Function Manual 07/2007

Safety Integrated

SINAMICS S120

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SINAMICS

S120
Safety Integrated

Function Manual

Applies for:
Firmware Version FW2.5 SP1

(FHS), 07/2007
6SL3097-2AR00-0BP0

Safety Guidelines

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

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

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

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

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

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

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

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Prescribed Usage

Note the following:

⚠WARNING
This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

Trademarks

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Disclaimer of Liability

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

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Automation and Drives
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90327 NÜRNBERG
GERMANY

Order number: 6SL3097-2AR00-0BP0
℗ 08/2007

Preface

SINAMICS documentation

The SINAMICS documentation is organized in 2 parts:

- General documentation / catalogs
- Manufacturer/service documentation

A current overview of the documentation in the available languages is provided in the Internet:

http://www.siemens.com/motioncontrol

Select the menu items "Support" --> "Technical Documentation" --> "Overview of Publications."

The Internet version of DOConCD (DOConWEB) is available on the Internet:

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

Information on the range of training courses and FAQs (Frequently Asked Questions) is available on the Internet:

http://www.siemens.com/motioncontrol

Follow the menu item "Support".

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

Table 1 Usage phases and the available documents/tools

Usage phase	Document/tool
Orientation	SINAMICS S Sales Documentation
Planning/configuration	• SIZER configuration tool • Configuration Manuals, Motors
Decision/ordering	SINAMICS S Catalogs
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 Chassis Power Units • SINAMICS S120 Equipment Manual for AC Drives

Usage phase	Document/tool
Commissioning	• STARTER parameterization and commissioning tool • SINAMICS S120 Getting Started • SINAMICS S120 Commissioning Manual • SINAMICS S120 CANopen Commissioning Manual • SINAMICS S120 Function Manual • SINAMICS S List Manual
Usage/operation	• SINAMICS S120 Commissioning Manual • SINAMICS S List Manual
Maintenance/servicing	• SINAMICS S120 Commissioning Manual • SINAMICS S List Manual
References	• SINAMICS S List Manual

Target group

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

Benefits

The Safety Integrated Function Manual covers all information, procedures and operations required for commissioning safety functions and servicing of SINAMICS S120.

Search guides

The following guides are provided to help you locate information in this manual:

1. Contents
2. List of abbreviations
3. Index

Standard scope

The scope of the functionality described in this document can differ from the scope of the functionality 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 servicing.
- Functions can be described in the documentation that are not available in a particular product version of the drive system. The functionality of the supplied drive system should only be taken from the ordering documentation.
- 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. This documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

Preface FHS_Technical Support

Technical Support

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

European and African time zones

A&D Technical Support

Tel.: +49 (0) 180 5050 - 222
Fax: +49 (0) 180 5050 - 223
Internet: http://www.siemens.de/automation/support-request

America time zone

A&D Technical Support

Tel: +1 423 262 2522
Fax: +1 423 262 2289
Internet: http://www.siemens.de/automation/support-request
Email: techsupport.sea@siemens.com

Asia and Pacific time zones

A&D Technical Support

Tel: +89 1064 719 990
Fax: +86 1064 747 474
Internet: http://www.siemens.de/automation/support-request
Email: adsupport.asia@siemens.com

Note

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

http://www.siemens.com/automation/service&support

Questions on the manual

Please send any questions about the technical documentation (e.g. suggestions for improvement, corrections) to the following fax number or E-Mail address:

Fax: +49 (0) 9131 / 98 - 63315
Email: docu.motioncontrol@siemens.com
Fax form: Refer to the reply form at the end of this manual

Internet address for SINAMICS

http://www.siemens.com/sinamics

Preface FHS_EC Declaration of Conformity

EC Declaration of Conformity

The EC Declaration of Conformity for the EMC Directive can be obtained from:

- Internet

http://www.ad.siemens.de/csinfo
Product/Order no: 15257461

- Branch offices

For the responsible regional offices of the A&D MC business division of Siemens AG.

Notation

The following notation and abbreviations are used in this documentation:

Notation for parameters (examples):

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

Notation for faults and alarms (examples):

- F12345 Fault 12345
- A67890 Alarm 67890

ESD Notes

⚠ CAUTION

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

Regulations for the ESD handling:

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

Electronic components may be touched by persons only when

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

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

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

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

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

Measurements may be made on electronic components when the measuring unit is grounded (e.g. with a protective conductor) or prior to measuring with a potential-free measuring unit, the measuring head is briefly discharged (e.g. by touching a bare metal housing).

Safety instructions

⚠ DANGER

- Commissioning must not start until you have ensured that the machine in which the components described here are to be installed complies with Directive 98/37/EC.
- SINAMICS devices and AC motors must only be commissioned by suitably qualified personnel.
- The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and follow the specified danger and warning notices.
- When electrical equipment and motors are operated, the electrical circuits automatically conduct a dangerous voltage.
- When the machine or system is operated, hazardous axis movements can occur.
- All of the work carried-out on the electrical machine or system must be carried-out with it in a no-voltage condition.
- SINAMICS devices with AC motors must only be connected to the power supply via an AC-DC residual-current-operated device with selective switching once verification has been provided that the SINAMICS device is compatible with the residual-current-operated device in accordance with EN 50178, Chapter 5.2.11.2.

⚠ WARNING

- The successful and safe operation of this equipment and motors is dependent on correct transport, proper storage, installation and mounting as well as careful operator control, service and maintenance.
- For special versions of the drive units and motors, information and data in the Catalogs and quotations additionally apply.
- In addition to the danger and warning information provided in the technical customer documentation, the applicable national, local, and plant-specific regulations and requirements must be taken into account.
- Only protective extra-low voltages (PELV) that comply with EN60204-1 may be connected to all connections and terminals between 0 and 48 V.

⚠ CAUTION

- The motors can have surface temperatures of over +80 °C.
- This is the reason that temperature-sensitive components, e.g. cables or electronic components may neither be in contact nor be attached to the motor.
- When attaching the connecting cables, you must ensure that:
  – they are not damaged
  – they are not under tension
  – they cannot come into contact with any rotating parts

CAUTION

- As part of routine tests, SINAMICS devices with AC motors undergo a voltage test in accordance with EN 50178. Before the voltage test is performed on the electrical equipment of industrial machines to EN 60204-1, Section 19.4, all connectors of SINAMICS equipment must be disconnected/unplugged to prevent the equipment from being damaged.
- Motors should be connected-up according to the circuit diagram provided. otherwise they can be destroyed.

Note

When operated in dry operating areas, SINAMICS equipment with AC motors conforms to Low-Voltage Directive 73/23/EEC.

Table of contents

General information about SINAMICS Safety Integrated

1

1.1 Introduction

Safety Integrated

The "Safety Integrated" functions enable the implementation of highly effective application-oriented functions for man and machine protection. This innovate safety technology offers the following benefits:

- Increased safety
- Increased profitability
- Greater flexibility
- Higher level of plant availability

Standards and Directives

The various standards and directives governing safety technology must be observed. Directives are considered binding to machine manufacturers and operators.

Standards generally reflect the state-of-the-art and act as a basis for implementing safety concepts. Unlike directives, however, they are not binding.

The list below provides a selection of standards and directives in the field of safety technology.

- EC Machinery Directive 98/37/EC

  This directive defines basic protection objectives in the field of safety technology.
- EN 292-1

  Basic terminology and general principles of presentation
- EN 954-1/ISO 13 849-1

  Safety-related parts of control systems
- EN 1050

  Risk assessment
- IEC 60204-1

  Safety of machinery - Electrical equipment of machines - Part 1: Electrical equipment of machinery - General requirements

- IEC 61508

  Functional safety of electrical/electronic/programmable electronic safety-related systems

  This standard defines safety integrity levels (SIL) which not only describe a certain degree of integrity with regard to failsafe software but also defined, quantitative error probability ranges with regard to the hardware.

- IEC 61800-5-2

  Adjustable-speed electrical power drive systems
  Part 5-2: Safety requirements - Functional

Note

In conjunction with certified components, the safety functions of the SINAMICS S120 drive system fulfill the following requirements:

- Category 3 to EN 954-1.
- Safety integrity level 2 (SIL 2) to IEC 61508.

A list of certified components is available on request from your local Siemens office.

1.2 Supported functions

Supported functions:

The functions mentioned here are in compliance with IEC 61800-5-2.

The following Safety Integrated (SI) functions are available:

- Safety Integrated basic functions

  These functions are part of the standard scope of the drive.

  – Safe torque off (STO)

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

    Note

    When a drive object that has Safety Integrated functions released is switched to "Parking" mode, the Safety Integrated software responds by activating STOP without generating a separate message.

  – Safe Stop 1 (SS1, time controlled)

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

  – Safe Brake Control (SBC)

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

SBC is not supported by chassis components. Power Modules Blocksize also require a Safe Brake Relay for this function.

- Safety Integrated extended functions
  - Safe Stop 1 (SS1, time and acceleration controlled)

    The SS1 function is based on the "Safe Torque Off" function. This means that a Category 1 stop in accordance with EN 60204-1 can be implemented.
  - Safe Stop 2 (SS2)

    The SS2 function brakes the motor safely with a subsequent transition to "Safe Operational Stop" (SOS).
  - Safe Operational Stop (SOS)

    "Safe Operational Stop" (SOS) protects against unintentional movements. The drive is in closed-loop control mode and is not disconnected from the power supply.
  - Safely Limited Speed (SLS)

    The "Safely Limited Speed" (SLS) protects against excessively high drive speeds.
  - Safe Speed Monitor (SSM)

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

Prerequisites for the extended functions

- An appropriate license
- Activation via PROFIsafe or TM54F

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

- SINAMICS S120: FW version from 2.5 SP1
- SIMOTION D4x5: FW version from V4.1.1 (SINAMICS S120 with FW version from V2.5 SP1 integrated)
- Safe actual value acquisition (see chapter "Safe actual value acquisition")
- An activated speed controller in the drive
- Overview of hardware components that support the Extended Functions:
  - Control Unit CU310 from order no.: 6SL3040-0LA00-0AA1/6SL3040-0LA01-0AA1
  - Control Unit CU320 from order no.: 6SL3040-...-0AA1 and version C
  - SIMOTION CPU: D4x5 V4.1.1 (SINAMICS S120 with FW V2.5 SP1 integrated)
    D425 from 6AU1 425-0AA00-0AA0 HW release D
    D435 from 6AU1 435-0AA00-0AA1 HW release D
    D445 from 6AU1 445-0AA00-0AA0 HW release B
  - Motor Modules booksize from order no.: ...A3 or higher
  - Power Modules Blocksize
  - Control Unit Adapter 31 from order no.: 6SL3040-0PA00-0AA1

1.3 Parameter, Checksum, Version, Password

Properties of Safety Integrated parameters

The following applies to Safety Integrated parameters:

- They are kept separate for each monitoring channel.
- During startup, a checksum (Cyclic Redundancy Check, CRC) over the safety parameters is generated and checked. The display parameters are not contained in the CRC.
- Data storage: The parameters are stored on the non-volatile CompactFlash card.
- Factory settings for safety parameters

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

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

NOTICE
The following safety parameters are not protected by the safety password: • p9370 SI Motion acceptance test mode (Motor Module) • p9570 SI Motion acceptance test mode (Control Unit) • p9510 SI Motion isochronous PROFIBUS Master • p9533 SI Motion SLS Setpoint speed limitation • p9705 BI: SI Motion Test stop signal source

Checking the checksum

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

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

Basic functions

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

Extended Functions

- r9398[0...1] SI Motion actual checksum SI parameters (Motor Module)
- r9399[0...1] SI Motion specified checksum SI parameters (Motor Module)

- r9728[0...1] SI Motion actual checksum SI parameters
- r9729[0...1] SI Motion specified checksum SI parameters

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

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

Safety Integrated versions

The safety software has a separate version ID for the Control Unit and Motor Module.

For the basic functions

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

For the extended functions

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

⚠ WARNING

From FW2.5 the following applies:

The upgrade/downgrade of DRIVE-CLiQ components is carried out automatically by the system if there is a difference between the firmware version on the components and the components firmware version on the CF card.
This automatic upgrade/downgrade must not be disabled when Safety Integrated is used.

Password

The safety password protects the safety parameters against unauthorized write access.

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

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

  In other words:
  The safety password does not need to be set during initial 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 CF card and in the STARTER project.
  - No safety password is required in the case of spare part installation.

- Change password for the drives
  - p0010 = 95 Commissioning mode
  - p9761 = Enter "old safety password".
  - p9762 = Enter "new password".
  - p9763 = Confirm "new password".
  - The new and confirmed safety password is valid immediately.
- Change password for the TM54F
  - p0010 = 95 Commissioning mode
  - p10061 = Enter "Old TM54F Safety Password" (factory setting "0")
  - p10062 = Enter "new password"
  - p10063 = Acknowledge "new password"
  - The new and acknowledged safety password is valid immediately.

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

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

Parameter overview for password (see SINAMICS S List Manual)

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

1.4 DRIVE-CLiQ rules for Safety Integrated Functions

Note

The Safety Integrated Functions (Basic and Extended Functions) are generally governed by the same DRIVE-CLiQ rules as specified in the chapter "Rules for wiring with DRIVE-CLiQ" in
References: /FH1/ SINAMICS S120 Function Manual.

This specification also lists the exceptions for Safety Integrated components depending on the firmware version.

The following rules are also valid particularly for the Safety Extended Functions:

- Maximum of 5 servo axes with Extended Functions for default cycle time settings (monitoring cycle: 12 ms; application cycle: 125 µs).
- Maximum of 2 vector axes with Extended Functions for default cycle time settings (monitoring cycle: 12 ms; application cycle: 250 µs).
- TM54F may not be connected in series with the Motor Modules.
- Maximum of 4 Motor Modules with Extended Functions in series.

System features

2

2.1 Certification

The safety functions described in this manual were developed in accordance with requirements to IEC 61508, ISO 13849-1 (previously EN 954-1) and IEC 61800-5-2 standards. Certification procedures are in progress at an accredited test institute.

The certificate and the list of certified components can be obtained from your local sales office after inspections have been concluded.

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

Probability of failures

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

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 PHF values can be requested from your local sales office.

2.3 Safety instructions

⚠WARNING

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

The drives of vertical axes must be in torque state.

A complete forced dormant error detection cycle is required after power on (refer to the chapter "Forced dormant error detection").

⚠CAUTION

The "automatic restart" function may not be used in parallel with the safety functions STO/SBC and SS1, as IEC 60204 Part 1 (1998), Chapter 9.2.5.4.2 does not allow this configuration.
(Cancelation of a safety shutdown function should not lead to a machine restart)

⚠WARNING

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

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

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

To observe during power on:

The safety functions are only ready for activation after system startup was successfully completed.

⚠ WARNING

- Encoder faults within a single-encoder system are detected by means of various HW and SW monitoring functions. It is not allowed to disable these monitoring functions and they must be parameterized carefully. Depending on the fault type and on the responding monitoring function, either the Category 0 or the Category 1 stop function to EN 60204-1 is activated (fault reaction function STOP A or STOP B according to Safety Integrated).
- The Category 0 stop function to EN 60204-1 (STO in Safety Integrated) means that the drives are coasted to a stop instead of being braked to zero speed; this may take longer depending on the decay of kinetic energy. This must be included in the logic of the protective door lock, for example, by means of logic operation of SSM (n<nx).
- Safety Integrated is not capable of detecting parameterization errors made by the machine manufacturer. The required safety level can only be reached by by means of an elaborate acceptance test.
- Motor Modules or the motor must be replaced with a device of the same type, as the parameter settings will otherwise lead to incorrect response of Safety Integrated. The corresponding drive must be re-commissioned after an encoder was replaced.

⚠ CAUTION

The automatic FW update by means of p7826 = 1 (upgrade and downgrade) is available as of firmware version FW2.5 and may never be deactivated if Safety Integrated is being used.

NOTICE

It is not allowed to deactivate components at which the safety functions are activated, for example, by means of p0105.

2.4 Residual risk

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

⚠WARNING

- Faults in the absolute track (C-D track), cyclic interchange of the drive phases (V-W-U instead of U-V-W) and reversal of the control direction may cause acceleration of the drive. However, the fault prevents activation of the category 1 and 2 stop functions to IEC 60204-1 (fault reaction functions STOP B to E according to Safety Integrated). The category 0 stop function to IEC 60204-1 (fault reaction function STOP A according to Safety Integrated) is not triggered unless the transition or delay time set in the parameter has expired. These faults are detected (fault reaction function STOP B/C) if SBR is active. The Category 0 stop function to IEC 60204-1 (fault reaction functions STOP A according to Safety Integrated) is activated as early as possible irrespective of this delay. Electrical faults (defective components or similar) may also lead to the response stated above.
- Simultaneous failure of two power transistors (one in the upper and the other offset in the lower inverter bridge) in the inverter may cause brief movement of the drive, depending on the number of poles of the motor.
  Maximum value of this movement:

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

  Synchronous linear motors: max. movement = pole width

⚠WARNING

- 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.
- Mechanical forces greater than the maximum drive torque may force a drive currently operated in position control mode out of the Safe Operational Stop state (SOS) and trigger a category 1 stop function to IEC 60204-1 (fault reaction function STOP B).

⚠ WARNING

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 a static state of the encoder signals (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. Under the aspect of closed-loop control it is conceivable that particularly vertical (suspended) drives move downward and that this movement is not detected.

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

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

In order to exclude the fault described in b), for example:

- An FMEA regarding encoder shaft breakage (or slip of the encoder shaft coupling), and a solution to prevent loose encoder housings, integration of a fault exclusion process to CDV IEC 61800-5-2, or
- Implementation of a two-encoder system (the encoders may not be mounted on the same shaft).

2.5 Response times

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

Table 2-1 Response times with control signals by way of terminals on the Control Unit and Motor Module

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

Control by way of PROFIsafe

Table 2-2 Response times with control by way of PROFIsafe

Function	Standard	Worst case
STO	4 x p9500 + r9780	4 x p9500 + 3 x r9780
SBC	4 x p9500 + 2 x r9780	4 x p9500 + 6 x r9780
SS1 (time and acceleration controlled), SS2 Call Speed limit violated	 4 x p9500 + 2 ms 2 x p9500 + 2 ms	 5 x p9500 + 2 ms 2.5 x p9500 + r9780 + t_DP[1]
SOS position tolerance violated	1.5 x p9500 + 2 ms	3 x p9500 + t_DP[1] + 2 ms
SLS speed limit violated [2]	2 x p9500 + 2 ms	3.5 x p9500 + t_DP[1] + 2 ms
SSM	4 x p9500	4.5 x p9500 + t_DP[1]

Control by way of TM54F

Table 2-3 Response times with control by way of TM54F

Function	Standard	Worst case
STO	2.5 x p9500 + r9780 + 1.5 ms	3 x p9500 + 3 x r9780 + 2 ms
SBC	2.5 x p9500 + 2 x r9780 + 1 ms	3 x p9500 + 6 x r9780 + 2 ms
SS1 (time and acceleration controlled), SS2 Call Speed limit violated	 2.5 x p9500 + 3 ms 2 x p9500 + 2 ms	 4 x p9500 + 4 ms 2.5 x p9500 + r9780 + t_DP[1]
SOS position tolerance violated	1.5 x p9500 + 2 ms	3 x p9500 + t_DP[1] + 2 ms
SLS speed limit violated [2]	2 x p9500 + 2 ms	3.5 x p9500 + t_DP[1] + 2 ms
SSM	3 x p9500	3.5 x p9500 + t_DP[1]

Information on the tables:

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

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

Basic Functions 3

Note

The Basic Functions are also described in the following manual:

Reference: /FH1/SINAMICS S120 Function Manual Drive Functions

3.1 Safe Torque Off (STO)

General description

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

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

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

Functional features of "Safe Torque Off"

- This function is integrated in the drive; this means that a higher-level controller is not required.
- The function is drive specific, that is, it must be commissioned individually on a drive-by-drive basis.
- Enable of the function using parameters required
- When the "Safe Torque Off" function is selected:
  - The motor cannot be started accidentally.
  - The pulse disable safely disconnects the torque-generating motor power supply.
  - The power unit and motor are not electrically isolated.

⚠ WARNING

Appropriate measures must be taken to ensure that the motor does not move once the motor power supply has been disconnected ("coast down") (e.g. enable the "Safe Brake Control" function with a vertical axis).

⚠ CAUTION
If two power transistors in the power unit (one in the upper and one offset in the lower inverter bridge) fail at the same time, this can cause a momentary movement. The maximum movement can be: Synchronous rotary motors: max. movement = 180° / no. of pole pairs Synchronous linear motors: max. movement = pole width

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

Enabling the "Safe Torque Off (STO)" function

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

NOTICE
It is not possible to activate the control via TM54F and PROFIsafe at the same time.

- STO via terminals:
  - p9601.0 = 1, p9801.0 = 1
- STO via TM54F (only with "Extended Functions" option):
  - p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 0, p9801.3 = 0
- STO via PROFIsafe (only with "Extended Functions" option):
  - p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 1, p9801.3 = 1

Selecting/deselecting "Safe Torque Off"

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

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

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

- Each monitoring channel cancels safe pulse suppression via its switch-off signal path.
- The safety prompt "Apply motor holding brake" is canceled.
- Any pending STOP F or STOP A commands are canceled (see r9772/r9872).

Note

If "Safe Torque Off" is de-selected and selected again through one channel within the time in p9650/p9850, the pulses are canceled but a signal is not output.

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

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

1. Deselect the function in each monitoring channel via the input terminals.
2. Issue drive enable signals.
3. Revoke the closing lockout and switch the drive back on.
   – 1/0 edge at input signal "ON/OFF1" (cancel power-on inhibit)
   – 0/1 edge at input signal "ON/OFF1" (switch on drive)
4. Run the drives again.

Status for "Safe Torque Off"

The status of the "Safe Torque Off (STO)" function is displayed using the following parameters:

Parameter overview (see List Manual)

- r9772 CO/BO: SI status (Control Unit)
- r9872 CO/BO: SI status (Motor Module)
- r9773 CO/BO: SI status (Control Unit + Motor Module)
- r9774 CO/BO: SI status (Safe Torque Off group)

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

Response time with the "Safe Torque Off" function

The following values can be specified for the response times when the function is selected/deselected via input terminals:

- Typical response time

  2 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)
- Max. response time in the event of a fault

  4 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)

Examples, Booksize:

Assumption:

Safety monitoring clock cycle time CU (r9780) = 4 ms and
inputs/outputs sampling time (r0799) = 4 ms

t_{R_typ} = 2 x r9780 (4 ms) + r0799 (4 ms) = 12 ms

t_{R_max} = 4 x r9780 (4 ms) + r0799 (4 ms) = 20 ms

Parameter overview (see List Manual)

- p0799 CU inputs/outputs sampling times
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

3.2 Safe Stop 1 (SS1, time controlled)

General description

The "Safe Stop 1" function can be used to stop the drive in accordance with EN 60204-1, stop category 1. After "Safe Stop 1" has been selected, the drive brakes with the OFF3 ramp (p1135), and after the delay time set in p9652/p9852, changes to the status Safe Torque Off (STO).

CAUTION
When the SS1 (time-controlled) function has been activated through the parameterization of a delay in p9652/p9852, it is no longer possible to select STO via terminals.

Functional features of "Safe Stop 1"

SS1 is activated by p9652 and p9852 (delay time) not equal to "0"

- The function can only be activated in conjunction with "Safe Torque Off".
- When SS1 is selected, the drive is braked along the OFF3 ramp (p1135) and STO/SBC is automatically initiated after the delay time has expired (p9652/p9852).

  After the function has been activated the delay time runs - even if the function is de-selected during this time. In this case, after the delay time has expired, the STO/SBC function is selected and then again de-selected immediately.
- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.

Release of the SS1 function

The function is enabled by entering the delay time in p9652 and p9852.

Prerequisite

The "Safe Torque Off" function must be enabled.

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

The time in p9652/9852 must be dimensioned so that after selection, the drive brakes down to a standstill.

Status for "Safe Stop 1"

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

- r9772 CO/BO: SI status (Control Unit)
- r9773 CO/BO: SI status (Control Unit + Motor Module)
- r9774 CO/BO: SI status (Safe Torque Off group)
- r9872 CO/BO: SI status (Motor Module)

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

Overview of key parameters (see SINAMICS S List Manual)

- see "Safe Torque Off" function
- p1135 OFF3 ramp-down time
- p9652 SI Safe Stop 1 delay time (Control Unit)
- p9852 SI Safe Stop 1 delay time (Motor Module)

3.3 Safe Brake Control (SBC)

Description

Safe brake control is used to activate holding brakes that function according to the standby current principle (e.g. motor holding brake).

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

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

Note

Chassis components do not support this function.

Note

To ensure that this function can be used for Power Modules Blocksize, a Safe Brake Relay must be used (for more information, see the Equipment Manual).

When the Power Module is configured automatically, the Safe Brake Relay is detected and the motor holding brake type is defaulted (p1278 = 0).

⚠ WARNING

"Safe Brake Control" does not detect faults in the brake itself, such as brake winding short-circuit, worn brakes, etc.

If a cable breaks, this is only recognized by the "Safe Brake Control" function when the status changes, i.e. when the brake is applied/released.

Functional features of "Safe Brake Control" (SBC)

- When "Safe Torque Off" is selected or when safety monitors are triggered, "SBC" is performed with safe pulse cancelation.
- Unlike conventional brake control, SBC is executed via p1215 through two channels.
- SBC is executed regardless of the brake control or mode set in p1215. SBC is not recommended, however, when 1215 = 0 or 3.
- The function must be enabled via parameter.
- Each time "Safe Torque Off" is selected, the holding brake is applied immediately with forced dormant error detection.

Enabling the "Safe Brake Control (SBC)" function

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

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

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

Two-channel brake control

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

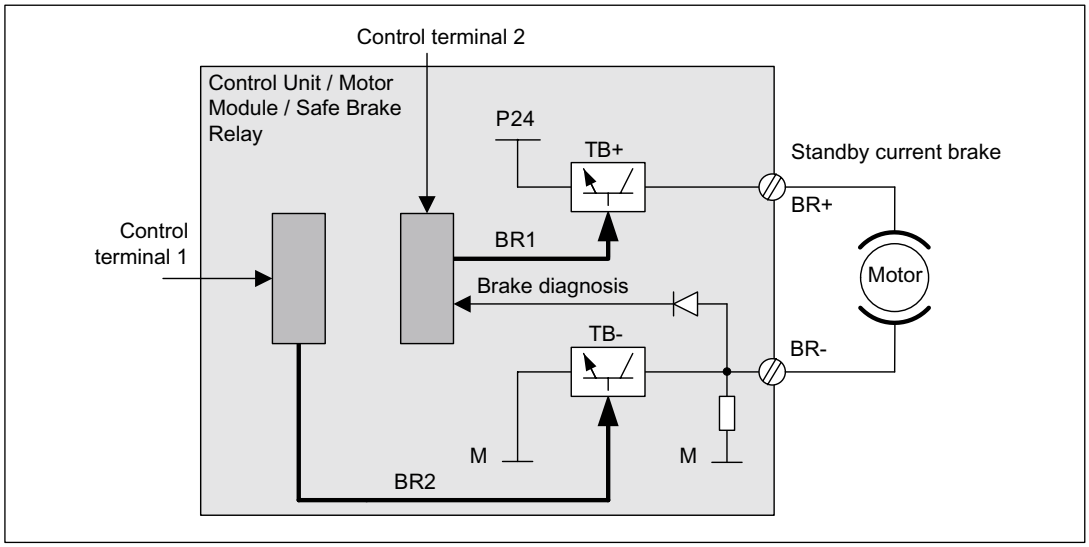


Figure 3-1 Two-channel brake control, booksize

The Motor 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 (when the brake is released or applied).

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

Response time with the "Safe Brake Control" function

The following values can be specified for the response times when the function is selected/deselected via input terminals:

- Typical response time

  4 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)

- Max. response time in the event of a fault

  8 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)

Examples:

Assumption:

Safety monitoring clock cycle time CU (r9780) = 4 ms and inputs/outputs sampling time (r0799) = 4 ms

t_{R_typ} = 4 x r9780 (4 ms) + r0799 (4 ms) = 20 ms

t_{R_max} = 8 x r9780 (4 ms) + r0799 (4 ms) = 36 ms

Parameter overview (see SINAMICS S List Manual)

- p0799 CU inputs/outputs sampling times
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

3.4 Forced dormant error detection

Forced dormant error detection or test for the switch-off signal paths

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

To fulfill the requirements of EN 954-1 regarding timely error detection, the two switch-off signal paths must be tested at least once within a defined time to ensure that they are functioning properly. This functionality must be implemented by means of forced dormant error detection function, triggered either in manual mode or by the automated process.

