-DI/F-DO.
6. Set the signal source which triggers the start using parameter p10007. This can be, for example, a control signal or switch via a BICO switchable signal.

While being executed, message A01772 (test stop failsafe output active) is displayed. The messages A01772 and A01774 only disappear again after the execution. If an error has been detected by the forced checking procedure (test stop), fault F01773 is output. Using the test sequence specified for each mode, you can see which error has occurred from the fault value of the test step.

WARNING

Danger to life due to unwanted movement given improper use of the feedback DI of the F-DO

With the test sequence, unwanted movements of the drive can be caused if the DI of the F-DO is not only used for feedback with test stop/forced checking procedure but also for other purposes.

- Only use the DI of the F-DO for the feedback signal with forced checking procedure (test stop) - and not for other purposes.

Forced checking procedure (test stop): Duration

You can calculate the duration using this formula:

$$T_{\text{Test stop}} = \underbrace{8 \cdot p9500}_{\text{Test of the F-DO}} + \underbrace{6 \cdot p10001}_{\text{Evaluation of the active F-DIs}}$$

6.9.2.1 Test mode 1: Evaluation of internal diagnostic signal (passive load)

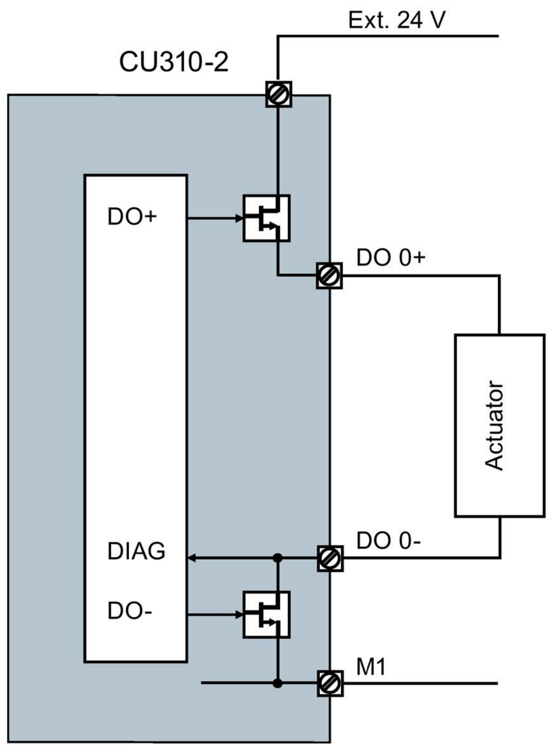


Figure 6-13 F-DO circuit "Test mode 1: Evaluation of internal diagnostic signal (passive load)"

DO+	DO-	Expected response, DIAG signal
OFF	OFF	LOW
ON	ON	LOW
OFF	ON	LOW
ON	OFF	HIGH
OFF	OFF	LOW

Test sequence for test mode 1

6.9.2.2 Test mode 2: Read back F-DO in DI (relay circuit)

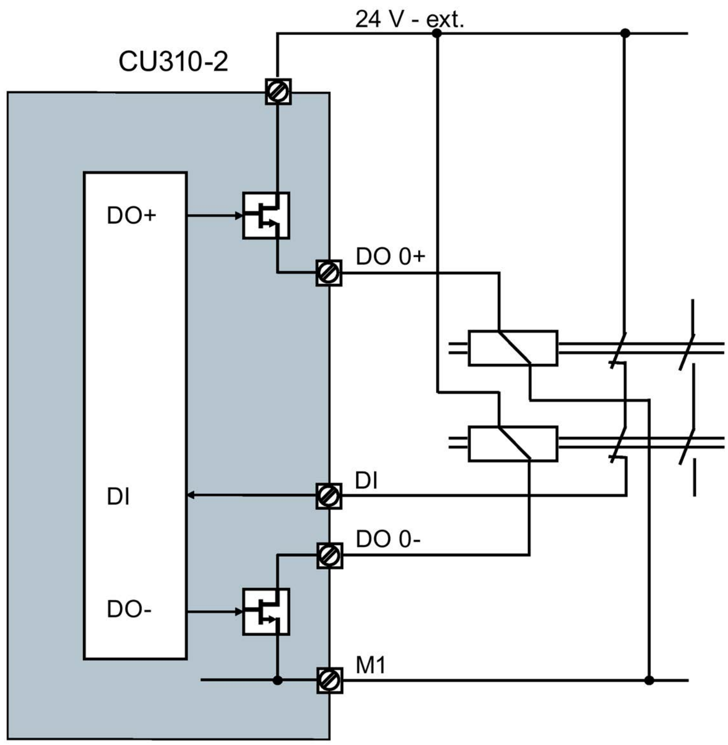


Figure 6-14 F-DO circuit "Test mode 2: Read back F-DO in DI (relay circuit)"

DO+	DO-	Expected response, DI signal
OFF	OFF	HIGH
ON	ON	LOW
OFF	ON	LOW
ON	OFF	LOW
OFF	OFF	HIGH

Test sequence for test mode 2

6.9.2.3 Test mode 3: Read back F-DO into the DI (actuator with feedback signal)

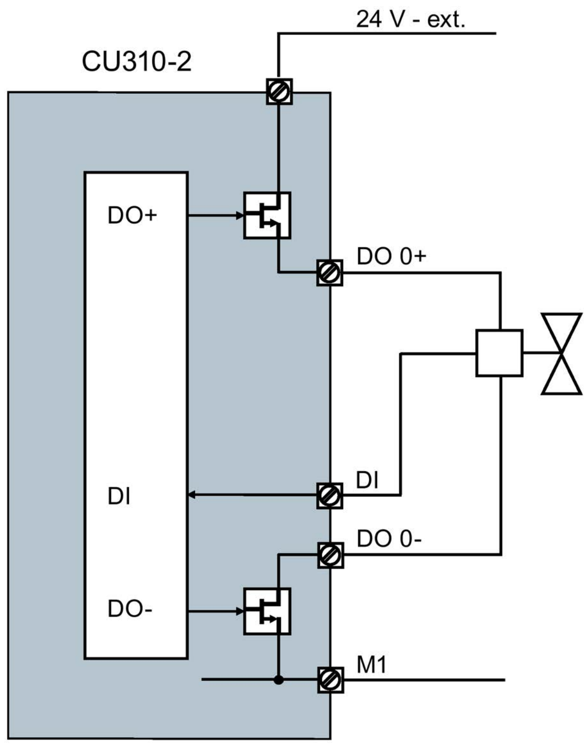


Figure 6-15 F-DO circuit "Test mode 3: Read back F-DO into the DI (actuator with feedback signal)"

DO+	DO-	Expected response, DI signal
OFF	OFF	HIGH
ON	ON	LOW
OFF	ON	HIGH
ON	OFF	HIGH
OFF	OFF	HIGH

Test sequence for test mode 3

6.9.2.4 Test stop mode parameters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p9500 SI Motion monitoring clock cycle (Control Unit) (Extended and Advanced Functions)
- p10001 SI Motion wait time for test stop at DO
- p10003 SI Motion forced checking procedure timer
- p10007 BI: SI Motion forced checking procedure F-DO signal source
- p10017 SI Motion digital inputs debounce time (CPU 1)
- p10046 SI Motion F-DO feedback signal input activation
- p10047 SI Motion F-DO test stop mode (processor 1)

6.10 Commissioning TM54F

6.10.1 Basic sequence of commissioning

The following conditions must be met before you can configure the TM54F:

- Initial commissioning of all drives has been completed.
- F-DIs and F-DOs of the TM54F that are to be used must be wired.

Configuration sequence

1. Insert the TM54F
2. Configure the TM54F and generate the drive groups
3. Configure Safety functions of the drive groups
4. Configure inputs, configure outputs
5. Copy parameters to the 2nd drive object (TM54F_SL)
6. Changing the safety password
7. Activate the configuration by selecting "Activate settings"
8. Save the entire project to Startdrive
9. Save the project in the drive by selecting "Copy RAM to ROM"
10. Execute POWER ON
11. Acceptance test

Note

Commissioning TM54F

- TM54F is not yet available in Startdrive.
- You can find information on commissioning with STARTER in older editions of this manual.

6.10.2 Forced checking procedure (test stop) of the TM54F

Testing failsafe inputs and outputs

Failsafe inputs and outputs must be tested for fail-safety at defined time intervals (forced checking procedure (test stop)). The TM54F contains a function block that runs this forced checking procedure (test stop) in the following cases:

- When selected via a BICO source
- Automatically, each time the power supply voltage is switched on (POWER ON)

To monitor the time until the next required test, a timer (p10003) is started after every error-free forced checking procedure (test stop). The message A35014 "TM54F test stop necessary" is set on expiration of the monitored time and each time the Control Unit is switched on.

The failsafe digital inputs can be selected for the forced checking procedure (test stop) 3 modes can be selected for testing the output (see following chapter).

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. The user is therefore only informed that the forced checking procedure (test stop) is due in the form of an alarm, which requests the user to perform forced checking procedure (test stop) at the next possible opportunity.

Examples of when the forced checking procedure (test stop) must be performed:

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

Execution

When parameterizing, proceed as follows:

1. Derive the suitable mode from the circuit used in your application (see figures in the following chapters).
2. Use parameter p10047 to set the mode that is to be used.
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 that are not tested are shut down during the forced checking procedure (test stop).

4. Use parameter p10041 to define which failsafe 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.

   It is only possible to test the sensors connected to the F-DIs, if these are supplied from L1+ or L2+. If F-DOs of preprocessing devices are connected, forced checking procedure (test stop) cannot be used for this input.
5. 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.
6. With parameter p10003, set the interval within which the forced checking procedure (test stop) is to be performed. After this interval has elapsed, the user is informed by message A35014 that the forced checking procedure (test stop) must be performed for the TM54F.
7. Set the signal source which triggers the start using parameter p10007. This can be, for example, a control signal or switch via a BICO switchable signal.

   Alternatively, the forced checking procedure (test stop) can be performed automatically every time the power supply is switched on (POWER ON) (p9507.6 = 1).

During execution, message A35012 (TM54F: Test stop active). The values of the F-DIs are frozen for the duration of the forced checking procedure (test stop). The messages A35014 and A35012 only disappear again after the execution. If an error is found during the test, fault F35013 is output. Using the test sequence specified for each mode, you can see which error has occurred from the fault value of the test step.

CAUTION

F-DO that are fed back must only be used for the forced checking procedure (test stop)

With the sequence, unwanted responses of the drive can be caused if the F-DO is not only used for feedback with the forced checking procedure (test stop) - but also for other purposes.

- Note that the F-DO for feedback signals for the forced checking procedure (test stop) must not be used other purposes.

F-DOs that are not registered for evaluation by means of p10046 are set to "0" for the duration of the test ("failsafe values").

Forced checking procedure (test stop): Duration

The maximum time period for the test is: $T_{Test\ stop} = T_{FDIs} + T_{FDOs}$

- Test of the FDIs: T_{FDIs} = 3 · r10015 + 3 · X ms

  (X = 20 ms or r10015 or p10017 - the longest time of the 3 values determines the waiting time X)

- Test of the FDOs: T_{FDOs} = 8 · r10015 + 6 · Y ms

  (Y = p10001 or r10015 or p10017 - the longest time of the 3 values determines the wait time Y)

The safety functions of the TM54F are executed in the sampling time displayed in r10015. This sampling time corresponds to the lowest value of the communication sampling time entered in p10000[0..5].

Testing failsafe I/O

Fail-safe inputs and outputs must be tested for fail safety in defined time intervals (test stop or forced dormant error detection). For this purpose, SINAMICS S120 contains a function block which carries out this forced dormant error detection when selected via a BICO source. A timer is started after every error-free test stop to monitor the time until the next required test. After this time interval (p10003) has expired, and each time the Control Unit is switched on, the user is notified via message A01774 that a test stop must be performed for the F I/DO.

- Three test stop modes can be selected for testing the output (see following sections).
- The failsafe digital inputs must be checked by whoever carries out the forced dormant error detection.

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 whether the digital output F-DO 0 is to be tested.
4. Set the debounce time for the digital inputs using parameter p10017.
5. Use parameter p10001 to set the time within which the digital output signals to the corresponding digital inputs or DIAG inputs must be recognized.
6. 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 A01774 that a test stop must be performed for the F-DI/DO.
7. 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 A01772 (test stop fail-safe inputs / outputs active) appears. The messages A01772 and A01774 only disappear again after the test stop has been performed. If an error is found during the test stop, fault F01773 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 by using this formula:

$$T_{\text{Test stop}} = \underbrace{3 \cdot \text{p10000}}_{\substack{\text{Test of the} \\ \text{F-DIs}}} + \underbrace{2 \cdot (3\ \text{ms} + \text{p10017})}_{\substack{\text{Evaluation of the} \\ \text{inactive F-DIs}}} + \underbrace{8 \cdot \text{p10000}}_{\substack{\text{Test of the} \\ \text{F-DO}}} + \underbrace{6 \cdot (\text{p10001} + \text{p10017})}_{\substack{\text{Evaluation of the} \\ \text{active F-DIs}}}$$

6.10.2.1 Test mode 1: Evaluation of internal diagnostic signal (passive load)

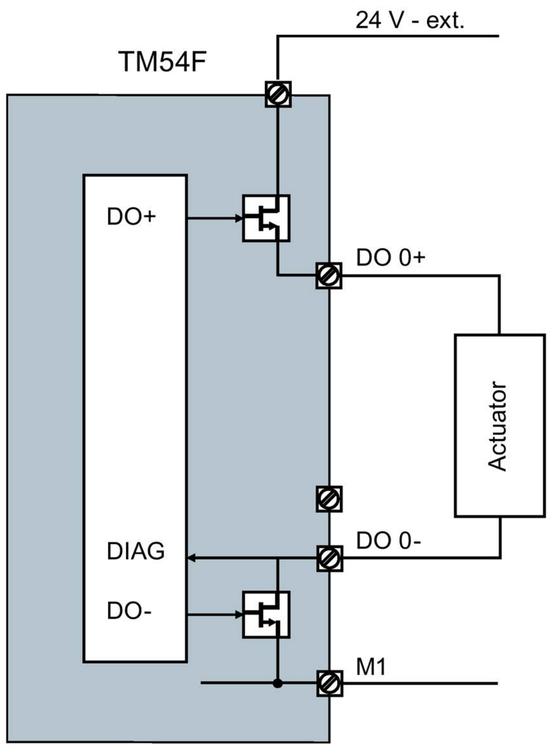


Figure 6-16 F-DO circuit "Test mode 1: Evaluation of internal diagnostic signal (passive load)"

L1+	L2+	Comment
OFF	ON	F-DIs 0 ... 4 Check for 0 V
OFF	OFF	F-DIs 5 ... 9 Check for 0 V

DO+	DO-	Expected response, DIAG signal
OFF	OFF	LOW
ON	ON	LOW
OFF	ON	LOW
ON	OFF	**HIGH**
OFF	OFF	LOW

Test sequence for test mode 1

6.10.2.2 Test mode 2: Read back F-DO in DI (relay circuit)

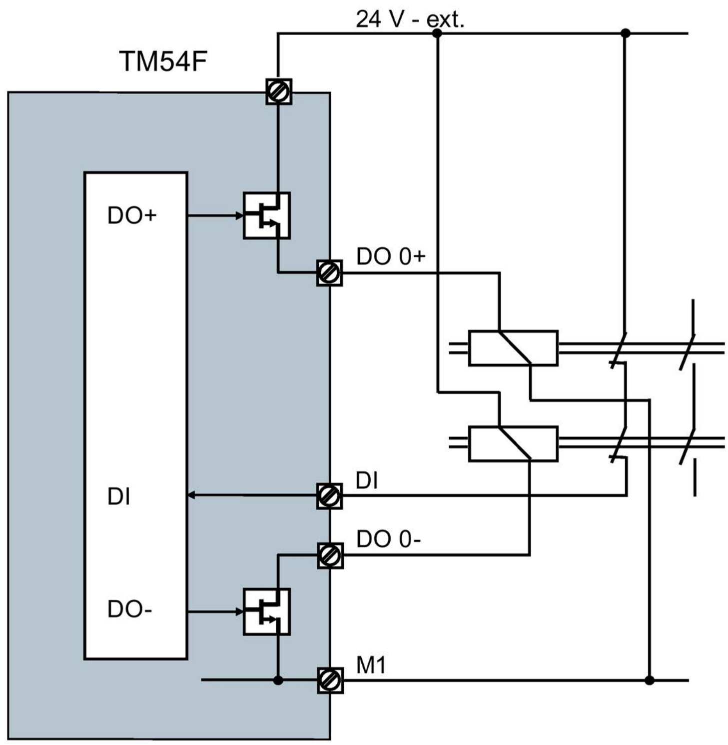


Figure 6-17 F-DO circuit "Test mode 2: Read back F-DO in DI (relay circuit)"

L1+	L2+	Comment
OFF	ON	F-DIs 0 ... 4 Check for 0 V
ON	ON	F-DIs 5 ... 9 Check for 0 V

DO+	DO-	Expected response, DI signal
OFF	OFF	**HIGH**
ON	ON	LOW
OFF	ON	LOW
ON	OFF	LOW
OFF	OFF	**HIGH**

Test sequence for test mode 2

6.10.2.3 Test mode 3: Read back F-DO into the DI (actuator with feedback signal)

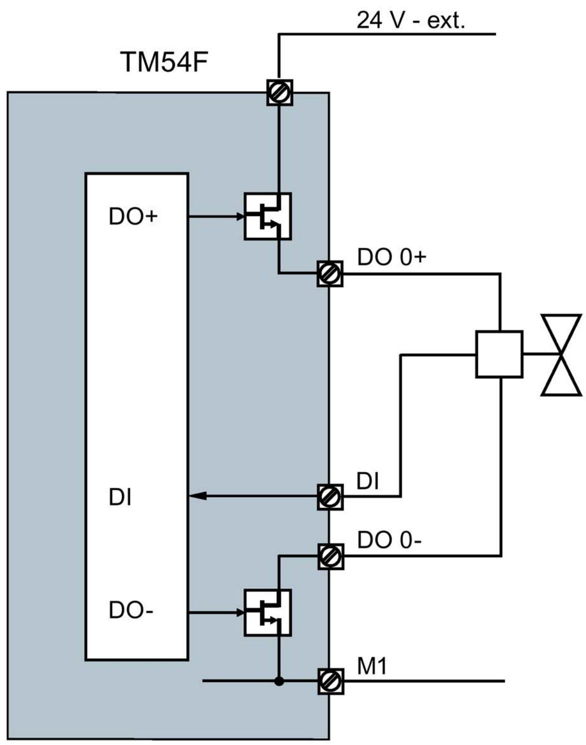


Figure 6-18 F-DO circuit "Test mode 3: Read back F-DO into the DI (actuator with feedback signal)"

L1+	L2+	Comment
OFF	ON	F-DIs 0 ... 4 Check for 0 V
ON	ON	F-DIs 5 ... 9 Check for 0 V

DO+	DO-	Expected response, DI signal
OFF	OFF	HIGH
ON	ON	LOW
OFF	ON	HIGH
ON	OFF	HIGH
OFF	OFF	HIGH

Test sequence for test mode 3

6.10.2.4 Test stop mode parameters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2892 SI TM54F - configuration, F-DI/F-DO Test

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r10015 SI TM54F sampling time
- p10001 SI TM54F wait time for test stop at DO 0 ... DO 3
- p10003 SI TM54F forced checking procedure timer
- p10007 BI: SI TM54F forced checking procedure F-DI/F-DO signal source
- p10017 SI TM54F digital inputs debounce time
- p10046 SI TM54F F-DO feedback signal input activation
- p10047[0...3] SI TM54F F-DO test stop mode

6.11 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 V5.5 SP1 or higher • S7 F Configuration Pack V5.5 SP5[1)] or higher • S7 Distributed Safety Programming V5.4 SP5[1)] or higher • Startdrive V15 SP1 • Drive ES Basic V5.4 SP4[1)] or higher[2)] • Correct installation of the software
Hardware:
• A control with safety functions (in our example, SIMATIC F-CPU 317F-2) • SINAMICS S120 (in our example, a CU320-2) • Correct installation of the devices

1) When using a SIMATIC F-CPU

2) As an alternative to Drive ES Basic, you can commission the communication using the GSD file.

