Controlling the Safety Integrated Functions of SINAMICS S120 with SIMATIC S7-1500 F-CPU via PROFIsafe

SINAMICS S120 / SIMATIC S7-1500 F-CPU / PROFIsafe

https://support.industry.siemens.com/cs/ww/en/view/109749224

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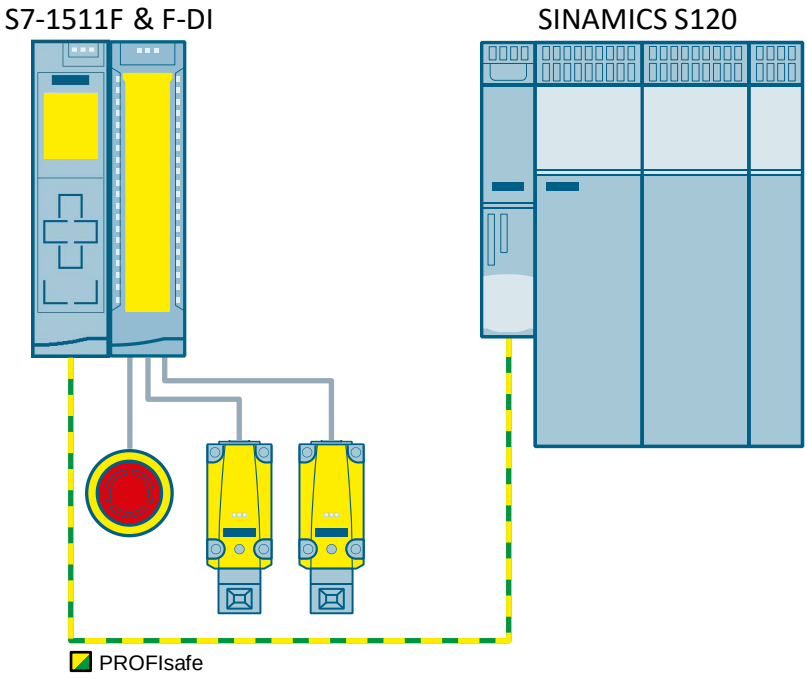
1 Introduction

1.1 Overview

This application example describes how to implement the following safety functions of the system with the Safety Integrated Functions of SINAMICS S120 and a SIMATIC S7-1500 F CPU.

1. If an emergency stop mushroom pushbutton is actuated or the safety door is opened in automatic mode ("serviceMode = FALSE"), the drive should be brought to a standstill as quickly as possible.
   The Safety Integrated Functions "Safe Stop 1 (SS1 ≙ STOP B)" initiates and monitors the braking process of the drive. STOP A (Safety Integrated Function "Safe Torque Off" (STO ≙ STOP A)) is triggered after the deceleration time has elapsed or when the speed falls below a parameterizable speed.
2. In service mode ("serviceMode = TRUE"), the drive should move at reduced speed when the safety door is open.
   The Safety Integrated Function "Safely-Limited Speed (SLS)" monitors whether the motor exceeds the specified speed limit. If the speed is exceeded, STOP B is initiated with a subsequent STOP A.

Figure 1-1: Overview of components



The safety-relevant data between the SINAMICS S120 drive and the higher-level SIMATIC S7-1500 F-CPU controller is exchanged via a PROFIsafe telegram.

The application example describes the following aspects:

- Configuring SINAMICS S120 with Startdrive
- Configuring PROFIsafe telegrams
- Configuring Safety Integrated Functions in the drive
- Creating an F program for Safety Integrated Functions
- Evaluating the Safety Information Channel in the standard program
- Commissioning Safety Integrated Functions

1.2 Components used

This application example was created with the following hardware and software components:

Note The components marked in light blue correspond to the components of the SINAMICS S120 training case with the article number "6ZB2480-0BA00".

Table 1-1: Components used

Component	Quantity	Article number	Note
CPU 1511F-1 PN	1	6ES7511-1FK02-0AB0	Firmware V2.6
F-DI 16X24V DC	1	6ES7526-1BH00-0AB0	-
SINAMICS Control Unit CU320-2 PN	1	6SL3040-1MA01-0AA0	Firmware V5.2
SINAMICS S120 Smart line module	1	6SL3130-6AE15-0AA0	-
SINAMICS S120 Double motor module	1	6SL3120-2TE13-0AA0	-
Sensor module SMC20	1	6SL3055-0AA00-5BA1	-
Synchronous motor with incremental encoder without DRIVE-CLIQ interface	1	1FK7022-5AK71-1AG0	-
Synchronous motor with absolute encoder and with DRIVE-CLIQ interface	1	1FK7022-5AK71-1LG0	-
STEP 7 Professional V15.1	1	6ES7822-1..05-..	-
STEP 7 Safety Advanced V15.1		6ES7833-1FA15-0YH5	-