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

- p9659 SI timer for the forced dormant error detection

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

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

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

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

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

When to carry out forced dormant error detection:

- 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 8 hours).
- In automatic mode (time and event dependent).

NOTICE

The timer of the Basic Functions will be reset if the associated forced dormant error detection is executed and the Extended Functions are used simultaneously. The corresponding alarm of the Basic Functions is not triggered.

Discrepancy is not checked at the terminals used to select the Basic Functions as long as STO is set by the Extended Functions. That is, the test stop of Basic Functions always has to be executed without simultaneous selection of STO or SS1 by the Extended Functions. It is otherwise not possible to verify the correct control through the terminals.

Extended Functions

4

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

General description

The "Safe Stop 1" function can be implemented to stop the drive in accordance with IEC 60204-1, stop category 1. After "Safe Stop 1" is set at the OFF3 ramp (p1135), the drive brakes and changes to the Safe Torque Off (STO) status on expiration of the delay time (p9356/p9556), or after having reached the shutdown speed (p9360/p9560).

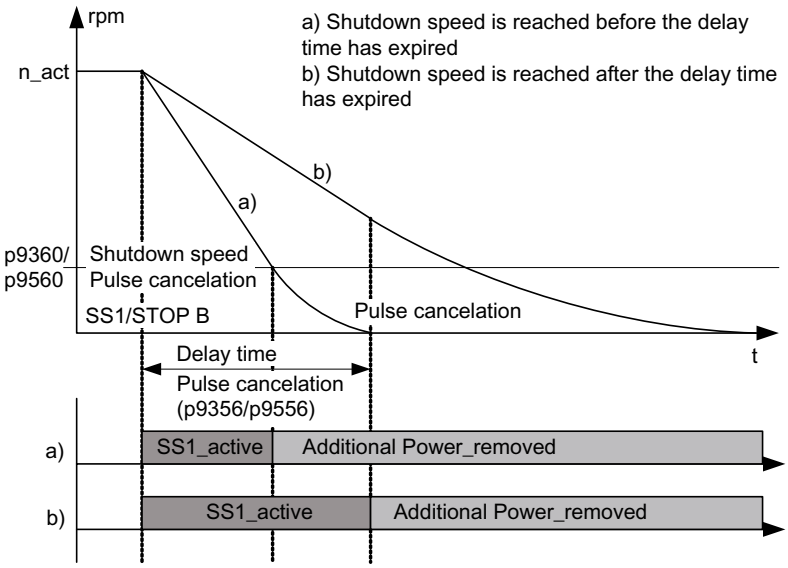


Figure 4-1 Sequence with SS1 selection

Functional features of "Safe Stop 1"

- If SS1 is selected, the drive is brought to a stop along the OFF3 ramp (p1135) and STO/SBC is automatically triggered on expiration of the delay time (p9356/p9556), or after having reached the shutdown speed (p9360/p9560).

  After the function has been activated the delay time runs - even if the function is de-selected during this time. In this case, after the delay time has expired, the STO/SBC function is selected and then again de-selected immediately.

- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.

- The Safe Acceleration Monitor (SBR) function is active in the ramp down phase (refer to the chapter "Safe Acceleration Monitor").

Commissioning

The function is activated by entering the delay time in p9356 and p9556, or the shutdown speed in p9360 and p9560.

In order to enable the deceleration of the drive to a standstill, the time set in p9360/p9560 must be of sufficient length to allow deceleration of the drive by means of the OFF3 ramp (p1135) below the shutdown speed set in p9356/p9556.

The shutdown speed setting in p9356/p9556 must exclude any risk to man and machine as of this speed and with subsequent coasting down by means of pulse inhibit signal.

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

System errors:

1. STOP F with subsequent STOP A
2. Safety message C01711/C30711

Prerequisite

The time set in p9356/9556 must be dimensioned so that after selection, the drive brakes down to a standstill.

Status for "Safe Stop 1"

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

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

Overview of key parameters (see SINAMICS S List Manual)

- p1135 OFF3 ramp-down time
- p9301 SI motion enable safety functions (Motor Module)
- p9501 SI motion enable safety functions (Control Unit)
- p9348 SI motion SBR actual speed tolerance (Motor Module)
- p9548 SI motion SBR actual speed tolerance (Control Unit)
- p9356 SI motion pulse cancelation delay time (Motor Module)
- p9556 SI motion pulse cancelation delay time (Control Unit)
- p9360 SI motion pulse cancelation shutdown speed (Motor Module)

- p9560 SI motion pulse cancelation shutdown speed (Control Unit)
- r9722 CO/BO: SI motion, status signals

4.2 Safe Stop 2 (SS2)

Description

The Safe Stop 2 (SS2) function is used to safely brake down the drive along the OFF3 ramp (p1135), with transition to the SOS state (refer to the chapter Safe Operational Stop) on expiration of the delay time (p9352/p9552). The delay time set must allow for the drive to brake down to a standstill within this time. The standstill tolerance (p9330/p9530) may not be violated after this time.

After the braking operation is completed, the drives remain in speed control mode (speed setpoint n = 0). The drive is not disconnected from hazardous voltage. The default setpoint (e.g from the setpoint channel, or from a higher-level control) remains inhibited as long as SS2 is selected. The Safe Acceleration Monitor (SBR) function is active within the ramp down phase.

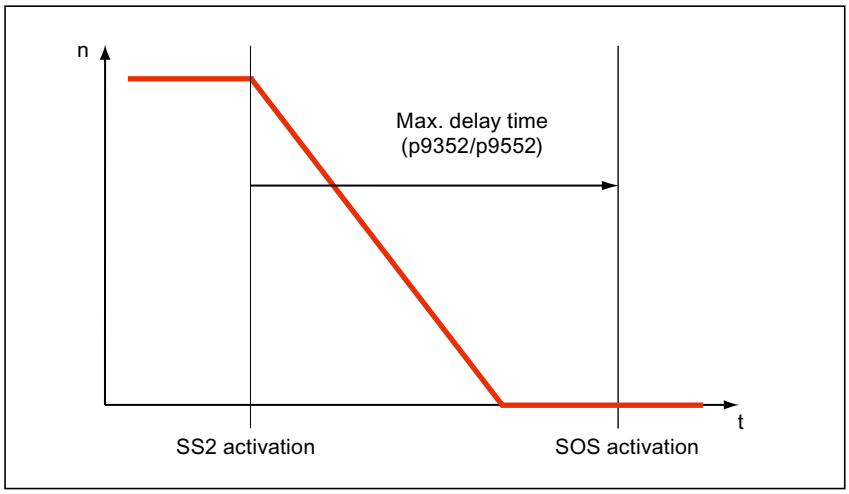


Figure 4-2 Sequence with SS2 selection

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

Standstill tolerance violated in p9330/p9530 (SOS):

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

System errors:

- STOP F with subsequent STOP A

- Safety message C01711/C30711

Overview of important parameters (refer to the List Manual)

- p1135 OFF3 ramp-down time
- p9301 SI motion enable safety functions (Motor Module)
- p9501 SI motion enable safety functions (Control Unit)
- p9330 SI motion standstill tolerance (Motor Module)
- p9530 SI motion standstill tolerance (Control Unit)
- p9348 SI motion SBR actual speed tolerance (Motor Module)
- p9548 SI motion SBR actual speed tolerance (Control Unit)
- p9352 SI motion transition time STOP C to SOS (Motor Module)
- p9552 SI motion transition time STOP C to SOS (Control Unit)
- r9722 CO/BO: SI motion, integrated drive status signals

4.3 Safe Operational Stop (SOS)

Description

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

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

Drive standstill is monitored by means of an SOS tolerance window (p9330 and p9530). The SOS function is activated on expiration of the delay time set in p9351/p9551 after SOS is selected. The drive must be ramped down to a standstill within this delay time. Any delay time is cleared after SOS is canceled and the drive can start up immediately.

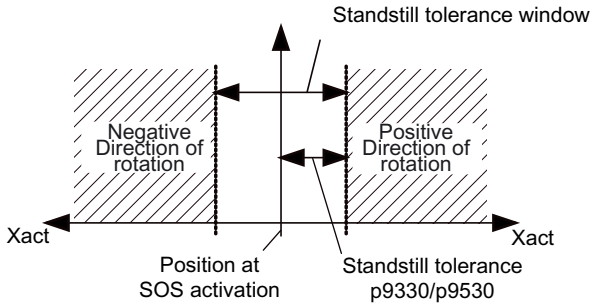


Figure 4-3 Standstill tolerance

Responses

Standstill tolerance violated in p9330/p9530:

- STOP B with subsequent STOP A

- Safety message C01707/C30707

System errors:

- STOP F
- Safety message C01711/C30711

Features

- The drive remains in the closed-loop control mode
- A programmable standstill tolerance window is available
- STOP B is the stop response after SOS has responded

Note

The range of the tolerance window should be oriented on the default standstill monitoring limit and be slightly higher than this limit.

Activation of the default monitoring functions may otherwise not be possible.

Note that safe position monitoring within a single-encoder system only works at a rough resolution (4 x pulses per revolution) (refer to the chapter "Safe actual value acquisition".

Overview of parameters

- p9301 SI motion enable safety functions (Motor Module)
- p9501 SI motion enable safety functions (Control Unit)
- p9330 SI motion standstill tolerance (Motor Module)
- p9530 SI motion standstill tolerance (Control Unit)
- p9351 SI motion SLS changeover delay time (Motor Module)
- p9551 SI motion SLS(SG) changeover delay time (Control Unit)
- r9722 CO/BO: SI motion integrated drive status signals

4.4 Safely Limited Speed (SLS)

Description

The "Safely Limited Speed" (SLS) function is used to protect a drive against unintentional high speed. This is achieved by monitoring the current drive speed up to a switched speed limit.

SLS is used to prevent any unintentional movements outside the valid high limit. Limits must be specified based on results of the risk analysis. It is possible parameterize up to 4 different speed values.

The speed limit is activated after SLS is selected and on expiration of the delay time (p9351/p9531). The drive must be braked down to a speed below the new limit within this

delay time if a lower speed limit is selected. A delay time is not set if a higher speed limit is selected.

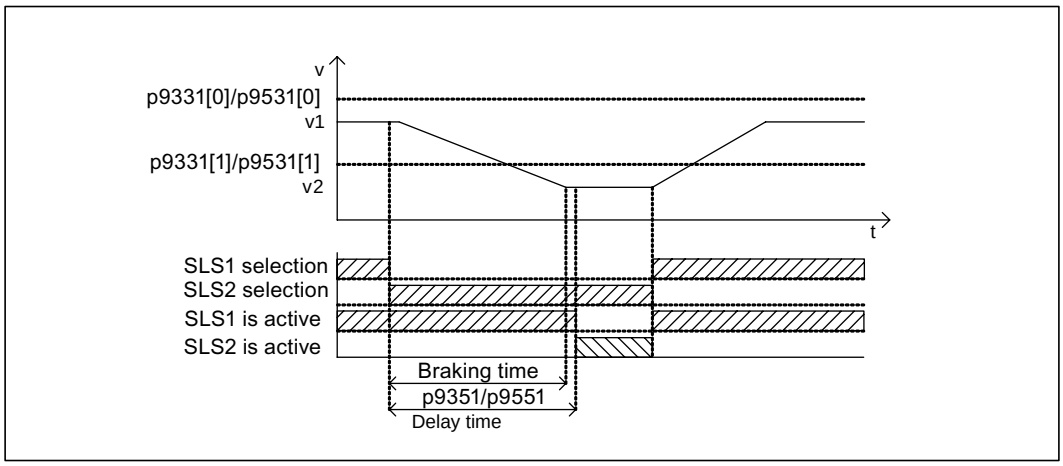


Figure 4-4 Delay time SLS phase changeover

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

By contrast to SI limit parameters, this parameter specifies limits on the motor side instead of limits on the load side.

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

Responses

Speed limit exceeded:

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

System errors:

- STOP F
- Safety messages C01711/C30711

Features

- 4 programmable limits p9331[0...3] and p9531[0...3]
- Programmable stop response by means of p9363/p9563

Changeover of speed limits

The changeover is controlled by means of binary signals from two F-DIs. The speed selection status can be checked at the r9720.9/r9720.10 parameters. Parameters r9722.9 and r9722.10 indicate the actual speed limit, bit r9722.4 must carry a "1" signal.

Table 4-1 Changeover of speed limits:

F-DI for bit 0 (r9720.9)	F-DI for bit 1 (r9729.10)	Speed limit
0	0	p9331**[0]**/p9531**[0]**
0	1	p9331**[1]**/p9531**[1]**
1	0	p9331**[2]**/p9531**[2]**
1	1	p9331**[3]**/p9531**[3]**

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

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

In order to reach the reduced speed that is below the new limit value, the drive must be decelerated accordingly within the delay time. However, if the actual speed is higher than the new limit value and the time has expired, an appropriate alarm with the configured stop response will be generated.

Overview of important parameters (refer to the List Manual)

- p9301.0 SI motion enable safety functions (Motor Module), enable SOD/SLS
- p9501.0 SI motion enable safety functions, enable SOS/SLS
- p9331 SI motion SLS limits (Motor Module)
- p9531 SI motion SLS(SG) limits (Control Unit)
- p9533 SI motion speed setpoint limit (Control Unit)
- p9351 SI motion SLS changeover delay time (Motor Module)
- p9551 SI motion SLS changeover delay time (Control Unit)
- p9363 SI motion stop response SLS (Motor Module)
- p9563 SI motion SLS(SG)-specific stop response (Control Unit)
- r9720 CO/BO: SI motion integrated drive control signals
- r9722 CO/BO: SI motion integrated drive status signals
- r9733 CO: SI motion effective speed setpoint limiting

4.5 Safe Speed Monitor (SSM)

Description

The SSM function is used to safely indicate undershoot of a speed limit (example: for standstill detection) in both rotary directions. A failsafe output signal is available for further processing.

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

NOTICE
The speed limit of the SSM function (p9346/p9546) is also used as shutdown limit for the SBR function (safe acceleration monitoring). The SBR is deactivated if the speed is below this limit. The effect of the SSM safety function is therefore heavily limited if a relatively high SSM/SBR speed limit is set and the SS1 and SS2 stop functions are activated.

Features

- Safe monitoring of the speed limit specified in p9346 and p9546
- Failsafe output signal
- No stop response

Overview of important parameters (refer to the List Manual)

- p9346 SI motion velocity limit n_x (Motor Module)
- p9546 SI motion velocity limit n_x
- r9722 CO/BO: SI motion PROFIsafe status signals

4.6 Safe Acceleration Monitor (SBR)

Description

The "Safe Acceleration Monitor (SBR)" function is used for safe monitoring of acceleration. This safety function is not autarkic and is part of the SS1 (time and acceleration controlled) and SS2 (or STOP B and STOP C) safety functions. A STOP A is generated if any drive acceleration within the ramp-down phase exceeds the tolerance defined in p9348/p9548. The monitoring function is activated after SS1 (or STOP B) and SS2 (or STOP C) are set and is deactivated after the speed drops below the value set in p9346/p9546.

NOTICE

The speed limit set at the SSM function (p9346/p9546) is also used as shutdown limit for the SBR function (safe acceleration monitoring). The SBR is deactivated if the speed is below this limit.

The effect of the SSM safety function is therefore heavily limited if a relatively high SSM/SBR speed limit is set and the SS1 and SS2 stop functions are activated.

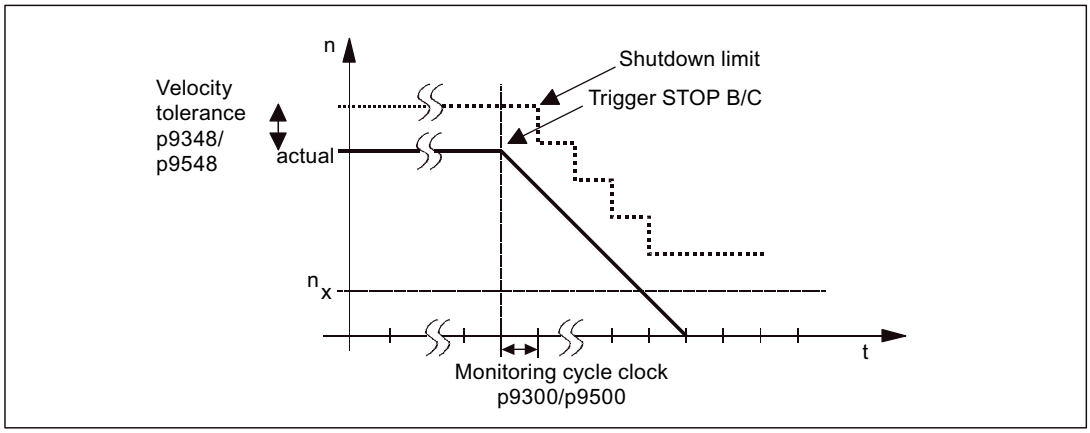


Figure 4-5 Characteristics of the shutdown limit for SBR

Calculating SBR tolerance of the actual speed

The following rules are valid for the parameterization of SBR tolerance:

The maximum speed increase after STOP B/C was triggered is derived from the effective acceleration and the duration of the acceleration phase. The duration of the acceleration phase is equivalent to one monitoring clock cycle (p9300/p9500) MC (delay from detecting a STOP B/C until n_{set} = 0):

SBR tolerance

Actual speed SBR = acceleration * acceleration duration

The following setup rule is derived thereof:

At linear axes:
SBR tolerance [mm/min] = a [m/s^2] * MC [s] * 1000 [mm/m] * 60 [s/min]

At rotary axes:
SBR tolerance [rev/min] = a [rev/s^2] * MC [s] * 60 [s/min]

Recommendation:
The SBR tolerance value entered should be approx. 20% higher than the calculated value.

Responses

Speed limit violated (SBR):

- STOP A
- Safety message C01706/C30706

System errors:

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

Features

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

Overview of important parameters

- p9346 SI motion velocity limit n_x (Motor Module)
- p9560 SI motion velocity limit n_x (Control Unit)
- p9348 SI motion SBR actual speed tolerance (Motor Module)
- p9548 SI motion SBR actual speed tolerance (Control Unit)

4.7 Response to fault/limit value violation

Stop response

Faults in Safety Integrated and violation of limits may trigger the following stop response:

Table 4-2 Stop response overview

Stop response	Action	Effect
STOP A	Immediate pulse cancelation	Drive coasts down
STOP B	Immediate input of speed setpoint = 0 and start of timer t_B STOP A is triggered on expiration of t_B or if $n_{is} < n_{shutdown}$.	The drive brakes down along the OFF3 ramp and then goes into STOP A state
STOP C	Immediate input of speed setpoint = 0 and start of timer t_C SOS is activated on expiration of t_C.	The drive brakes down along the OFF3 ramp, SOS is then activated
STOP D	Timer t_D starts No drive-integrated response SOS is activated on expiration of t_D.	The drive must be braked down by the higher-level control (within the drive group)! SOS is activated on expiration of the time t_D. An automatic response is only triggered if the standstill tolerance window is violated in SOS.

Stop response	Action	Effect
STOP E (in preparation)	(in preparation, current behavior similar to STOP D)	(in preparation, current behavior similar to STOP D)
STOP F	Timer t_{F1} (Basic Functions) or t_{F2} (Extended Functions) No drive response	If a safety function (SOS, SLS) is active, transition to STOP A state on expiration of t_{F1} (Basic Functions), or to STOP B state on expiration of t_{F2} (Extended Functions).

On delays at the stop response transitions

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

Stop response priorities

Table 4-3 Stop response priorities

Priority classes	Stop response
Highest priority	STOP A
.....	STOP B
...	STOP C
..	STOP D
.	STOP E (in preparation)
Lowest priority	STOP F

4.8 Safe actual value acquisition

Supported encoder systems

Safety functions used to monitor movements (e.g. SS2, SOS, SLS and SSM) require safe actual value acquisition. This function is required for safe acquisition of the actual speed.

The following encoder type is supported:

- Optoelectronic encoder with sin/cos signal

Single-encoder system

Encoders within single-encoder systems are used to generate the failsafe actual values of the drive. The safety-relevant actual values are generated either directly in the encoder or in the Sensor Module and are transferred without retroaction to the Control Unit by way of failsafe communication via DRIVE-CLiQ.

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 way of a Sensor Module, or directly via DRIVE–CLiQ.

NOTICE
When specifying the standstill tolerance window, observe that failsafe position monitoring within a single-encoder system only works at a rough resolution with 4 pulses per revolution.

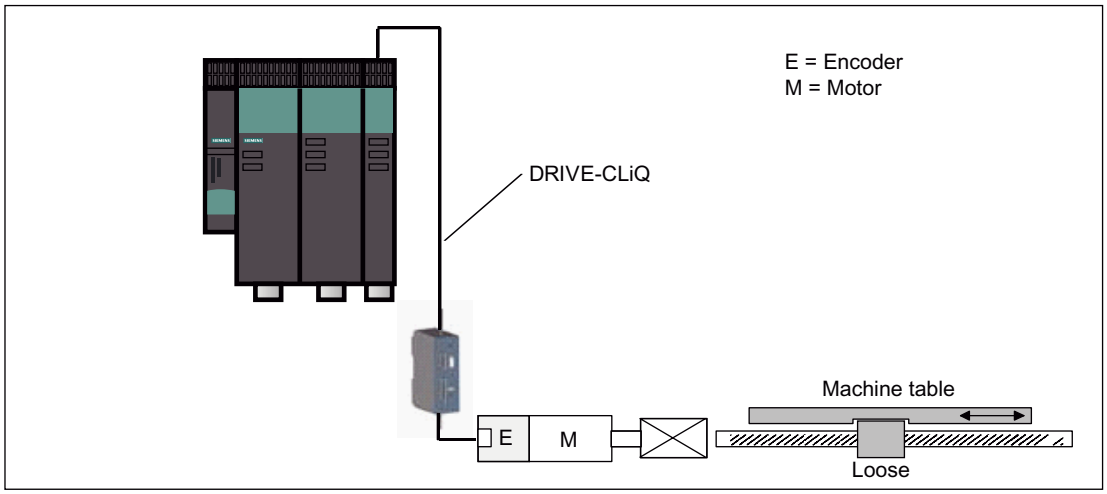


Figure 4-6 Example of a single-encoder system

Two-encoder system

The failsafe actual values for a drive are provided by two separate encoders. The safety-relevant actual values are generated either directly in the encoders or in the Sensor Modules and are transferred without retroaction to the Control Unit by way of failsafe communication via DRIVE-CLiQ. Each measuring system requires a separate connection or a separate Sensor Module.

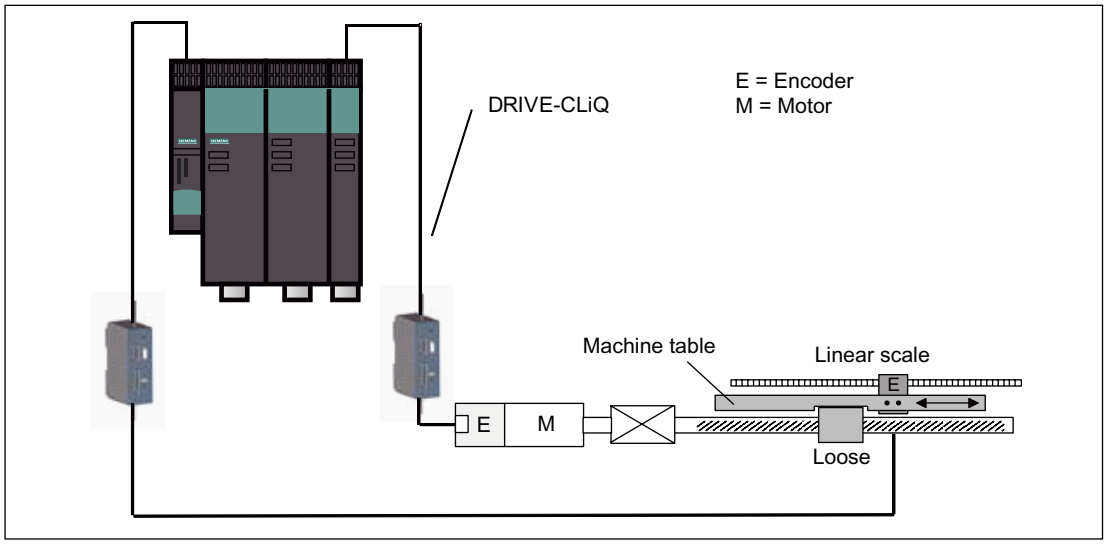


Figure 4-7 Example of a two-encoder system on a linear axis via ball bearing spindle

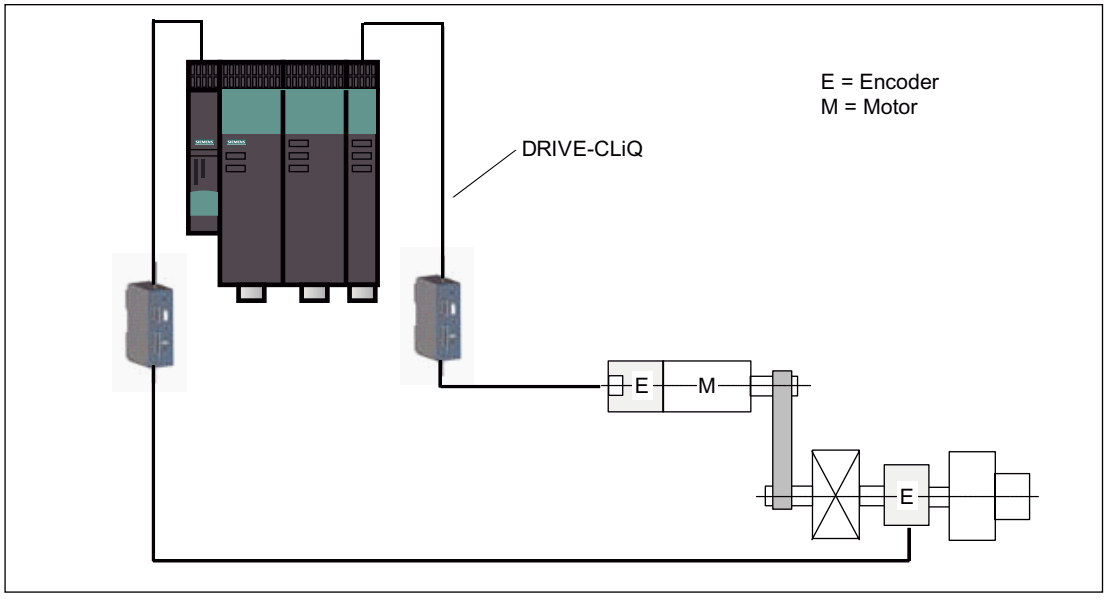


Figure 4-8 Example of a two-encoder system on a rotary axis

Actual value synchronization

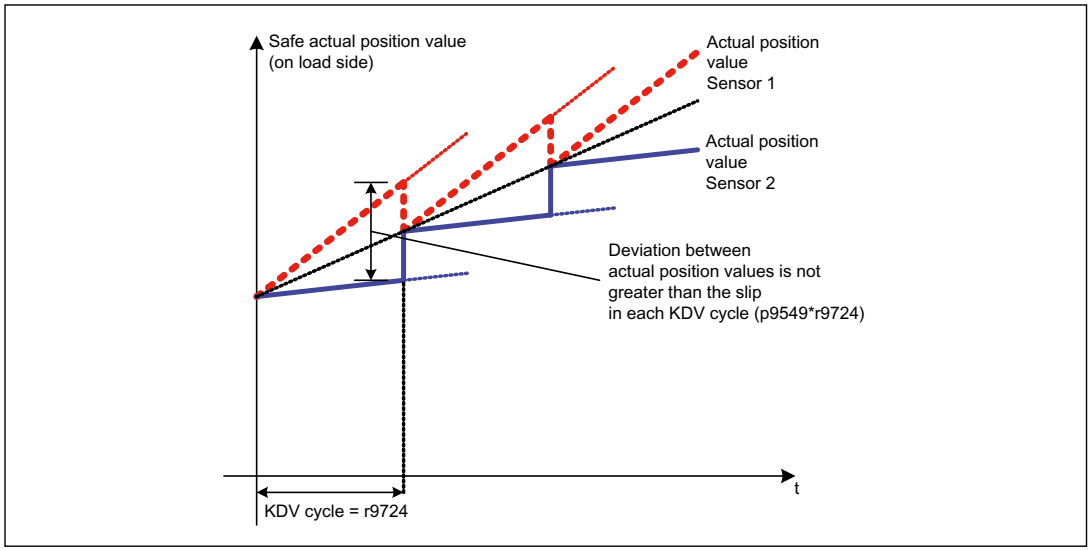


Figure 4-9 Example diagram of actual value synchronization

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

Overview of important parameters (refer to the List Manual)

- p9301.3 SI motion enable safety functions (Motor Module), actual value synchronization
- p9501.3 SI motion enable safety functions (Control Unit), actual value synchronization
- p9302 SI motion axis type (Motor Module)
- p9502 SI motion axis type (Control Unit)
- p9317 SI motion linear scale, grid division (Motor Module)
- p9517 SI motion linear scale, grid division (Control Unit)
- p9318 SI motion encoder pulses per revolution (Motor Module)
- p9518 SI motion encoder pulses per revolution (Control Unit)
- p9319 SI motion fine resolution Gn_XIST1
- p9519 SI motion fine resolution G1_XIST1 (Control Unit)
- p9320 SI motion spindle pitch
- p9520 SI motion spindle pitch (Control Unit)
- p9321[0...7] SI motion gearbox encoder/load denominator (Motor Module)
- p9521[0...7] SI motion gearbox encoder/load denominator (Control Unit)
- p9322[0...7] SI motion gearbox encoder/load numerator (Motor Module)
- p9522[0...7] SI motion gearbox encoder/load numerator (Control Unit)

- p9326 SI motion encoder assignment (Motor Module)
- p9526 SI motion encoder assignment second channel
- p9342 SI motion actual value comparison tolerance (crosswise) (Motor Module)
- p9542 SI motion actual value comparison tolerance (crosswise) (Control Unit)
- p9349 SI motion slip velocity tolerance (Motor Module)
- p9549 SI motion slip velocity tolerance (Control Unit)
- r9713 SI motion diagnostics actual position (MAKSIP)
- r9724 SI motion crosswise comparison clock cycle

4.9 Forced dormant error detection

Forced dormant error detection and function test through test stop

The proper function of the two shutdown signal paths must be tested at least once within a defined time in order to meet requirements as per EN 954-1 in terms of timely fault detection.