Note

Required software or hardware components

If a single software or hardware component is either older than those specified in this document or is missing, PROFIsafe can no longer be configured via PROFIBUS or PROFINET.

6.11.1 PROFIsafe via PROFIBUS

Note

Startdrive

Please note that you cannot yet use this function with Startdrive.

You can find information on how to commission this function with STARTER in older editions of this manual.

6.11.2 PROFIsafe via PROFINET

An example of how you can control the Safety Integrated Functions of the SINAMICS S120 with SIMATIC S7-1500F via a PROFIsafe telegram can be found here (https://support.industry.siemens.com/cs/ww/en/view/109749224).

6.11.3 PROFIsafe configuration with Startdrive

Activating PROFIsafe via the expert list

In order to activate the Safety Integrated Functions via PROFIsafe you must set p9601.3 = 1 in the parameter view. Set Bit 0 to either "1" or "0", depending on whether you want to enable the control via terminals in parallel via PROFIsafe or not. The value of p9601.2 is used to select as to whether the Safety Integrated Basic Functions (= 0) or the Extended/Advanced Functions (= 1) are used.

Note

In addition to configuring the PROFIsafe control, generally additional parameter changes are required; these depend on which safety functions are used. You will find notes on this in Chapter "Description of Safety Integrated functions (Page 69)".

Saving and copying the Safety Integrated function parameters

- After setting the specific parameters of the Safety Integrated Functions (e.g. the PROFIsafe address), these settings must be copied from the Control Unit into the Motor/Power Module: Accepting the settings in the drive (Page 286)
- Alternatively, you can perform this procedure using the parameter view:
  - p9700 SI Motion copy function
  - p9701 SI Motion confirm data change

Acceptance test

An acceptance test needs to be carried out once configuration and commissioning are complete (see Section "Acceptance test (Page 331)").

Note

Changing the collective signature of the safety program

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.

6.11.3.1 Selecting a PROFIsafe telegram

Proceed as follows to define the PROFIsafe telegram:

1. In parameter p60022 select the required telegram.
2. In parameter p9611, select the same telegram number.

Note

Compatibility mode

If you set p9611 = 998 for p60022 = 0 (for instance, if you have upgraded the safety project to firmware V4.5), then the PROFIsafe telegram 30 is also set as for p60022 = 30 and p9611 = 30.

PROFIsafe configuration

The PROFIsafe address is required for control of the safety functions via PROFIsafe.

Note

You can only change communication parameters in Startdrive in the setting dialog.

---

1. Click the icon "Telegram configuration"

   The properties of the PROFINET interface are displayed in the Inspector window. The "Cyclic data traffic" setting range is active. Here you define the telegrams for the drive objects.
2. Click the <Add telegram> entry in the telegram configuration of "Drive axis_x".
3. Select the "Add safety telegram" option in the drop-down list of the entry:

   Startdrive then inserts the "Safe actual value" and "Safe setpoint" lines. The relevant PROFIsafe telegrams are preassigned.
4. Open the new "Safe setpoint" screen form (for Drive axis_x) in the Inspector window.
5. Correct the PROFIsafe address of the drive in the "F-address" field.
6. In the function view, switch back to the "control" screen form.

   The value of the F-address is displayed in the "PROFIsafe address" (p9610) field. A preassigned PROFIsafe telegram is displayed in the "PROFIsafe telegram no." drop-down list.
7. Click "Accept values" to transfer the telegram from the default settings into the Safety programming.
8. Select the desired stop response for a failure of the PROFIsafe communication in the "PROFIsafe failure response" (p9612) drop-down list.

Note

Unique PROFIsafe addresses

You must ensure the unique assignment of the PROFIsafe address throughout the network and the CPU.

- The failsafe I/O of PROFIsafe address type 1 is addressed clearly by its failsafe destination address.
- The failsafe destination address of the failsafe I/O (drive units in this case) must be unique for the entire failsafe I/O throughout the network and the CPU (system-wide). The failsafe I/O of PROFIsafe address type 2, e.g. modules of the ET 200SP type, must also be taken into account.
- Note also the corresponding documentation in the TIA Portal online help in Section "SIMATIC Safety - Configuration and programming". (SDR001)

6.12 Modular machine concept Safety Integrated

The modular machine concept for Safety Integrated Basic, Extended and Advanced 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:

- After the components with safety functions have been activated for the first time after series commissioning, replacement of the hardware must be confirmed (see Section "Information pertaining to component replacements (Page 371)").
- Once all the drives (including Safety Integrated Extended/Advanced 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.

NOTICE
Deactivate with p0895 not permitted
Deactivation of drive objects or power unit components using parameter p0895 is not permitted when the safety functions are enabled.

- The drive objects of the TM54F can be deactivated using 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. When it is activated again on the following restart or POWER ON and hardware replacement confirmation (see Chapter "Information pertaining to component replacements (Page 371)").
- Component exchange on a Control Unit (e.g. to localize faults). For Safety Integrated, this is the same as a hardware replacement. This must be connected after a restart or POWER ON with a hardware replacement confirmation (see Chapter "Information pertaining to component replacements (Page 371)").
- If a drive with enabled safety functions is copied offline, fault F01656 may be output when the project is downloaded. This behavior occurs whenever component numbers change during copying (e.g. different drive object number or hardware). In this case, please observe the procedure when fault F01656 occurs (see SINAMICS S120/S150 List Manual).

6.13 Information pertaining to series commissioning

A commissioned project that has been uploaded to Startdrive can be transferred to another drive unit keeping the existing safety parameterization.

1. Load the Startdrive project into the drive unit.
2. Make sure that nobody is in the danger zone, and only then switch on the machine.
3. Note the following warnings for "Extended/Advanced Functions via PROFIsafe":
   - F01650 (fault value 2005) indicates the replacement of a Control Unit.
   - A01695 indicates the replacement of a Sensor Module. As a consequence, a defect is also signaled in a monitoring channel (C30711 with fault value 1031 and stop response STOP F).
4. If you are using Startdrive, you must perform the following steps:
   - Click on **Acknowledge hardware replacement** in the start screen of the safety functions.
   - Faults F01650/F30650 are output (acceptance test required; see Section "Test scope for specific measures (Page 341)").
   - Continue with step 6.
5. If you are working with SINAMICS with a BOP or SIMOTION with HMI, then you must perform the following steps:
   - Activate "Safety Integrated commissioning" (p0010 = 95)
   - Start the copy function for Node Identifier (p9700 = 1D hex)
   - Confirm the hardware CRC on the drive object (p9701 = EC hex)
   - Exit the "Safety Integrated commissioning" mode (p0010 = 0)
   - Continue with step 6.
6. Perform steps 4 or 5 when replacing a Sensor Module at the drive object servo or vector, and when replacing 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

Unwanted motion if components are replaced without a function test

After a component replacement, accidents resulting in serious injuries or death can be caused by unwanted motion if no function test has been performed.

- You can find more detailed information in the sections "Test scope for specific measures (Page 341)" and "acceptance testing (Page 331)".

Safety message for series commissioning under Safety Integrated Extended/Advanced 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. To acknowledge the Safety message, you must first manually correct the serial number for the absolute encoder, e.g. with Startdrive. The description can be found in Section "Information pertaining to component replacements (Page 371)". You can then carry on with the commissioning.

6.14 Application examples

You can find SINAMICS application examples on the Internet page "SINAMICS application examples".

We can offer you efficient system strategies, especially as a result of the optimum interaction between SIMATIC control technology and SINAMICS drive systems.

The application examples provide you with:

- Reusable modules for scaling setpoints and actual values
- Explanation of the necessary configuring steps together with screenshots
- Security through already tested programs and modules for accessing parameters
- Significantly lower commissioning times
- Detailed documentation with parts lists of the hardware and software components being used

Further, you can also find technological application examples, such as winders, traversing arms and basic synchronous operation. These application examples also explain how to use free function blocks (FBLOCKS), logic processing integrated in the drive with Drive Control Chart (DCC) and Safety Integrated.

Finding and calling application examples

1. Call the following site in your Internet browser:

   SINAMICS application examples (https://www.automation.siemens.com/mc-app/sinamics-application-examples/Home/Index?language=en)

2. Select the required filter in the search mask.

   Example:

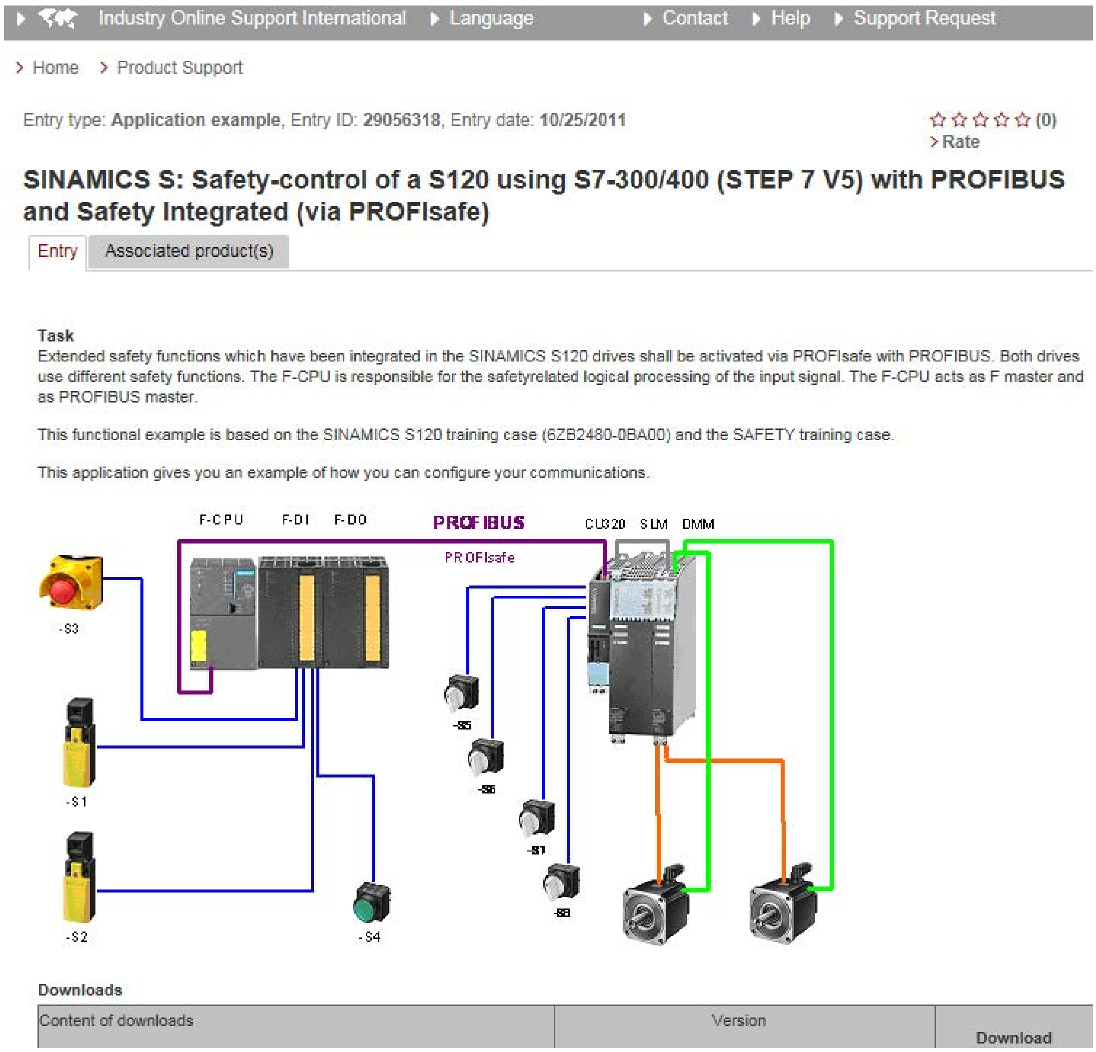
   The result list is updated every time a filter setting is specified.

Application	DriveType	DriveFunction	Control	EngineeringEnvironment	Communication	Speciality
› SINAMICS S: Safety-control of a S120 using S7-300/400 (STEP 7 V5) with PROFIBUS and Safety Integrated (via PROFIsafe)	S120	Safety-control	S7-300/400	STEP 7 V5	PROFIBUS	Safety Integrated
› SINAMICS S: Safety-control of a S120 using S7-300/400 (STEP 7 V5) with PROFIBUS and Safety Integrated (via TM54F)	S120	Safety-control	S7-300/400	STEP 7 V5	PROFIBUS	Safety Integrated
› SINAMICS S: Safety-control of a S120 using S7-300/400 (STEP 7 V5) with PROFINET (Shared Device) and Safety Integrated (via PROFIsafe)	S120	Safety-control	S7-300/400	STEP 7 V5	PROFIBUS PROFINET	Safety Integrated

   Individual filters can be reset by clicking the X to the right of the filter. You can reset all filters simultaneously by clicking the "Reset filters" button.

3. The first details of the required application description can then be displayed in a tooltip. To do this, click the appropriate entry in the result list.

   The required tooltip is then displayed in the Siemens Industry Online Support.



▶ Industry Online Support International ▶ Language ▶ Contact ▶ Help ▶ Support Request

› Home › Product Support

Entry type: **Application example**, Entry ID: **29056318**, Entry date: **10/25/2011**

☆☆☆☆☆ (0)
› Rate

SINAMICS S: Safety-control of a S120 using S7-300/400 (STEP 7 V5) with PROFIBUS and Safety Integrated (via PROFIsafe)

Entry | Associated product(s)

Task

Extended safety functions which have been integrated in the SINAMICS S120 drives shall be activated via PROFIsafe with PROFIBUS. Both drives use different safety functions. The F-CPU is responsible for the safetyrelated logical processing of the input signal. The F-CPU acts as F master and as PROFIBUS master.

This functional example is based on the SINAMICS S120 training case (6ZB2480-0BA00) and the SAFETY training case.

This application gives you an example of how you can configure your communications.

Downloads

Content of downloads	Version	Download

Generally, you can download a detailed application description as PDF via the tooltip.

7 Acceptance test

Note

Responsibilities

The machine manufacturer is responsible for carrying out and documenting the acceptance test: In Chapter "Acceptance test with Startdrive (Page 344)" you will find a suggestion for how to carry out and document the acceptance test for the individual safety functions.

7.1 General information about the acceptance test

Why is acceptance required?

The EC Machinery Directive and DIN EN ISO 13849-1 stipulate:

- You must check safety-related functions and machine parts after commissioning.

  → Acceptance test.

  For SINAMICS Safety Integrated Functions (SI Functions) this specifically means: The acceptance test is used to check the functionality of the Safety Integrated monitoring and stop functions used in the drive. The test objective is to verify proper implementation of the defined safety functions and test mechanisms (measures for forced checking procedure (test stop)) and to examine the response of specific monitoring functions to explicitly entered 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).

  Note

  Purpose of the acceptance test

  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 to derive real values (e.g. maximum values for over-travel distances).

- You must create an "acceptance report" showing the test results.

  → Documentation.

Requirements

The acceptance test requirements (configuration check) for electrical drive safety functions emanate from DIN EN 61800-5-2, Section 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

A complete acceptance test is required when first commissioning Safety Integrated functionality on a machine. The acceptance tests must be carried out for each individual drive. Safety-related function expansions, transfer of the commissioning settings to other series machines, hardware changes, software upgrades or similar activities 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.