Components of the application example

This application example consists of the following components:

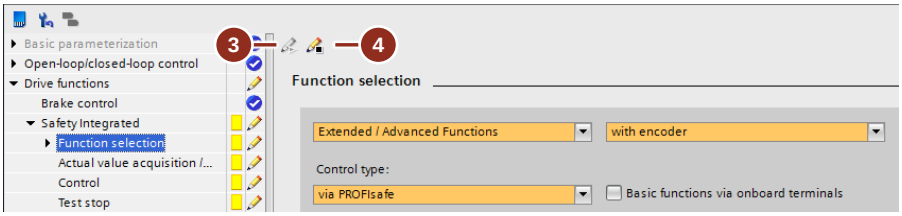
Table 1-2 Components of the application example

Component	File name
Documentation	109749224_SafetyS120_TO_Axis_DOC_v14_en.pdf
TIA Portal project	109749224_SafetyS120_TO_Axis_PROJ_v14.zip

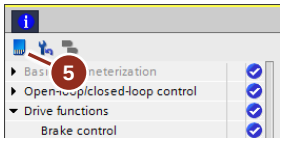
Using the TIA Portal Project

When using the TIA Portal project, the hardware exchange must be acknowledged after downloading the SINAMICS configuration. Proceed as follows:

1. Establish an online connection to the drive unit and open the editor for the drive parameters.
2. Navigate to "Drive Functions > Safety Integrated > Function Selection".
3. Start the safety commissioning by clicking on the "Edit" button.
4. End the safety commissioning by clicking on the "Stop processing" button. This recalculates the safety checksums.



5. To save the parameters in the ROM, click on "Safe the data of all drive objects retentively".



6. Repeat steps 1 to 5 for the second drive.
7. Disconnect the online connection to the drive unit.
8. Load the drive device into the project.
9. Save the project.

2 Basics

2.1 Safety Integrated Functions

SINAMICS S120 distinguishes between Safety Integrated Basic Functions, Safety Integrated Extended Functions and Safety Integrated Advanced Functions. The Safety Integrated Basic Functions are included in the standard scope of the drive. A license is required for each drive for the Safety Integrated Extended Functions and the Safety Integrated Advanced Functions.

The following Safety Integrated Functions are integrated in SINAMICS S120 drives according to DIN EN 61800-5-2:

Table 2-1: Safety Integrated Functions of SINAMICS S120 according to DIN EN 61800-5-2

	Name	Function	Description
Basic Functions	STO (≙ STOP A)	Safe Torque Off	Safely disconnects the torque-generating motor power supply. The restart interlock prevents it from restarting. (Category 0 stop function according to EN 60204-1)
	SS1 (≙ STOP B)	Safe Stop 1	Fast and safely monitored stopping of the drive on the OFF3 ramp. Transition to STO when a delay time has expired or the shutdown speed has been reached. (Category 1 stop function according to EN 60204-1)
	SBC	Safe Brake Control	SBC is used only when there is a motor brake. SBC always responds in conjunction with STO.
Extended Functions	SS2 (≙ STOP C)	Safe Stop 2	Fast and safely monitored stopping of the drive on the OFF3 ramp. Transition to SOS when a delay time has expired; the drive remains in closed-loop control. (Cat. 2 stop function according to EN 60204-1)
	SOS (≙ STOP D)	Safe Operating Stop	The function is used for safe monitoring of a drive's standstill position; the drive remains in closed-loop control. When SOS is active, personnel can enter, for example, protected machine areas without shutting down the machine.
	SLS	Safely Limited Speed	Safe monitoring of a drive's speed. Configurable shutdown response when the limit value is violated. This enables the machine operator, in service mode, to slowly move a drive while the safety door is open. You can switch between four SLS levels. The limit value of the first SLS level can be additionally specified by PROFIsafe telegrams 901 and 902. This allows dynamic modification of the SLS limit value during operation.
	SSM	Safe Speed Monitor	Safely indicates if the speed value falls below a speed limit ($n < n_x$)
	SDI	Safe Direction	Safely monitors the direction of motion (positive and negative direction). Configurable shutdown response when moving the drive in a non-released direction.
	SLA	Safely-Limited Acceleration	Safely Limited Acceleration monitors (the same as SLS) the acceleration, and intervenes when a limit value is violated. SLA cannot prevent that the acceleration threshold is briefly exceeded.

	Name	Function	Description
	SBT	Safe Brake Test	Checks the holding torque of up to two brakes. With the functions SBC and SBT a safe break can be realized. The Safe Brake Test (SBT) is a diagnostic function that is included in the list of Safety Integrated Extended Functions for organizational reasons only.
Advanced Functions	SLP	Safely Limited Position	Safely monitors the positioning range. Configurable shutdown response when the drive exits the position range.
	SP	Safe Position	Transfers the safe position values to a higher-level fail-safe controller via a PROFIsafe telegram.
	SCA	Safe Cam	The "Safe Cam" function outputs a safe signal if the drive is within a specified position range. It facilitates the realization of safe axis-specific range detection.