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

The test stop cycle is monitored. On expiration of the programmed timer, the alarm A01697: "SI motion: Test of motion monitoring required" is generated and a status bit is set which can be transferred to an output or to a PZD bit via BICO. This alarm does not affect machine operation.

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

- p9559 SI motion forced dormant error detection timer (Control Unit)
- p9705 BI: SI motion test stop signal source
- r9723.0 CO/BO: SI motion PROFIsafe diagnostics signals, dynamic response required

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

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

Examples of when to carry out forced dormant error detection:

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

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

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

In order to be able to utilize the TM54F test stop function, all F-DIs used must be interconnected as shown in the wiring example in the SINAMICS S120 GH1 Equipment Manual. The digital inputs of F-DI 0 to F -DI 4 must be connected to the "L1+" power supply. The digital inputs of F-DI 5 to F -DI 9 must be connected to the "L2+" power supply.

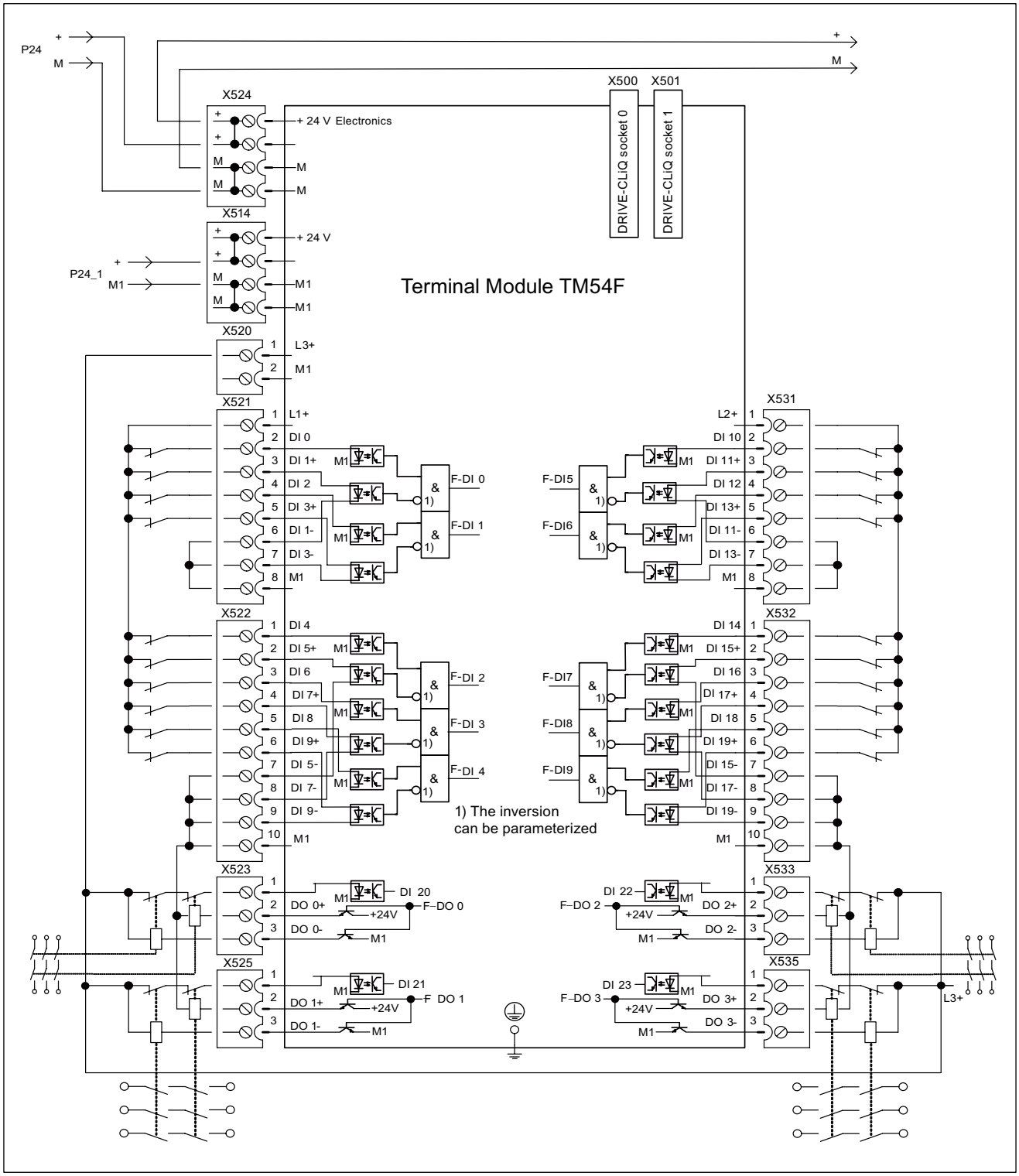


Figure 4-10 Example of the TM54F wiring

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

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

In order to be able to use the test stop function, interconnect the F-DO used in accordance with the example of the wiring in the SINAMICS S120 GH1 Equipment Manual and wire the forced feedback signals of the two relays to the corresponding digital input (DI 20 to DI 23).

The corresponding DIs must be registered for the test stop by means of p10046.

NOTICE
F-DOs which are not registered for evaluation by means of p10046 are set to "0" for the duration of the test stop ("failsafe values"). Maximum test stop period: 19 * p10000 + 2 * 20 ms + 6 * p10001

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

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

The test stop cycle is monitored. On expiration of the programmed timer, the alarm A35014: "TM54F: Test stop required" is output.

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

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

Control of the safety functions 5

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

Description

The failsafe input and output signals (F-DI and F-DO) interface the internal Safety Integrated functionality with the process.

F-DI signals (Failsafe Digital Inputs) control active monitoring of the activation/deactivation of safety functions. This function also depends on the status of sensors (e.g. switches).

F-DO signals (Failsafe Digital Outputs) are feedback information of the safety functions. They are also suitable for the failsafe control of actuators (e.g. line contactor).

Dual-channel processing of I/O signals

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

The following options are available for controlling Safety Integrated functions:

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

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

NOTICE
Each Control Unit must be controlled either by way of PROFIsafe, or by way of TM54F. A mixed mode is not allowed.

5.2 Control via terminals on the Control Unit and the power unit

Features

- Only for the STO, SS1 (time-controlled) and SBC functions
- Dual-channel structure via two digital inputs (Control Unit/power unit)
- Different terminal strips depending on design
- Automatic ANDing of up to 8 digital inputs (p9620[0...7]) on the Control Unit with parallel configuration of chassis type power units

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

	1. Switch-off signal path (p9620[0])	2. Switch-off signal path
Control Unit CU320	X122.1....4 / X132.1...4 (on the CU320) digital input 0 to 7	(see Motor Modules / Power Modules)
Single Motor Module Booksize	(see CU320)	X21.3 and X21.4 (on the Motor Module)
Single Motor Module Chassis	(see CU320)	X41.1 and X41.2 (on the CIB)
Double Motor Module Booksize	(see CU320)	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	(see CU320)	X210.3 and X210.4 (on the CUA31)
Power Module Blocksize with CU310	X121.1...4 (on the CU310) digital input 0 to 3	X120.7 and X120.8 (on the CU310)
Power Module Chassis with CU310	X121.1...4 (on the CU310) digital input 0 to 3	X41.1 and X41.2 (on the CIB)
For further information about the terminals, see the Equipment Manuals.		

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

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

- 1. Switch-off signal path (CU310/CU320)

  The desired input terminal is selected via BICO interconnection (BI: p9620[0]).
- 2. Switch-off signal path (Motor Module/Power Module/CUA31)

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

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

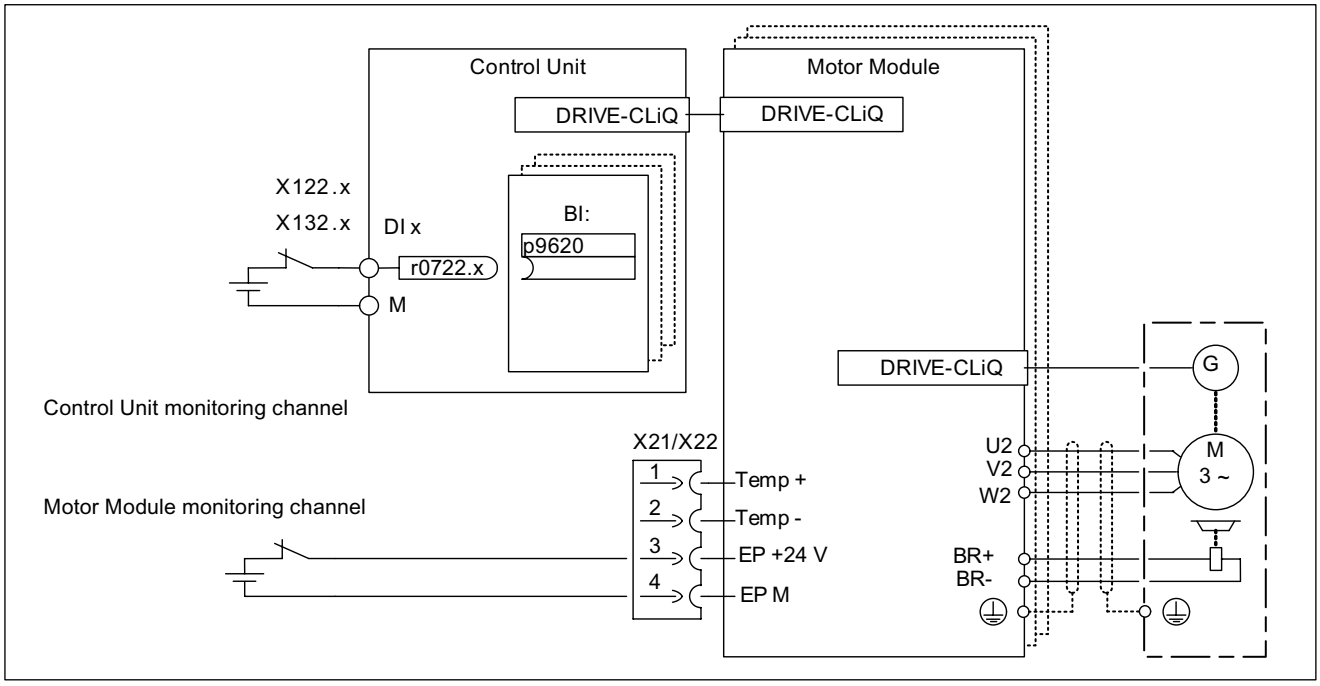


Figure 5-1 Terminals for "Safe Torque Off", example for Motor Modules Booksize and CU320

Grouping drives (not for CU310)

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 (CU320)

  By connecting the binector input to the joint input terminal on the drives in one group.

- 2. Switch-off signal path (Motor Module/CUA31)

  By appropriately connecting-up the terminals for the individual Motor Modules/Power Modules belonging to the group with CUA31.

Note

The grouping must be identical in both monitoring channels.

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

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

Example: Terminal groups

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

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

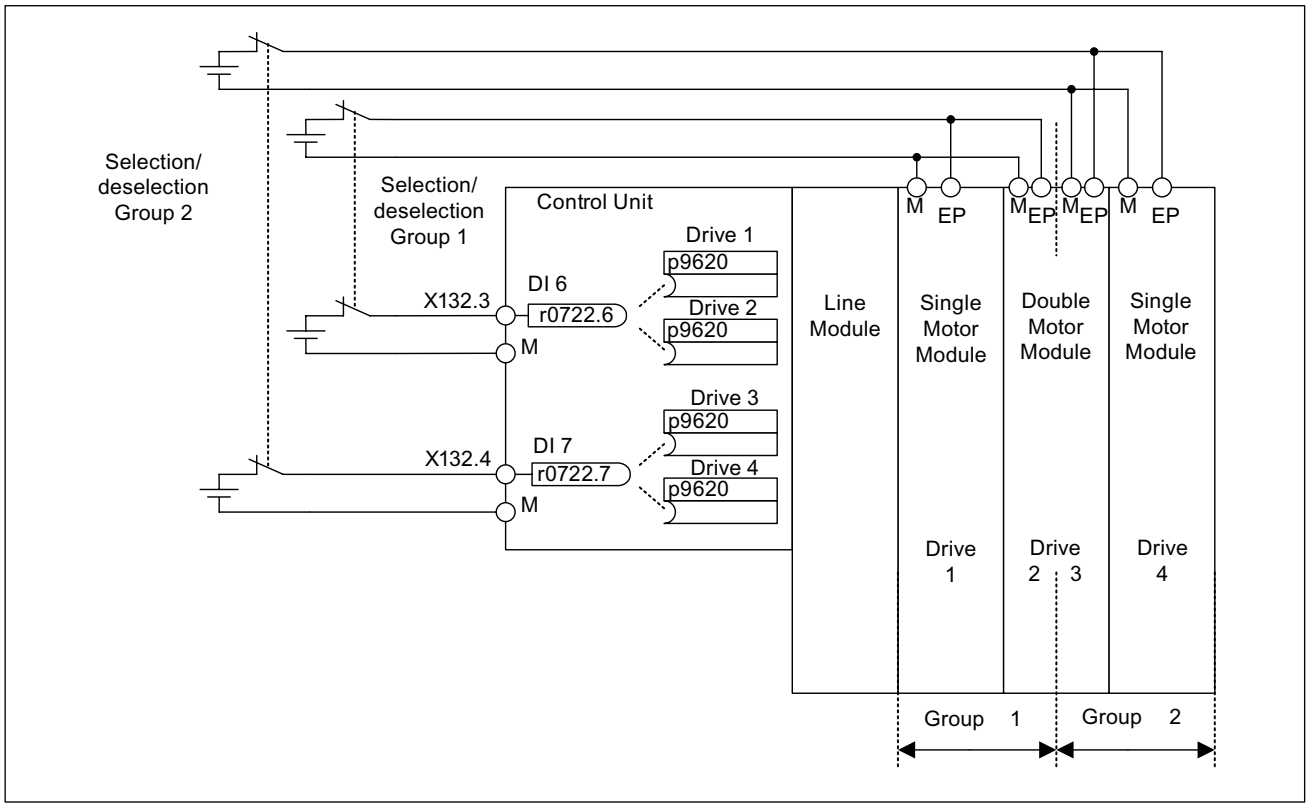


Figure 5-2 Grouping terminals with Motor Modules Booksize and CU320

Information on the parallel connection of chassis type Motor Modules

When Motor Modules of chassis type 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.

Simultaneity and tolerance time of the two monitoring channels

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

1 signal: Deselecting the function

0 signal: Selecting the function

"Simultaneously" means:

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

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

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

5.3 Control by way of TM54F terminals

5.3.1 General information

Description

Terminal Module TM54F is a terminal expansion module for snap-on rail mounting to DIN EN 60715. The TM54F features failsafe digital I/O for controlling the Safety Integrated functions.

Each Control Unit can be assigned only one TM54F which is connected via DRIVE-CLiQ.

NOTICE
The TM54F may not be interconnected in series with the Motor Modules and must be operated on a separate DRIVE-CLiQ segment (separate port on the Control Unit). It is allowed to connect other TMs and Sensor Modules to this SQ segment.

TM54F features the following terminals:

Table 5-2 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 with activated forced dormant error detection	4

[1] Sensors: Failsafe devices for command operations and status logging, for example emergency stop pushbuttons, safety locks, position switches and light arrays / light curtains.

[2] Dynamic response: The sensor power supply is cycled on and off when forced dormant error detection is active for the sensors, cable routing and the evaluation electronics of TM54F.

The TM54F provides 4 failsafe digital outputs and 10 failsafe digital inputs. A failsafe digital output consists of a 24 V DC/M switching output plus a digital input for reading back the switching state. A failsafe digital input consists of two digital inputs.

Note

You have the following options of acknowledging TM54F faults after troubleshooting:

- A rising edge at one of the binector inputs p2103, p2104 or p2105 at the two drive objects TM54F_MA and TM54F_SL.
- Acknowledgment in STARTER
- POWER ON

5.3.2 Overview of the F-DIs

Description

Failsafe digital inputs (F-DI) consist of two digital inputs. The cathode of the optocoupler is routed to the second digital input in order to allow the connection of an M-switching F-DO output (the anode must be wired to 24 V DC).

Parameter p10040 is used to determine whether an F-DI is operated as NC/NC or NC/NO contact. The status of DI can be read at parameter r10051 for the drive objects TM54F_MA and TM54F_SL. The same bits of both drive objects are logically linked by AND operation and return the status of the relevant F-DI.

The signal states at the two associated digital inputs (F-DI) must assume the same status configured in p10040 within the monitoring time set in p10002.

IN order to enable forced dormant error detection, connect the digital inputs of F-DI 0 ... 4 with the dynamic voltage supply L1+ and the digital inputs with F-DI 5 ... 9 to L2+ (for additional information on forced dormant error detection, refer to the corresponding function description in the chapter "Extended Functions").

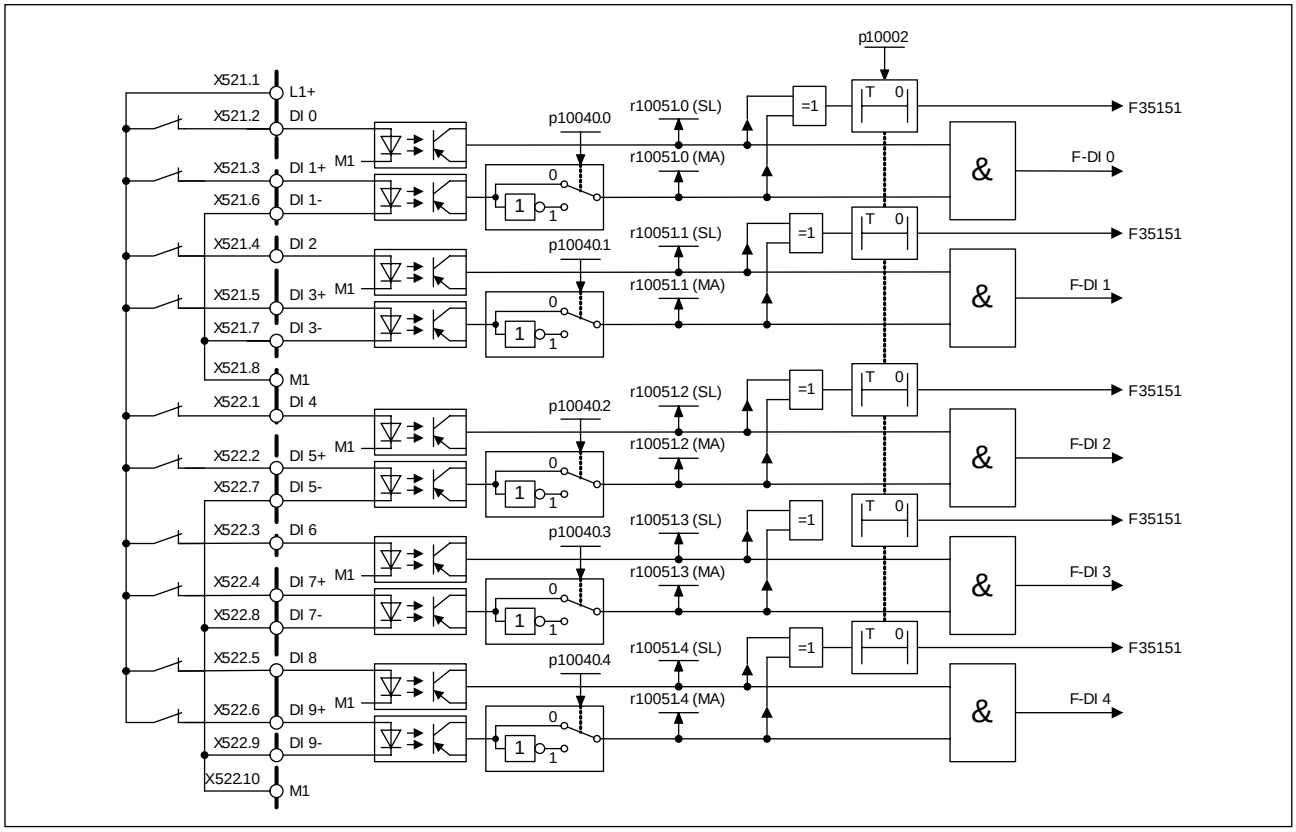


Figure 5-3 Overview of F-DI 0 ... 4

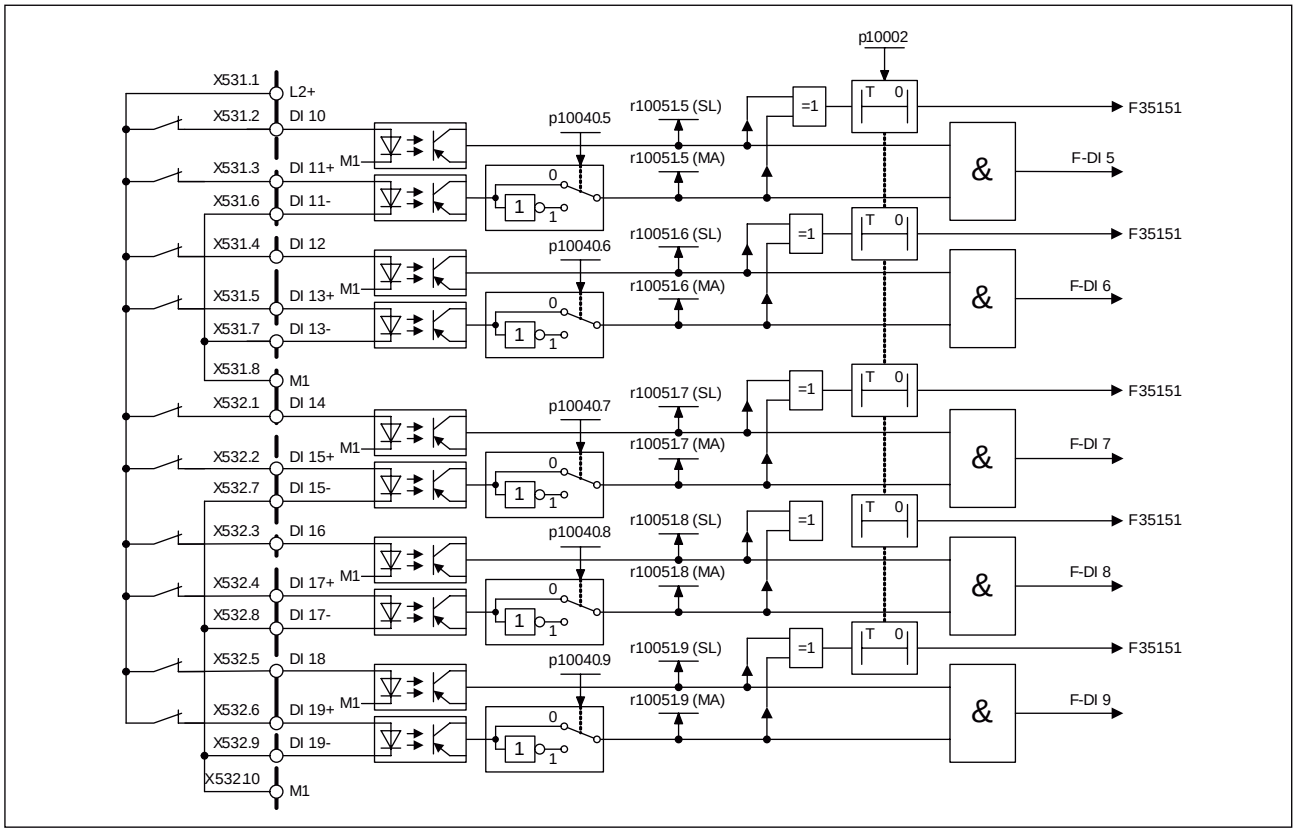


Figure 5-4 Overview of F-DI 5 ... 9

F-DI features

- Failsafe configuration with two digital inputs per F-DI
- 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
- 2. Digital input with additional tap of the optocoupler cathode for connecting an M-switching output of a failsafe controller.

Overview of important parameters (refer to the List Manual)

- p10002 SI discrepancy monitoring time
- p10040 SI F-DI input mode
- r10051 CO/BO: SI status of digital inputs

5.3.3 Overview of the F-DOs

Description

Failsafe digital outputs (F-DO) consist of two digital outputs plus one digital input that checks the switching state for forced dormant error detection. The first digital input switches 24 V DC, and the second switches M of the X514 voltage supply.

The status of each F-DO can be read at parameter r10052. The status of the associated DI can be read at parameter r10053 for the drive objects of the slave (TM54F_SL).

In order to enable forced dormant error detection, connect the corresponding digital input for the forced feedback signals of the relays (for additional information on forced dormant error detection, refer to the corresponding function description in the "Extended Functions" chapter).