Requirements for the acceptance test

- The machine is properly wired.
- All safety equipment (such as protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- Access rights to SI parameters must be protected by a password. This procedure must be documented in the acceptance report - the password itself must not appear there.
- Commissioning of the open-loop and closed-loop control must 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

Acceptance test

The acceptance test comprises 2 parts:

- Checking whether the safety functions in the converter are correctly set:
  - Does the speed control handle the configured application cases in the machine?
  - Do the set interface, times and monitoring functions match the configuration of the machine?
- Checking whether the safety-relevant functions in the plant or machine function correctly.

  This part of the acceptance test goes beyond the converter acceptance test:
  - Are all safety equipment such as protective door monitoring devices, light barriers or emergency-off switches connected and ready for operation?
  - Does the higher-level control correctly respond to the safety-relevant feedback signals of the converter?
  - Do the converter settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of the safety-relevant components and functions of the machine or plant.
- Report of the acceptance test results.
- Report of the settings of the safety functions.
- The documentation must be signed by the person who carried out the acceptance test.

Authorized persons

Personnel from the **machine manufacturer**, who, on account of their technical qualifications and knowledge of the safety functions, are in a position to perform the acceptance test in the correct manner.

> **⚠ WARNING**
>
> **Unwanted motion due to incorrect parameter changes**
>
> Incorrect parameter changes for SI functions can result in unwanted motion leading to death or severe injury.
>
> - After making a change to a parameter for the Safety Integrated Functions, always perform an acceptance test for the function in question.
> - Document the values calculated in an acceptance report.

> **⚠ WARNING**
>
> **Unsafe operating states due to manipulation of the Safety Integrated parameters after the acceptance test**
>
> Incorrect parameter changes to Safety Integrated Functions after an acceptance test can result in unwanted motion resulting in severe injury or death.
>
> - To prevent access to your plants and systems by unauthorized persons, implement access restrictions and take the precautions described in the security information (see Chapter "Industrial security (Page 18)" and manual "SINUMERIK/SIMOTION/SINAMICS Motion Control Industrial Security").
> - To avoid incorrect changes to the configuration and parameters of the Safety Integrated Functions, take the precautions described in this manual.
> - Check the Safety log book of SINAMICS Safety Integrated at regular intervals. Verify that no changes have been made to the parameters since the last acceptance test was performed.
> - If any changes have been made and they are intentional, repeat the acceptance test for the Safety Integrated Functions affected. The purpose of the acceptance test is to ensure and document safe operation of the plant. Correct any unintentional changes back to the original values and repeat the acceptance test.

More information

Note

More information

- See the information in sections "Description of Safety Integrated functions (Page 69)" and "Commissioning (Page 263)".
- In Chapter "Acceptance test with Startdrive (Page 344)" you will find a suggestion for how to carry out and document the acceptance test for the individual safety functions.
- An acceptance report template in electronic format is available at your local Siemens sales office.

Note

PFH values

The PFH values of the individual SINAMICS S120 safety components can be found at:

PFH (https://support.industry.siemens.com/cs/ww/en/view/76254308)

Note on the acceptance test mode

The acceptance test mode can be activated for a definable period (p9558) by setting the appropriate parameters (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 p9558.

It is only worth activating acceptance test mode during the acceptance test of the SS2, SOS, SDI, SLS and SLP functions. It has no effect on other functions.

Normally, SOS can be selected directly or via SS2. To be able to trigger violation of the SOS standstill limits with acceptance test mode active (even in the "SS2 active" state), the setpoint is enabled again by the acceptance test mode after deceleration and transition to SOS to allow the motor to travel. 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

Axis movement during the acceptance test

If a speed setpoint ≠ 0 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. If persons are in the danger zone, accidents causing death or severe injury can occur.

- Take suitable measures to ensure that nobody is in the danger zone during the acceptance test.

7.2 Contents and depth of the acceptance test

7.2.1 Content of the complete acceptance test

A) Documentation

Documentation of the machine and of safety functions

- Machine description (with overview)
- Specification of the controller (if this exists)
- 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.
- SI functions for each drive
- Information about safety equipment

B) Function test diagnostic/safety functions

Detailed function test and evaluation of SI functions used. For some functions, trace recordings of individual parameters can be used.

The Acceptance test wizard (Page 344) in Startdrive supports you with these actions.

- Encoder parameterization test
  - Required when using the Extended/Advanced Functions with encoder
  - Only required at an encoder replacement
- Test of the SI function "Safe Torque Off" (STO)
  - Required when used in Basic and/or Extended Functions
- Test of the SI function "Safe Stop 1" (SS1)
  - Required when used in Basic and/or Extended Functions
  - If the Extended Functions are used, individual parameters can be traced.
- Test of the SI function "Safe Brake Control" (SBC)
  - Required when using Basic and/or Extended Functions
- Test of the SI function "Safe Stop 2" (SS2)
  - For this purpose, individual parameters can be traced/recorded.
- Test of the SI function "Safe Operating Stop" (SOS)
  - For this purpose, individual parameters can be traced/recorded.
- Test of the SI function "Safely-Limited Speed" (SLS)
  - For this purpose, individual parameters can be traced/recorded.

- Test of the SI function "Safe Direction" (SDI)
  – For this purpose, individual parameters can be traced/recorded.
- Test of the SI function "Safe Speed Monitor" (SSM)
  – For this purpose, individual parameters can be traced/recorded.
- Test of the SI function "Safely-Limited Position" (SLP)
  – For this purpose, individual parameters can be traced/recorded.
- Testing the SI function "Safe Cam" (SCA)
  – For this purpose, individual parameters can be traced/recorded.
- Testing the SI function "Safely-Limited Acceleration" (SLA)
  – For this purpose, individual parameters can be traced/recorded.
- Testing the "Safe Brake Test" (SBT) diagnostics function
  – If the Extended Functions are used, individual parameters can be traced.

C) Functional testing of the forced checking procedure (test stop)

Test of the forced checking procedure (test stop) of the safety functions on each drive (for the Basic and/or Extended/Advanced Functions) and the TM54F (if used).

- Test of the forced checking procedure (test stop) 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/Advanced Functions, you need to perform the forced checking procedure (test stop).
- Forced checking procedure (test stop) of the TM54F (if available)
  – Perform forced checking procedure (test stop) of the TM54F
- Forced checking procedure (test stop) of the CU310-2 (if available)
  – Perform forced checking procedure (test stop) of the CU310-2

D) Conclusion of the report

Report of the commissioning status tested and countersignatures

- Inspection of SI parameters
- Logging of checksums (for each drive)
- Issuing of the safety password and documenting this process (do not specify the safety password in the report!)
- RAM to ROM backup, upload of project data to Startdrive, and backup of the project
- Countersignature

7.2.2 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 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
4. Extending/changing the SI functions per drive
5. Extending/changing the specifications of the safety equipment

B) Function test diagnostic/safety functions

Detailed function test and evaluation of SI functions used. For some functions, trace recordings of individual parameters can be used.

The Acceptance test wizard (Page 344) in Startdrive supports you with these actions.

1. Test of the SI function "Safe Torque Off" (STO)
   - Required when used in Basic and/or Extended Functions
   - You do not need to prepare a trace recording for this test.
2. Test of the SI function "Safe Stop 1" (SS1)
   - Required when used in Basic and/or Extended Functions
   - If the Extended Functions are used, individual parameters can be traced.
3. Test of the SI function "Safe Brake Control" (SBC)
   - Required when using Basic and/or Extended Functions
   - You do not need to prepare a trace recording for this test.
4. Test of the SI function "Safe Stop 2" (SS2)
   - For this purpose, individual parameters can be traced/recorded.
5. Test of the SI function "Safe Operating Stop" (SOS)
   - For this purpose, individual parameters can be traced/recorded.
6. Test of the SI function "Safely-Limited Speed" (SLS)
   - For this purpose, individual parameters can be traced/recorded.
7. Test of the SI function "Safe Direction" (SDI)
   - For this purpose, individual parameters can be traced/recorded.
8. Test of the SI function "Safe Speed Monitor" (SSM)
   - For this purpose, individual parameters can be traced/recorded.

9. Test of the SI function "Safely-Limited Position" (SLP)
   - For this purpose, individual parameters can be traced/recorded.
10. Testing the SI function "Safe Cam" (SCA)
    - For this purpose, individual parameters can be traced/recorded.
11. Testing the SI function "Safely-Limited Acceleration" (SLA)
    - For this purpose, individual parameters can be traced/recorded.
12. Testing the "Safe Brake Test" (SBT) diagnostics function
    - If the Extended Functions are used, individual parameters can be traced.

C) Functional testing of the forced checking procedure (test stop)

Test of the forced checking procedure (test stop) of the safety functions on each drive (for the Basic and/or Extended/Advanced Functions) and the TM54F (if used).

1. Test of the forced checking procedure (test stop) 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/Advanced Functions, you need to perform the forced checking procedure (test stop).
2. Forced checking procedure (test stop) of the TM54F (if available)
   - Perform forced checking procedure (test stop) of the TM54F
3. Forced checking procedure (test stop) of the CU310-2 (if available)
   - Perform forced checking procedure (test stop) of the CU310-2

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**
>
> **Axis movement during the acceptance test**
>
> The operation causes the machine to move.
>
> • Take suitable measures to ensure that nobody is in the danger zone during the acceptance test.

2. Test of failsafe actual value acquisition
   – Only necessary when using Extended Advanced Functions
   – If the motion monitoring functions are activated (e.g. SLS or SSM with hysteresis), briefly operate the drive in both directions.
3. Encoder parameterization test
   – Required when using the Extended/Advanced Functions with encoder
   – Only required at an encoder replacement
   – You do not need to prepare a trace recording for this test.

E) Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Extension of checksums (for each drive)
2. Countersignature

7.2.3 Test scope for specific measures

Scope of partial acceptance tests for specific measures

The measures and points specified in the table refer to the information given in Section Content of the partial acceptance test (Page 338).

Table 7- 1 Scope of partial acceptance tests for specific measures

Measure	A) Documentation	B) Functional testing of safety functions	C) Functional testing of the forced checking procedure (test stop)	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 following hardware: Control Unit, Motor Module, Power Module, or Safe Brake Relay	Yes, Points 1 and 2	Yes, Points 1 or 2 and 3	Yes, only Point 1	Yes, only Point 1	Yes
Replacement of 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 modification[1](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
Other firmware version[1] on Simotion D	Yes, only Point 2	Yes, if new safety functions are to be used	Yes	Yes, only Point 1	Yes

[1] Upgrading or downgrading

7.2.4 Relevant checksums for the acceptance

Checksums of the safety functions

The following checksums are available for every drive with activated safety functions.

Safety function/parameters	Checksum	Reason for changing the checksum
Basic Functions		
p9799	Reference checksum (channel 1)	Changing the safety parameters of basic functions
p9899	Reference checksum (channel 2)	
Extended/Advanced Functions		
p9799	Reference checksum (channel 1)	Changing a safety parameter of the Extended/ Advanced Functions
p9899	Reference checksum (channel 2)	
p9729[0]	Reference checksum SI parameters for motion monitoring (channel 1)	Changing a safety parameter of the Extended/ Advanced Functions, which does not refer to encoder data.
p9729[1]	Reference checksum SI parameters for actual values (channel 1)	Changing encoder parameters (e.g. encoder pulse number, fine resolution, …) or mechanical settings (e.g. gear unit, spindle pitch, …)
p9729[2]	Reference checksum SI parameters for hardware (channel 1)	As soon as a Sensor Module evaluated by safety integrated is replaced
p9399[0]	Reference checksum SI parameters for motion monitoring (channel 2)	Changing a safety parameter of the Extended/ Advanced Functions
p9399[1]	Reference checksum SI parameters with hardware reference (channel 2)	Replacing safety-relevant hardware
TM54F		
p10005[0]	Reference checksum, hardware-independent TM54F parameters (available for master and slave modules)	Changing a TM54F safety parameter
p10005[1]	Reference checksum, hardware-dependent TM54F parameters	Replacing a Motor Module which is controlled via the TM54F

All safety changes (functional or related to the hardware) are documented in the safety logbook of the Control Unit. As soon as a safety parameter is changed, then the checksum in the Control Unit also changes. As a consequence, it is sufficient to document the functional checksum of the safety logbook (r9781[0]) and the associated time stamp (r9782[0]).

Note

For the functional checksum, it must be guaranteed that the components to be replaced are replaced by identical components (the same MLFB).

The following diagram shows the functional reference checksums of the SINAMICS components for the safety logbook of the Control Unit.

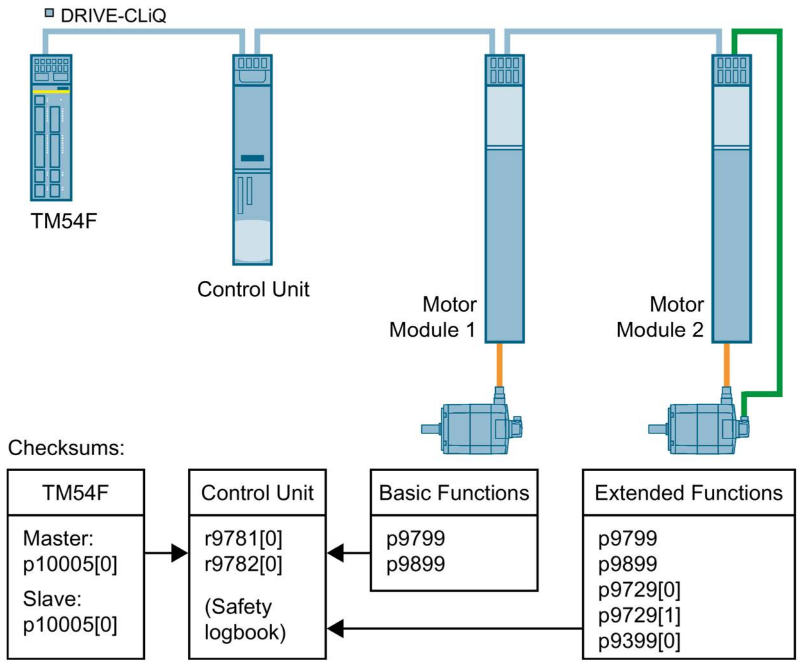


Figure 7-1 Parameters for the functional reference checksums of SINAMICS components

7.3 Acceptance test with Startdrive

7.3.1 Notes

Note

Conditions for the acceptance test

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

Acceptance test for Basic and Extended Functions

In the function selection, the Safety Integrated acceptance test offers you the testable functions for selection, depending on the device type and its settings (Basic or Extended Functions, control via PROFIsafe or terminals).

Note

Trace recordings

The trace recordings for the Extended Functions allow the analysis of the machine behavior during the test execution. Here you use the signal characteristics to check whether the machine behavior meets your expectations. The recorded signals allow, for example, the delay times and over-travel distances to be evaluated.

Note

Non-critical alarms

When evaluating the alarm buffer you can tolerate the following alarms:

- A01697 SI Motion: Motion monitoring test required
- A35014 TM54F: Test stop required

  These alarms occur after every system startup and can be evaluated as non-critical.
- A01699 SI CU: Shutdown path test required

  This alarm occurs after the time in p9659 has expired.

You do not need to include these alarms in the acceptance report.

Note

No acceptance test with alarm A01796

If the alarm A01796 is active, the pulses are safely canceled, and an acceptance test is not possible.

7.3.2 Preparing the acceptance test

Establishing an overview of all drives

1. Click "Acceptance test" in the project tree.
2. Select the "Overview" screen form in the secondary navigation.
3. Click "Determine" to determine all drives with Safety Integrated Functions in your Startdrive project.
4. The overview window lists all available drives with Safety Integrated Functions as well as their respective test status.
   Color coding of the test status:
   - Gray: Safety Integrated Functions have been parameterized, but the acceptance test has not yet been performed
   - Red: Acceptance test failed
   - Blue: Acceptance test in the initial state
   - Green: Acceptance test successful
5. Click "Output" to generate an overview as a table in "xlsx" format. You can open this table in Microsoft Excel and other spreadsheet programs (e.g. LibreOffice).
   You can use the overview to track and/or document your work progress, especially for projects with several drives.

Preparing the acceptance test

1. The drives to be tested have been fully parameterized and commissioned. Subsequent changes require performing a new acceptance test.
2. Click "Acceptance test" in the project tree.

   Those Safety Integrated Functions available in the drive unit are offered for selection. Whereby, the selection considers whether Basic Functions, Extended Functions or Advanced Functions were selected as well as the activation type (PROFIsafe or onboard terminals).
3. Select in the secondary navigation for the desired drive unit all Safety Integrated Functions to be tested.

   The active functions are preselected automatically. This preselection can be changed and functions selected or deselected.
4. Click "Accept" to specify the function selection for the Safety Integrated acceptance test. Entries for the functions to be tested are displayed in the secondary navigation. Navigate with these settings to the individual tests.
5. Establish an online connection to the drive unit to be tested.

Resetting test results

1. Click the "Reset test results" button to delete all the results of the tests previously performed for this drive.
   This restores the initial state from which you can perform the acceptance tests again.

7.3.3 Performing the acceptance test (example)

Description

After accepting the function selection in the "Preparing the acceptance test (Page 345)" step, the functions to be tested are displayed in the secondary navigation.

You can now perform the tests from top to bottom or in any required sequence.

The status of the individual tests is represented as follows:

- Blue: The test is initial and has not yet been tested.
- Green: The test was performed successfully.
- Red: The test was aborted with error. The test can be repeated by reselecting the function.

Structure of the acceptance test wizards

The listed wizards have the same structure for every acceptance test.

The upper area contains the workflow that represents the individual test steps and their status.
The states have the following meaning:

- Blue: Active test step.
- Green: Test step completed.

The instructions for the test steps are displayed in the area below the workflow. The test steps must be performed by the user. After performing the instructions, click "Next" to advance to the next step. At the end, the test is completed by clicking "Finish". The status of this test is then updated in the secondary navigation.

The operator controls for the test steps are located in the lower area. This includes, for example, the control panel for traversing the axis to be tested.