2.2 Interaction between Safety Integrated Functions and the technology objects

The technology objects (TOs) speed, positioning and synchronous axes support the "Safety Integrated Basic Functions" of the drive. A triggering of the Basic Safety Function is detected by the TO and a corresponding warning is issued (technology alarm 550 - alarm reaction: follow-up setpoints) or alarm (technology alarm 421 - alarm reaction): Withdraw enable) is displayed.

In the user program, the "Enable" input of the "MC_Power" Motion Control instruction must **not** be set to "FALSE" especially for technology alarm 550.

After acknowledgement and release of the drive by the actual safety function, the technology alarm can be acknowledged on the relevant TO by the Motion Control instruction "MC_Reset". The TO is then automatically enabled if "MC_Power.Enable" = "TRUE" has remained.

The "Safety Integrated Extended / Advanced Functions" are **not** independently supported by the TO. In this case, the user program must react accordingly, e.g. reduce the speed when SLS is selected.

2.3 Safety Information Channel

The Safety Information Channel (SIC) is transmitted from the drive to the controller via the SIEMENS telegram 700 and contains the status word S_ZSW1B and the SLS velocity limit S_V_LIMIT_B.

With the SIC, the status of the Safety Integrated Functions can be evaluated in the standard program.

If, for example, SLS or SOS was selected at the drive, the controller must react accordingly within a delay time set in the drive. In the case of SLS, the user program must delay the technology object at least to the speed limit transferred in S_V_LIMIT_B. If the speed is exceeded after the delay time has elapsed, the stop reaction set as a safety error reaction is executed by the drive.

Table 2-2 Structure of the telegram 700

PZD	Received data	Transmit data	Parameter in the drive
PZD1	-	S_ZSW1B	r9734
PZD2	-	S_V_LIMIT_B	r9733[2]
PZD3	-		

2.4 Configuring SINAMICS S120 drive

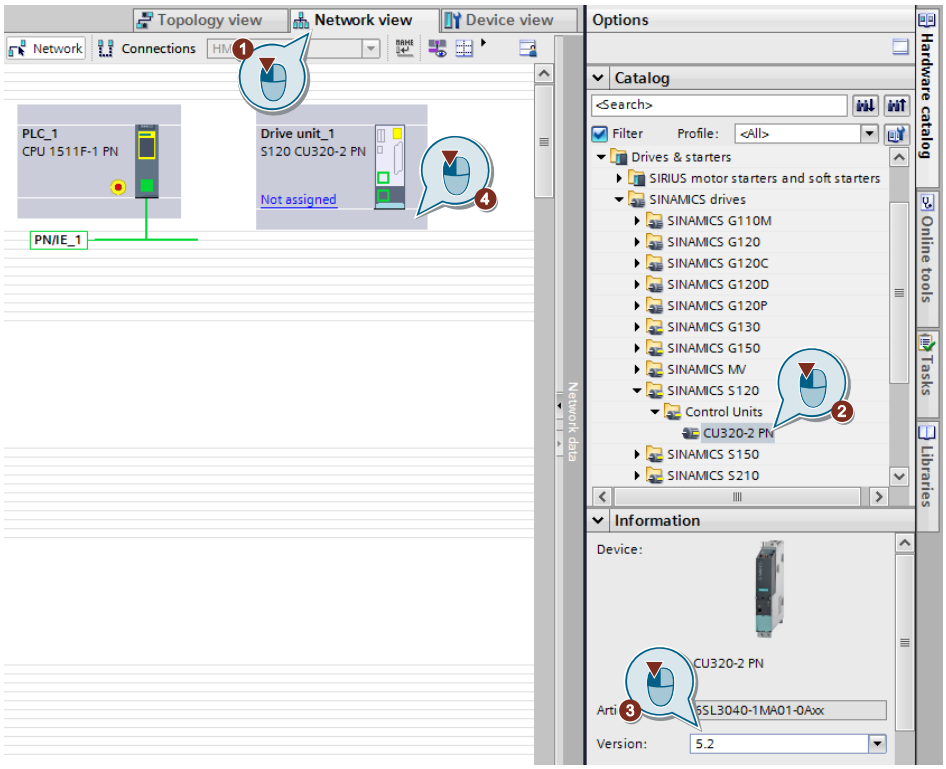
2.4.1 Automatically detecting device configuration of the drive

As of TIA Portal V15, you can automatically detect and read out the device configuration of the SINAMICS S120 drive.