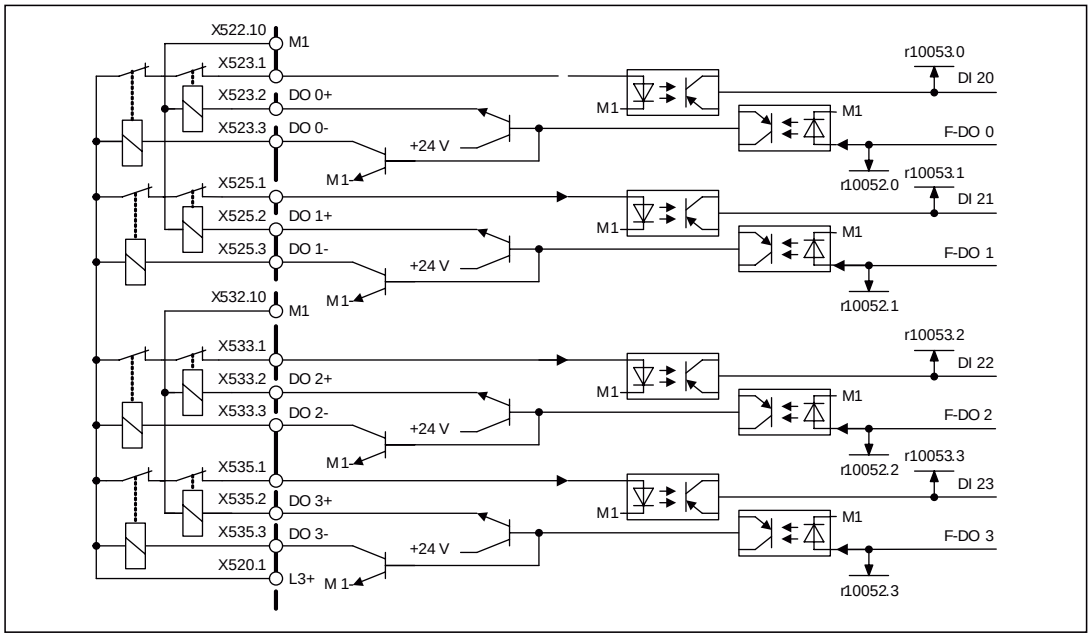


Figure 5-5 F-DO overview (without description of the main contacts of the relays)

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 (p10043) each one of the four drive groups with the F-DO:

- Power removed (STO active)
- SS1 active
- SS2 active
- SOS active
- SLS active

- SSM feedback active
- Safe state

  The following signals can be requested by means of p10039[0...3] for each drive group (index 0 corresponds with drive group 1 etc.):

  – Power removed (STO active)
  – SS1 active
  – SS2 active
  – SOS active
  – SLS active

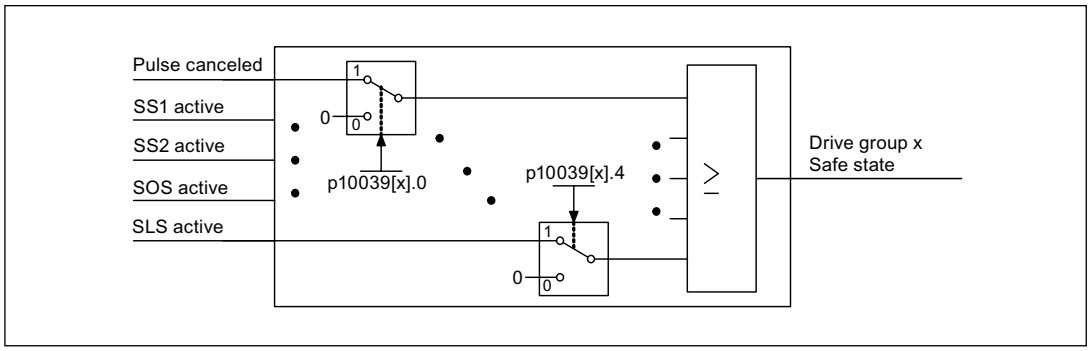


Figure 5-6 Safe state selection

  The same signals (high-active) of each drive or drive group are logically linked by means of AND operation. The different signals selected through p10039 are logically linked by means of OR operation. Result of these logic operations is the "Safe State" for each drive group.

- SOS selected
- Internal event (no active safety fault)

Each F-DO supports the interconnection of up to 6 signals by way of indexing (p10042[0...5] to p10045[0...5]) and their output as logical AND operation.

F-DO features

- Each F-DO with failsafe configuration consisting of two digital outputs plus one digital input for reading back the switching state for forced dormant error detection
- Status parameters r10052/r10053

Function diagrams (refer to List Manual)

- 2853 TM54F (F-DO 0 ... F-DO 3, DI 20 ... DI 23)
- 2856 TM54F Safe State selection
- 2857 TM54F assignment (F-DO 0 ... F-DO 3)

Overview of important parameters (refer to the List Manual)

- p10042[0..5] SI F-DO 0 signal sources
- ...
- p10045[0..5] SI F-DO 3 signal sources
- r10052 CO/BO: SI status of digital outputs
- r10053 CO/BO: SI status of digital inputs 20 ... 23 (only at slave object, TM54F_SL)

5.4 Configuring PROFIsafe

5.4.1 PROFIsafe user data

Introduction

Drives with PROFIsafe configuration in the drive unit represent PROFIsafe slaves (failsafe slave) featuring failsafe PROFIBUS communication with the failsafe host.

The drive unit is equipped with dual-channel PROFIsafe communication functions, that is, with one channel in the Control Unit and one in the Motor Module.

The failsafe values are activated and STO is set immediately if a PROFIsafe communication error is detected.

All parameters used to control PROFIsafe communication are protected against unintentional changes by password and checksum. The telegrams are configured using the configuration tool (e.g. HW Config + F-Configuration Pack) on the failsafe host.

A separate PROFIsafe telegram (PROFIsafe slot) is created for each drive.

Control via PROFIsafe is enabled by setting p9601.3 = p9801.3 = 1.

It is not possible to enable parallel control via TM54F. Control of the Basic Functions via the Control Unit and Motor Module (p9601.0/p9801.0) terminals may be enabled in parallel. This setup allows you to select the STO and SBC functions both on PROFIsafe and by way of the on-board terminals of the Control Unit and Motor Module.

PROFIsafe STW

Refer to the function diagram [2840].

Table 5-3 Description of the PROFIsafe STW

Bit	Meaning	Remarks		BICO
0	STO	1	STO deactivation	r9720.0
		0	STO activation	
1	SS1	1	SS1 deactivation	r9720.1
		0	SS1 activation	
2	SS2	1	SS2 deactivation	r9720.2

Bit	Meaning	Remarks		BICO
		0	SS2 activation	
3	SOS	1	SOS deactivation	r9720.3
		0	SOS activation	
4	SLS	1	SLS deactivation	r9720.4
		0	SLS activation	
5	Reserved	-	-	-
6	Reserved	-	-	-
7	Internal Event ACK	1/0	Acknowledgment	r9720.7
		0	No acknowledgment	
8	Reserved	-	-	-
		-	-	
9	SLS limit select bit 0	-	Selection of the speed limit for SLS (2-bit counter)	r9720.9
10	SLS limit select bit 1	-		r9720.10
11...15	Reserved	-	-	-

PROFIsafe status word

Refer to the function diagram [2840].

Table 5-4 Description of the PROFIsafe status word (ZSW)

Bit	Meaning	Remarks		BICO
0	Power removed (STO active)	1	STO active	r9722.0
		0	STO deactivated	
1	SS1 active	1	SS1 active	r9722.1
		0	SS1 deactivated	
2	SS2 active	1	SS2 active	r9722.2
		0	SS2 deactivated	
3	SOS active	1	SOS active	r9722.3
		0	SOS deactivated	
4	SLS active	1	SLS active	r9722.4
		0	SLS deactivated	
5	Reserved	-	-	-
6	Reserved	-	-	-
7	Internal Event	1	Internal Event	r9722.7
		0	no Internal Event	
8	Reserved	-	-	-
		-	-	
9	SLS limit bit 0	-	Selection of the speed limit for SLS (2-bit counter)	r9722.9
10	SLS limit bit 1	-		r9722.10
11	SOS selected	1	SOS selected	r9722.11
		0	SOS deactivated	

Bit	Meaning	Remarks		BICO
12...14	Reserved	-	-	-
15	SSM	1	SSM (n below limit)	r9722.15
		0	SSM (n higher than/equal to limit)	

Commissioning

6

6.1 General commissioning information

6.1.1 Introduction

The safety functions are commissioned using the screen forms in the STARTER. These functions are available for each drive at "Functions" -> "Safety Integrated".

The password "0" is set by default.

Information pertaining to operation with isochronous PROFIBUS

NOTICE
Always set parameter p9510 = 1 if a PROFIdrive controller exchanges isochronous process data with the Control Unit. This setting is also required if the drive itself does not exchange process data in isochronous mode. Refer to parameter p0092.

6.1.2 Setting the sampling times

Terminology

The software functions installed in the system are executed cyclically at different **sampling times** (p0115, p0799 and p4099).

Safety functions are executed within the **monitoring clock cycle** (p9300/p9500) and TM54F is executed within the **sampling time** (p10000).

Communication on PROFIBUS is handled cyclically by means of the **communication clock cycle.**

Rules for setting the sampling times:

- The monitoring clock cycle (p9300/p9500) on isochronous PROFIBUS must be an integer multiple of the communication clock cycle.
- The monitoring clock cycle must be an integer multiple of 1 ms if isochronous PROFIBUS is not used.

- The communication clock cycle must be executed at least with factor 4 to the current controller clock cycle (with isochronous PROFIBUS) or 1 ms (with non-isochronous PROFIBUS).
- The monitoring clock cycle can be set within the limits from 4 ms to 25 ms.

  However, the calculation time required for the Extended Functions in the Control Unit depends on the monitoring clock cycle, that is, shorter clock cycles extend the calculation time. The availability of a specific monitoring clock cycle therefore depends on calculation time resources of the Control Unit.

  Calculation time resources on the Control Unit are influenced primarily by the number of drives, the number of drives with enabled Extended Functions, the connected DRIVE-CLiQ components, the selected DRIVE-CLiQ topology, the use of CBE20 and by the selected technological functions.
- A sampling time of 125 µs or 250 µs can be set at the current controller (p0115[0]).
- The sampling time set at the TM54F must be equivalent to the monitoring clock cycle (p10000 = p9300/p9500).
- The PROFIsafe scan cycle is set permanently to 2 x p9300/p9500.

Overview of important parameters (refer to the List Manual)

- p9300 SI motion monitoring clock cycle (Motor Module)
- p9500 SI motion monitoring clock cycle (Control Unit)
- p10000 SI sampling time (TM54F)

6.2 Commissioning TM54F by means of STARTER/SCOUT

6.2.1 Basic sequence of commissioning

The following conditions must be met before you can configure the TM54F:

- Concluded initial commissioning of all drives

Table 6-1 Configuration sequence

Step	Execution
1	Insert the TM54F
2	Configure the TM54F and generate the drive groups
3	Configure the drive groups
4	Configure the inputs
5	Configure the outputs
6	Copy the parameters to the second drive object (TM54F_SL)
7	Activate the configuration by selecting "Activate settings"
8	Save the project in STARTER
9	Save the project in the drive by selecting "Copy RAM to ROM"

Step	Execution
10	Execute POWER ON
11	Acceptance test

6.2.2 Configuration start screen

Description

The following functions can be selected in the start screen:

- Configuration

  Opens the "Configuration" screen
- Inputs

  Opens the "Inputs" screen
- Outputs

  Opens the "Outputs" screen
- Drive group 1 ... 4

  Opens the corresponding screen of drive group 1 to 4
- Copy parameters

  Copy the configuration to the second drive object (TM54F_SL) after having edited the configuration and pressed the "Change settings" button.
- Change/activate settings
  - Change settings

    You can select this button and enter the TM54F password in order to edit the configuration data. The button function changes to "Activate settings".
  - Activate settings

    This function activates your parameter settings and initiates calculation of the actual CRC and the corresponding transfer to the target CRC.

    The parameters are activated after restart, and you are requested to carry out the acceptance test.

    A message is output requesting you to save the project and then restart the system. It is also required to carry out an acceptance test.
- Change password (p10061 ... p10063)

  In order to change the password, enter the old password (factory setting: 0) and then enter and confirm the new password.

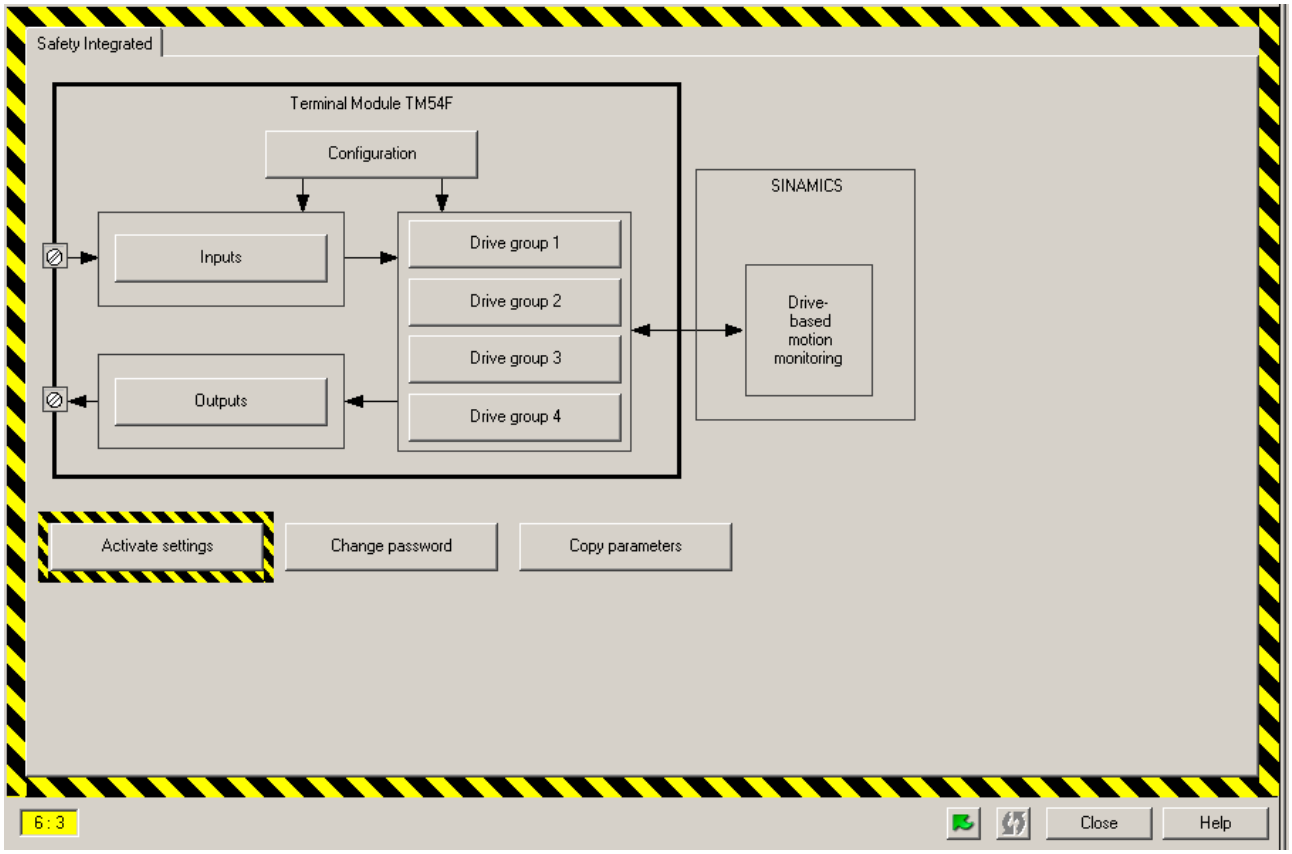


Figure 6-1 Configuration start screen TM54F

6.2.3 TM54F configuration

Configuration screen of TM54F for Safety Integrated

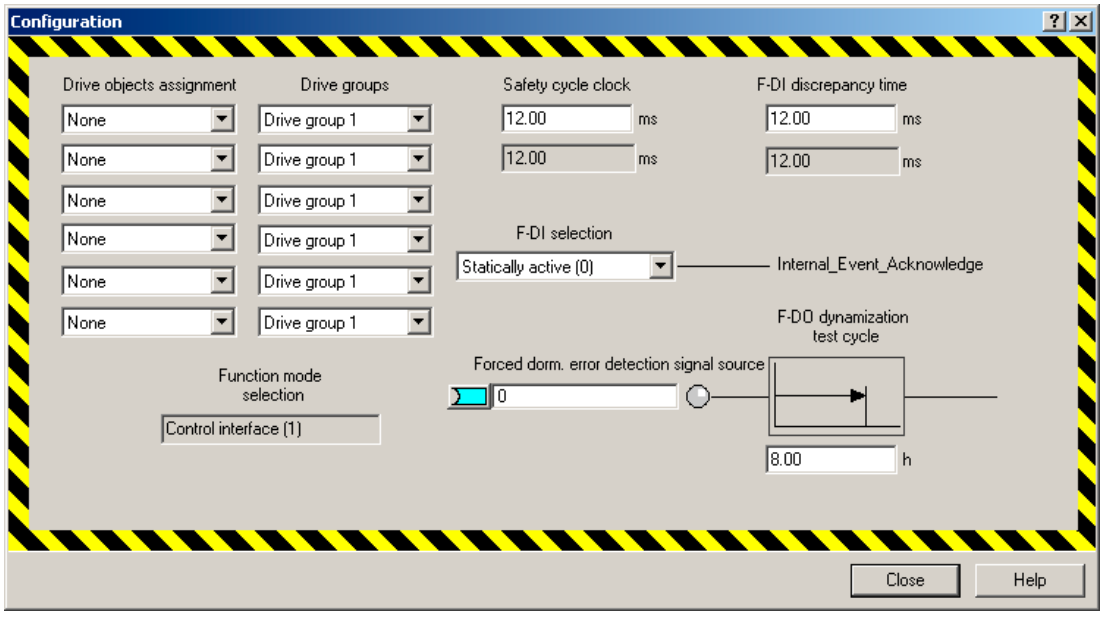


Figure 6-2 TM54F configuration

Functions of this screen:

- Drive objects assignment (p10010)

  Selection of a drive object to be assigned to a drive group.

- Drive groups (p10011)

  Each configured safety drive can be assigned to a drive group using a drop-down list box. The list box displays the drives and their names.

- Safety clock cycle (p10000)

  The safety clock cycle corresponds to the sampling time of TM54F.

  – Enter the safety clock cycle in this input box

  Note

  The safety clock cycle (p10000) set at the TM54F must be equivalent to the monitoring clock cycle set in p9300/p9500.

- Discrepancy time (p10002)

  The signal states at the two terminals of an F-DI are monitored in order to determine whether these have assumed the same logical state within the discrepancy time.

- F-DO dynamization test cycle (p10003)

  Failsafe I/O must be tested at defined intervals in order to validate their failsafe state (test stop, or forced dormant error detection). The TM54F module is provided with a function block which is selected by way of a BICO source to execute this forced dormant error

detection (e.g. switch the L1+ and L2+ sensor power supply). Each selection triggers a timer in order to monitor the test cycle. An alarm is set on expiration of the monitored time.

- F-DI selection (p10006)

  The Extended Functions enter a safety alarm in a special alarm buffer upon the detection of internal errors or violation of limits. This alarm must be acknowledged safely. You can assign an F-DI terminal pair for safe acknowledgment.

- Function mode selection (in preparation)

6.2.4 F-DI/F-DO configuration

Inputs screen F-DI

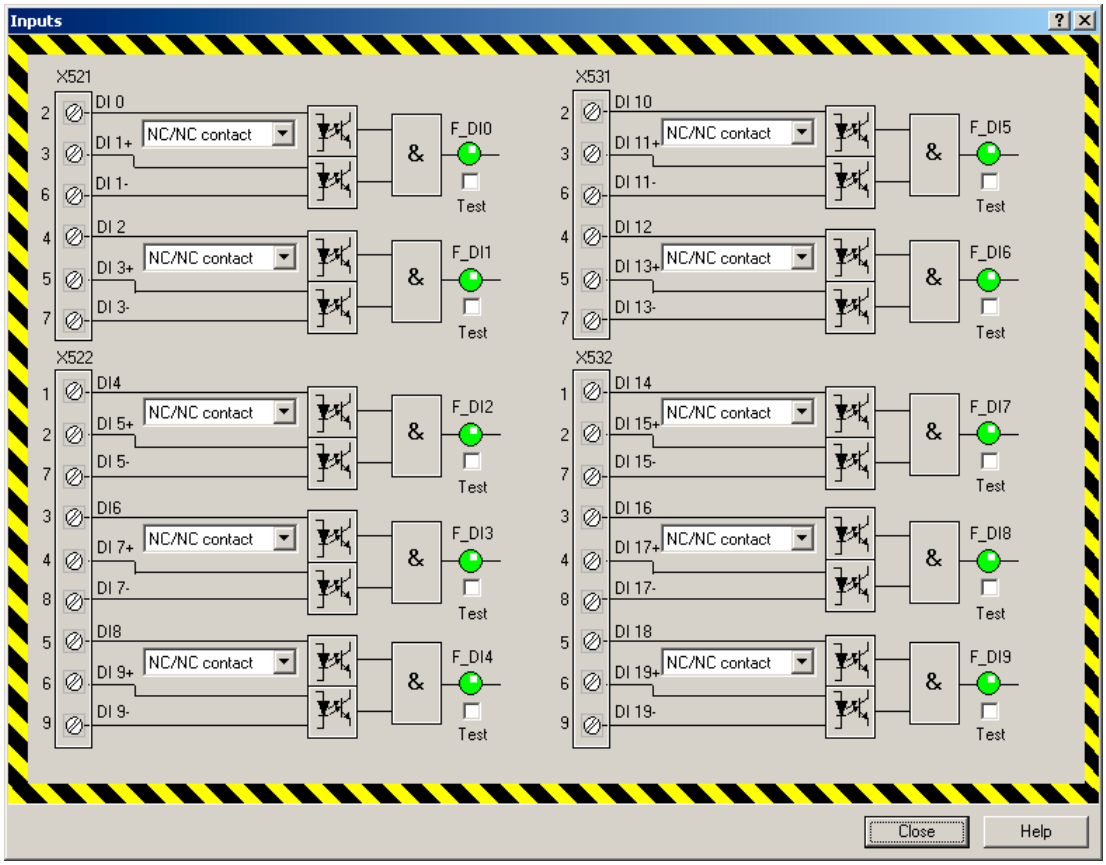


Figure 6-3 Inputs screen

NC/NO contact (p10040)

Terminal property F-DI 0-9 (p10040.0 = F-DI 0, ... p10040.9 = F-DI 9). Configure only the property of the second (lower) digital input. Always connect an NC contact to digital input 1 (upper). Digital input 2 can be configured as NO contact.

Activate test mode (p10041)

A check mark at an F-DI defines whether the pair of digital inputs is to be integrated in the forced dormant error detection test of the assigned power supply (L1+ or L2+) (for additional information, refer to the chapter "Forced dormant error detection", under Extended Functions).

LED in F-DI screen

The LED downstream of the AND element indicates the logical state (inactive: gray, active: green, discrepancy error: red).

Outputs screen F-DO

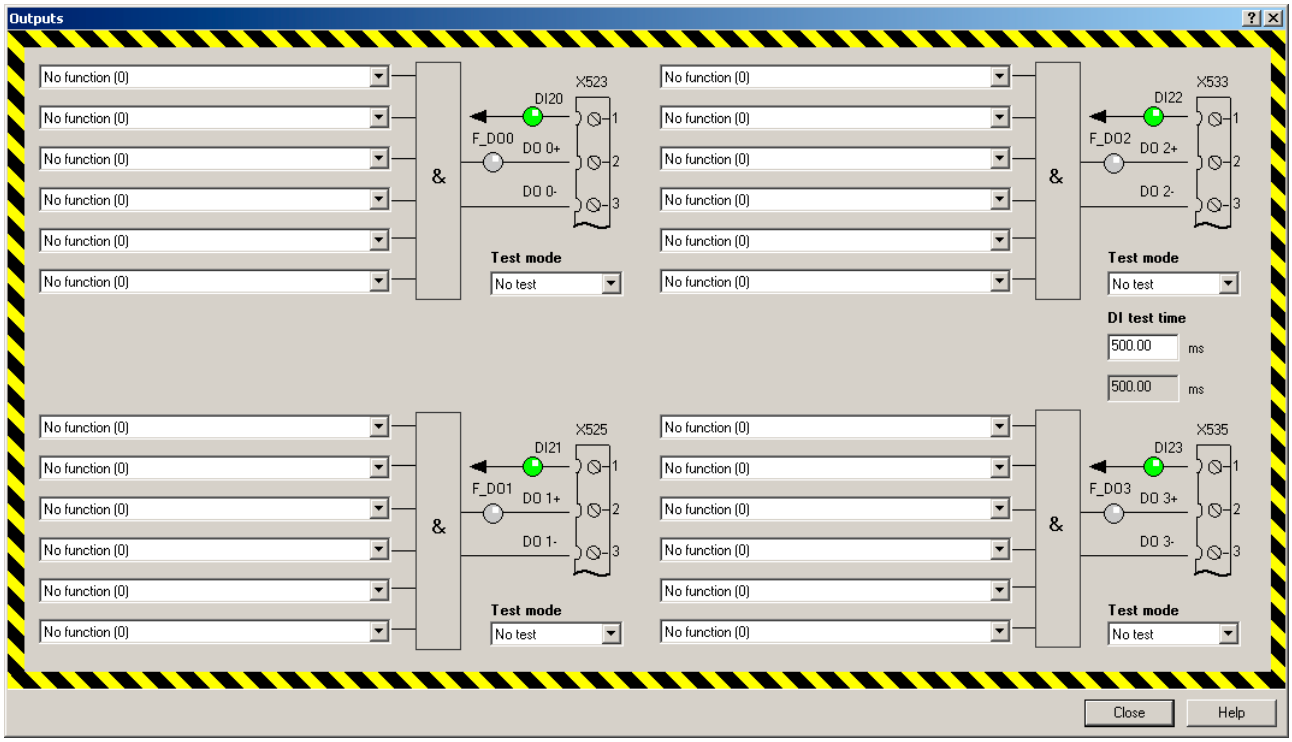


Figure 6-4 Outputs screen

Signal source for F-DO (p10042 - p10045)

An AND element with 6 inputs is interconnected with each output terminal pair of an F-DO; the signal sources for the AND inputs can be selected:

- No signal source (input set to logical HIGH; default)
- Status signals of the drive of drive group 1 to 4

  For additional information on status signals, refer to the chapter "F-DO overview" in the "Control by means of TM54F terminals".

Test selection F-DO (p10046 [0..3])

The test stop for forced dormant error detection can be activated for each F-DO by means of a pull-down menu (for additional information, refer to the chapter "Forced dormant error detection", under Extended Functions).

LED in the F-DO screen

The LED downstream of the AND element indicates the logical state (inactive: gray, active: green).

The LED of the digital inputs DI20 to DI23 indicate the status of the digital input (inactive: gray, active: green).

6.2.5 Control interface

Control interface screen

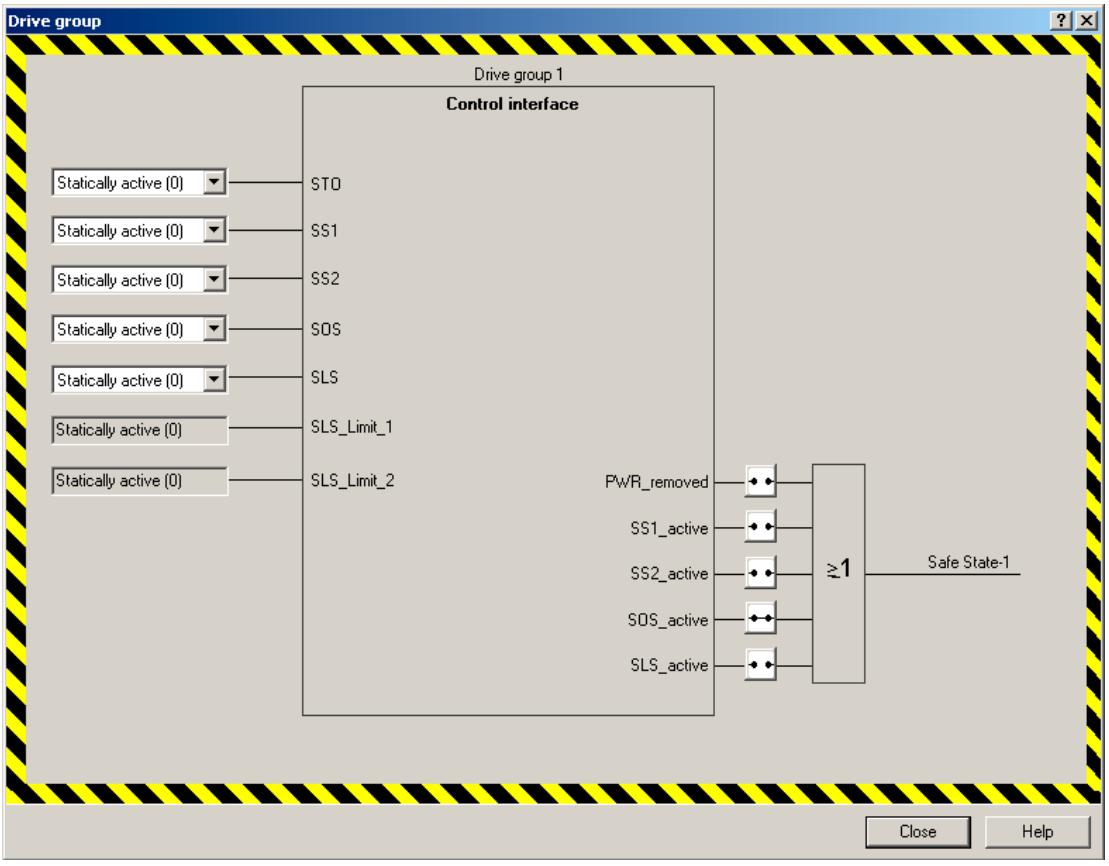


Figure 6-5 Control interface screen TM54F

Functions of this screen:

- Selection of an F-DI for the STO, SS1, SS2, SOS and SLS functions and for SLS speed limits (bit coded) (p10022 to p10028).