Starting and performing the acceptance test

1. Click one of the functions to be tested (SS1 in this case).
   The wizard is started in the working area.
2. Enter a test designation. This designation also appears later in the acceptance report.

3. You can change the trace settings for this test or use the preassignment. The preassignment is adequate for most applications.

   A change permits adaptation to the mechanical conditions of the machine, e.g. when the axis mechanical system exhibits a very high moment of inertia so that longer ramp-up times for accelerating and braking are required.

4. Observe the safety information and notes on the start screen form of the acceptance test.

5. Once you have performed all preparations, click "Start test".
   The wizard for the selected test opens.

6. In the first step, the drive must be moved so that an emergency stop can be initiated. Select in the "Move drive via" drop-down list whether the drive should be moved via the control panel or via the user program of a higher-level control.

   – Control panel:
     If the drive is moved via the control panel, it is displayed in this screen form.
     Activate the master control, enter a setpoint and start the motor in the desired direction of rotation.
     Click "Next" to advance to the next step.

   – User program:
     Start moving when the drive is moved from the user program.
     Click "Next" to advance to the next step once the motor starts to turn.

7. Initiate emergency stop (SS1) on the selected drive. Click "Next" when the LED indicates that SS1 is active.
   The motor brakes on the OFF3 braking ramp. The transition to STO is made based on the parameter assignment (e.g. after expiration of the delay time or when the shut-down speed is undershot). If a brake parameterized via SBC is present, it is closed after transition to STO.

8. Return the master control when the drive is stationary. Click "Next".

9. The previous workflow is recorded and represented as trace.
   Check the chronological and content workflow of the test based on the signal recording.
   In this test, STO may be initiated only when the motor has almost become stationary.
   Click "Next" provided the test workflow meets your expectations.

10. Alternatively: Cancel the test by clicking "Cancel" if the workflow does not meet your expectations.
    In this case, check the correctness of all input conditions and repeat the test, if necessary.
    Sample scenario: STO is initiated, even though the motor speed is still high. In this case, a possible cause could be incorrect parameterization, e.g. an insufficiently short delay time from SS1 to STO or an excessively high shut-down speed.

11. Deselect SS1 and click "Next".

    The test was performed successfully.

12. Click "Finish" to exit the wizard.

Result

The test status in the secondary navigation is updated.

Execute the wizards of all further functions similarly through the tests.

7.3.4 Completing the acceptance test with report

Description

The acceptance report can be created at any time, for example, even when individual tests have not yet been performed or completed with faults. This allows the intermediate states also to be documented.

The actual final acceptance report, however, makes sense only when all tests have been performed successfully.

Requirement

- All tests have been successfully completed. The individual tests are all identified positively with a green tick.

Creating an acceptance report

1. The overview under "Create report" lists all drives and their current test status.
2. In the "Completion" screen form, select the drives for which you would like to create the report.
   You can select any number of drives, regardless of their test status.
   The drive instances to which the results were transferred are also displayed in the list as drop-down sub-entries. These drive instances are always included in the acceptance report with the selection of the respective main drive.
3. Click on the "Create" button.
   The "Save as" dialog opens.
4. When you select a drive, its drive name is preset as a suggestion for the file name for the acceptance test as standard.
   When you select multiple drives, a dialog for selecting the directory for storing the report opens. For each drive selected, a report is saved with the name of the drive.

Optional: Creating a function table

You can use the function table to create a user-defined overview that is documented in the acceptance report in addition to the results of acceptance test.
The overview is structured as follows:

Column	Explanation
Operating mode	Select one of the specified operating modes from the drop-down list to map the desired scenario.
Description	Enter an explanatory comment for the selected operating mode.
Protective device	Select the protective mechanism to be used in the applicable scenario from the drop-down list.
Version	Enter an explanatory comment on the protective device being used.
Axis	Select the respective drive axis from the drop-down list.
Monitoring	Select the Safety Integrated Function being used from the drop-down list.

Result

The acceptance report is created as a table in "xlsx" format and can thus be opened in Microsoft Excel and other spreadsheet programs (e.g. LibreOffice).

The report comprises several individual tables. These include:

- Cover page: Introduction with the machine description
- Drive_x - overview: Documentation of the parameters and traces for this drive
- Drive_x - function test: Documentation of all test data for this drive

  Test status color coding:
  - Red: Failed
  - Yellow: Not tested
  - Green: Test successful
- Completion: Summary and signatures

Note

Correct display of the acceptance report

How the acceptance report is displayed is dependent on the Windows settings and spreadsheet program used to call up the file.

- Microsoft Excel
  The acceptance report is displayed correctly in Microsoft Excel when the following is configured in the Windows display settings:
  Control Panel > Appearance and Personalization > Display > Make text and other items larger or smaller > Option "Smaller – 100%"
- LibreOffice
  The acceptance report is displayed independently of the Windows settings and is thus always correct.

7.3.5 Transferring acceptance test results

To simplify further acceptance tests, you can transfer the results of successful tests to drives with the same functionality. The Safety Integrated acceptance test wizard lists the suitable drives.

1. Open the "Result transfer" screen form for a drive for which you have successfully completed the acceptance test.
2. Click on the "Determine" button to determine suitable drives.
   After initial determination, the button changes to "Refresh".
3. Select the drives to which you want to transfer the results.
   The selected drives become instances of the tested drive.
4. Click the "Accept" button.
   The transfer status is displayed in the screen form.

7.4 Safety logbook

The "Safety Logbook" function is used to detect changes to safety parameters that affect the associated CRC sums. CRCs are only generated when p9601 (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 CRC has changed.

The following changes are recorded by the safety logbook:

- Functional changes are recorded in the checksum r9781[0]:
  - Functional CRCs of the motion monitoring functions (p9729[0..1]), axis specific (Extended and Advanced Functions)
  - Functional cyclic redundancy checks of the basic safety functions integrated in the drive (p9799, SI setpoint checksum SI parameters CU), for each axis.
  - Functional CRCs of the TM54F (p10005[0]), global (Basic, Extended and Advanced Functions)
  - Enabling functions integrated in the drive (p9601), axis specific (Basic, Extended and Advanced Functions)
- Hardware-dependent changes are recorded in the checksum r9781[1]:
  - Hardware-dependent CRC of the motion monitoring functions (p9729[2]), axis specific (Extended and Advanced Functions)
  - Functional CRCs of the TM54F (p10005[1]), global (Basic, Extended and Advanced Functions)

System features

8

8.1 Latest information

Important note for maintaining the operational safety of your system:

NOTICE
Danger to operational safety due to unwanted motion
Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operating company. If information on a lack of product safety becomes known in the course of observing a product, this information is declared in various ways. 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 and carefully read the corresponding newsletter in order to obtain the latest information and to allow you to modify your equipment accordingly.

To subscribe to the newsletter, please proceed as follows:

1. Go to the following Siemens internet site in your browser:

   Siemens Drives
   (https://www.industry.siemens.com/newsletter/public/AllNewsletters.aspx)

2. Select the desired language for the Web page.

   Note

   Newsletter

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

   ---

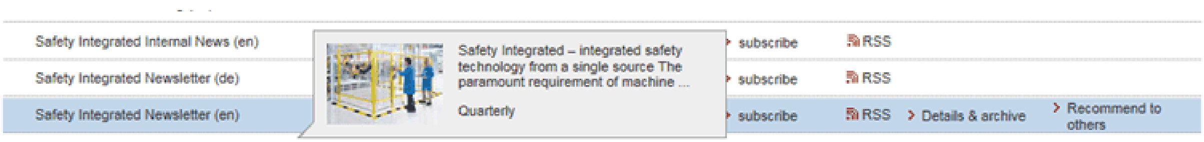
3. Click on "Login / registration".
4. Login with your access data. If you do not yet have a login and password, select "Yes, I would like to register now".

   You can subscribe to the individual newsletters in the following window.

5. Under the "All newsletters" heading on this page, you can see which newsletter is currently available.

6. Open the topic "Products and solutions".

   You will now be shown which newsletter is available for this particular subject area or topic. You can subscribe to the appropriate newsletter by clicking on the "Subscribe" entry. If you require more detailed information on the newsletters, then please use the supplementary function on the website.



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

   – Safety Integrated Newsletter

8.2 Certification

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

- Category 3 to DIN EN ISO 13849-1
- Performance level (PL) d according to DIN EN ISO 13849-1
- Safety integrity level 2 (SIL 2) according to IEC 61508 and EN 61800-5-2

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

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

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to IEC 61508, IEC 62061 and DIN EN 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.

Corresponding PFH values are provided for the SINAMICS S120 drive system, depending on the hardware configuration (number of drives, control type, number of encoders used). The various integrated safety functions are not differentiated.

- The PFH values of the individual SINAMICS S120 safety components can be found at:

  PFH values (https://support.industry.siemens.com/cs/ww/en/view/76254308)

- The PFH values of all safety components from Siemens are available in the "Safety Evaluation Tool"; see:

  Safety Evaluation Tool (http://www.industry.siemens.com/topics/global/en/safety-integrated/machine-safety/safety-evaluation-tool/Pages/default.aspx)

8.4 Response times

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

Note

Actual value of the monitoring cycle (r9780)

You can only see the actual value of the monitoring cycle (r9780) if you are connected ONLINE with the drive. However, you can use the following values to roughly calculate the response times:

- If P0115[0] = 31.25 µs or 62.5 µs or 125 µs, then r9780 = 4 ms.
- If p0115[0] = 250 µs, then r9780 = 8 ms.
- If p0115[0] = 400 µs or 500 µs, then r9780 = 16 ms.

Note for understanding the tables

The drive system is the component that provides the safety functions. The designation "fault-free drive system" means that the component that provides the safety functions does not have a defect itself:

- Worst case for a fault-free drive system

  For faults outside the drive system (e.g. faulty setpoint input from a control system, limit value violations as a result of the behavior of the motor, closed-loop control, load, etc.), the "Worst case for a fault-free drive system" response time is guaranteed.

- Worst case when a fault exists

  For a single fault within the drive system (e.g. a defect in a switch-off signal path of the power unit, in an encoder actual value measurement, in a microprocessor (Control Unit or Motor Module) etc.), the "Worst case when a fault exists" response time is guaranteed.

8.4.1 Control of Basic Functions via terminals on the Control Unit and Motor Module (CU310-2 and CU320-2)

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

Table 8- 1 Response times for control via terminals on the Control Unit and the Motor Module.

Function	Worst case for	
	Drive system has no fault	**A fault is present**
STO	2 · r9780 + t_E[1)]	3 · r9780 + t_E[1)]
SBC	4 · r9780 + t_E[1)]	8 · r9780 + t_E[1)]
SS1/SS1E (time-controlled) Selection until STO is initiated	2 · r9780 + p9652 + t_E[1)]	3 · r9780 + p9652 + t_E[1)]
SS1/SS1E (time-controlled) Selection until SBC is initiated	4 · r9780 + p9652 + t_E[1)]	8 · r9780 + p9652 + t_E[1)]
SS1 (time-controlled) Selection until braking is initiated	3 · r9780 + 2 ms + t_E[1)]	4 · r9780 + 2 ms + t_E[1)]

[1)] The following applies for t_E (debounce time of the digital input being used):

p9651 = 0	t_E[1)] = 2 · p0799 (default = 4 ms)
p9651 ≠ 0	t_E[1)] = p9651 + p0799 + 1 ms

[1)] The minimum time for t_E is t_E_min = 2 ms.

8.4.2 Control of Basic Functions via PROFIsafe (CU310-2 and CU320-2)

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

Note

Internal SINAMICS response times

The specified response times are internal SINAMICS response times. Program run times in the F-host and the transmission time via PROFIBUS or PROFINET are not taken into account. When calculating the response times between the F-CPU and the converter, you must take into account that faults in the communication can result in a safety function only being selected after the PROFIsafe monitoring time (F_WD_Time) has expired. The PROFIsafe monitoring time (F_WD_Time) must also be included in the calculation when an error occurs.

Table 8- 2 Response times when controlling via PROFIsafe

Function	Worst case for	
	Drive system has no fault	**A fault is present**
STO	5 · r9780 + t_K[2)]	5 · r9780 + t_K[2)]
SBC	6 · r9780 + t_K[2)]	10 · r9780 + t_K[2)]
SS1/SS1E (time controlled) Selection until STO is initiated	5 · r9780 + p9652 + t_K[2)]	5 · r978 + p9652 + t_K[2)]
SS1/SS1E (time controlled) Selection until SBC is initiated	6 · r9780 + p9652 + t_K[2)]	10 · r9780 + p9652 + t_K[2)]
SS1 (time controlled) Selection until braking is initiated	5 · r9780 + 2 ms + t_K[2)]	5 · r9780 + 2 ms + t_K[2)]

2) t_K is the time for internal communication within the SINAMICS module. t_K can be determined as follows:

Isochronous communication	t_K = To (for To, see parameter r2064[4])
Non-isochronous communication	t_K = 4 ms Applies to modules on which p2048 (for communication via IF1) or p8848 (for communication via IF2) do not exist.
	t_K = value from p2048 or p8848 Applies to modules on which p2048 (for communication via IF1) or p8848 (for communication via IF2) exist.

8.4.3 Control of Basic Functions via TM54F

The following table lists the response times from the control via TM54F until the response actually occurs.

Table 8- 3 Response times for control via TM54F

Function	Worst case for	
	Drive system has no fault	A fault is present
STO	3 · r9780 + p10017 + 2 ms	3 · r9780 + p10017 + 2 ms
SBC	4 · r9780 + p10017 + 2 ms	8 · r9780 + p10017 + 2 ms
SS1/SS1E (time-controlled) Selection until STO is initiated	3 · r9780 + p9652 + p10017 + 2 ms	3 · r9780 + p9652 + p10017 + 2 ms
SS1/SS1E (time-controlled) Selection until SBC is initiated	4 · r9780 + p9652 + p10017 + 2 ms	8 · r9780 + p9652 + p10017 + 2 ms
SS1 (time-controlled) Selection until braking is initiated	3 · r9780 + p10017 + 4 ms	3 · r9780 + p10017 + 4 ms

8.4.4 Control of Extended Functions with encoder via PROFIsafe (CU310-2 and CU320-2)

The following table lists the response times[1)2)] from receiving the PROFIsafe telegram at the Control Unit up to initiating the particular response.

Table 8- 4 Response times when controlling via PROFIsafe

Function	Worst case for: Drive system has no fault	Worst case for: A fault is present
STO	5 · p9500[8)] + r9780 + t_K[6)]	5 · p9500[8)] + 2 · r9780 + t_K[6)]
SBC	5 · p9500[8)] + 2 · r9780 + t_K[6)]	5 · p9500[8)] + 6 · r9780 + t_K[6)]
SS1 (time controlled), SS1E, SS2E: Time from selecting up to starting the safe timer SS1 (acceleration controlled), SS2: Time from selecting up to initiating braking SOS: Time from selecting up to starting standstill monitoring	5 · p9500[8)] + 2 ms + t_K[6)]	5 · p9500[8)] + 2 ms + t_K[6)]
SBR or SAM (limit value violation until STO active)	2 · p9500 + r9780	2.5 · p9500 + r9780 + t_ACT[5)]
SOS standstill tolerance window violated	1.5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_ACT[5)]
SLS speed limit violated [3)]	2 · p9500 + 2 ms	3.5 · p9500 + 2 ms + t_ACT[5)]
SSM[4)]	4 · p9500	4.5 · p9500 + t_ACT[5)]
SDI (limit value violation until braking is initiated)	1.5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_ACT[5)]
SLA: Selection or deselection	5 · p9500[8)] + t_K	5 · p9500[8)] + t_K
SLA: Limit value violation	3 · p9500 + 2 ms	4 · p9500 + 2 ms + t_act

1) The specified response times are valid for Extended Functions with and without selection.

2) 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. When calculating the response times between the F-CPU and the converter, you must take into account that faults in the communication can result in a safety function only being selected after the PROFIsafe monitoring time (F_WD_Time) has expired. The PROFIsafe monitoring time (F_WD_Time) must also be included in the calculation when an error occurs.

3) SLS: Specification of the response time required to initiate a braking response in the drive - or for the output of the "SOS selected" message to the motion control system.

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

5) t_ACT:

For p9511 ≠ 0		t_ACT = p9511
For p9511 = 0	If an isochronous PROFIBUS master is available:	t_ACT = PROFIBUS cycle
	Otherwise:	t_ACT = 1 ms

6) t_K is the time for internal communication within the SINAMICS module; t_K can be determined as follows:

For isochronous communication	t_K = To (for To, see parameter r2064[4])
For non-isochronous communication	t_K = 4 ms (for modules, on which p2048 or p8848[7] does not exist)
	t_K = value from p2048 or p8848[7] (for modules on which p2048 or p8848[7] exists)

7) p2048 applies to communication via IF1, p8848 to communication via IF2.

8) This component will be reduced from 5 · p9500 to 3 · p9500 if an isochronous PROFIsafe telegram is used with optimally timed execution on the F-CPU.

8.4.5 Control of Extended Functions with encoder via TM54F (CU310-2 and CU320-2)

The table below shows the response times[1)] from the occurrence of a signal at the terminals until the response is initiated.

Table 8- 5 Response times for control via TM54F

Function	Worst case for	
	Drive system has no fault	**A fault is present**
STO	3,5 · p9500 + r9780 + p10017[4)] + 1 ms	4 · p9500 + 2 · r9780 + p10017[4)] + 1 ms
SBC	3,5 · p9500 + 2 · r9780 + p10017[4)] + 1 ms	4 · p9500 + 6 · r9780 + p10017[4)] + 1 ms
SS1 (time and acceleration controlled), SS1E (tme controlled), SS2 selection until braking is initiated	3,5 · p9500 + p10017[4)] + 3 ms	4 · p9500 + p10017[4)] + 3 ms
SBR or SAM (limit value violation until STO active)	2 · p9500 + r9780	2,5 · p9500 + r9780 + t_IST[5)]
SOS standstill tolerance window violated	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[5)]
SLS speed limit violated [2)]	2 · p9500 + 2 ms	3,5 · p9500 + 2 ms + t_IST[5)]
SSM[3)]	3 · p9500	3,5 · p9500 + t_IST[5)]
SDI (limit value violation until braking is initiated)	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[5)]

1) The specified response times are valid for Extended Functions with and without selection!