  A separate screen is available for each drive group. An F-DI can be assigned several functions in several drive groups.

- Configuration of the "Safe State" signal (p10039)

  A failsafe output signal "Safe State" is generated for each drive group based on the following status signals:

- PWR_removed (STO active)
- SS1 active
- SS2 active
- SOS active
- SLS active

The status signals with the same function and of different drives of a drive group are logically linked by AND operation. The status signals of individual functions (PWR_removed, SS1 active etc.) are logically linked by OR operation.

The "Safe State" signals can be assigned to an F-DO.

6.3 PROFIsafe network transition with SIMOTION D

The next sections deal with the configuration of PROFIsafe communication via PROFIBUS between the integrated drive unit SINAMICS S120 of a SIMOTION D or CX32 and a higher-level SIMATIC F-CPU.

The configuration and operation of failsafe communication (named F-communication in the following, F = failsafe) is based on the following software and hardware requirements:

Software packages to be installed on the programming device:

- STEP7 V5.4 + SP2
- S7 F Configuration Pack V5.5 SP3
- S7 Distributed Safety Programming V5.4 SP3
- SIMOTION SCOUT V4.1.1

Hardware:

- The components which are compatible with PROFIsafe are listed in the chapter "Supported functions", under "Prerequisites for Extended Functions".

Topology (network view of the project)

The basic topology of components which participate in PROFIsafe communication via PROFIBUS is structured as follows (SIMATIC-F-CPU and D4x5 with integrated SINAMICS S120 or CX32):

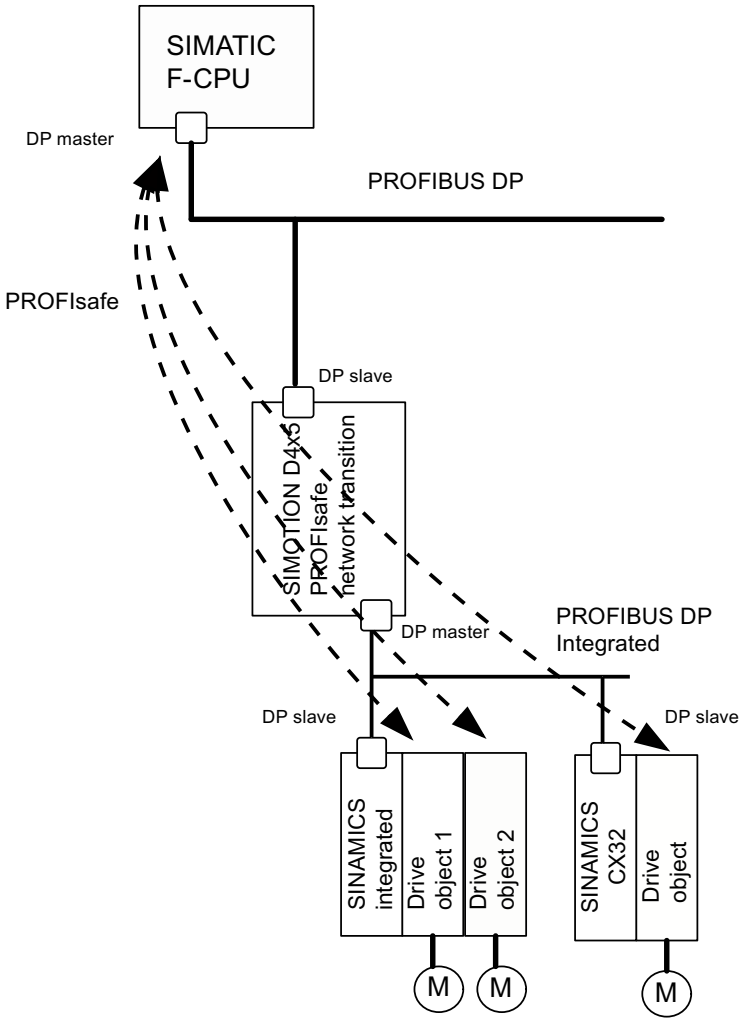


Figure 6-6 Topology PROFIsafe, SIMATIC-F-CPU and D4x5 with integrated SINAMICS S120 or CX32

The drive unit (SINAMICS) and the SIMATIC F-CPU are located on different PROFIBUS subnets. This structure requires configuration of a PROFIsafe network transition to SIMOTION D.

Configuring PROFIsafe communication

The next sections describe the configuration of PROFIsafe communication between a SIMATIC F-CPU and a drive object of an integrated SINAMICS drive unit of a SIMOTION D. The procedure for configuring PROFIsafe communication between a SIMATIC F-CPU and a drive unit of a CX 32 is basically the same and is not covered separately.

1. Create an F-CPU or a CPU 317F-2 and a SIMOTION-D4x5 PLC (with integrated SINAMICS S120) in HW Config in accordance with the hardware installed.
2. Define a SIMOTION CPU for operation as DP slave and the F-CPU as associated DP master.
3. Configure the SINAMICS drive unit in SIMOTION SCOUT/STARTER in accordance with your hardware configuration.

4. Create a PROFIsafe slot in the "Configuration" dialog box of the SINAMICS drive unit. Select the PROFIBUS message frame tab, select the drive object which is to communicate with the SIMATIC F-CPU via PROFIsafe, click "Insert line" and then select "PROFIsafe".

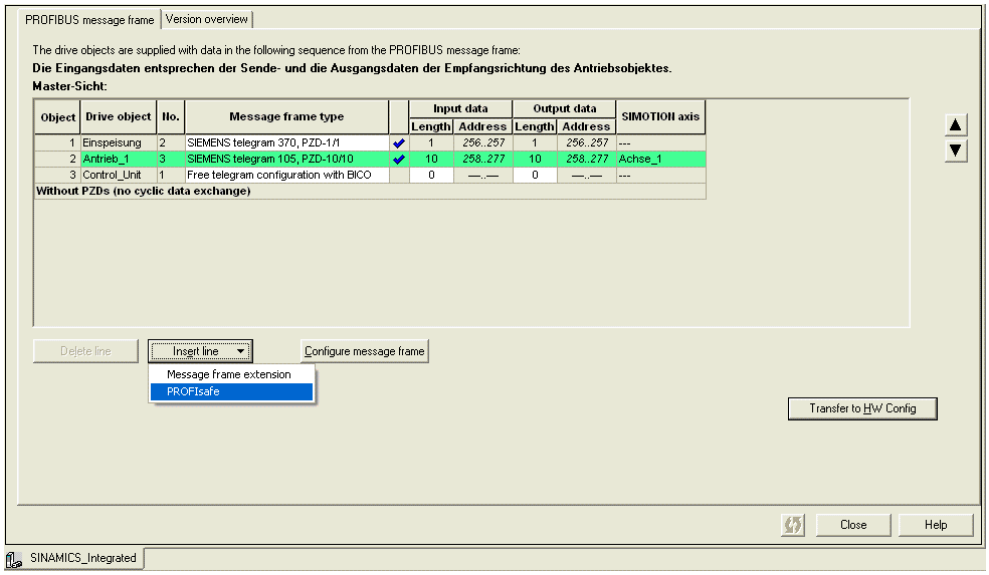


Figure 6-7 Inserting a PROFIsafe slot

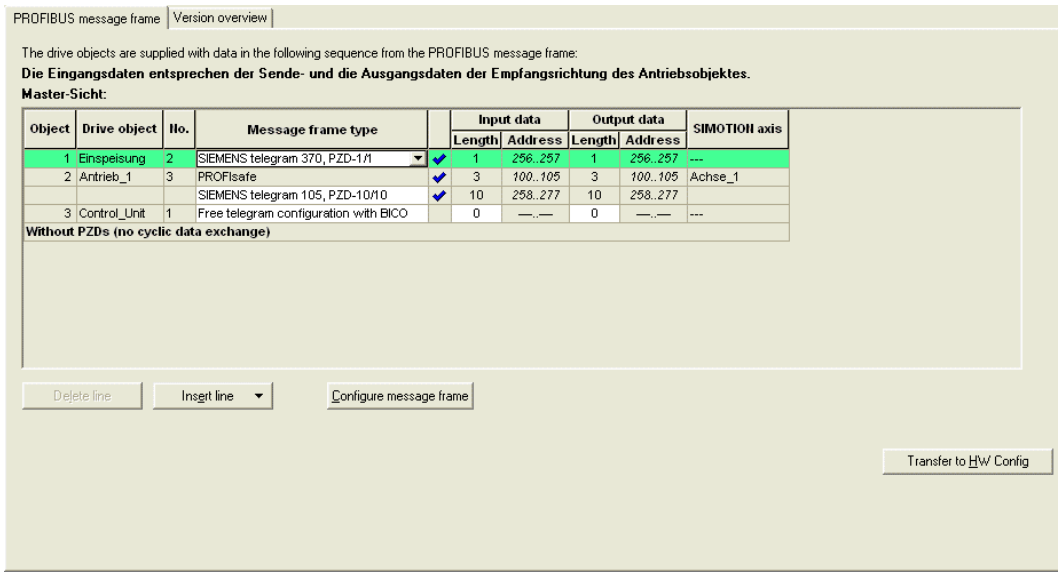


Figure 6-8 PROFIBUS message frame

5. Transfer the new PROFIsafe slot to HW Config by clicking the "Transfer to HW Config" button.
6. Open HW Config of the F-CPU and interconnect the SIMOTION station with a PROFIBUS segment of the F-CPU.
7. The F-communication parameters are displayed in the DP slave (SIMOTION CPU) properties,
"F Configuration" tab.

DP partner (F I/O): Properties of the SINAMICS drive.

local: Properties of the SIMOTION CPU.
Enter the logical start address for F-communication of the SIMOTION CPU in the "Address" row.
The send and receive safety message frames are assigned an address space of 6 bytes which must be located outside the process image of the SIMOTION-CPU (>= 64).

Master (safety program): SIMATIC F-CPU properties.
Select the "Address" (LADDR) row and enter the logical start address for F-communication of the SIMATIC F-CPU. The send and receive safety message frames are assigned an address space of 6 bytes which must be located within the process image of the SIMATIC F-CPU.
This address can be used in the safety program of the SIMATIC F-CPU to access the PROFIsafe STW or ZSW.

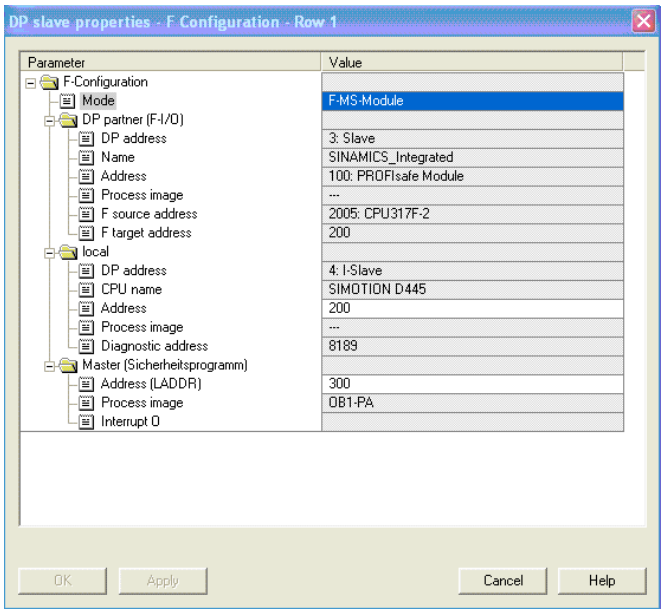


Figure 6-9 Master-slave coupling in PROFIsafe

8. Open HW Config of the SIMOTION CPU.

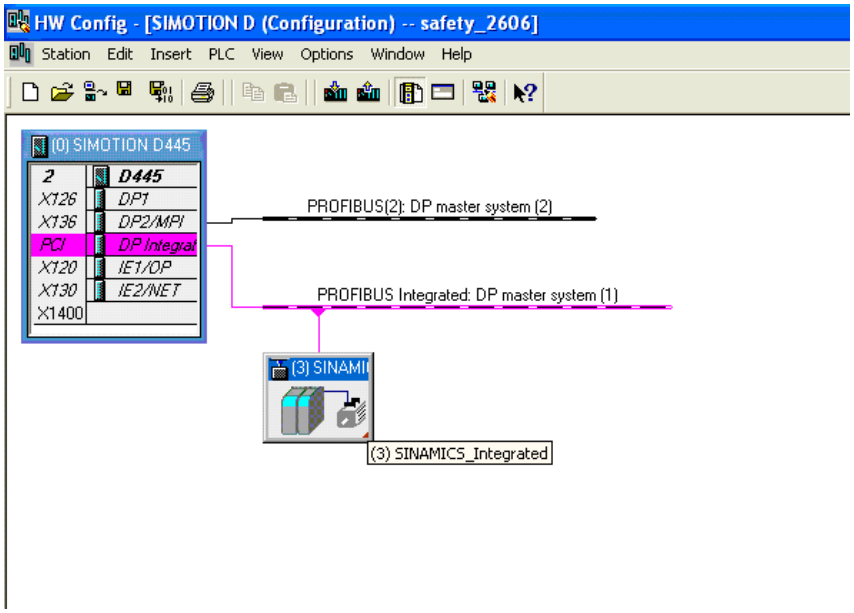


Figure 6-10 SIMOTION D configuration

9. Double-click the icon of the SINAMICS drive unit and select the "Details" tab in the "Configuration" tab.

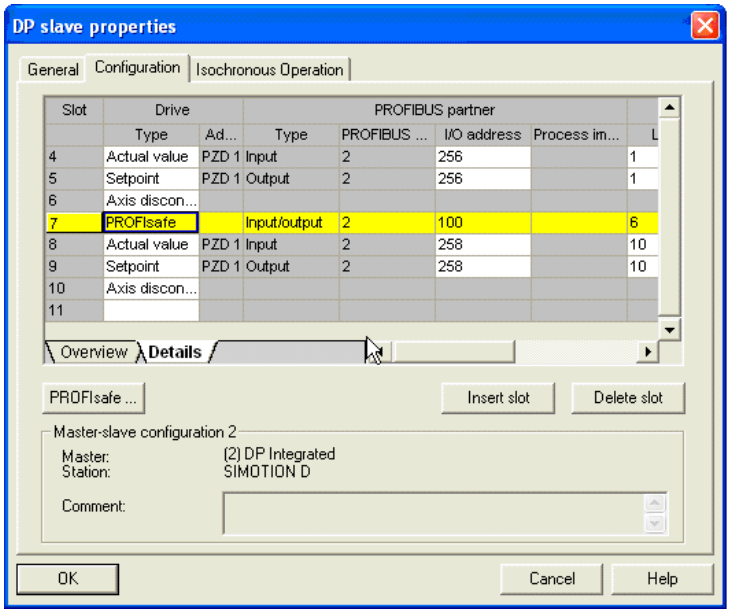


Figure 6-11 PROFIsafe configuration for SINAMICS drive unit

10. Click "PROFIsafe…" and then define the F parameters which are important to F-communication. If the "PROFIsafe…" button is grayed out you can click on "Activate..." in order to enable the button function.

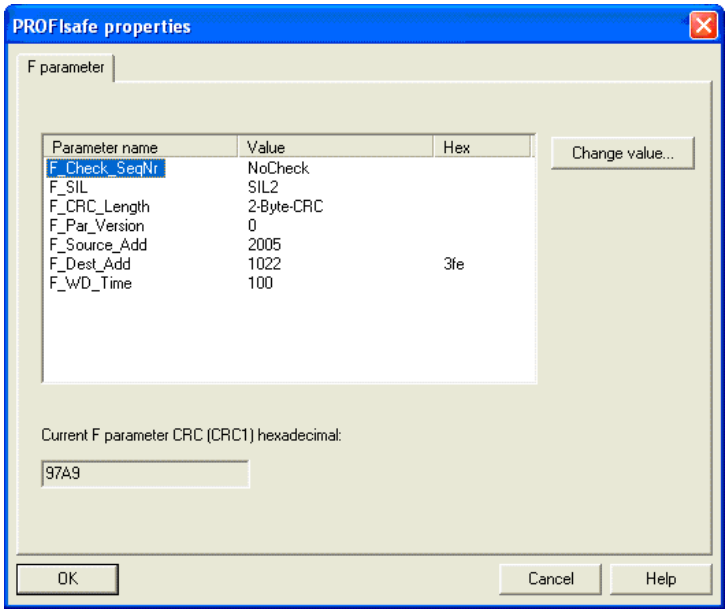


Figure 6-12 Setting F parameters

Setting F parameters:

The top five failsafe parameters in this list are configured by default and cannot be edited. The following range of values is valid for the two remaining parameters:

F_Dest_Add: 1-65534
F_Dest_Add determines the PROFIsafe destination address of the drive object.
Any value within the range is allowed, however, it must be entered once again in the safety configuration of the drive in the SINAMICS drive unit. The F_Dest_Add value must be set in p9610 (CU) and in p9810 (Motor Module).

Note

The failsafe addresses (F-Dest_Add and F-Source_Add) are checked in terms of redundancy after you close the "PROFIsafe properties" dialog box. This function is only available if a master-slave link between the SIMOTION CPU and the SIMATIC F-CPU exists.

F_WD_Time: 10- 65535
A valid current safety message frame must be received from the F-CPU within the monitoring time. The drive will otherwise go into safe state.
Select a monitoring time of sufficient length to let the communication functions tolerate message frame delays, however, make allowances for appropriate short fault reaction times (e.g. to interruption of communications).

For additional information on failsafe parameters, refer to the online help of the "PROFIsafe properties" dialog box ("Help" button).

Compile HW Config of the SIMOTION CPU. Compile the F-CPU configuration data in HW Config.

Note

For information about the creation of a safety program and access to PROFIsafe user data (e. g STW and ZSW) within the safety program, refer to the "SIMATIC, S7 Distributed Safety - Configuring and Programming" Programming and Operating Manual.

Safety configuration (online) in the SINAMICS drive

1. Call the configuration for Safety Integrated by selecting "Functions" at the SINAMICS drive entry in the tree structure.
2. Click "Change settings". Enter the default safety password "0" and then select the "Motion monitoring via PROFIsafe" setting in the screen.

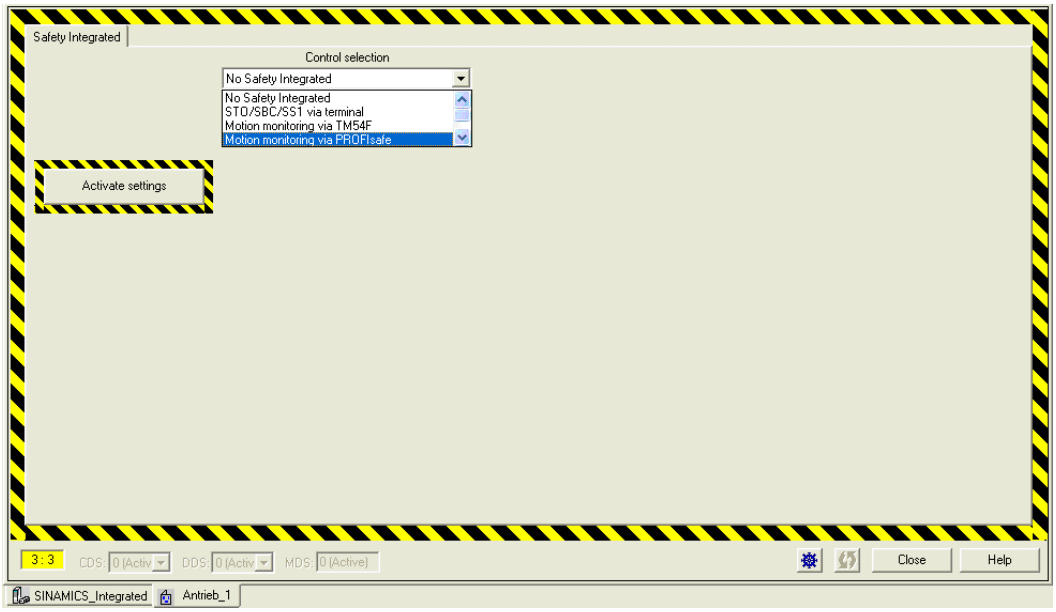


Figure 6-13 Motion monitoring via PROFIsafe

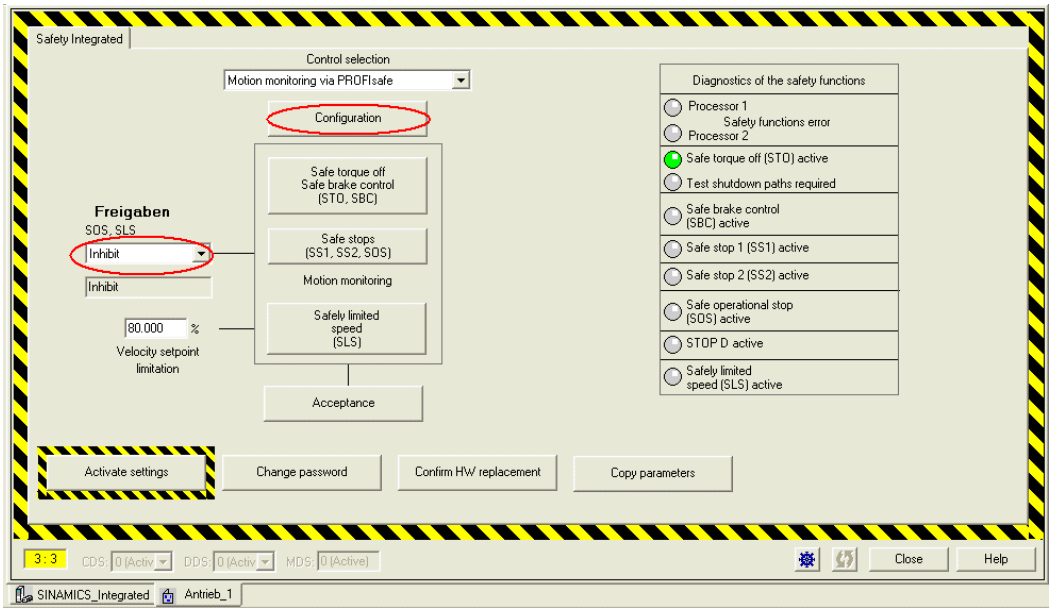


Figure 6-14 Activating PROFIsafe settings

3. Enable the SOS and SLS functions, click the "Configuration" button and then enter the PROFIsafe address of the drive in hexadecimal notation at the already defined parameter F_Dest_Add in the configuration screen (refer to the chapter "Configuring PROFIsafe communication", item 10).

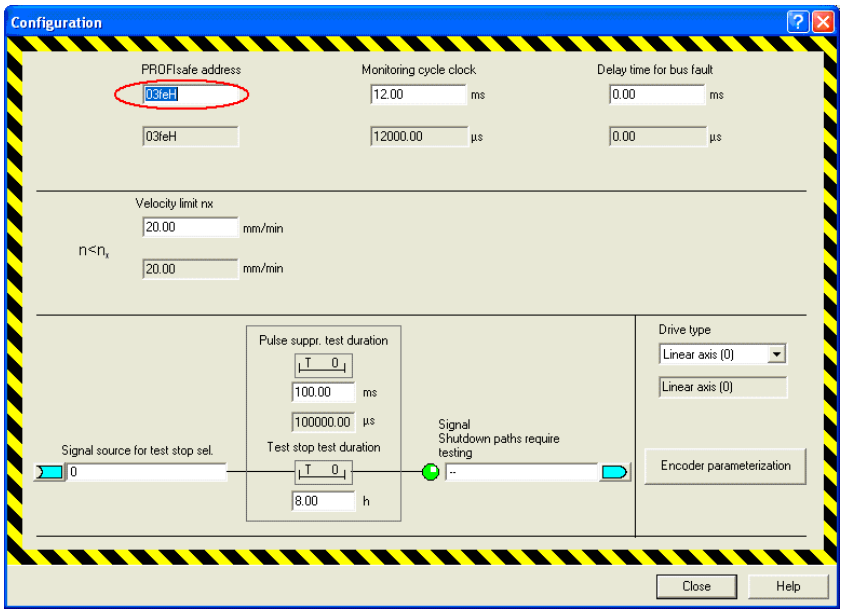


Figure 6-15 PROFIsafe configuration, PROFIsafe address for the drive

4. Click "Copy parameters" and then click "Activate settings". Click "Entire project" to save your settings.

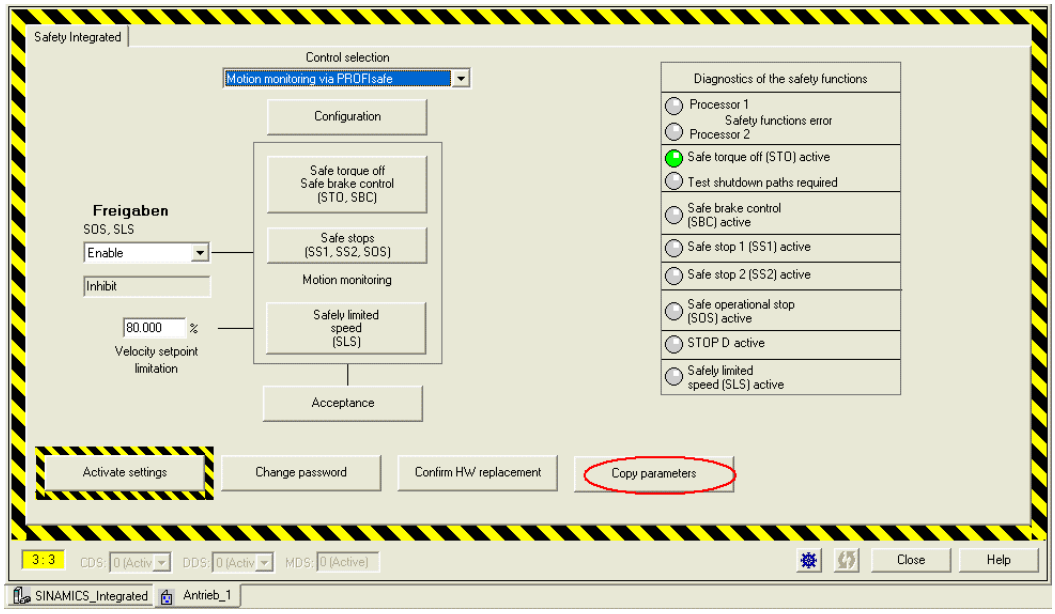


Figure 6-16 Copying PROFIsafe parameters

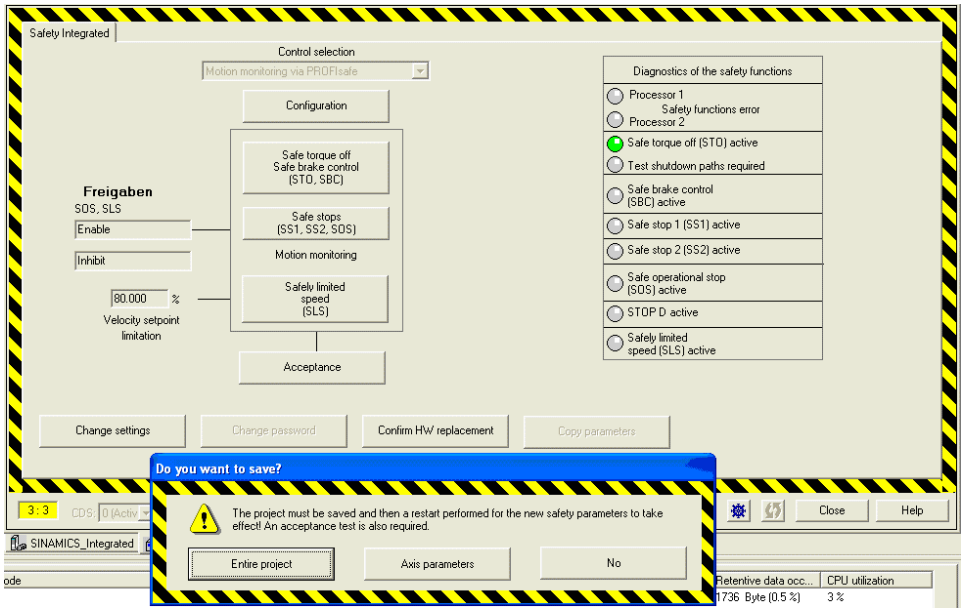


Figure 6-17 Activating PROFIsafe settings and saving the entire project

5. The following settings have to be made in the drive expert list and additional steps have to be taken in order to transfer the safety parameters:

- Set drive parameter p10 = 95 (commissioning mode). Enter the currently valid password by way of p9761. Set p9510 = 1 (isochronous PROFIBUS). In order to enable confirmation of your changes to data in the safety parameters (identical actual and target checksum), parameter p9701 = 172 (hex: AC) must be set. Reset p10 to zero.
- Execute "Copy RAM to ROM" for the SINAMICS project.
- Perform a POWER ON. The safety configuration data are now active in the drive.

Acceptance inspection

After having successfully completed configuring and commissioning, conduct an acceptance test of the drive's safety functions (refer to chapter 8).

Observe the information with regard to the acceptance of PROFIsafe communication provided in the "SIMATIC, S7 Distributed Safety - Configuring and Programming" Programming and Operating Manual.

In addition to the required printed copies of the inspection log files of the SIMATIC F-CPU, you should also generate a printed copy of the hardware configuration data of your SIMOTIOM CPU. Select "Station -> Print" in HW Config of the SIMOTION CPU.

Check the failsafe parameters of the SINAMICS slave (particularly F-WD_TIME) based on this hardcopy. The signatures in the footer of all hardcopies should be identical in order to guarantee consistency of the printed copies. Archive the hardcopy alongside the inspection log files of the SIMATIC F-CPU and of the STEP7 project.

Note

The global signature of the safety program of the SIMATIC F-CPU changes if changes are made in HW Config to the failsafe parameters of the SINAMICS drive. The global signature therefore allows you to identify changes to safety-relevant settings in the F-CPU or in HW Config of the SIMOTION CPU (failsafe parameters of the SINAMICS slave). However, this global signature does not cover changes to failsafe drive parameters configured in SCOUT.

6.4 Commissioning PROFIsafe by means of STARTER/HW Config

6.4.1 Procedure for configuring PROFIsafe communication

Example configuration

The next sections deal with a sample configuration of PROFIsafe communication between a SINAMICS S120 drive unit and higher-level SIMATIC F-CPU operating as PROFIBUS master.

The configuration and operation of failsafe communication (F-communication) is based on the following software and hardware requirements:

Necessary software packages:

- STEP 7 V5.4 SP2 or higher
- S7 F Configuration Pack V5.5 SP3 or higher
- S7 Distributed Safety Programming V5.4 SP3 or higher
- STARTER V4.1.1 + Drive ES-Basic or SCOUT V4.1.1

Hardware:

- SIMATIC F-CPU e.g. CPU 317F-2

Topology (network view of the project)

Components participating in F-communication via PROFIBUS are basically wired as follows:

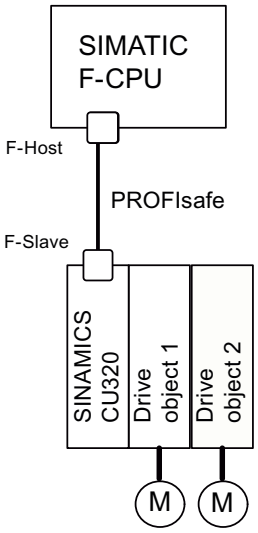


Figure 6-18 Example of a PROFIsafe topology

Configuring PROFIsafe communication

The next sections describe the configuration of PROFIsafe communication between a SIMATIC F-CPU and a drive unit.

Create an F-CPU such as CPU 317F-2 and a SINAMICS S120 in HW Config in accordance with the hardware installed.

1. Set up the SINAMICS S120 for operation as a DP slave and the connected F-CPU as associated DP master.
2. The PROFIsafe slots can be inserted by selecting "Insert object" in the DP slave properties, "Configuration" tab and must be configured by means of the PROFIsafe option.
3. The message frame configuration for F-communication is displayed in the DP slave properties (SINAMICS S120), "Configuration" tab.

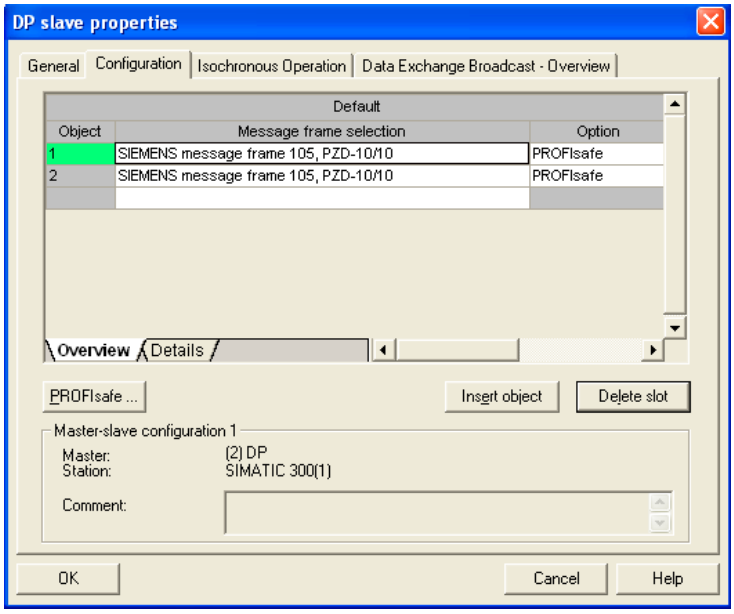


Figure 6-19 Example: PROFIsafe configuration (HW Config)

4. Double-click the icon of the SINAMICS drive unit and select the "Details" tab in the "Configuration" tab.
5. Click "PROFIsafe…" and then define the F parameters which are important to F-communication.

Setting F parameters:

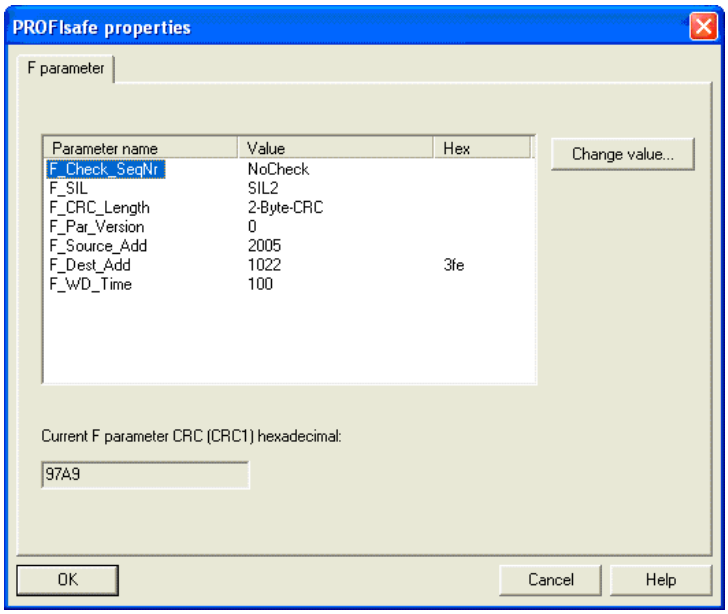


Figure 6-20 PROFIsafe properties (HW Config)

The top five failsafe parameters in this list are configured by default and cannot be edited. The following range of values is valid for the two remaining parameters:

F_Dest_Add: 1-65534
F_Dest_Add determines the PROFIsafe destination address of the drive object.
Any value within the range is allowed, however, it must be entered once again in the safety configuration of the drive in the SINAMICS drive unit. The F_Dest_Add value must be set in p9610 (Control Unit) and in p9810 (Motor Module). You can handle these settings quite comfortably using the PROFIsafe STARTER screen (see the picture below)

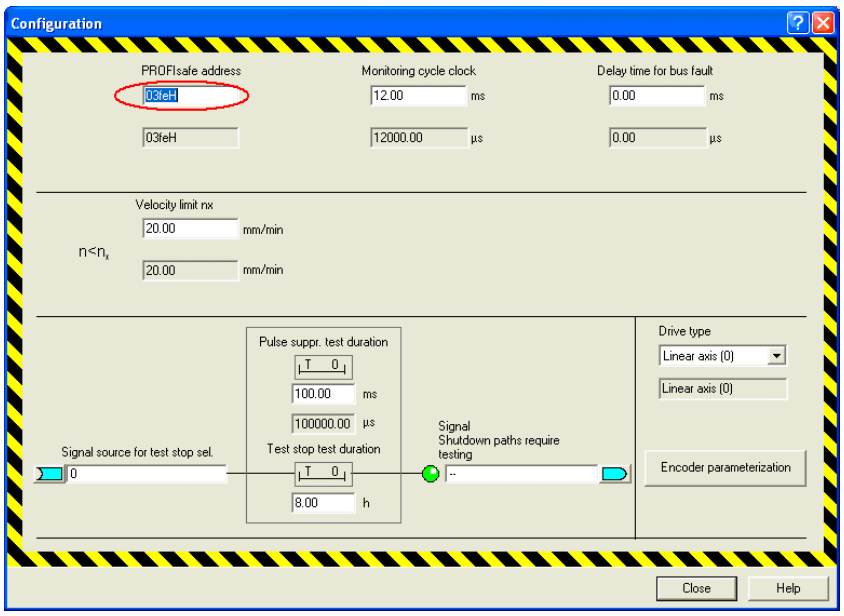


Figure 6-21 PROFIsafe STARTER configuration

F_WD_Time: 10- 65535
A valid current safety message frame must have been received from the F-CPU within the monitoring time. The drive will otherwise go into safe state.
Select a monitoring time of sufficient length to let the communication functions tolerate message frame delays, however, make allowances for appropriate short fault reaction times (e.g. to interruption of communications).

For additional information on failsafe parameters, refer to the online help of the "PROFIsafe properties" dialog box ("Help" button).

Compile the F-CPU configuration data in HW Config.

6.5 Commissioning a linear/rotary axis

The section below outlines commissioning of the safety functions of a linear/rotary axis using a TM54F.

1. Go online in the STARTER, select the required drive object from the project tree of the STARTER and then select "Functions -> Safety Integrated" to open the start screen for the configuration of Safety Integrated.
   Click "Change settings". The commissioning mode is selected.
   You are only allowed to edit safety parameters in commissioning mode for Safety Integrated (p0010 = 95) after having entered the valid password in an input dialog box (parameter p9761 for drives or p10061 for TM54F).

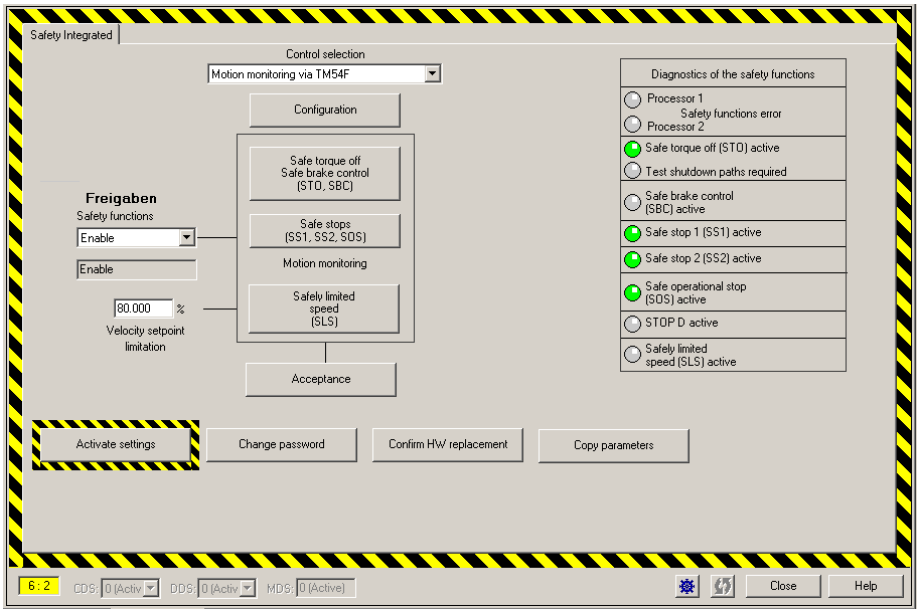


Figure 6-22 Safety commissioning of a linear/rotary axis

2. Select "Motion monitoring via TM54F" from the "Control selection" drop-down list box.
3. Enable the SOS, SLS function (p9501) by selecting it from the "Enables SOS, SLS" drop-down list box. Click the "Configuration" button.
4. The safety configuration screen of the drive opens.

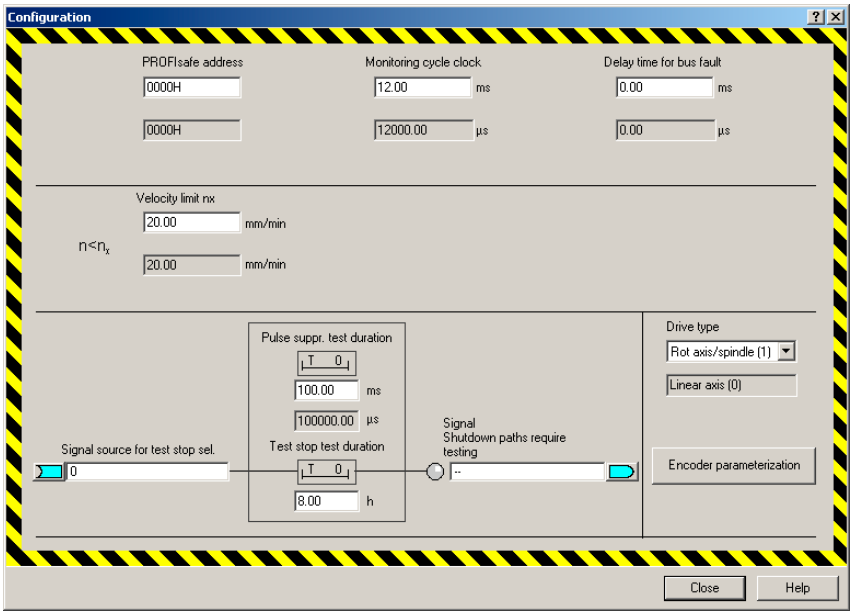


Figure 6-23 Safety drive configuration

5. Set the same monitoring clock cycle (safety clock cycle) as set at the TM54F (refer to the chapter "TM54 Configuration").
6. Select the required drive type (linear/rotary axis) from the corresponding drop-down list box (p9502). Continue at item 12 if you have not changed the selected drive type.

7. Close the screen. Click "Copy parameters" and then click "Activate settings" (exit commissioning mode, p0010=0).
8. Execute the "Copy RAM to ROM" function for the entire project by clicking the "Entire project" button.
9. Perform a POWER ON. The new parameterization is now active.
10. Go online again. The alarms indicate that safety commissioning was not completed (different actual and target checksum) can be ignored.
11. Upload the project to the programming device. The display of parameter units (rotary/linear axis) will be updated accordingly in STARTER.
12. Set up further configurations and update the parameters in accordance with currently required monitoring limits, timers or encoder settings.

6.6 Information pertaining to component replacements

Replacing components

For information about component replacements, refer to the chapter "Example of component replacements" in the SINAMICS S120 Function Manual FH1.

⚠ WARNING
Observe the instructions with regard to changes to software components or to changes to these in the chapter "Safety instructions"!

1. The faulty component was replaced in accordance with safety regulations.
2. Make sure that everybody has cleared the danger zone and then power up the machine.
3. Error F35150 (communication error, after replacement of a Motor Module) or F30711 is output with fault value 1031 (data transfer error after replacement of a Sensor Module).
4. With STARTER:
   – Click "Acknowledge hardware replacement" in the start screen of safety functions.
5. Without STARTER:
   – Start the copying function for Node Identifier (p9700 = 1D hex)
   – Confirm the hardware CRC on the drive object (p9701 = EC hex)

   Carry out these two tasks after having replaced a Sensor Module at drive object servo or vector, and after having replaced a Motor Module at drive object TM54F_MA (if installed).
6. Backup all parameters to the CompactFlash card
7. Perform a POWER ON at all components.
8. The alarms F01650/F30650 (acceptance test required) are output.
9. Before anyone is allowed to enter the danger zone again and before operation is resumed, select the STO function once and briefly move the drives affected by the

component replacement in plus and minus direction (+/-) with activated safety monitoring function (SLS, if parameterized) in order to verify proper functionality.

6.7 Information pertaining to series commissioning

A commissioned project which has been uploaded to STARTER can be transferred to another drive unit including the existing safety parameterization.

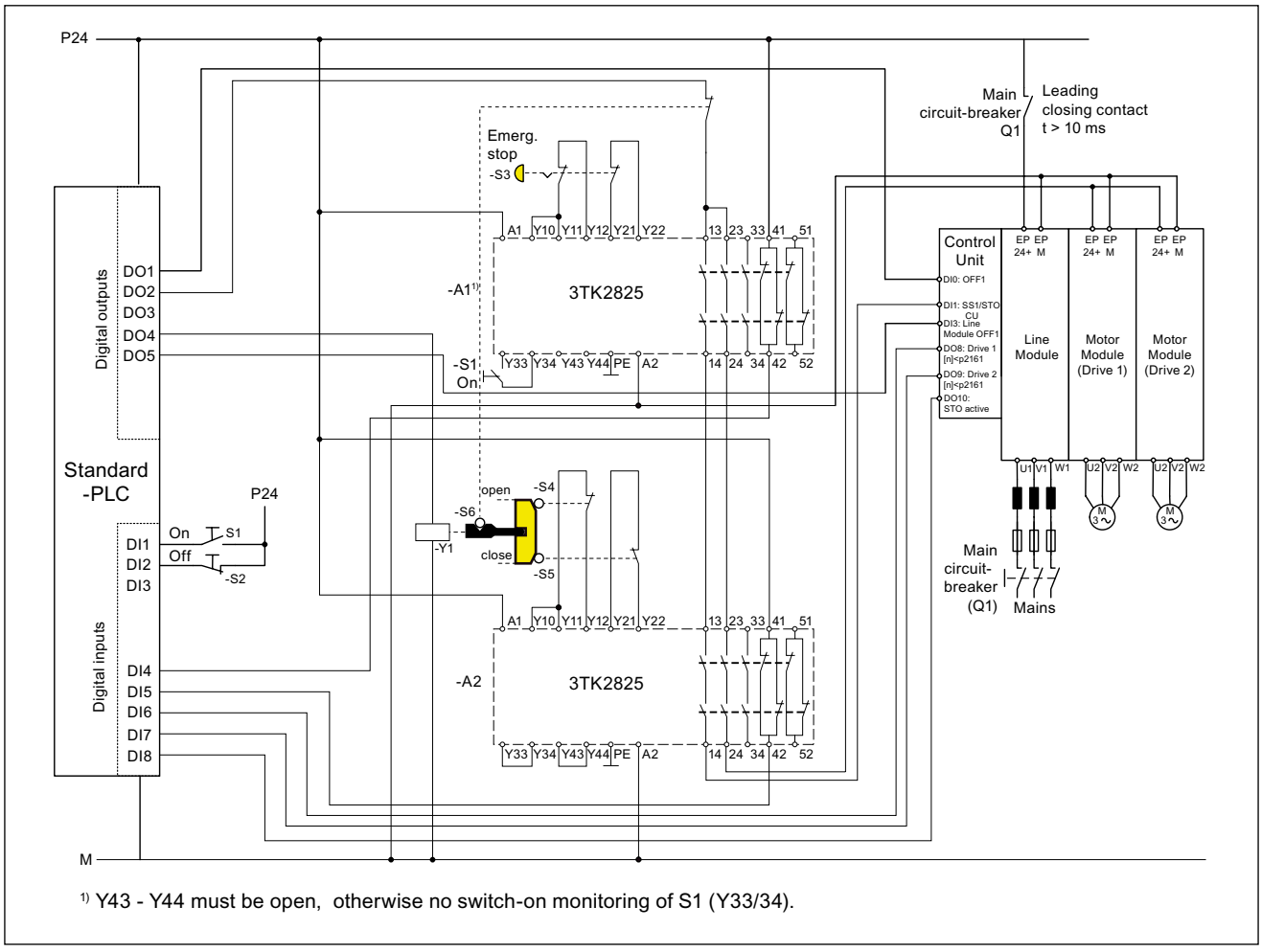
1. Download the STARTER project to the drive unit.
2. The alarms F01650/F30650 (acceptance test required) are output.

   You can acknowledge these fault alarms as a complete acceptance test is not required if no changes were made to safety function parameters.
3. Click "Acknowledge hardware replacement" in the start screen of safety functions.
4. Backup all parameters to the CompactFlash card.
5. Perform a POWER ON at all components.
6. Before anyone is allowed to enter the danger zone again and before operation is resumed, select the STO function once and briefly move the drives affected by the component replacement in plus and minus direction (+/-) with activated safety monitoring function (SLS, if parameterized) in order to verify proper functionality.

Application examples

7

7.1 Safe Stop 1 (SS1, time-controlled) when protective door is locked, emergency stop switch-off



[1] Y43 - Y44 must be open, otherwise no switch-on monitoring of S1 (Y33/34).

Figure 7-1 Application example

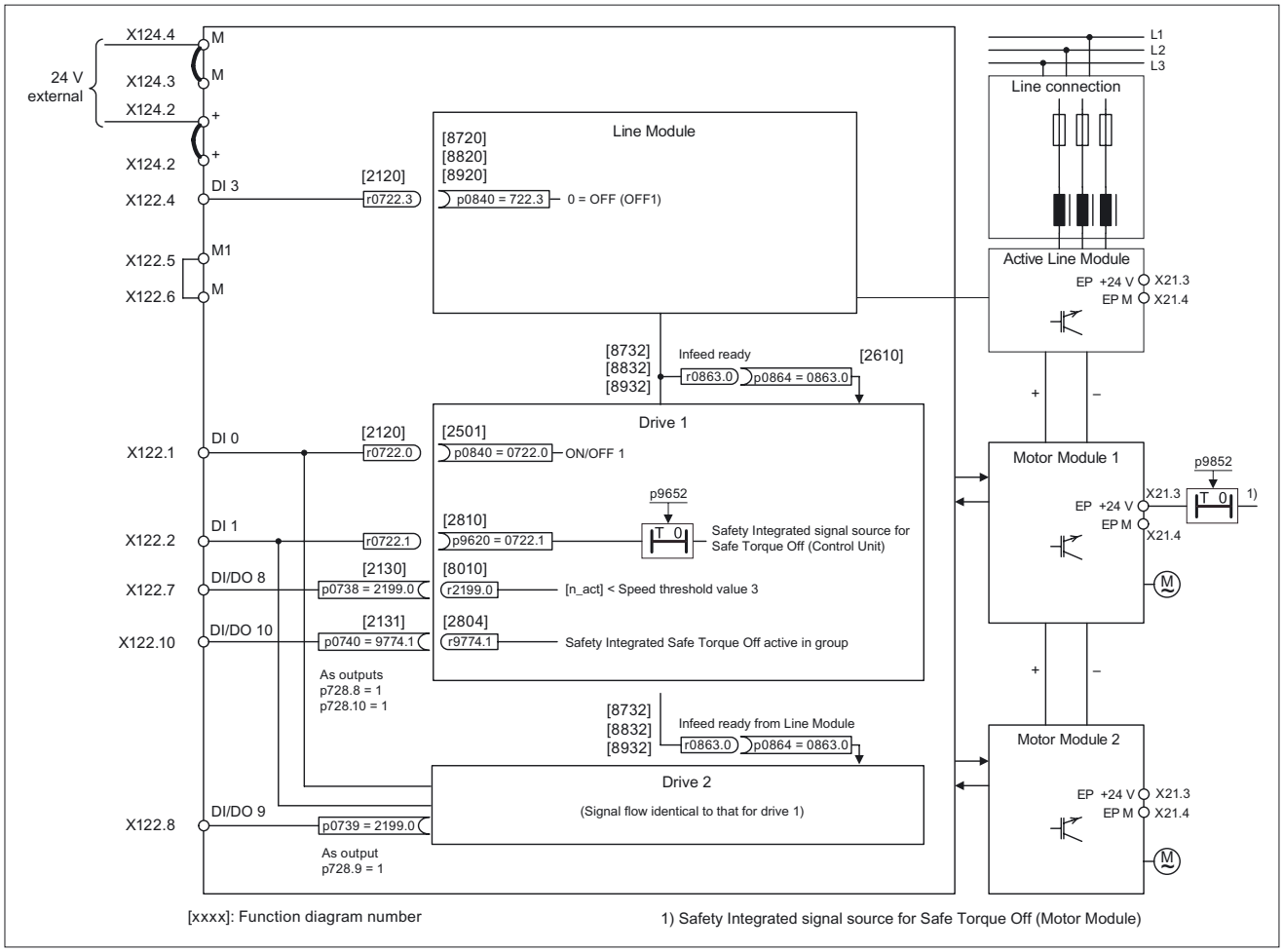


Figure 7-2 Safety Integrated signal flow application example

Note

This example illustrates implementation options. The solution required for the machine must be suitable for the machine function, which means that parameters and control commands are defined individually.

NOTICE

The fault responses and output functions (e.g. inversion or simulation) must not be changed or activated with respect to the factory setting.

Description of functions

With two SIGUARD safety combinations for emergency stop and the protective door, as well as a standard PLC, the system can be configured according to EN 954-1, category 3, and EN1037. The drives are brought to a standstill in accordance with stop category 1 to EN 60204-1.

- The "Safe Torque Off" safety function, which is integrated in the drive, complies with category 3 to EN 954-1 and SIL 2 to IEC 61508. The non-safe message "Safe Torque Off active" is sufficient.
- Safety combinations for emergency stop and protective door monitoring comply with category 4 (instantaneous enable circuits).
- The electric circuits for emergency stop and protective door monitoring are monitored for cross-circuits on two channels.
- Switches S4, S5, and S6 are positively-opening position switches corresponding to EN 1088.
- Being a higher-level circuit with contacts, the "Safe Stop 1 (SS1)" function also works if the PLC malfunctions or fails.
- I/O communication via the digital interface between the drive and PLC can also be replaced by non-safe standard communication (e.g. PROFIBUS).
- This application example is based on the basic functions "Safe Torque Off" (STO) and "Safe Stop 1" (SS1).
  The speed ramps and speed thresholds are monitored in non-safe mode.

Note

In order to implement the Emergency Stop function (stopping in an emergency - emergency stop) it is not absolutely necessary to electrically isolate the drive converter from the line supply using electromechanical switching devices according to EN 60204-1 (1998) and IEC60204-1 (2005). When work is carried-out on the motor or drive converter, the voltage must be disconnected via a main circuit-breaker (that can be locked-out). Other Standards (e.g. NFPA79-2002 / USA) specify additional requirements regarding the EMERGENCY STOP function. For the EMERGENCY SWITCHING-OFF function (switching-off in an emergency) according to EN 60204-1 (1998) and IEC 60204-1 (2005), the supply voltage to the equipment must be disconnected through an electromechanical switching device. The risk analysis to be carried-out by the machinery construction OEM must determine which emergency functions (emergency operations) are actually required for a specific application.