2) SLS: Specification of the response time required to initiate a braking response 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 fallen below up to output of the information at the F-DO.

4) For CU310-2, use the parameter p10017 of the drive object "TM54F_xx" to calculate the response time, not that of the control unit.

5) For t_ACT, the following applies:

For p9511 ≠ 0		t_ACT = p9511
For p9511 = 0	If an isochronous PROFIBUS master is available:	t_ACT = PROFIBUS cycle
	Otherwise:	t_ACT = 1 ms

8.4.6 Control of Extended Functions with encoder via terminals (only CU310-2)

The table below shows the response times[1)] from the occurrence of a signal at the terminals until the response is initiated.

Table 8- 6 Response times when controlling the Extended Functions with encoder via safe onboard terminals (only CU310-2)

Function	Worst case for	
	Drive system has no fault	A fault is present
STO	3,5 · p9500 + r9780 + t_E[5)]	4 · p9500 + 2 · r9780 + t_E[5)]
SBC	3,5 · p9500 + 2 · r9780 + t_E[5)]	4 · p9500 + 9 · r9780 + t_E[5)]
SS1 (time and acceleration controlled), SS1E (tme controlled), SS2 selection until braking is initiated	3,5 · p9500 + 2 ms + t_E[5)]	4 · p9500 + 2 ms + t_E[5)]
SBR or SAM (limit value violation until STO active)	2 · p9500 + r9780	2,5 · p9500 + r9780 + t_IST[4)]
SOS standstill tolerance window violated	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[4)]
SLS speed limit violated [2)]	2 · p9500 + 2 ms	3,5 · p9500 + 2 ms + t_IST[4)]
SSM[3)]	3 · p9500	3,5 · p9500 + t_IST[4)]
SDI (limit value violation until braking is initiated)	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[4)]

1) The specified response times are valid for Extended Functions with and without selection!

2) SLS: Specification of the response time required to initiate a braking response 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 fallen below up to output of the information via the TM54F terminals.

4) t_ACT:

For p9511 ≠ 0		t_ACT = p9511
For p9511 = 0	If an isochronous PROFIBUS master is available:	t_ACT = PROFIBUS cycle
	Otherwise:	t_ACT = 1 ms

5) For t_E, the following applies:

p10017 = 0	t_E = 2 · p0799
p10017 ≠ 0	t_E = p10017 + p0799 + 1 ms

8.4.7 Control of Extended Functions without encoder via PROFIsafe (CU310-2 and CU320-2)

The following table lists the response times[1)2)] from receiving the PROFIsafe telegram at the Control Unit up to initiating the particular response.

Table 8- 7 Response times when controlling via PROFIsafe

Function		**Worst case for**	
		Drive system has no fault	**A fault is present**
STO		5 · p9500 + r9780 + t_K[4)]	5 · p9500 + 2 · r9780 + t_K[4)]
SBC		5 · p9500 + 2 · r9780 + t_K[4)]	5 · p9500 + 6 · r9780 + t_K[4)]
SS1 (speed controlled/time and acceleration controlled), SS1E (time controlled)		5 · p9500 + 2 ms + t_K[4)]	5 · p9500 + 2 ms + t_K[4)]
SBR or SAM (limit value violation until STO active)		3 · p9500 + r9780 + p9587 + 4 ms	3,5 · p9500 + r9780 + p9587 + 32 ms
SLS speed limit violated [3)]	Standard[3)]	3 · p9500 + p9587 + 6 ms	4,5 · p9500 + r9780 + p9587 + 32 ms
	Start phase[3)]	3 · p9500 + p9587 + p9586[3)] + 6 ms	4,5 · p9500 + r9780 + p9587 + p9586[3)] + 32 ms
SSM[6)]		6 · p9500 + p9587 + 4 ms	6,5 · p9500 + p9587 + 32 ms
SDI (limit value violation until braking is initiated)	Standard[3)]	2,5 · p9500 + p9587 + 6 ms	4 · p9500 + r9780 + p9587 + 32 ms
	Start phase[3)]	2,5 · p9500 + p9587 + p9586[3)] + 6 ms	4 · p9500 + r9780 + p9587 + p9586[3)] + 32 ms
SP[7)]		6 · p9500 + p9587 + 4 ms	6,5 · p9500 + p9587 + 32 ms

1) The specified response times are valid for Extended Functions with and without selection!

2) 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. When calculating the response times between the F-CPU and the converter, you must take into account that faults in the communication can result in a safety function only being selected after the PROFIsafe monitoring time (F_WD_Time) has expired. The PROFIsafe monitoring time (F_WD_Time) must also be included in the calculation when an error occurs.

3) Start phase: This describes the behavior after switching on (ON command with previously deleted pulses).
Standard: This behavior applies when the pulses have already been enabled.
There is a different behavior because, with the aid of p9586, the encoderless actual value acquisition after pulse enable can only be activated after a delay.

4) t_K is the time for internal communication within the SINAMICS module; t_K can be determined as follows:

For isochronous communication	t_K = To (for To, see parameter r2064[4])
For non-isochronous communication	t_K = 4 ms (for modules, on which p2048 or p8848[5)] does not exist)
	t_K = value from p2048 or p8848[5)] (for modules on which p2048 or p8848[5)] exists)

5) p2048 applies to communication via IF1, p8848 to communication via IF2.

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

7) SP: The data corresponds to the times between acquisition of the safe position and transfer of the safe position via PROFIsafe.

8.4.8 Control of Extended Functions without encoder via terminals (only CU310-2)

The table below shows the response times[1] from the occurrence of a signal at the terminals until the response is initiated.

> **⚠ CAUTION**
>
> **Extension of the response times for SLS without encoder or SDI without encoder under certain circumstances**
>
> If the safety functions SLS without encoder or SDI without encoder are already selected when the gating pulses for the Power Module are enabled, then during the starting phase, it is absolutely imperative that you take into account that the response times – when limit values are violated and for system errors – are extended by the time value set in parameter p9586[2] with respect to the standard values (see table above).
>
> After the time interval set in p9586, the standard response times apply (see table above).

Table 8- 8 Response times for control of the Extended Functions without encoder via terminals (only CU310-2)

Function		Worst case for	
		Drive system has no fault	A fault is present
STO		3,5 · p9500 + r9780 + t_E[3]	4 · p9500 + 2 · r9780 + t_E[3]
SBC		3,5 · p9500 + 2 · r9780 + t_E[3]	4 · p9500 + 9 · r9780 + t_E[3]
SS1 (speed controlled/time and acceleration controlled), SS1E (time controlled)		3,5 · p9500 + 2 ms + t_E[3]	4 · p9500 + 2 ms + t_E[3]
SBR or SAM (limit value violation until STO active)		3 · p9500 + r9780 + p9587 + 4 ms	3,5 · p9500 + r9780 + p9587 + 32 ms
SLS speed limit violated [3]	Standard[2]	3 · p9500 + p9587 + 6 ms	4,5 · p9500 + r9780 + p9578 + 32 ms
	Start phase[2]	3 · p9500 + p9586[2] + p9578 + 6 ms	4,5 · p9500 + r9780 + p9586[2] + p9578 + 32 ms
SSM		4 · p9500 + p9587 + 4 ms	4,5 · p9500 + p9587 + 32 ms
SDI (limit value violation until braking is initiated)	Standard[2]	2,5 · p9500 + p9587 + 6 ms	4 · p9500 + r9780 + p9587 + 32 ms
	Start phase[2]	2,5 · p9500 + p9587 + p9586[2] + 6 ms	4 · p9500 + r9780 + p9587 + p9586[2] + 32 ms

1) The specified response times are valid for Extended Functions with and without selection!

2) Start phase: This describes the behavior after switching on (ON command with previously deleted pulses).
Standard: This behavior applies when the pulses have already been enabled.
There is a different behavior because, with the aid of p9586, the encoderless actual value acquisition after pulse enable can only be activated after a delay.

3) For t_E, the following applies:

p10017 = 0	t_E = 2 · p0799
p10017 ≠ 0	t_E = p10017 + p0799 + 1 ms

8.4.9 Control of Extended Functions without encoder via TM54F (CU310-2 and CU320-2)

The table below shows the response times[1)] from the occurrence of a signal at the terminals until the response is initiated.

CAUTION

Extension of the response times for SLS without encoder or SDI without encoder under certain circumstances

If the safety functions SLS without encoder or SDI without encoder are already selected when the gating pulses for the Power Module are enabled, then during the starting phase, it is absolutely imperative that you take into account that the response times – when limit values are violated and for system errors – are extended by the time value set in parameter p9586[2)] with respect to the standard values (see table above).

After the time interval set in parameter p9586, the standard response times apply (see table above).

Table 8- 9 Response times for control via TM54F

Function		**Worst case for**	
		Drive system has no fault	**A fault is present**
STO		3,5 · p9500 + r9780 + p10017[3)] + 1 ms	4 · p9500 + 2 · r9780 + p10017[3)] + 1 ms
SBC		3,5 · p9500 + 2 · r9780 + p10017[3)] + 1 ms	4 · p9500 + 6 · r9780 + p10017[3)] + 1 ms
SS1 (speed controlled/time and acceleration controlled), SS1E (time controlled)		3,5 · p9500 + p10017[3)] + 3 ms	4 · p9500 + p10017[3)] + 3 ms
SBR or SAM (limit value violation until STO active)		3 · p9500 + +r9780 + p9587 + 4 ms	3,5 · p9500 + r9780 + p9587 + 32 ms
SLS speed limit violated [3)]	Standard[2)]	3 · p9500 + p9587 + 6 ms	4,5 · p9500 + r9780 + p9587 + 32 ms
	Start phase[2)]	3 · p9500 + p9587 + p9586[2)] + 6 ms	4,5 · p9500 + r9780 + p9587 + p9586[2)] + 32 ms
SSM		4 · p9500 + p9587 + 4 ms	4,5 · p9500 + p9587 + 32 ms
SDI (limit value violation until braking is initiated)	Standard[2)]	2,5 · p9500 + p9587 + 6 ms	4 · p9500 + r9780 + p9587 + 32 ms
	Start phase[2)]	2,5 · p9500 + p9587 + p9586[2)] + 6 ms	4 · p9500 + r9780 + p9587 + p9586[2)] + 32 ms

1) The specified response times are valid for Extended Functions with and without selection!

2) Start phase: This describes the behavior after switching on (ON command with previously deleted pulses).
Standard: This behavior applies when the pulses have already been enabled.
There is a different behavior because, with the aid of p9586, the encoderless actual value acquisition after pulse enable can only be activated after a delay.

3) For CU310-2, use the parameter p10017 of the drive object "TM54F_xx" to calculate the response time, not that of the control unit.

8.4.10 Control of Advanced Functions with encoder via PROFIsafe (CU310-2 and CU320-2)

The following table lists the response times[1)] from receiving the PROFIsafe telegram at the Control Unit up to initiating the particular response.

Table 8- 10 Response times when controlling via PROFIsafe

Function	Worst case for	
	Drive system has no fault	**A fault is present**
SLP (limit value violation until a response is initiated)	1.5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_ACT[2)]
SCA: Time between violation of a cam start or end position and output of the feedback message in S_ZSW_CAM1	3.5 · p9500	4 · p9500 + t_ACT[2)]
SP[4)] with isochronous PROFIsafe telegram	3 · p9500	3 · p9500 + t_ACT[2)]

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. When calculating the response times between the F-CPU and the converter, you must take into account that faults in the communication can result in a safety function only being selected after the PROFIsafe monitoring time (F_WD_Time) has expired. The PROFIsafe monitoring time (F_WD_Time) must also be included in the calculation when an error occurs.

2) t_ACT:

For isochronous communication	t_K = To (for To, see parameter r2064[4])
For non-isochronous communication	t_K = 4 ms (for modules, on which p2048 or p8848[7)] does not exist)
	t_K = value from p2048 or p8848[7)] (for modules on which p2048 or p8848[7)] exists)

4) SP: The data corresponds to the times between acquisition of the safe position and transfer of the safe position via PROFIsafe.

8.4.11 Control of Advanced Functions with encoder via TM54F (CU310-2 and CU320-2)

The table below shows the response times after the appearance of a signal at the terminals.

Table 8- 11 Response times for control via TM54F

Function	Worst case for	
	Drive system has no fault	A fault is present
SLP (limit value violation until a response is initiated)	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[1)]

[1)] For t_ACT, the following applies:

For p9511 ≠ 0		t_ACT = p9511
For p9511 = 0	If an isochronous PROFIBUS master is available:	t_ACT = PROFIBUS cycle
	Otherwise:	t_ACT = 1 ms

8.4.12 Control of Advanced Functions with encoder via terminals (only CU310-2)

The table below shows the response times after the appearance of a signal at the terminals.

Table 8- 12 Response times when controlling the Advanced Functions with encoder via safe onboard terminals (only CU310-2)

Function	Worst case for	
	Drive system has no fault	**A fault is present**
SLP (limit value violation until a response is initiated)	1,5 · p9500 + 2 ms	3 · p9500 + 2 ms + t_IST[1)]

1) t_ACT:

For p9511 ≠ 0		t_ACT = p9511
For p9511 = 0	If an isochronous PROFIBUS master is available:	t_ACT = PROFIBUS cycle
	Otherwise:	t_ACT = 1 ms

8.4.13 Advanced Functions without encoder via PROFIsafe (CU310-2 and CU320-2)

The following table lists the response times[1)] from receiving the PROFIsafe telegram at the Control Unit up to initiating the particular response.

Table 8- 13 Response times when controlling via PROFIsafe

Function	Worst case for	
	Drive system has no fault	A fault is present
SP[2)]	6 · p9500 + p9587 + 4 ms	6,5 · p9500 + p9587 + 32 ms

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. When calculating the response times between the F-CPU and the converter, you must take into account that faults in the communication can result in a safety function only being selected after the PROFIsafe monitoring time (F_WD_Time) has expired. The PROFIsafe monitoring time (F_WD_Time) must also be included in the calculation when an error occurs.

2) SP: The data corresponds to the times between acquisition of the safe position and transfer of the safe position via PROFIsafe.

Maintenance 9

9.1 Information pertaining to component replacements

Replacing a component from the perspective of Safety Integrated

Note

Note additional safety instructions

Observe the instructions with regard to changing or replacing software components in Section "Safety instructions (Page 20)"!

The faulty component was replaced according to safety regulations. The information relevant from the perspective of Safety Integrated is provided in the following. For information about component replacements, see "Example of component replacements" in the SINAMICS S120 Function Manual Drive Functions.

- Based on the NodeID and the saved CRC of the particular hardware component, the drive identifies that a component has been replaced. You can take the responses of the drive and the actions that have to be carried out from the following table:

	Replaced component	Control type	Drive response (fault)	User action			Diagnostic parameters
				Fault acknowledgment required[1)]	Acknowledgment is required that the component has been replaced[2)]	Save[3)]	
Basic Functions	Control Unit	All	F01641.0 = 1	Yes	No	Yes	r9776.2 = 1
	Motor Module	All	F01641.1 = 1	Yes	No	Yes	r9776.2 = 1
	Power Module	All	F01641.2 = 1	Yes	No	Yes	r9776.2 = 1

	Replaced component	Control type	Drive response (fault)	User action			Diagnostic parameters
				Fault acknowledgment required[1)]	Acknowledgment is required that the component has been replaced[2)]	Save[3)]	
Extended/Advanced Functions	Control Unit	All	F01641.0 = 1	Yes	No	Yes	r9776.2 = 1
	Motor Module	PROFIsafe, OnBoard F-DI, without selection	F01641.1 = 1	Yes	No	Yes	r9776.2 = 1
		TM54F	F01640.1 = 1	Yes	Yes	Yes	r9776.2 = 1 r9776.3 = 1
	Power Module	All	F01641.2 = 1	Yes	No	Yes	r9776.2 = 1
	Sensor Module (CPU 1)	All	F01641.3 = 1	Yes	No	Yes	r9776.2 = 1
	Sensor Module (CPU 2)	All	F01640.4 = 1	Yes	Yes	Yes	r9776.2 = 1 r9776.3 = 1
	Encoder[4)]	All	F01641.5 = 1 F01641.6 = 1	Yes	No	Yes	r9776.2 = 1
	TM54F	All	F01641 (only on TM54F_MA)	Yes	No	Yes	r9776.2 = 1

1) The fault must be acknowledged each time a component is replaced using a standard acknowledgment (e.g. using a 0/1 signal at p2103). However, even without acknowledgment the drive can still be operated.

2) The replacement of the components listed in the table must be acknowledged in order to ensure the new internal device communications to be established. When replacing other components, acknowledgment is not required, as the new communications to be established are automatically ensured.
To acknowledge a component replacement, perform the following sequence on all of the drive objects involved:
- Check whether the following preconditions are fulfilled:
 - p0010 = 0
 - It is not permissible for a firmware update to be active on the drive object.
- Set p9702 = 29 (= 1D hex)
- When the acknowledgement process is finished, p9702 jumps back to the value 0.

3) The modified data must be saved after a component has been replaced:
- It is not permissible for a firmware update to be active on the drive object.
- Copy from RAM to ROM by setting p0977 = 1.
If the data is not saved, the fault is output again after the next POWER ON.

4) Only for encoders with serial number (e.g. EnDat)

Replacing motors for safety without encoder

When using safety functions without encoder, the motor pole pair number plays a decisive role. If a motor is replaced, then the behavior depends on the pole pair number: If a motor with a higher pole pair number is used (other than that configured), the mechanical speed is less than that calculated by Safety Integrated. If a motor with a lower pole pair number is used (e.g. when a motor is replaced), the mechanical speed is higher than that calculated by Safety Integrated.