Behavior for Emergency Stop

An emergency stop is triggered by the S3 button ("Emergency stop"). The drive is brought to a standstill in accordance with stop category 1 of EN 60204-1.

- Open the safe enable contacts of the safety combination A1. This activates the "Safe Stop 1" drive function on two channels via terminal X122.2 (DI 1) on the Control Unit and terminals X21.3 (EP +24 V) and X21.4 (EP M) on the Motor Module. "Safe Torque Off" is selected after the set SS1 delay time (p9852, p9652) has elapsed. When all the grouped drives have reached the "Safe Torque Off active" status, this is signaled back via terminal X122.10 (DO 10: STO group active).
- The confirmation from the safety combination and the drive is monitored in the PLC to ensure that it is plausible.

Behavior when the protective door is opened

To issue a request to open the protective door, press the S2 button ("OFF"). The drive is brought to a standstill in accordance with stop category 1 of EN 60204-1.

- Resetting the PLC output DO 2 will trigger an SS1 at terminal X122.2 on the CU (DI 1) and at the EP terminals of the Motor Modules. The drives are immediately braked via the speed ramp (p1135). The speed ramp is not monitored for SS1. The pulses are safely canceled after the safe SS1 delay time (p9852, p9652) has elapsed.
- When all drives have executed the safe pulse cancelation, the feedback "STO in group active" (DO 10) is issued from the CU to the PLC. In addition, a request is made via the PLC (PLC: DI 7 and DI 8) if the drives have fallen below the preset speed threshold (D0 8 and DO 9: |n|<p2161).
  Only when these conditions are met, solenoid Y1 (PLC output DO 4) is energized and the lock of the protective door opened.
- When the protective doors are opened, the protective door safety circuit is interrupted and safety combination A2 opens its safety circuits.

Note

The position of the protective door interlock is monitored by S6! If a fault on the PLC causes the lock of the protective door to open, an SS1 is initiated via S6 at terminal X122.2 (DI 1) of the Control Unit and at the EP terminals of the Motor Modules. The drives are immediately braked via the speed ramp (p1135), and the pulses canceled after the SS1 delay time has elapsed. When the protective door is opened, the "Safe Stop 1" function is safely selected.

Switching on the drives

The drives can be started when the protective door is shut and emergency STOP pushbutton S3 is released. The emergency STOP pushbutton S3 must be unlocked before pushbutton S1 ("ON") is actuated. With the safety combination, the ON circuit Y33, Y34 is checked for a short-circuit when terminals Y43 , Y44 are open (i.e. if Y33 and Y34 are closed before emergency stop pushbutton S3 is closed, this is identified as a fault). The Line Module must be switched on via PLC output DO 5 on the PLC by means of an edge from "0" to "1".

- Once you have pressed button S1 ("ON"), safety combination A1 switches to "ready for operation". When PLC output DO 4 is reset, the coil of tumbler Y1 is no longer energized and the protective door is locked. Safety combination A2 is also ready for operation.
- By setting the PLC output DO 2, the SS1 and STO safety function is de-selected on two channels via terminal DI 1 X122.2 on the Control Unit and terminals X21.3 (EP +24 V) and X21.4 (EP M) on the Motor Modules.
- Due to a rising edge at PLC output DO1, the drives can be switched back to "operation" mode via terminal X122.1 (DI 0: OFF1).

Acceptance test and acceptance report 8

8.1 General information

Requirements for acceptance tests are derived from the EC Machinery Directive. IEC 22G WG 10 is currently working on a "Functional safety" standard which includes a detailed description of acceptance test requirements. The machine manufacturer (OEM) is committed accordingly

- to carry out an acceptance test for safety-related functions and machine parts
- to issue an "Acceptance certificate" which describes the test results.

The acceptance test for systems with Safety Integrated Extended Functions (SI functions) is focused on validating the functionality of Safety Integrated monitoring and stop functions implemented in the drive system. The test objective is to verify proper implementation of the defined safety functions and of test mechanisms (forced dormant error detection measures) and to examine the response of specific monitoring functions to the explicit input of values outside tolerance limits. The test must cover all drive-specific Safety Integrated motion monitoring functions and global Safety Integrated functionality of Terminal Module TM54F (if used).

Note

A new acceptance test must be carried out if any changes were made to SI function parameters and must be logged in the acceptance report.

Note

The acceptance test is used to qualify the parameterization of safety functions. The measured values are used to check the plausibility of the configured safety functions. The measured values are typical but no worst case values. They represent the behavior of the machine at the time of measurement. These measurements cannot be used, for example, to derive maximum ramp-down values.

Authorized person, acceptance report

The test of each SI function must be carried out by an authorized person and logged in the acceptance report. The report must be signed by the person who carried out the acceptance test. The acceptance report must be kept in the logbook of the relevant machine. Access rights to SI parameters must be protected by password and be recorded accordingly in the acceptance report. In this context this is a person who is authorized by the machine manufacturer and who has adequate professional training and knowledge of the safety functions in order to conduct the acceptance test in a proficient manner.

Note

- Observe the information in the chapter "Procedures for initial commissioning".
- The acceptance report presented below is both an example and recommendation.
- An acceptance report template in electronic format is available at your local sales office.

Necessity of an acceptance test

A complete acceptance test (as described in this chapter) is required after initial commissioning of Safety Integrated functionality on a machine. An acceptance test, possible with reduced scope, is always required after safety-related functions were extended, after the transfer of commissioned objects to other series machines, after changes were made to the hardware and after software upgrades. A summary of conditions which determine the necessary test scope or proposals in this context is provided below.

In order to define a partial acceptance test, it is necessary in the first instance to specify the acceptance test objects, and in the second instance to define logical groups which represent the elements of the acceptance test. The acceptance test must be carried out separately for each individual drive (as far as the machine allows).

Prerequisites for the acceptance test

- The machine is properly wired.
- All safety equipment such as protective door monitoring devices, light barriers or emergency-off switches are connected and ready for operation.
- Commissioning of the open-loop and closed-loop control should be concluded, as the ramp-down path may otherwise change as a result of changed dynamic response of the drive controller, for example. These include, for example:
  - Configuration of the setpoint channel
  - Position control in the higher-level controller
  - Drive control

Information on the acceptance test mode (p9370/p9570)

The acceptance test mode can be activated by setting corresponding parameters (p9370/p9570). Safety alarms which must be reset by means of POWER ON and which are generated after activation can be acknowledged as usual. The acceptance test mode also allows operation of the drive beyond SOS limits (p9331/p9531).

Activation of the acceptance test mode is therefore only useful in conjunction with the test of SOS and SLS functions with stop response STOP A or STOP B.

The SOS can be selected either directly, or by way of SS2 (with deactivated acceptance test mode). Deactivate the SS2 brake ramp in SS2 state in active acceptance test mode in order to enable drive movements after having triggered a violation of standstill limits.

Content of the complete acceptance test

Documentation

Documentation of the machine and of safety functions

1. Machine description (with overview)
2. Specification of the controller (if this exists)
3. Configuration diagram
4. Function table

   Active monitoring functions depending on the operating mode, the protective doors and other sensors. This table should reflect the objective or results of project engineering.
5. SI functions for each drive
6. Information about safety equipment

Function test Part 1

General function test, including a check of the wiring/programming

1. Test of shutdown paths

   (Test of forced dormant error detection at the inputs and outputs)
2. Test of the SS1 and SS2 stop functions
3. Test the forced dormant error detection of the inputs and outputs

   (only if a TM54F module is used)
4. Test of the emergency stop function and of safety circuits
5. Changeover test of SI functions

Function test Part 2

Detailed function test and valuation of SI functions used.

1. Test of the SI function "Safe Operational Stop" (SOS)

   (with evaluated measurement diagram or measured values)
2. Test of the SI function "Safely Limited Speed" (SLS)

   (with evaluated measurement diagram or measured values)
3. Test of the SI function "Safe Speed Monitor" (SSM)

   (with evaluated measurement diagram or measured values)

Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Inspection of SI parameters
2. Logging of checksums (for each drive)
3. Assigning and logging the Safety password

   (do not disclose in the report!)
4. RAM to ROM backup and upload of project data to the STARTER and backup of the project
5. Countersignature

Appendix

Effect of the acceptance test on specific measures

Table 8-1 Scope of the acceptance test depending on specific measures

Measure	Documentation	Function test Part 1	Function test Part 2	Conclusion of the report
Replacement of the encoder system	No	No	Test of failsafe actual value acquisition	Supplementation New checksums and countersignature as required
Replacement of an SMC/SME Module	Supplementation of hardware data/configuration/ software version data	No	Test of failsafe actual value acquisition	Supplementation New checksums and countersignature
Replacement of a motor with DRIVE-CLiQ	Supplementation of hardware data/configuration/ software version data	No	Test of failsafe actual value acquisition	Supplementation New checksums and countersignature
Replacement of the Control Unit power unit - hardware	Supplementation of hardware data/configuration/ software version data	No	Partially, if the system scan cycle times or the dynamic response were changed (drive-specific)	Supplementation New checksums and countersignature as required
Replacement of SI-relevant distributed I/O devices	Supplementation of hardware data/configuration/ software version data	Yes, with comment restriction to replaced components	No	No
Firmware - upgrade(CU/power unit/ Sensor Modules)	Supplementation Version data	yes, including a note informing of the time of implementation of the new functionality	yes, if the system scan cycle times or the dynamic response were changed or test of the new functionality	Supplementation New checksums and countersignature as required
Change to a single limit (e.g. SLS limit)	Supplementary SI function per drive	No	Partially, test of the changed limit	Supplementation New checksums and countersignature
Enhancement of functions (e.g. additional actuator, additional SLS stage)	Supplementary SI functions per drive or function table	yes, with note restriction to adapted parts as required	Partially, test of any additional limits	No if data are identical (check of checksums)
Transfer of project data to other machines via series commissioning	Possibly supplement to the machine description (check of the firmware version)	Yes, with note	No, if no changes were made to SI parameters	No, if data are identical (check of checksums)

8.2 Acceptance test procedure

Note

The acceptance test is used to check that the safety functions have been correctly parameterized. The measured values (e.g. distance, time) and system behavior identified (e.g. initiation of a specific stop) within the acceptance test are used to validate configured safety functions. The objective of an acceptance test is to identify potential configuration errors or to record the valid configuration.

8.3 Acceptance report

8.3.1 Plant description - Documentation part 1

Table 8-2 Machine description and overview diagram

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Electrical drives	
Other drives	
Overview diagram of machine	

Table 8-3 Values of relevant parameters

Versions of the firmware and of Safety Integrated			
Parameter Control Unit		FW version	-
		r0018 =	-

Parameter Motor Modules	**Drive number**	**FW version**	**SI version**
		-	r9590 = r9770 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
		r0128 =	r9390 = r9870 =
Parameters Sensor Modules	**Drive number**	**FW version**	**SI version**
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
		r0148 =	r9890 =
Terminal Module parameters	**Drive number**	**FW version**	**SI version**
		r0158 =	r10090 =
		r0158 =	r10090 =
Monitoring clock cycles of Safety Integrated			
	Drive number	**SI monitoring clock cycle Control Unit**	**SI monitoring clock cycle Motor Module**
Parameter Motor Modules Basic Functions		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
	Drive number	**SI monitoring clock cycle Motor Module**	**SI monitoring clock cycle Control Unit**
Parameters Motor Modules Extended Functions		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
		p9300 =	p9500 =
TM54F parameters		p10000 =	

8.3.2 Description of safety functions - Documentation Part 2

8.3.2.1 Introduction

This example contains the description of a plant; the settings for a specific plant must be adapted accordingly.

8.3.2.2 Function table

Table 8-4 Example table: Active monitoring functions depending on the operating mode, the protective doors or other sensors

Mode of operation	Protective door	Drive	Status of monitoring functions
Production	closed and locked	1 2	deactivated SLS enabled
	unlocked	1 2	SOS STO deactivated
Setup	closed and locked	1 2	deactivated SLS 1 enabled
	unlocked	1 2	SLS 1 disabled / enabled

Comments:

8.3.2.3 SI functions for each drive

Table 8-5 Function overview of safety functions

Drive	SI function	Limit	active if
1	SOS	100 mm	refer to the function table
	SLS 1	200000 mm/min	refer to the function table
	SLS 2	50000 mm/min	refer to the function table
2	SOS	100 mm	refer to the function table
	SLS 1	50 rpm	refer to the function table

Comments:

All drives use the SI function SS1 for EMERGENCY STOP functionality.

Drive 2 is equipped with a holding brake which is controlled by two channels via the corresponding Motor Module output.

Drive-specific data

Table 8-6 Drive-specific data

SI function	Parameters	Value
Enable	p9601	
	p9801	
PROFIsafe address		
SOS		
SLS1 (limit 1)		
SLS2 (limit 2)		
SSM		
STOP F -> STOP A delay time		

8.3.2.4 Control of the SI functions by way of TM54F

Documentation of the parameters

Table 8-7 Parameters for control by way of TM54F

Functionality	Parameters	Value

8.3.2.5 Control of SI functions by way of PROFIsafe

Documentation of the parameters

Table 8-8 Parameters for control by way of PROFIsafe

Functionality	Parameters	Value

8.3.2.6 Safety equipment

Protective door The protective door is unlocked by means of single-channel request key
Protective door switch The protective door is equipped with a safety door switch. The safety door switch returns the dual-channel signal "Door closed and locked". Changeover and selection of safety functions in accordance with the table shown above.
Mode selector switch The "Production" and "Setup" modes are set by means of a mode selector switch. The key switch features two contact levels. Changeover and selection of safety functions in accordance with the table shown above.
EMERGENCY-STOP pushbutton The dual-channel EMERGENCY-STOP pushbuttons are wired in series. The EMERGENCY-STOP signal activates SS1 for all drives and initiates the evaluation of external brakes and of STO.
Test stop Activation by means of: • Machine power on • Unlocking the protective door

8.4 Acceptance tests

8.4.1 Acceptance test for Safe Torque Off (STO)

"Safe Torque Off" (STO) function

This test comprises the following steps:

Table 8-9 "Safe Torque Off" (STO) function

No.	Description	Status
1.	Initial state	
	Drive in "Ready" status (p0010 = 0)	
	STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	No safety faults and alarms (r0945, r2122, r2132)	
	r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
2.	Run the drive	

No.	Description	Status
3.	Ensure that the correct drive is running	
4.	Select STO when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		
5.	Check the following:	
	• The drive coasts to a standstill or is braked and stopped by the mechanical brake (if available and configured (p1215, p9602, p9802)).	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9772.0 = r9772.1 = 1 (STO selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• When terminals are grouped for "Safe torque off": r9774.0 = r9774.1 = 1 (STO selected and active - group)	
6.	Deselect STO	
7.	Check the following:	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive	
9.	Ensure that the correct drive is running	
	The following is tested: • Correct DRIVE-CLiQ wiring between Control Unit and Motor Modules • Correct assignment of drive No. – Motor Module – motor • The hardware is functioning properly • The switch-off signal paths are wired correctly • Correct assignment of the terminals for STO on the Control Unit • Correct STO grouping (if available) • Correct parameterization of the STO function • Routine for forced dormant error detection of the switch-off signal paths	

8.4.2 Acceptance test for Safe Stop 1, time controlled (SS1)

"Safe Stop 1" function (SS1, time-controlled)

This test comprises the following steps:

Table 8-10 "Safe Stop 1" function (SS1)

No.	Description	Status
1.	Initial state	
	Drive in "Ready" status (p0010 = 0)	
	STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	Enable SS1 function (p9652 > 0, p9852 > 0)	
	No safety faults and alarms (r0945, r2122, r2132)	
	r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	r9772.2 = r9872.2 = 0 (SS1 not requested – CU and MM)	
	When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
2.	Run the drive	
3.	Ensure that the correct drive is running	
4.	Select SS1 when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		
5.	Check the following:	
	• The drive is braked along the OFF3 ramp (p1135)	
	Before the SS1 delay time (p9652, p9852) expires, the following applies:	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive - CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9772.2 = r9872.2 = 1 (SS1 active – CU and MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9773.2 = 1 (SS1 active – drive)	
	STO is initiated after the SS1 delay time expires (p9652, p9852)	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9722.0 = r9772.1 = 1 (STO selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9772.2 = r9872.2 = 0 (SS1 inactive – CU and MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9773.2 = 0 (SS1 inactive – drive)	
6.	Deselect SS1	
7.	Check the following:	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9722.0 = r9772.1 = 0 (STO de-selected and inactive - CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9772.2 = r9872.2 = 0 (SS1 inactive – CU and MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9773.2 = 0 (SS1 inactive – drive)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive	

No.	Description	Status
9.	Ensure that the correct drive is running	
	The following is tested: • Correct parameterization of the SS1 function	

8.4.3 Acceptance test for "Safe Brake Control" (SBC)

"Safe Brake Control" function (SBC)

This test comprises the following steps:

Table 8-11 "Safe brake control" (SBC) function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" status (p0010 = 0)	
	• STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Vertical axis: Brake as in sequential control (p1215 = 1) • No vertical axis: Brake always released (p1215 = 2)	
	• Vertical axis: Mechanical brake is applied • No vertical axis: Mechanical brake is released	
	• No safety faults or alarms (r0945, r2122)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9772.4 = r9872.4 = 0 (SBC not requested – CU and MM)	
2.	Run drive (applied brake is released)	
3.	Ensure that the correct drive is running	
4.	Select STO/SS1 when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		

No.	Description	Status
5.	Check the following: • Drive is braked and stopped by the mechanical brake. • No safety faults or alarms (r0945, r2122) • r9772.0 = r9772.1 = 1 (STO selected and active – CU) • r9872.0 = r9872.1 = 1 (STO selected and active – MM) • r9773.0 = r9773.1 = 1 (STO selected and active – drive) • r9772.4 = r9872.4 = 1 (SBC requested – CU and MM)	
6.	Deselect STO	
7.	Check the following:	
	• Vertical axis: Mechanical brake remains applied • No vertical axis: Mechanical brake is released • No safety faults or alarms (r0945, r2122)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9772.4 = r9872.4 = 0 (SBC not requested – CU and MM)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive (vertical axis: mechanical brake is released)	
9.	Ensure that the correct drive is running	
	The following is tested: • The brake is connected properly • The hardware is functioning properly • The SBC is parameterized correctly • Routine for the forced dormant error detection of the brake control	

8.4.4 Acceptance test for Safe Stop 1, time and acceleration controlled

"Safe Stop 1" function (SS1, time and acceleration controlled)

This test comprises the following steps:

Table 8-12 "Safe Stop 1" function (SS1)

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• SOS/SLS function enabled (p9501.0 = 1)	
	• No safety alarm (r0945, r2122, r9747)	

No.	Description	Status
2.	Move the drive	
3.	Check whether the expected drive is moving	
4.	Start Trace (trigger r9720.1 = 0) Trace recording of the following values: • Safe actual speed (r9714) • SS1 deactivation (r9720.1) • STO active (r9722.0) • SS1 active (r9722.1)	
5.	Select SS1 while the drive is moving	
Note: The acceptance test must be conducted for each configured control which can be set, for example, by way of TM54F or PROFIsafe.		
6.	The drive must decelerate to the standstill limit	
7.	Save / print the Trace (refer to the example below)	
8.	Canceling SS1	
9.	Acknowledge "Power on inhibit" and move the drive	
10.	Check whether the expected drive is moving	

Example of the Trace

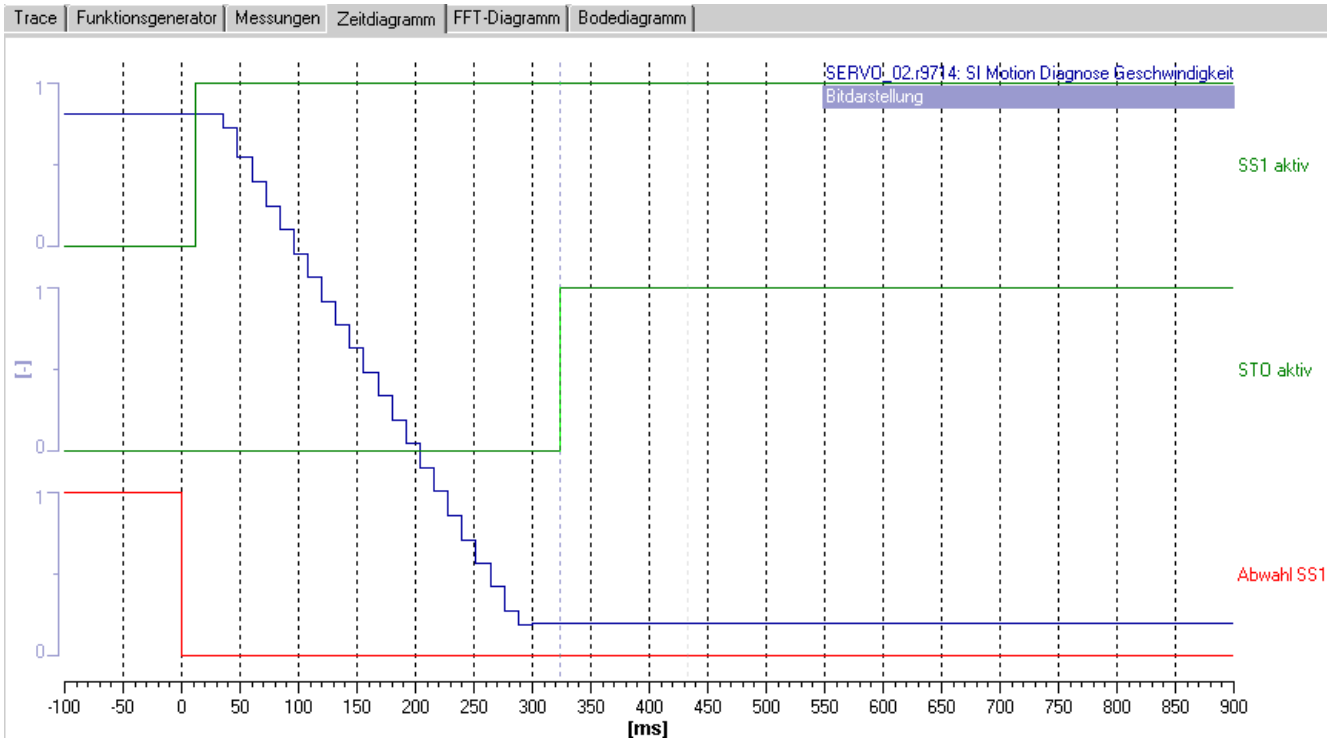


Figure 8-1 Example Trace SS1

8.4.5 Acceptance test for Safe Stop 2 (SS2)

"Safe Stop 2" function (SS2)

The functional test must be carried out separately for each drive (as far as the machine allows).

The test comprises the following steps:

Table 8-13 "Safe Stop 2" function (SS2)

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• SOS/SLS function enabled (p9501.0 = 1)	
	• No safety alarm (r0945, r2122, r9747)	
2.	Move the drive	
3.	Check whether the expected drive is moving	
4.	Start Trace (trigger SS2 selected r9720.2 = 0) Trace recording of the following values: • Safe actual speed (r9714) • SS2 deactivation (r9720.2) • SS2 active (r9722.2) • SOS active (r9722.3)	
5.	Select SS2 while the drive is moving	
Note: The acceptance test must be conducted for each configured control which can be set, for example, by way of TM54F or PROFIsafe.		
6.	The drive must decelerate to the standstill limit	
7.	Save / print the Trace (refer to the example below)	
8.	SS2 deactivated	
9.	Drive returns to the setpoint	

Example of the Trace

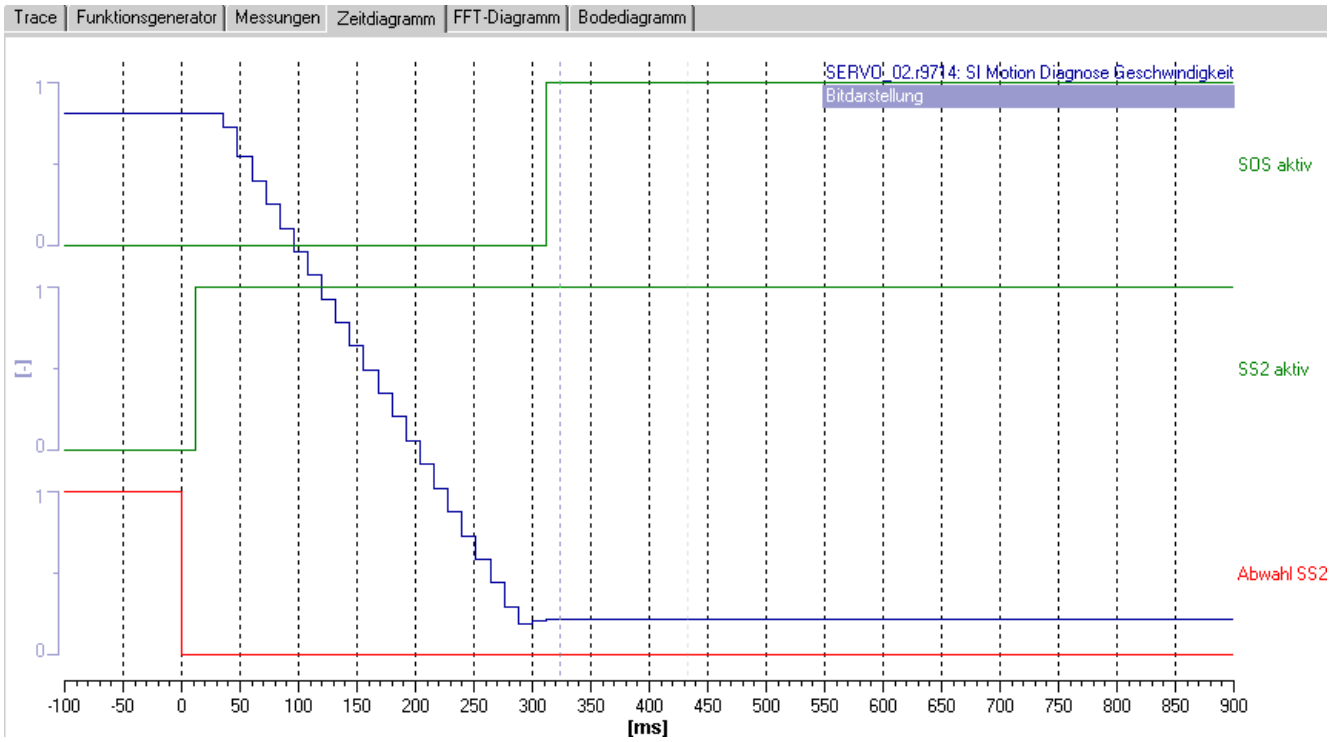


Figure 8-2 Example Trace SS2

8.4.6 Acceptance test for Safe Operational Stop (SOS)

"Safe Operational Stop" (SOS) function

The functional test must be carried out separately for each drive (as far as the machine allows).

The test comprises the following steps:

Table 8-14 "Safe Operational Stop" (SOS) function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• SOS/SLS function enabled (p9501.0 = 1)	
	• No safety alarm (r0945, r2122, r9747)	
2.	Activation of the acceptance test mode by means of p9370 = p9570 = 00AC (hex)	
3.	Deactivate any speed setpoint limit in the higher-level controller	

No.	Description	Status
4.	Start Trace (trigger actual position r9713 > 0) Trace recording of the following values: • Safe actual position value (r9713[0/1]) • STOP A or B active (r9721.12) • STO active (r9721.0) • SOS active (r9722.3)	
5.	Run the drive beyond the standstill limit set in p9330/p9530	
6.	The drive must decelerate to the standstill limit	
7.	Save / print the Trace (refer to the example below)	
8.	Deactivation of the acceptance test mode by means of p9370 = p9570 = 0000 (hex)	

Example of the Trace

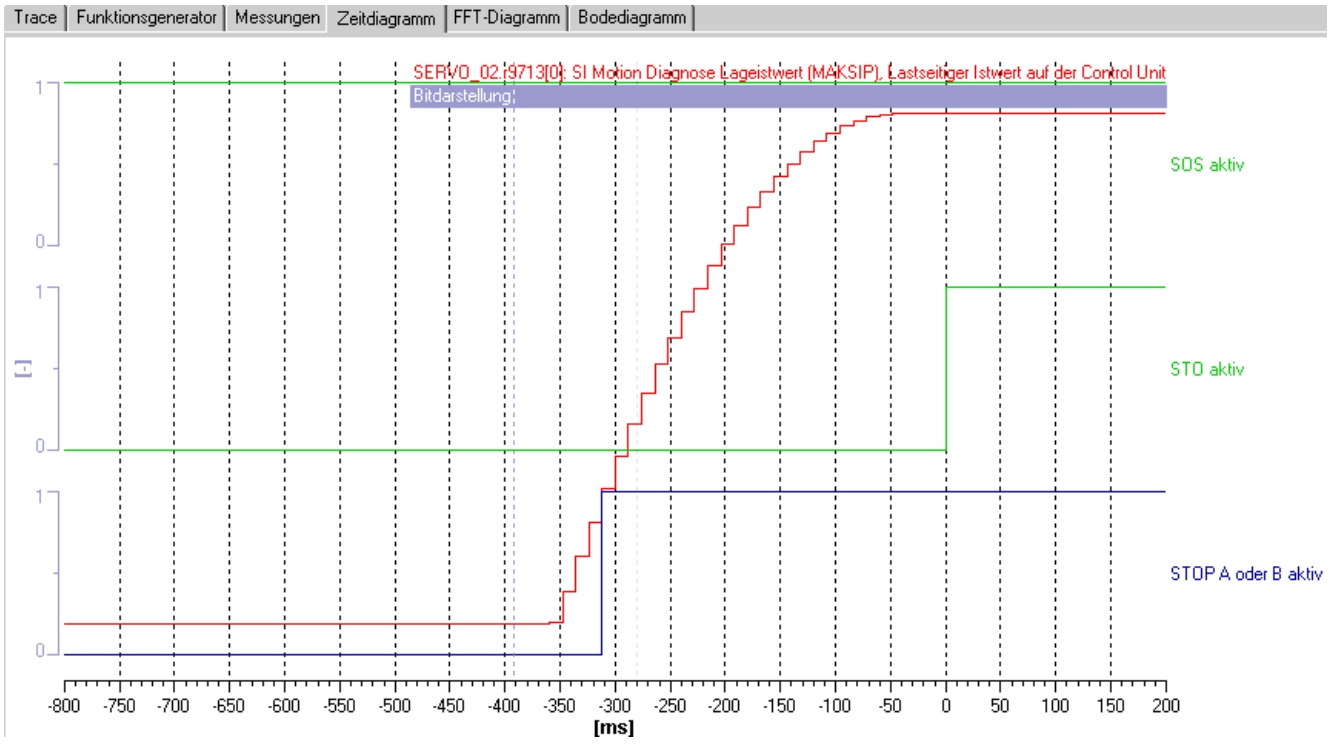


Figure 8-3 Example Trace SOS

8.4.7 Acceptance test for Safely Limited Speed (SLS)

"Safely Limited Speed" (SLS) function

The functional test must be carried out separately for each drive and for each SLS speed limit used (as far as the machine allows).

The test comprises the following steps:

Table 8-15 "Safely Limited Speed" (SLS) function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• SOS/SLS function enabled (p9501.0 = 1)	
	• No safety alarm (r0945, r2122, r9747)	
2.	Activation of the acceptance test mode by means of p9370 = p9570 = 00AC (hex)	
3.	Deactivate any speed setpoint limit in the higher-level controller	
4.	Start Trace (trigger r9722.7 = 1/0 edge) Trace recording of the following values: • Safe actual speed (r9714) • STOP C active (r9721.13) • SOS active (r9722.3) • SLS active (r9722.4)	
5.	Run the drive beyond the speed limit set in p9331/p9531	
6.	The drive must decelerate to the standstill limit	
7.	Save / print the Trace (refer to the example below)	
8.	Deactivation of the acceptance test mode by means of p9370 = p9570 = 0000 (hex)	

Example of the Trace

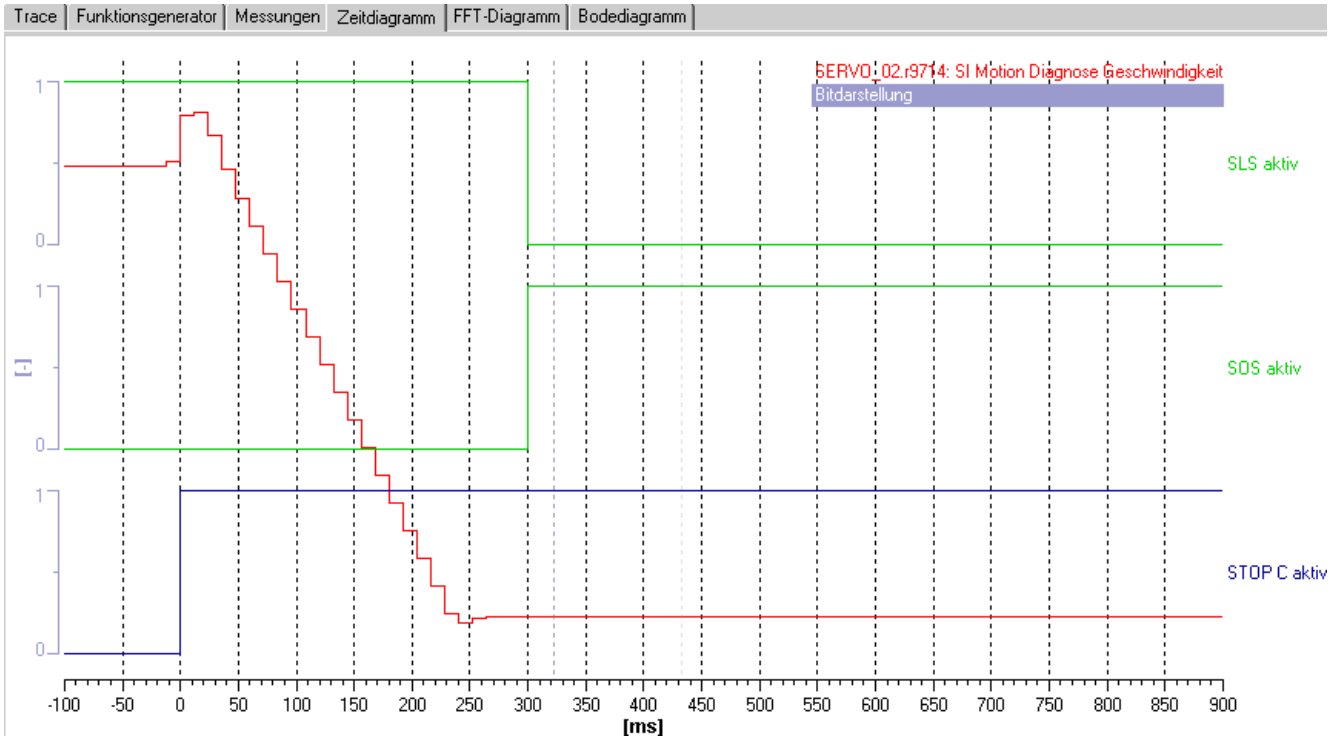


Figure 8-4 Example Trace SLS

8.4.8 Acceptance test for Safe Speed Monitoring (SSM)

"Safe Speed Monitor" (SSM) function

The functional test must be carried out separately for each drive (as far as the machine allows).

The test comprises the following steps:

Table 8-16 "Safe Speed Monitor" (SSM) function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• Safety Integrated Extended Functions enabled (p9601.2 = 1)	
	• SOS/SLS function enabled (p9501.0 = 1)	
	• No safety alarm (r0945, r2122, r9747)	
2.	Start Trace (trigger r9722.15 = 1/0 edge) Trace recording of the following values: • Safe actual speed (r9714) • SSM (n below limit) r9722.15	
3.	Operate the drive above the speed limit set in p9346/p9546	
4.	Operate the drive below the speed limit set in p9346/p9546 minus the hysteresis set in p9347/p9547	
5.	Save / print the Trace (refer to the example below)	

Example of the Trace

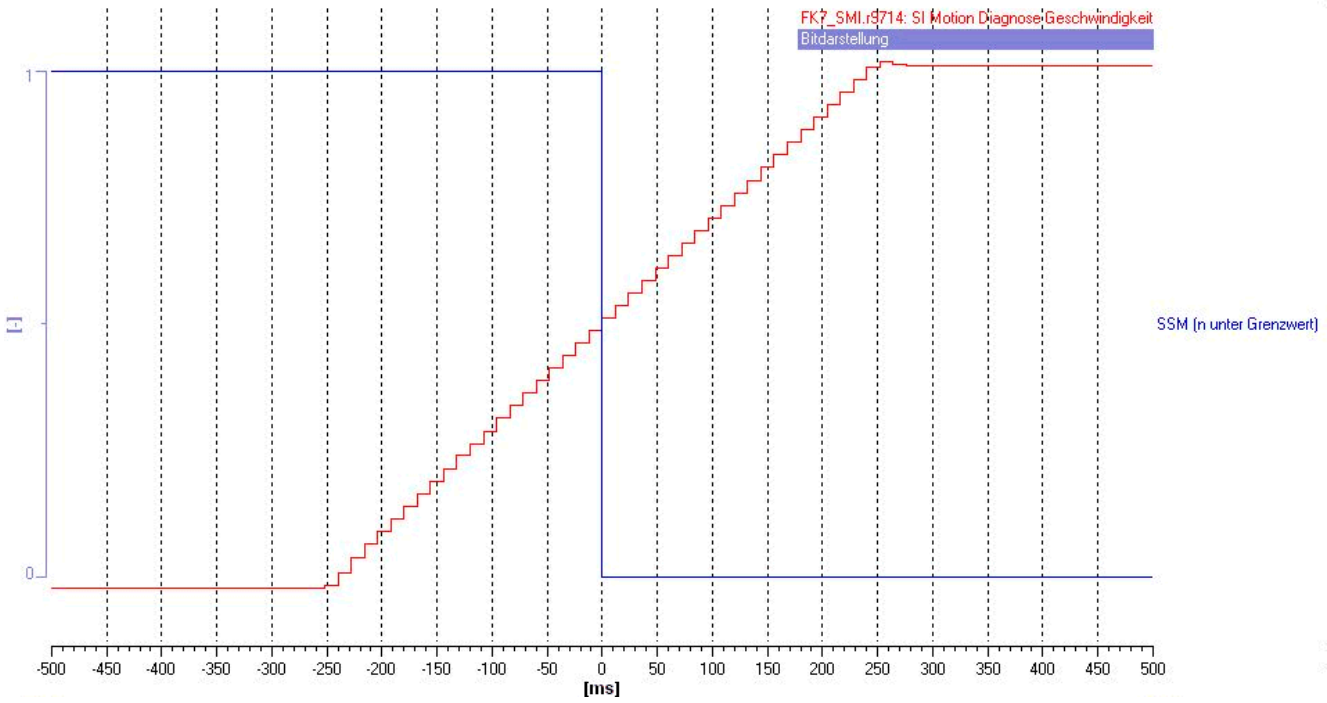


Figure 8-5 Example Trace SSM

Appendix A

A

A.1 List of abbreviations

Note

The following list of abbreviations includes all abbreviations and their meanings used in the entire SINAMICS user documentation.

Abbreviation	Meaning, German	Meaning, English
A		
A...	Warnung	Alarm
AC	Wechselstrom	Alternating Current
ADC	Analog-Digital-Konverter	Analog Digital Converter
AI	Analogeingang	Analog Input
AIM	Active Interface Module	Active Interface Module
ALM	Active Line Module	Active Line Module
AO	Analogausgang	Analog Output
AOP	Advanced Operator Panel	Advanced Operator Panel
APC	Advanced Positioning Control	Advanced Positioning Control
ASC	Ankerkurzschluss	Armature Short-Circuit
ASCII	Amerikanische Code-Norm für den Informationsaustausch	American Standard Code for Information Interchange
ASM	Asynchronmotor	Induction motor
B		
BB	Betriebsbedingung	Operating condition
BERO	Firmenname für einen Näherungsschalter	Tradename for a type of proximity switch
BI	Binektoreingang	Binector Input
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit	German Institute for Occupational Safety
BICO	Binektor-Konnektor-Technologie	Binector Connector Technology
BLM	Basic Line Module	Basic Line Module
BOP	Basic Operator Panel	Basic Operator Panel
C		
C	Kapazität	Capacitance
C...	Safety-Meldung	Safety message

Abbreviation	Meaning, German	Meaning, English
CAN	Serielles Bussystem	Controller Area Network
CBC	Kommunikationsbaugruppe CAN	Communication Board CAN
CD	Compact Disc	Compact Disc
CDS	Befehlsdatensatz	Command Data Set
CF	CompactFlash	CompactFlash
CI	Konnektoreingang	Connector Input
CNC	Computerunterstützte numerische Steuerung	Computer Numerical Control
CO	Konnektorausgang	Connector Output
CO/BO	Konnektor-/Binektorausgang	Connector Output/Binector Output
COB-ID	CAN Object-Identification	CAN Object-Identification
COM	Mittelkontakt eines Wechselkontaktes	Common contact of a change-over relay
CP	Kommunikationsprozessor	Communications Processor
CPU	Zentrale Recheneinheit	Central Processing Unit
CRC	Checksummenprüfung	Cyclic Redundancy Check
CSM	Control Supply Module	Control Supply Module
CU	Control Unit	Control Unit
D		
DAC	Digital-Analog-Konverter	Digital Analog Converter
DC	Gleichstrom	Direct Current
DCB	Drive Control Block	Drive Control Block
DCC	Drive Control Chart	Drive Control Chart
DCN	Gleichstrom negativ	Direct Current Negative
DCP	Gleichstrom positiv	Direct Current Positive
DDS	Antriebsdatensatz	Drive Data Set
DI	Digitaleingang	Digital Input
DI/DO	Digitaleingang/-ausgang bidirektional	Bidirectional Digital Input/Output
DMC	DRIVE-CLiQ Module Cabinet (Hub)	DRIVE-CLiQ Module Cabinet (Hub)
DO	Digitalausgang	Digital Output
DO	Antriebsobjekt	Drive Object
DP	Dezentrale Peripherie	Decentralized Peripherals (Distributed I/Os)
DPRAM	Speicher mit beidseitigem Zugriff	Dual-Port Random Access Memory
DRAM	Dynamischer Speicher	Dynamic Random Access Memory
DRIVE-CLiQ	Drive Component Link with IQ	Drive Component Link with IQ
DSC	Dynamic Servo Control	Dynamic Servo Control
E		
EASC	Externer Ankerkurzschluss	External Armature Short-Circuit
EDS	Geberdatensatz	Encoder Data Set
EGB	Elektrostatisch gefährdete Baugruppen	Electrostatic Sensitive Devices (ESD)
ELP	Erdschlussüberwachung	Earth Leakage Protection
EMK	Elektromagnetische Kraft	Electromagnetic Force (EMF)
EMV	Elektromagnetische Verträglichkeit	Electromagnetic Compatibility (EMC)

Abbreviation	Meaning, German	Meaning, English
EN	Europäische Norm	European Standard
EnDat	Geber-Schnittstelle	Encoder-Data-Interface
EP	Impulsfreigabe	Enable Pulses
EPOS	Einfachpositionierer	Basic positioner
ES	Engineering System	Engineering System
ESB	Ersatzschaltbild	Equivalent circuit diagram
ESR	Erweitertes Stillsetzen und Rückziehen	Extended Stop and Retract
F		
F...	Störung	Fault
FAQ	Häufig gestellte Fragen	Frequently Asked Questions
FBL	Freie Funktionsblöcke	Free Blocks
FCC	Function Control Chart	Function Control Chart
FCC	Flussstromregelung	Flux Current Control
F-DI	Fehlersicherer Digitaleingang	Failsafe Digital Input
F-DO	Fehlersicherer Digitalausgang	Failsafe Digital Output
FEM	Fremderregter Synchronmotor	Separately excited synchronous motor
FEPROM	Schreib- und Lesespeicher nichtflüchtig	Flash-EPROM
FG	Funktionsgenerator	Function Generator
FI	Fehlerstrom-Schutzschalter	Earth Leakage Circuit-Breaker (ELCB)
FP	Funktionsplan	Function diagram
FPGA	Field Programmable Gate Array	Field Programmable Gate Array
FW	Firmware	Firmware
G		
GB	Gigabyte	Gigabyte
GC	Global-Control-Telegramm (Broadcast-Telegramm)	Global Control Telegram (Broadcast Telegram)
GSD	Gerätestammdatei: beschreibt die Merkmale eines PROFIBUS-Slaves	Device master file: describes the features of a PROFIBUS slave
GSV	Gate Supply Voltage	Gate Supply Voltage
GUID	Globally Unique Identifier	Globally Unique Identifier
H		
HF	Hochfrequenz	High Frequency
HFD	Hochfrequenzdrossel	High frequency reactor
HLG	Hochlaufgeber	Ramp-function generator
HMI	Mensch-Maschine-Schnittstelle	Human Machine Interface
HTL	Logik mit hoher Störschwelle	High-Threshold Logic
HW	Hardware	Hardware
I		
i. V.	In Vorbereitung: diese Eigenschaft steht zur Zeit nicht zur Verfügung	In preparation: this feature is currently not available
I/O	Eingang/Ausgang	Input/Output
I2C	Serieller interner Datenbus	Inter-Integrated Circuit
IASC	Interner Ankerkurzschluss	Internal Armature Short-Circuit
IBN	Inbetriebnahme	Commissioning

Abbreviation	Meaning, German	Meaning, English
ID	Identifizierung	Identifier
IEC	Internationale Norm in der Elektrotechnik	International Electrotechnical Commission
IF	Interface	Interface
IGBT	Bipolartransistor mit isolierter Steuerelektrode	Insulated Gate Bipolar Transistor
IL	Impulslöschung	Pulse suppression
IPO	Interpolatortakt	Interpolator clock
IT	Drehstromversorgungsnetz ungeerdet	Insulated three-phase supply network
IVP	Interner Spannungsschutz	Internal Voltage Protection
J		
JOG	Tippen	Jogging
K		
KDV	Kreuzweiser Datenvergleich	Data cross-checking
KIP	Kinetische Pufferung	Kinetic buffering
Kp	Proportionalverstärkung	Proportional gain
KTY	Spezieller Temperatursensor	Special temperature sensor
L		
L	Induktivität	Inductance
LED	Leuchtdiode	Light Emitting Diode
LIN	Linearmotor	Linear motor
LR	Lageregler	Position controller
LSB	Niederstwertiges Bit	Least Significant Bit
LSS	Netzschalter	Line Side Switch
LU	Längeneinheit	Length Unit
LWL	Lichtwellenleiter	Fiber-optic cable
M		
M	Masse	Reference potential, zero potential
MB	Megabyte	Megabyte
MCC	Motion Control Chart	Motion Control Chart
MDS	Motordatensatz	Motor Data Set
MLFB	Maschinenlesbare Fabrikatebezeichnung	Machine-readable product designation
MMC	Mensch-Maschine-Kommunikation	Man-Machine Communication
MSB	Höchstwertiges Bit	Most Significant Bit
MSCY_C1	Zyklische Kommunikation zwischen Master (Klasse 1) und Slave	Master Slave Cycle Class 1
MSC	Motorstromrichter	Motor power converter
MT	Messtaster	Measuring probe
N		
N. C.	Nicht angeschlossen	Not Connected
N...	Keine Meldung oder Interne Meldung	No Report
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regeltechnik in der chemischen Industrie	Standardization association for instrumentation and control in the chemical industry
NC	Öffner	Normally Closed (contact)
NC	Numerische Steuerung	Numerical Control

Abbreviation	Meaning, German	Meaning, English
NEMA	Normengremium in USA (United States of America)	National Electrical Manufacturers Association
NM	Nullmarke	Zero Mark
NO	Schließer	Normally Open (contact)
NSR	Netzstromrichter	Line power converter
O		
OA	Open Architecture	Open Architecture
OEM	Original Equipment Manufacturer	Original Equipment Manufacturer
OLP	Busstecker für Lichtleiter	Optical Link Plug
OMI	Option Module Interface	Option Module Interface
P		
p...	Einstellparameter	Adjustable parameter
PB	PROFIBUS	PROFIBUS
PcCtrl	Steuerungshoheit	Master Control
PD	PROFIdrive	PROFIdrive
PDS	Leistungsteildatensatz	Power Unit Data Set
PE	Schutzerde	Protective Earth
PELV	Schutzkleinspannung	Protective Extra Low Voltage
PEM	Permanenterregter Synchronmotor	Permanent-magnet synchronous motor
PG	Programmiergerät	Programming terminal
PI	Proportional Integral	Proportional Integral
PID	Proportional Integral Differential	Proportional Integral Differential
PLC	Speicherprogrammierbare Steuerung (SPS)	Programmable Logic Controller (PLC)
PLL	Phase Locked Loop	Phase Locked Loop
PNO	PROFIBUS Nutzerorganisation	PROFIBUS user organization
PPI	Punkt zu Punkt Schnittstelle	Point to Point Interface
PRBS	Weißes Rauschen	Pseudo Random Binary Signal
PROFIBUS	Serieller Datenbus	Process Field Bus
PS	Stromversorgung	Power Supply
PSA	Power Stack Adapter	Power Stack Adapter
PTC	Positiver Temperaturkoeffizient	Positive Temperature Coefficient
PTP	Punkt zu Punkt	Point-To-Point
PWM	Pulsweitenmodulation	Pulse Width Modulation
PZD	PROFIBUS Prozessdaten	PROFIBUS process data
R		
r...	Beobachtungsparameter (nur lesbar)	Display parameter (read only)
RAM	Speicher zum Lesen und Schreiben	Random Access Memory
RCCB	Fehlerstrom-Schutzschalter	Residual Current Circuit Breaker
RCD	Fehlerstrom-Schutzschalter	Residual Current Device
RJ45	Norm. Beschreibt eine 8-polige Steckverbindung mit Twisted-Pair Ethernet.	Standard. Describes an 8-pole plug connector with twisted pair Ethernet.
RKA	Rückkühlanlage	Recooling system
RO	Nur lesbar	Read Only

Abbreviation	Meaning, German	Meaning, English
RPDO	Receive Process Data Object	Receive Process Data Object
RS232	Serielle Schnittstelle	Serial Interface
RS485	Norm. Beschreibt die Physik einer digitalen seriellen Schnittstelle.	Standard. Describes the physical characteristics of a digital serial interface.
RTC	Echtzeituhr	Real Time Clock
RZA	Raumzeigerapproximation	Space vector approximation (SVA)
S		
S1	Dauerbetrieb	Continuous operation
S3	Aussetzbetrieb	Periodic duty
SBC	Sichere Bremsenansteuerung	Safe Brake Control
SBH	Sicherer Betriebshalt	Safe operating stop
SBR	Sichere Bremsrampe	Safe braking ramp
SBT	Sicherer Bremsentest	Safe Brake Test
SCA	Sichere Nocke	Safe Cam
SDI	Sichere Richtung	Safe Direction
SE	Sicherer Software-Endschalter	Safe software limit switch
SG	Sicher reduzierte Geschwindigkeit	Safely reduced speed
SGA	Sicherheitsgerichteter Ausgang	Safety-related output
SGE	Sicherheitsgerichteter Eingang	Safety-related input
SH	Sicherer Halt	Safety standstill-
SI	Safety Integrated	Safety Integrated
SIL	Sicherheitsintegritätsgrad	Safety Integrity Level
SLI	Sicheres Schrittmaß	Safely Limited Increment
SLM	Smart Line Module	Smart Line Module
SLP	Sicher begrenzte Position	Safely Limited Position
SLS	Sicher begrenzte Geschwindigkeit	Safely Limited Speed
SLVC	Geberlose Vektorregelung	Sensorless Vector Control
SM	Sensor Module	Sensor Module
SMC	Sensor Module Cabinet	Sensor Module Cabinet
SME	Sensor Module External	Sensor Module External
SN	Sicherer Software-Nocken	Safe software cam
SOS	Sicherer Betriebshalt	Safe Operational Stop
SPC	Sollwertkanal	Setpoint Channel
SPI	Serielle Schnittstelle für Peripherieanbindung	Serial Peripheral Interface
SPS	Speicherprogrammierbare Steuerung	Programmable Logic Controller (PLC)
SS1	Sicherer Stop 1	Safe Stop 1
SS2	Sicherer Stop 2	Safe Stop 2
SSI	Synchron Serielle Schnittstelle	Synchronous Serial Interface
SSM	Sichere Rückmeldung der Geschwindigkeitsüberwachung (n < nx)	Safe Speed Monitoring
SSR	Sichere Bremsrampe	Safe Stop Ramp
STO	Sicher abgeschaltetes Moment	Safe Torque Off
STW	PROFIBUS Steuerwort	PROFIBUS control word

Abbreviation	Meaning, German	Meaning, English
T		
TB	Terminal Board	Terminal Board
TIA	Totally Integrated Automation	Totally Integrated Automation
TM	Terminal Module	Terminal Module
TN	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
Tn	Nachstellzeit	Integral time
TPDO	Transmit Process Data Object	Transmit Process Data Object
TT	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
TTL	Transistor-Transistor-Logik	Transistor-Transistor Logic
Tv	Vorhaltezeit	Derivative-action time
U		
UL	Underwriters Laboratories Inc.	Underwriters Laboratories Inc.
USV	Unterbrechungsfreie Stromversorgung	Uninterruptible Power Supply (UPS)
V		
VC	Vektorregelung	Vector Control
Vdc	Zwischenkreisspannung	DC link voltage
VdcN	Teilzwischenkreisspannung negativ	Partial DC link voltage negative
VdcP	Teilzwischenkreisspannung positiv	Partial DC link voltage positive
VDE	Verband Deutscher Elektrotechniker	Association of German Electrical Engineers
VDI	Verein Deutscher Ingenieure	Association of German Engineers
Vpp	Volt Spitze zu Spitze	Volt peak to peak
VSM	Voltage Sensing Module	Voltage Sensing Module
W		
WEA	Wiedereinschaltautomatik	Automatic restart
WZM	Werkzeugmaschine	Machine tool
X		
XML	Erweiterbare Auszeichnungssprache (Standardsprache für Web-Publishing und Dokumentenmanagement)	Extensible Markup Language
Z		
ZK	Zwischenkreis	DC Link
ZSW	PROFIBUS Zustandswort	PROFIBUS status word

Overview of SINAMICS Documentation (07/2007)

General Documentation/Catalogs

SINAMICS
G110
G120
G120D

D11.1
G110/G120
Inverter chassis units
G120D
Distributed frequency inverters

SINAMICS
G130
G150

D11
Drive Converter
Chassis Units
Drive Converter
Cabinet Units

SINAMICS
S120

D21.1
Drive System
0.12 kW to 1200 kW

SINAMICS
S150

D21.3
Drive Converter
Cabinet Units
75 kW to 1200 kW

Manufacturer/Service Documentation

SINAMICS
G110

– Getting Started
– Operating Instructions
– List Manual

SINAMICS
G120

– Getting Started
– Operating Instructions
– Function Manual
– List Manual

SINAMICS
G130

– Operating Instructions
– List Manual

SINAMICS
G150

– Operating Instructions
– List Manual

SINAMICS
GM150
SM150
GL150

– Operating Instructions
– List Manual

Manufacturer/Service Documentation

SINAMICS
S120

– Equipment Manual for Control Units and Additional System Components
– Equipment Manual for Booksize Power Units
– Equipment Manual Chassis Power Units
– Equipment Manual Booksize Cold–Plate Power Units
– Equipment Manual Cabinet Modules
– Equipment Manual AC Drive
– Equipment Manual Chassis Liquid Cooled Power Units

SINAMICS
S120

– Getting Started
– Commissioning Manual
– Commissioning Manual CANopen
– Function Manual Drive Functions
– Function Manual Safety Integrated
– Function Manual DCC Standard Blocks
– Programming and Operating Manual DCC Editor Description
– List Manual

SINAMICS
S150

– Operating Instructions
– List Manual

Manufacturer/Service Documentation

SINAMICS
G110/G120/
S120
Motors

DOCONCD

Configuration Manual
Motors

EMC
Installation Guideline

If you come across any misprints in this document, please let us know using this form. We would also be grateful for any suggestions and recommendations for improvement.

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Suggestions and/or corrections

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