- After a replacement such as this, perform a test by comparing the safe actual speed (r9714) with the normal speed (r0063 or the output frequency), and if required, correct the configured pole pair number.

Acceptance test and acceptance report

⚠WARNING

Unwanted motion if components are replaced without a function test

After a component replacement, connections or functions can be defective so that death or serious injury can result if a person enters the danger zone of the motors.

- After component replacement, always run a simplified function test.

  You can find more detailed information in the chapters "Test scope for specific measures (Page 341)" and "Acceptance test (Page 331)".

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r9670 SI module identification Control Unit
- r9671[0...n] SI module identification Motor Module
- p9672 SI module identification Power Module
- p9673 SI module identification sensor channel 1
- p9674 SI module identification sensor channel 2
- p9675 SI module identification sensor channel 1
- p9676 SI module identification sensor channel 2
- p9702 Acknowledge SI component replacement
- r9776 SI diagnostics
- r9793[0...9] SI diagnostics component replacement
- r10070 SI TM54F module identification

9.2 Note regarding firmware update

⚠ WARNING

Firmware update without POWER ON and acceptance test

If the message A01007 "POWER ON required for DRIVE-CLiQ component" appears after a firmware update, death or serious injury can be caused if a person enters the danger zone of the motors.

- Then perform a partial acceptance test.
- Do not enter the danger zone of the motor until the acceptance test has been successfully completed.

⚠ WARNING

Unwanted motion if components are replaced without a function test

After a component replacement, connections or functions can be defective so that death or serious injury can result if a person enters the danger zone of the motors.

- Perform a POWER ON before resuming operation.
- After component replacement, always run a simplified function test.

  You can find more detailed information in the chapters "Test scope for specific measures (Page 341)" and "Acceptance test with Startdrive (Page 344)".

9.3 Safety faults

9.3.1 Stop responses

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

Table 9- 1 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STOP A[1)] (corresponds to STO[2)])	• For all acknowledgeable safety faults with pulse suppression • Subsequent response of STOP B • Configurable subsequent stop p9563 for SLS • Configurable subsequent stop p9566 for SDI • Configurable subsequent stop p9562 for SLP • Configurable subsequent stop p9579 for SLA	Immediate pulse suppression	Drive coasts down
STOP B[1)] (corresponds to SS1[3)])	Examples: • Standstill tolerance violated in p9530 (SOS) • Configurable subsequent stop p9563 for SLS • Configurable subsequent stop p9566 for SDI • Configurable subsequent stop p9562 for SLP • Subsequent response of STOP F • Configurable subsequent stop p9579 for SLA	Immediate input of speed setpoint = 0 and start of timer t_B . Once t_B or n_{act} < $n_{shutdown}$ has expired, STOP A is triggered.	STOP B with subsequent STOP A. The drive decelerates along the OFF3 ramp and then switches to STOP A. **Note:** For "SS1 with external stop" (SS1E), braking is **not** performed along the OFF3 ramp (see Chapter "Safe Stop 1 with external stop (Page 101)")
STOP C[1)] (corresponds to SS2[4)])	• Configurable subsequent stop p9563 for SLS • Configurable subsequent stop p9566 for SDI • Configurable subsequent stop p9562 for SLP Configurable subsequent stop p9579 for SLA	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 response	Triggered ...	Action	Effect
STOP D[1)]	• Configurable subsequent stop p9563 for SLS • Configurable subsequent stop p9566 for SDI • Configurable subsequent stop p9562 for SLP • Configurable subsequent stop p9579 for SLA	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 controller (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 E[1)]	• Configurable subsequent stop p9563 for SLS • Configurable subsequent stop p9566 for SDI • Configurable subsequent stop p9562 for SLP • Configurable subsequent stop p9579 for SLA	SOS triggered after the expiry of p9554	Controlling the drive-integrated ESR functionality
STOP F[1)]	If an error occurs in the data cross-check. Follow-up response STOP B or STOP A	Timer t_{F1} (Basic Functions) or t_{F2} (Extended/Advanced 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/Advanced Functions) has elapsed.

1) See also the following note "delayed pulse cancellation when the bus fails".

2) The behavior of the drive after STOP A is triggered corresponds (apart from the safety messages) to the behavior after STO is triggered. Note that the parameterization of STO applies equally for STOP A.

3) The behavior of the drive after STOP B is triggered corresponds (apart from the safety messages) to the behavior after SS1 is triggered. Monitoring with the aid of SAM or SBR, for example, works in exactly the same way. Note that the parameterization of SS1 applies equally for STOP B.

4) The behavior of the drive after STOP C is triggered corresponds (apart from the safety messages) to the behavior after SS2 is triggered. Monitoring with the aid of SAM or SBR (for safety with encoder), for example, works in exactly the same way. Note that the parameterization of SS2 applies equally for STOP C.

Note

Delayed pulse cancellation when the bus fails

For SLP, SLS, SDI and SLA the stop responses are also available with delayed pulse suppression when the bus fails (to prevent the drive from immediately responding with pulse suppression when a communication error occurs):

- If p9580 ≠ 0 and SLS is active, in the event of a communication failure, the parameterized ESR reaction only occurs if a STOP with delayed pulse suppression when the bus fails has been parameterized as the SLS response (p9563[0...3] ≥ 10).
- If p9580 ≠ 0 and SDI is active, in the event of a communication failure, the parameterized ESR reaction only occurs if a STOP with delayed pulse suppression when the bus fails has been parameterized as the SDI response (p9566 ≥ 10).
- If p9580 ≠ 0 and SLP is active, in the event of communication failure the parameterized ESR reaction is only realized if, as an SLP response, a STOP with delayed pulse suppression when the bus fails has been parameterized (p9562[0...1] ≥ 10).
- If p9580 ≠ 0 and SLA is active, in the event of a communication failure, the parameterized ESR reaction only occurs if a STOP with delayed pulse suppression when the bus fails has been parameterized as the SLA response (p9579 ≥ 10).

The delay time (p9580) must not exceed 800 ms.

Note

Delay time between STOP F and STOP B

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.

Switch-on delays at the stop response transitions

t_B p9556
t_C p9552
t_D p9553
t_{F1} p9658
t_{F2} p9555
$n_{shutdown}$: p9560

Description of faults and alarms

Note

References

The faults and alarms for SINAMICS Safety Integrated are described in the following documentation:

References: SINAMICS S120/S150 List Manual

9.3.2 Stop response priorities

Table 9- 2 Stop response priorities

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

Priorities of stop responses and Extended Functions

Table 9- 3 Priorities of stop responses and Extended Functions

Stop response/ Extended Function		Highest priority	...	...	...	...	Lowest priority
		STOP A	**STOP B**	**STOP C**	**STOP D**	**STOP E**	**STOP F**
Highest priority	**STO**	STOP A / STO	STO	STO	STO	STO	STO
.....	**SS1**	STOP A	STOP B / SS1	SS1	SS1	SS1	SS1
...	**SS2**	STOP A	STOP B	STOP C/SS2	SS2	SS2	SS2/STOP B[2)]
...	**SS2E**	STOP A	STOP B	STOP C/SS2	SS2	SS2	SS2/STOP B[2)]
..	**SOS**	STOP A[1)]	STOP B[1)]	SOS	SOS	STOP E/SOS	STOP B[2)]
Lowest priority	**SLS, SLA**	STOP A[3)]	STOP B[3)]	STOP C[4)]	STOP D[4)]	STOP E[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 or SLA 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 or SLA remains active during the braking phase, after which the system switches to SOS.

The table above specifies which stop response / safety function is set if 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 (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 selecting STO
- STOP B corresponds to selecting SS1
- STOP C corresponds to selecting SS2
- STOP D corresponds to selecting SOS
- STOP E corresponds to selecting SOS (for additional activation of the standard "Extended stop and retract (ESR)" function)
- When the SS2 function is active, STOP F results in subsequent STOP B. SS2 remains active.

Examples for illustrating the information in the table:

- Safety function SS1 has just been selected. STOP A remains selected.
- By selecting a STOP with a higher priority, STOPs that are present with a lower priority will be replaced. This means that when SS1 is selected (≙ STOP B), any STOPs C-F that are present will be replaced.
- 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.
- 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 brake 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.

9.3.3 Acknowledging safety faults

Note

Acknowledgment through Power Off/On

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

Acknowledgment via TM54F/CU310-2

Parameter p10006 "SI acknowledgement internal event input terminal" allows faults to be acknowledged in the following objects:

- Safety drives
- The TM54F F-DI
- CU310-2

The **"safe fault acknowledgment"** mechanism functions as follows:
The F-DI on the TM54F or on the CU310-2 that was parameterized with the function p10006 "Safety Integrated acknowledgment internal event input terminal", is activated. In this way, faults that have occurred on the drives or on the TM54F are acknowledged using a safe input signal. The falling edge at this input resets the status "Internal Event" in the drives and, if used, in the TM54F or the CU310-2.

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

After "safe fault acknowledgment", when using a TM54F, an acknowledgment must be made at the Control Unit. This acknowledgement has the following effect:

- TM54F faults are deleted from the fault buffer.
- The red Ready LED on the TM54F is reset.

Acknowledgment 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 resets the status "Internal Event" in the relevant drive, which therefore 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 or SS1 is selected/deselected (and p9507.0 = 1 are set), then the safety messages are canceled automatically.
If, in addition to the "Basic Functions via terminals", the "Extended/Advanced Functions" are also enabled, then acknowledgment is also possible by selecting/deselecting STO via PROFIsafe or terminals at the TM54F or at the CU310-2.

9.4 Message buffer

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

Note

Messages of the Basic and the Extended/Advanced Functions

Set parameter p3117 = 1 if you need to save both the Basic Functions messages and the Extended/Advanced 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.

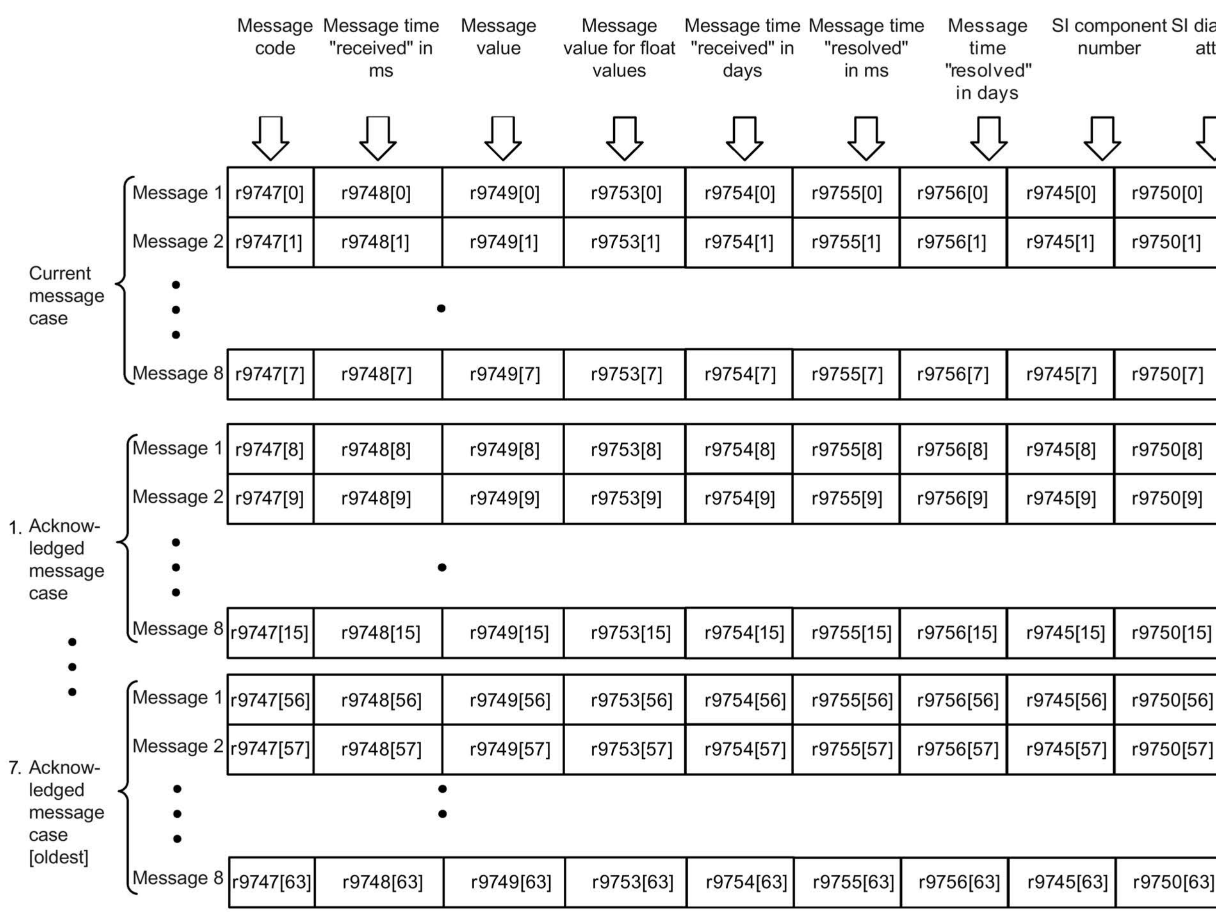


Figure 9-1 Structure of the message buffer

When a safety message is present, bit r2139.5 is set to 1 ("safety message active"). 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 a failsafe input F-DI of the TM54F/CU310-2 or via PROFIsafe.

Properties of the safety message buffer:

- The entries appear in the buffer according to the time at which they occurred.
- If a new message case occurs, the message buffer is reorganized accordingly. The history is recorded in the "Acknowledged message case" 1 to 7.
- 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".
- If "Current message case" contains 8 messages and a new message for the current message case is output, the message in the current message case parameters is overwritten with the new message in index 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 can be deleted as follows: p9752 = 0. Parameter p9752 (SI message cases, counter) is also reset to 0 at POWER ON. This also clears the fault memory.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r2139.0...15 CO/BO: Status word, faults/alarms 1
- r9744 SI message buffer changes, counter
- r9745[0...63] SI component
- 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

Standards and regulations 10

10.1 General information

10.1.1 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. For this purpose, companies describe in the various standards the current state of the art covering all aspects relevant to safety. If it can be justifiably assumed that all of the relevant standards are complied with, this ensures that state-of-the-art technology has been utilized and, in turn, a plant builder 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 based on internationally harmonized rules and regulations. This is also intended to avoid competitive advantages or disadvantages 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).

10.1.2 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 Standards. The requirements to implement functional safety are based on the following basic goals:

- Avoiding 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 avoiding systematic faults. This is expressed in the standards using specific classification. In IEC/EN 61508, IEC/EN 62061 "Safety Integrity Level" (SIL) and EN ISO 13849-1 "Category" and "Performance Level" (PL).

10.2 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).

10.2.1 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.

IEC 61800-5-2 Adjustable-speed electrical power drive systems Part 5-2 is relevant for the Machinery Directive: Safety requirements - Functional safety

Within the context of IEC 61508, IEC 61800-5-2 considers adjustable speed electric power drive systems (PDS), which are suitable for use in safety-related applications (PDS(SR)).

IEC 61800-5-2 places demands on PDS(SR) as subsystems of a safety-related system. This therefore permits the implementation of the electrical/electronic/programmable electronic elements of a PDS(SR) taking into account the safety-relevant performance of the safety function(s) of a PDS.

Manufacturers and suppliers of PDS(SR) can prove to users (e.g. integrators of control systems, developers of machines and plants etc.) the safety-relevant performance of their equipment by implementing the specifications stipulated in standard IEC 61800-5-2.

10.2.2 Harmonized European Standards

The two Standards Organizations CEN (Comité Européen de Normalisation) and CENELEC (Comité Européen de Normalisation Électrotechnique), mandated by the EU Commission, drew-up harmonized European standards in order to precisely specify the requirements of the EC directives for a specific product. These standards (EN standards) are published in the official journal of the commission of the European Parliament and Council and must be included without revision in domestic standards. 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 standards 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 standard. However, not every European Standard is harmonized in this sense. Key here is the listing in the official journal of the commission of the European Parliament and Council.

The European Safety of Machines standard is hierarchically structured. It is divided into:

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

Type A standards/basic standards

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

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

Type B standards/group standards

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

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

- Type B1 standards 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 standards 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 standards/product standards

C standards are product-specific standards (e.g. for machine tools, woodworking machines, elevators, packaging machines, printing machines etc.). Product standards cover machine-specific requirements. The requirements can, under certain circumstances, deviate from the basic and group standards. Type C/product standards 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 standards can be applied when the machine is constructed.

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

Standards (http://www.newapproach.org/)

Recommendation: Due to the rapid pace of technical development and the associated changes in machine concepts, the standards (and C standards 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.

10.2.3 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 safety functions failing in a dangerous fashion is sufficiently minimized. The EN ISO 13849-1 and IEC61508 standards 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 standards ensure that the relevant safety requirements of the Machinery Directive are fulfilled.

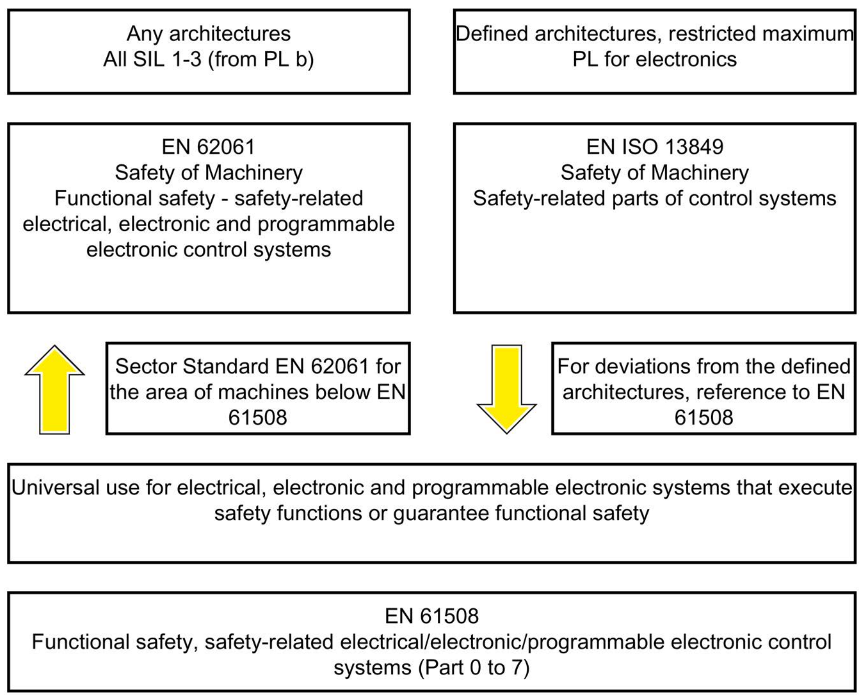


Figure 10-1 Standards for implementing safety-related controllers

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 standards in a joint table in the introduction to the standards. 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.

Further, Standard IEC 61800-5-2 is applicable for variable-speed electric drives with integrated safety functions. IEC 61800-5-2 defines requirements and gives recommendations for designing and developing, integrating and validating safety-related applications regarding their functional safety. IEC 61800-5-2 is applicable for adjustable speed electric power drive systems, which are handled in other parts of IEC 61800 standards.

	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 standards combined with B standards	Restricted to the designated architectures (see comment 1) and max. up to PL = e	X See comment 3
E	C standards combined with B standards	Restricted to the designated architectures (see comment 1) and max. up to PL = d	All architectures and max. up to SIL 3
F	C standards combined with A standards or C standards combined with A standards and B standards	X See comment 2	X See comment 3

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

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.

10.2.4 DIN EN ISO 13849-1

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

DIN EN ISO 13849-1 considers complete safety functions and all the devices required to execute these. With DIN EN ISO 13849-1, safety functions are considered from both a qualitative as well as a quantitative perspective. Performance levels (PL), which are based on specific 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, DIN EN ISO 13849-1 refers to IEC 61508.

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

Note

DIN EN ISO 13849-1 and machinery directive

Since May 2007, DIN EN ISO 13849-1 has been harmonized as part of the Machinery Directive.

10.2.5 EN 62061

EN 62061 (this is identical to IEC 62061) is a sector-specific standard below IEC/EN 61508. It describes the implementation of safety-related electrical control systems of machines and takes into account the complete lifecycle - from the conceptual phase to de-commissioning. 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 the requirements placed on implementing 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 IEC 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:
  Failure rate
- B10 value: For elements that are subject to wear
- T1:
  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:
  Diagnostic test interval
- β:
  Susceptibility to common cause failure
- DC:
  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 IEC 61508 or IEC 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. DIN EN ISO 13849-1 must be applied for non-electric systems.

Note

Function examples

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

Note

EN 62061 and machinery directive

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

10.2.6 Series of standards IEC 61508 (VDE 0803)

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

IEC 61508 is not harmonized in line with any EU directives, 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 IEC 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 particular case, the manufacturer may use IEC 61508. although no presumption of conformity exists here.
- A harmonized European standard (e.g. EN 62061, EN ISO 13849, EN 60204-1) references IEC 61508. This ensures that the appropriate requirements of the directives are fulfilled ("standard that is also applicable"). When manufacturers apply IEC 61508 properly and responsibly in accordance with this reference, they can use the presumption of conformity of the referencing standard.

IEC 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 not part of the standard, similar to DIN ISO 13849.

IEC 61508 has recently been declared the "International Basic Safety Publication", which makes it a framework for other sector-specific standards (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 IEC 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.

10.2.7 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 standards must be applied:

- EN ISO 12100 "Safety of Machinery - General Design Principles - Risk Assessment and Minimizing Risks"
- EN ISO 13849-1 "Safety-related parts of control systems"

EN ISO 12100 focuses on the risks to be analyzed and the design principles for minimizing risk.

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
  - Determines the limits of the machine (EN ISO 12100)
  - Identification of hazards (EN ISO 12100)
  - Estimating the level of risk (EN 1050 Paragraph 7)
- Risk evaluation

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.

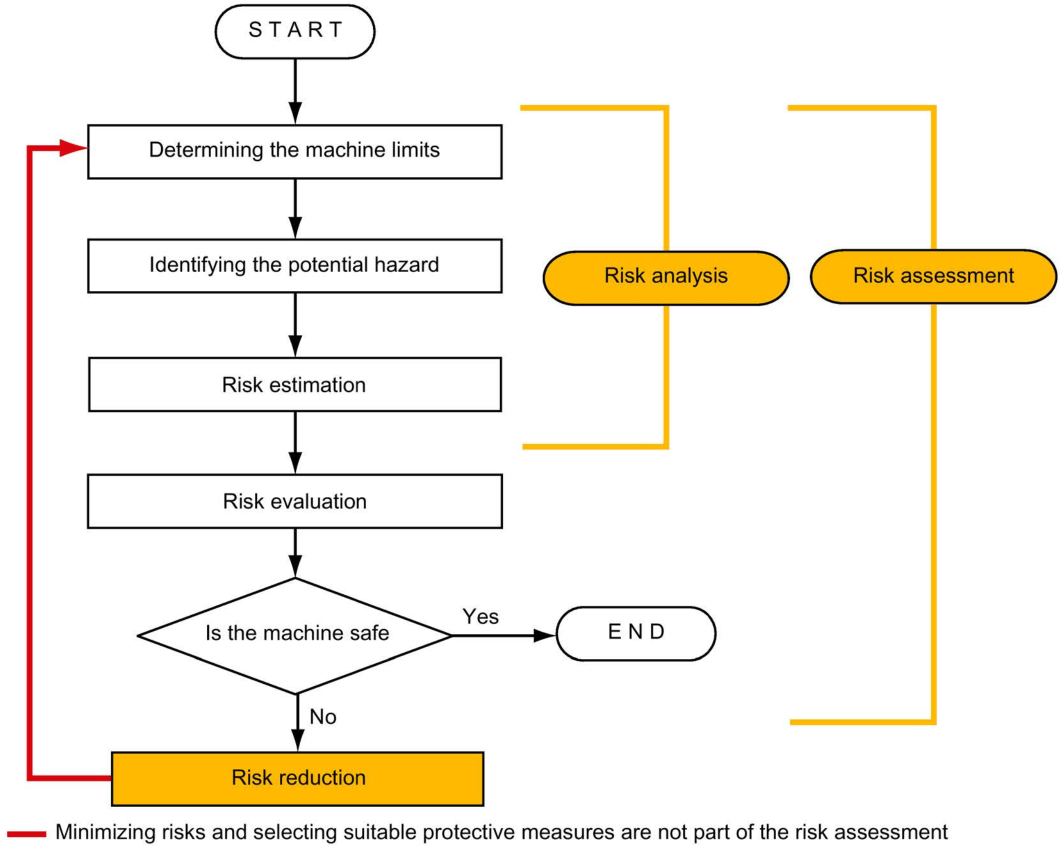


Figure 10-2 Iterative process for achieving safety

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 according to EN ISO 13849-1. For electrical and electronic control systems, EN 62061 can be applied instead of EN ISO 13849-1. Electronic controllers and bus systems must also comply with IEC 61508.

10.2.8 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 must be taken into account, graded according to the magnitude of the risk. 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 flow chart that instead of categories results in hierarchically graduated 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 according to ISO 12100 (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.

10.2.9 Residual risk

In today's technologically advanced world, the concept of safety is relative. The ability to ensure safety to the extent that risk is ruled out in all circumstances – "zero-risk guarantee" – is practically 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).

10.2.10 EC declaration of conformity

The EC Declaration of Conformity for the product can be obtained from your local Siemens office or in the Internet at:

EC declaration of conformity
(https://support.industry.siemens.com/cs/ww/en/view/67385845)

10.3 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.

10.3.1 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.)

OSHA (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.

10.3.2 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 standards (e.g. NFPA 79) and international standards (e.g. IEC/EN 61508 for E/E/PES systems) are the basis for testing.

10.3.3 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). Just the same as 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 in accordance with NFPA 79 9.4.3:

1. Control systems that contain software-based controllers must:
   - In the event of a single fault
     (a) Initiate that the system switches 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 standards 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:

NRGF (http://www.ul.com) → Online Certifications Directory → UL Category code/Guide information → search for category "NRGF"

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

10.3.4 ANSI B11

ANSI B11 standards are joint standards 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. The 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 results of a risk analysis can be used to select a suitable safety system based on the safety class of the application in question.

10.4 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 standards have been defined, an administrative recommendation to apply JIS (Japanese Industrial Standard) is in place. Japan bases its approach on the European concept and uses basic standards as national standards:

Table 10- 1 Japanese standards

ISO/IEC number	JIS number	Comment
ISO12100 (EN 1050)	JIS B 9700, JIS B 9702	Earlier designation TR B 0008 and TR B 0009
ISO13849-1	JIS B 9705-1	-
ISO13849-2	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

10.5 Equipment regulations

In addition to the requirements of the guidelines and standards, company-specific requirements must be taken into account. Large corporations in particular (e.g. automobile manufacturers) make 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.

10.6 Other safety-related issues

10.6.1 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.

Note

These publications are in German. In some instances, they are also available in English and French.

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 Internet address (http://www.bghm.de/) (website is in German, although some of the sheets are available in English):

1. First select the area "Arbeitsschützer", followed by the menu item "Praxishilfen" and finally "DGUV-Informationen".

10.6.2 Additional references

- Safety Integrated, The Safety Program for Industries of the World (5th Edition and Supplement), Article No. 6ZB5 000-0AA01-0BA1
- Safety Integrated - Terms and Standards - Machine Safety Terminology (Edition 04/2007), Article No. E86060-T1813-A101-A1

Appendix A

A.1 Modules available in Startdrive

A list of the hardware and functions of the SINAMICS S120, which are supported by Startdrive V15, are provided in the Service and Support Portal at the following link (https://support.industry.siemens.com/cs/ww/en/view/109761180).

A.2 List of abbreviations

Note

The following list of abbreviations includes all abbreviations and their meanings used in the entire SINAMICS family of drives.

Abbreviation	Source of abbreviation	Meaning
A		
A…	Alarm	Warning
AC	Alternating Current	Alternating current
ADC	Analog Digital Converter	Analog digital converter
AI	Analog Input	Analog input
AIM	Active Interface Module	Active Interface Module
ALM	Active Line Module	Active Line Module
AO	Analog Output	Analog output
AOP	Advanced Operator Panel	Advanced Operator Panel
APC	Advanced Positioning Control	Advanced Positioning Control
AR	Automatic Restart	Automatic restart
ASC	Armature Short-Circuit	Armature short-circuit
ASCII	American Standard Code for Information Interchange	American coding standard for the exchange of information
AS-i	AS-Interface (Actuator Sensor Interface)	AS-Interface (open bus system in automation technology)
ASM	Asynchronmotor	Induction motor
AVS	Active Vibration Suppression	Active load vibration damping
B		
BB	Betriebsbedingung	Operation condition
BERO	-	Contactless proximity switch
BI	Binector Input	Binector input
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit	BG Institute for Occupational Safety and Health
BICO	Binector Connector Technology	Binector connector technology
BLM	Basic Line Module	Basic Line Module
BO	Binector Output	Binector output
BOP	Basic Operator Panel	Basic operator panel
C		
C	Capacitance	Capacitance
C…	-	Safety message
CAN	Controller Area Network	Serial bus system
CBC	Communication Board CAN	Communication Board CAN
CBE	Communication Board Ethernet	PROFINET communication module (Ethernet)

Abbreviation	Source of abbreviation	Meaning
CD	Compact Disc	Compact disc
CDS	Command Data Set	Command data set
CF Card	CompactFlash Card	CompactFlash card
CI	Connector Input	Connector input
CLC	Clearance Control	Clearance control
CNC	Computerized Numerical Control	Computer-supported numerical control
CO	Connector Output	Connector output
CO/BO	Connector Output/Binector Output	Connector/binector output
COB-ID	CAN Object-Identification	CAN Object Identification
CoL	Certificate of License	Certificate of License
COM	Common contact of a change-over relay	Center contact of a change-over contact
COMM	Commissioning	Commissioning
CP	Communication Processor	Communications processor
CPU	Central Processing Unit	Central processing unit
CRC	Cyclic Redundancy Check	Cyclic redundancy check
CSM	Control Supply Module	Control Supply Module
CU	Control Unit	Control Unit
CUA	Control Unit Adapter	Control Unit Adapter
CUD	Control Unit DC	Control Unit DC
D		
DAC	Digital Analog Converter	Digital analog converter
DC	Direct Current	Direct current
DCB	Drive Control Block	Drive Control Block
DCBRK	DC Brake	DC braking
DCC	Drive Control Chart	Drive Control Chart
DCN	Direct Current Negative	Direct current negative
DCP	Direct Current Positive	Direct current positive
DDC	Dynamic Drive Control	Dynamic Drive Control
DDS	Drive Data Set	Drive Data Set
DI	Digital Input	Digital input
DI/DO	Digital Input/Digital Output	Digital input/output, bidirectional
DMC	DRIVE-CLiQ Hub Module Cabinet	DRIVE-CLiQ Hub Module Cabinet
DME	DRIVE-CLiQ Hub Module External	DRIVE-CLiQ Hub Module External
DMM	Double Motor Module	Double Motor Module
DO	Digital Output	Digital output
DO	Drive Object	Drive object
DP	Decentralized Peripherals	Distributed I/O
DPRAM	Dual Ported Random Access Memory	Dual-Port Random Access Memory
DQ	DRIVE-CLiQ	DRIVE-CLiQ
DRAM	Dynamic Random Access Memory	Dynamic Random Access Memory
DRIVE-CLiQ	Drive Component Link with IQ	Drive Component Link with IQ
DSC	Dynamic Servo Control	Dynamic Servo Control

Abbreviation	Source of abbreviation	Meaning
DSM	Doppelsubmodul	Double submodule
DTC	Digital Time Clock	Timer
E		
EASC	External Armature Short-Circuit	External armature short-circuit
EDS	Encoder Data Set	Encoder data set
EEPROM	Electrically Erasable Programmable Read-Only Memory	Electrically Erasable Programmable Read-Only Memory
EGB	Elektrostatisch gefährdete Baugruppen	Electrostatic sensitive devices
EIP	EtherNet/IP	EtherNet Industrial Protocol (real-time Ethernet)
ELCB	Earth Leakage Circuit Breaker	Residual current operated circuit breaker
ELP	Earth Leakage Protection	Ground-fault monitoring
EMC	Electromagnetic Compatibility	Electromagnetic compatibility
EMF	Electromotive Force	Electromotive force
EMK	Elektromotorische Kraft	Electromotive force
EMV	Elektromagnetische Verträglichkeit	Electromagnetic compatibility
EN	Europäische Norm	European standard
EnDat	Encoder-Data-Interface	Encoder interface
EP	Enable Pulses	Pulse enable
EPOS	Einfachpositionierer	Basic positioner
ES	Engineering System	Engineering system
ESB	Ersatzschaltbild	Equivalent circuit diagram
ESD	Electrostatic Sensitive Devices	Electrostatic sensitive devices
ESM	Essential Service Mode	Essential service mode
ESR	Extended Stop and Retract	Extended stop and retract
F		
F…	Fault	Fault
FAQ	Frequently Asked Questions	Frequently Asked Questions
FBLOCKS	Free Blocks	Free function blocks
FCC	Function Control Chart	Function control chart
FCC	Flux Current Control	Flux current control
FD	Function Diagram	Function diagram
F-DI	Failsafe Digital Input	Fail-safe digital input
F-DO	Failsafe Digital Output	Fail-safe digital output
FEPROM	Flash-EPROM	Non-volatile write and read memory
FG	Function Generator	Function generator
FI	-	Fault current
FOC	Fiber-Optic Cable	Fiber-optic cable
FP	Funktionsplan	Function diagram
FPGA	Field Programmable Gate Array	Field Programmable Gate Array
FW	Firmware	Firmware
G		
GB	Gigabyte	Gigabyte

Abbreviation	Source of abbreviation	Meaning
GC	Global Control	Global control telegram (broadcast telegram)
GND	Ground	Reference potential for all signal and operating voltages, usually defined as 0 V (also referred to as M)
GSD	Gerätestammdatei	Generic Station Description: Describes the features of a PROFIBUS slave
GSV	Gate Supply Voltage	Gate supply voltage
GUID	Globally Unique Identifier	Globally Unique Identifier
H		
HF	High frequency	High frequency
HFD	Hochfrequenzdrossel	Radio frequency reactor
HLA	Hydraulic Linear Actuator	Hydraulic linear actuator
HLG	Hochlaufgeber	Ramp-function generator
HM	Hydraulic Module	Hydraulic Module
HMI	Human Machine Interface	Human Machine Interface
HTL	High-Threshold Logic	Logic with high interference threshold
HW	Hardware	Hardware
I		
i. V.	In Vorbereitung	Under development: This property is currently not available
I/O	Input/Output	Input/output
I2C	Inter-Integrated Circuit	Internal serial data bus
IASC	Internal Armature Short-Circuit	Internal armature short-circuit
IBN	Inbetriebnahme	Commissioning
ID	Identifier	Identification
IE	Industrial Ethernet	Industrial Ethernet
IEC	International Electrotechnical Commission	International Electrotechnical Commission
IF	Interface	Interface
IGBT	Insulated Gate Bipolar Transistor	Insulated gate bipolar transistor
IGCT	Integrated Gate-Controlled Thyristor	Semiconductor power switch with integrated control electrode
IL	Impulslöschung	Pulse suppression
IP	Internet Protocol	Internet Protocol
IPO	Interpolator	Interpolator
IT	Isolé Terre	Non-grounded three-phase line supply
IVP	Internal Voltage Protection	Internal voltage protection
J		
JOG	Jogging	Jogging
K		
KDV	Kreuzweiser Datenvergleich	Data cross-check
KHP	Know-how protection	Know-how protection
KIP	Kinetische Pufferung	Kinetic buffering
Kp	-	Proportional gain

Abbreviation	Source of abbreviation	Meaning
KTY84-130	-	Temperature sensor
L		
L	-	Symbol for inductance
LED	Light Emitting Diode	Light emitting diode
LIN	Linearmotor	Linear motor
LR	Lageregler	Position controller
LSB	Least Significant Bit	Least significant bit
LSC	Line-Side Converter	Line-side converter
LSS	Line-Side Switch	Line-side switch
LU	Length Unit	Length unit
LWL	Lichtwellenleiter	Fiber-optic cable
M		
M	-	Symbol for torque
M	Masse	Reference potential for all signal and operating voltages, usually defined as 0 V (also referred to as GND)
MB	Megabyte	Megabyte
MCC	Motion Control Chart	Motion Control Chart
MDI	Manual Data Input	Manual data input
MDS	Motor Data Set	Motor data set
MLFB	Maschinenlesbare Fabrikatebezeichnung	Machine-readable product code
MM	Motor Module	Motor Module
MMC	Man-Machine Communication	Man-machine communication
MMC	Micro Memory Card	Micro memory card
MSB	Most Significant Bit	Most significant bit
MSC	Motor-Side Converter	Motor-side converter
MSCY_C1	Master Slave Cycle Class 1	Cyclic communication between master (class 1) and slave
MSR	Motorstromrichter	Motor-side converter
MT	Messtaster	Probe
N		
N. C.	Not Connected	Not connected
N…	No Report	No report or internal message
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regel-technik in der chemischen Industrie	Standardization association for measurement and control in chemical industries
NC	Normally Closed (contact)	NC contact
NC	Numerical Control	Numerical control
NEMA	National Electrical Manufacturers Association	Standardization association in USA (United States of America)
NM	Nullmarke	Zero mark
NO	Normally Open (contact)	NO contact
NSR	Netzstromrichter	Line-side converter
NTP	Network Time Protocol	Standard for synchronization of the time of day

Abbreviation	Source of abbreviation	Meaning
NVRAM	Non-Volatile Random Access Memory	Non-volatile read/write memory
O		
OA	Open Architecture	Software component which provides additional functions for the SINAMICS drive system
OAIF	Open Architecture Interface	Version of the SINAMICS firmware as of which the OA application can be used
OASP	Open Architecture Support Package	Expands the commissioning tool by the corre-sponding OA application
OC	Operating Condition	Operation condition
OCC	One Cable Connection	One-cable technology
OEM	Original Equipment Manufacturer	Original equipment manufacturer
OLP	Optical Link Plug	Bus connector for fiber-optic cable
OMI	Option Module Interface	Option Module Interface
P		
p…	-	Adjustable parameters
P1	Processor 1	CPU 1
P2	Processor 2	CPU 2
PB	PROFIBUS	PROFIBUS
PcCtrl	PC Control	Master control
PD	PROFIdrive	PROFIdrive
PDC	Precision Drive Control	Precision Drive Control
PDS	Power unit Data Set	Power unit data set
PDS	Power Drive System	Drive system
PE	Protective Earth	Protective ground
PELV	Protective Extra Low Voltage	Safety extra-low voltage
PFH	Probability of dangerous failure per hour	Probability of dangerous failure per hour
PG	Programmiergerät	Programming device
PI	Proportional Integral	Proportional integral
PID	Proportional Integral Differential	Proportional integral differential
PLC	Programmable Logical Controller	Programmable logic controller
PLL	Phase-Locked Loop	Phase-locked loop
PM	Power Module	Power Module
PMI	Power Module Interface	Power Module Interface
PMSM	Permanent-magnet synchronous motor	Permanent-magnet synchronous motor
PN	PROFINET	PROFINET
PNO	PROFIBUS Nutzerorganisation	PROFIBUS user organization
PPI	Point to Point Interface	Point-to-point interface
PRBS	Pseudo Random Binary Signal	White noise
PROFIBUS	Process Field Bus	Serial data bus
PS	Power Supply	Power supply
PSA	Power Stack Adapter	Power Stack Adapter
PT1000	-	Temperature sensor
PTC	Positive Temperature Coefficient	Positive temperature coefficient

Abbreviation	Source of abbreviation	Meaning
PTP	Point To Point	Point-to-point
PWM	Pulse Width Modulation	Pulse width modulation
PZD	Prozessdaten	Process data
Q		
R		
r…	-	Display parameters (read-only)
RAM	Random Access Memory	Memory for reading and writing
RCCB	Residual Current Circuit Breaker	Residual current operated circuit breaker
RCD	Residual Current Device	Residual current device
RCM	Residual Current Monitor	Residual current monitor
REL	Reluctance motor textile	Reluctance motor textile
RESM	Reluctance synchronous motor	Synchronous reluctance motor
RFG	Ramp-Function Generator	Ramp-function generator
RJ45	Registered Jack 45	Term for an 8-pin socket system for data transmission with shielded or non-shielded multi-wire copper cables
RKA	Rückkühlanlage	Cooling unit
RLM	Renewable Line Module	Renewable Line Module
RO	Read Only	Read only
ROM	Read-Only Memory	Read-only memory
RPDO	Receive Process Data Object	Receive Process Data Object
RS232	Recommended Standard 232	Interface standard for cable-connected serial data transmission between a sender and receiver (also known as EIA232)
RS485	Recommended Standard 485	Interface standard for a cable-connected differential, parallel, and/or serial bus system (data transmission between a number of senders and receivers, also known as EIA485)
RTC	Real Time Clock	Real-time clock
RZA	Raumzeigerapproximation	Space-vector approximation
S		
S1	-	Continuous operation
S3	-	Intermittent duty
SAM	Safe Acceleration Monitor	Safe acceleration monitoring
SBC	Safe Brake Control	Safe brake control
SBH	Sicherer Betriebshalt	Safe operating stop
SBR	Safe Brake Ramp	Safe brake ramp monitoring
SBT	Safe Brake Test	Safe brake test
SCA	Safe Cam	Safe cam
SCC	Safety Control Channel	Safety Control Channel
SCSE	Single Channel Safety Encoder	Single-channel safety encoder
SD Card	SecureDigital Card	Secure digital memory card
SDC	Standard Drive Control	Standard Drive Control
SDI	Safe Direction	Safe motion direction

Abbreviation	Source of abbreviation	Meaning
SE	Sicherer Software-Endschalter	Safe software limit switch
SESM	Separately-excited synchronous motor	Separately excited synchronous motor
SG	Sicher reduzierte Geschwindigkeit	Safely limited speed
SGA	Sicherheitsgerichteter Ausgang	Safety-related output
SGE	Sicherheitsgerichteter Eingang	Safety-related input
SH	Sicherer Halt	Safe stop
SI	Safety Integrated	Safety Integrated
SIC	Safety Info Channel	Safety Info Channel
SIL	Safety Integrity Level	Safety Integrity Level
SITOP	-	Siemens power supply system
SLA	Safely-Limited Acceleration	Safely limited acceleration
SLM	Smart Line Module	Smart Line Module
SLP	Safely-Limited Position	Safely Limited Position
SLS	Safely-Limited Speed	Safely limited speed
SLVC	Sensorless Vector Control	Sensorless vector control
SM	Sensor Module	Sensor Module
SMC	Sensor Module Cabinet	Sensor Module Cabinet
SME	Sensor Module External	Sensor Module External
SMI	SINAMICS Sensor Module Integrated	SINAMICS Sensor Module Integrated
SMM	Single Motor Module	Single Motor Module
SN	Sicherer Software-Nocken	Safe software cam
SOS	Safe Operating Stop	Safe operating stop
SP	Service Pack	Service pack
SP	Safe Position	Safe position
SPC	Setpoint Channel	Setpoint channel
SPI	Serial Peripheral Interface	Serial peripheral interface
SPS	Speicherprogrammierbare Steuerung	Programmable logic controller
SS1	Safe Stop 1	Safe Stop 1 (time-monitored, ramp-monitored)
SS1E	Safe Stop 1 External	Safe Stop 1 with external stop
SS2	Safe Stop 2	Safe Stop 2
SS2E	Safe Stop 2 External	Safe Stop 2 with external stop
SSI	Synchronous Serial Interface	Synchronous serial interface
SSL	Secure Sockets Layer	Encryption protocol for secure data transfer (new TLS)
SSM	Safe Speed Monitor	Safe feedback from speed monitor
SSP	SINAMICS Support Package	SINAMICS support package
STO	Safe Torque Off	Safe torque off
STW	Steuerwort	Control word
T		
TB	Terminal Board	Terminal Board

Abbreviation	Source of abbreviation	Meaning
TEC	Technology Extension	Software component which is installed as an additional technology package and which expands the functionality of SINAMICS (previously OA application)
TIA	Totally Integrated Automation	Totally Integrated Automation
TLS	Transport Layer Security	Encryption protocol for secure data transfer (previously SSL)
TM	Terminal Module	Terminal Module
TN	Terre Neutre	Grounded three-phase line supply
Tn	-	Integral time
TPDO	Transmit Process Data Object	Transmit Process Data Object
TSN	Time-Sensitive Networking	Time-Sensitive Networking
TT	Terre Terre	Grounded three-phase line supply
TTL	Transistor-Transistor-Logic	Transistor-transistor logic
Tv	-	Rate time
U		
UL	Underwriters Laboratories Inc.	Underwriters Laboratories Inc.
UPS	Uninterruptible Power Supply	Uninterruptible power supply
USV	Unterbrechungsfreie Stromversorgung	Uninterruptible power supply
UTC	Universal Time Coordinated	Universal time coordinated
V		
VC	Vector Control	Vector control
Vdc	-	DC link voltage
VdcN	-	Partial DC link voltage negative
VdcP	-	Partial DC link voltage positive
VDE	Verband Deutscher Elektrotechniker	Verband Deutscher Elektrotechniker [Association of German Electrical Engineers]
VDI	Verein Deutscher Ingenieure	Verein Deutscher Ingenieure [Association of German Engineers]
VPM	Voltage Protection Module	Voltage Protection Module
Vpp	Volt peak to peak	Volt peak to peak
VSM	Voltage Sensing Module	Voltage Sensing Module
W		
WEA	Wiedereinschaltautomatik	Automatic restart
WZM	Werkzeugmaschine	Machine tool
X		
XML	Extensible Markup Language	Extensible markup language (standard language for Web publishing and document management)
Y		
Z		
ZK	Zwischenkreis	DC link
ZM	Zero Mark	Zero mark
ZSW	Zustandswort	Status word

A.3 Documentation overview

General documentation/catalogs			
SINAMICS	G110	D 11	- Converter Built-In Units 0.12 kW to 3 kW
	G120	D 31	- SINAMICS Converters for Single-Axis Drives and SIMOTICS Motors
	G130, G150	D 11	- Converter Built-In Units - Converter Cabinet Units
	S120, S150	D 21	- SINAMICS S120 Chassis Built-In Units and Cabinet Modules - SINAMICS S150 Converter Cabinet Units
	S120	D 21.4	- SINAMICS S120 and SIMOTICS
Manufacturer/service documentation			
SINAMICS	G110		- Getting Started - Operating Instructions - List Manuals
	G120		- Getting Started - Operating Instructions - Hardware Installation Manuals - Safety Integrated Function Manual - List Manuals
	G130		- Operating Instructions - List Manual
	G150		- Operating Instructions - List Manual
	GM150, SM120/SM150, GL150, SL150		- Operating Instructions - List Manuals
	S110		- Equipment Manual - Getting Started - Function Manual - List Manual
	S120		- Getting Started - Commissioning Manual - Function Manual Drive Functions - Function Manual Communication (from firmware V5.2) - Safety Integrated Function Manual - DCC Function Manual - List Manual - Equipment Manual for Control Units and Additional System Components - Equipment Manual for Booksize Power Units - Equipment Manual for Booksize Power Units C/D Type - Equipment Manual for Chassis Air-Cooled Power Units - Equipment Manual for Chassis Power Units, Liquid-cooled - Equipment Manual for Chassis Water-Cooled Power Units for Common Cooling Circuits - Equipment Manual Combi - Equipment Manual for Cabinet Modules - Equipment Manual for AC Drives - SINAMICS S120M Equipment Manual Distributed Drive Technology - SINAMICS HLA System Manual Hydraulic Drives
	S150		- Operating Instructions - List Manual
Motors			- Configuration Manuals, Motors
General			- Configuration Manual, EMC Guideline

A.4 Change history

Significant changes with respect to the Manual, Edition 11/2017

New functions in Firmware V5.2	See Chapter
Acceptance test wizard in Startdrive	Acceptance test with Startdrive (Page 344)
Safe Stop 2 Extended Stop and Retract	Safe Stop 2 Extended Stop and Retract (SS2ESR) (Page 109)
Commissioning with Startdrive	• Taken into account at many locations in the manual. • Modules available in Startdrive (Page 403)

Revised/supplementary descriptions	See Chapter
Acceptance test suggestions removed	Former Chapter A.4

Note

An overview of the availability of hardware components and software functions is provided in the appendix of the following literature:

- SINAMICS S120 Function Manual Drive Functions

A.5 Stop versions

Safe stops are used to stop a drive and bring it to a standstill. The type of stop response that occurs in the event of faults/errors can either be permanently specified by the system or configured by the machine manufacturer.

In this way, the shutdown of the machine can be optimally adapted to the respective situation.

In the following list, STOP B can be compared to an SS1 and STOP C to an SS2.

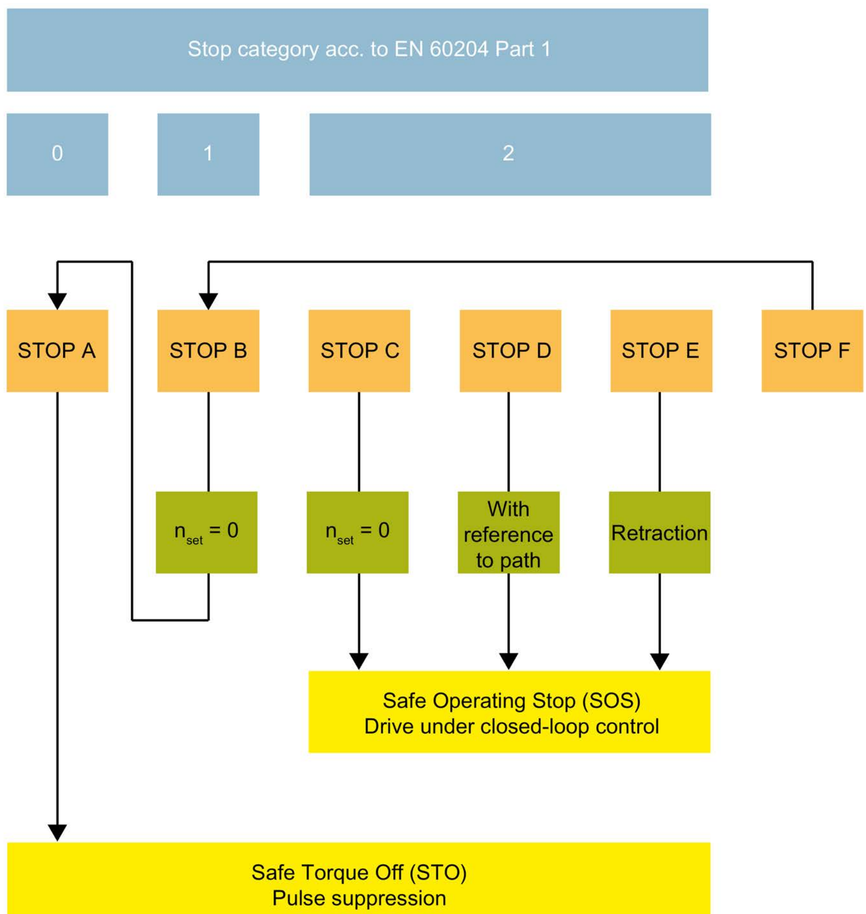


Figure A-1 Overview of the stop versions

STOP A

With STOP A (corresponds to a Stop Category 0 according to EN 60204-1, without electrical isolation), the drive is switched directly to zero torque via the STO function. A drive that is still running coasts to a standstill. A drive at standstill cannot be started again accidentally.

Application:

- E.g. for safety faults

STOP B

The drive is braked at the current limit under speed control and brought to a safe standstill (SOS) (corresponds to a Stop Category 1 according to EN 60204-1, without electrical isolation).

Application

- E.g. when SOS responds

STOP C

The drive is braked at the current limit under speed control and brought to a safe operating stop (corresponds to a Stop Category 2 according to EN 60204-1).

A STOP C followed by a STOP A is normally selected in the case of an emergency stop because this is the quickest way of stopping a drive.

Application:

- Operator protection

STOP D

The drives are braked together in a path-related (interpolatory) way on the contour and brought to a safe operating stop (SOS).

Application:

- Protection for tool and workpiece (machine protection)

STOP E

The drives are braked together, including a jerk motion during which the tool and workpiece are separated from one another, path-related and brought to a safe operating stop.

Application:

- Machine protection

STOP F

The STOP F is permanently assigned to the result and data cross-check and cannot be changed by the user.

If a discrepancy is found in the monitoring channels of Safety Integrated, a STOP F is triggered.

Depending on the parameter assignment, a STOP A or STOP B response is triggered.

Applications:

- Detection of errors during the crosswise data and result comparison
- Detection of communication errors between SINUMERIK and the drive
- Detection of encoder errors

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Further information

Siemens:
www.siemens.com

Industry Online Support (Service and Support):
www.siemens.com/online-support

IndustryMall:
www.siemens.com/industrymall

Siemens AG
Digital Factory
Motion Control
P.O. Box 3180
D-91050 Erlangen
Germany

Scan the QR-Code for product information