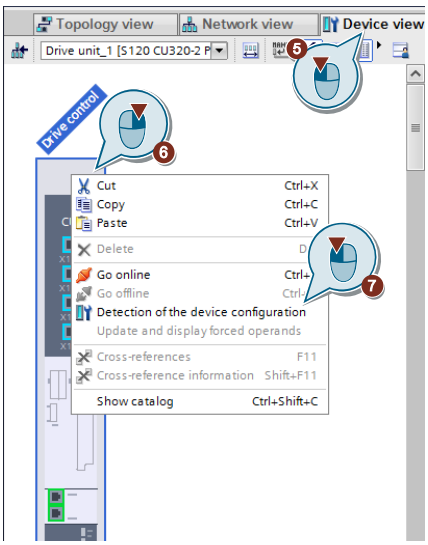
The "Detection of the device configuration" function reads out the actual topology of your drive and transfers this as the starting point for offline configuration in your Startdrive project. The wizard automatically detects existing modules and DRIVE-CLiQ circuits and creates the corresponding Drive Objects (DOs) and connections in the project.

To automatically recognize and read the device configuration, proceed as follows. The description assumes that an S7-1500 F-CPU has already been configured in your project.

1. Open the network view.
2. Select a SINAMICS S120 drive (Control Unit CU320-2 PN) in the hardware catalog.

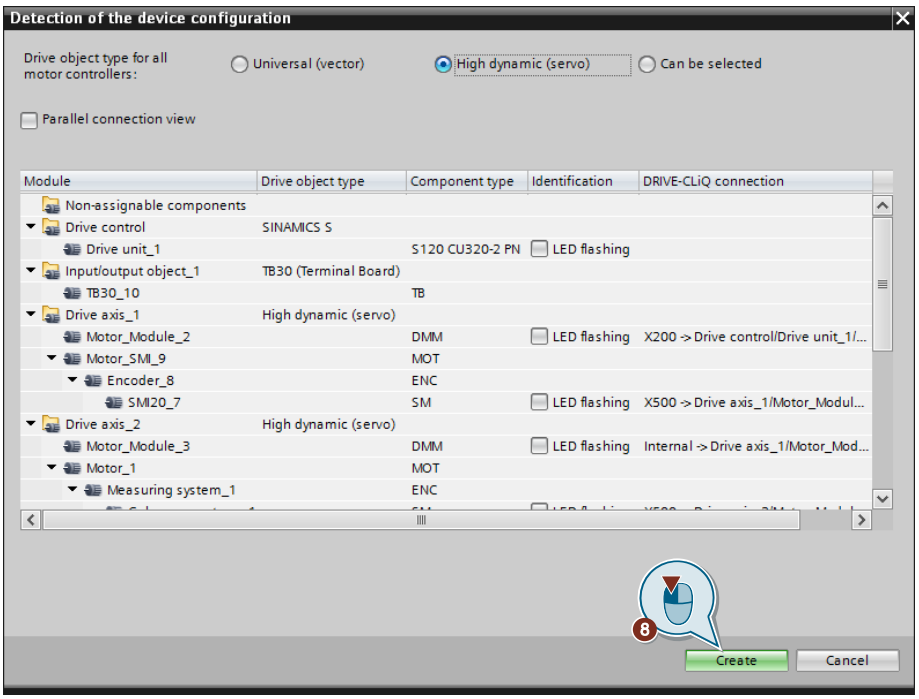


3. Select the firmware version.
4. Insert the drive into the project using Drag & Drop.
5. Open the device view of the drive.
6. Right-click on the drive to open the context menu.
7. Click on the menu item "Detection of the device configuration".

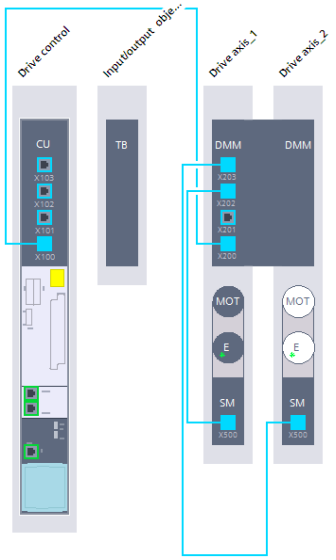


The topology of the drive is read out.

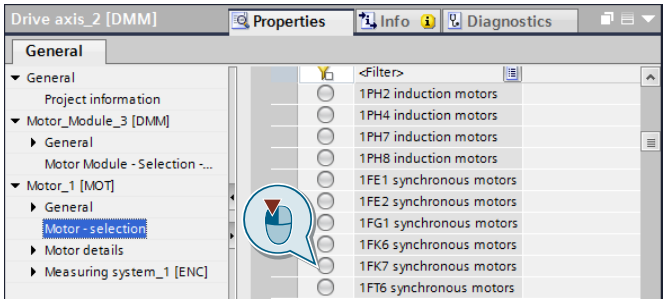
8. To transfer the assemblies to your offline project, click on the "Create" button.



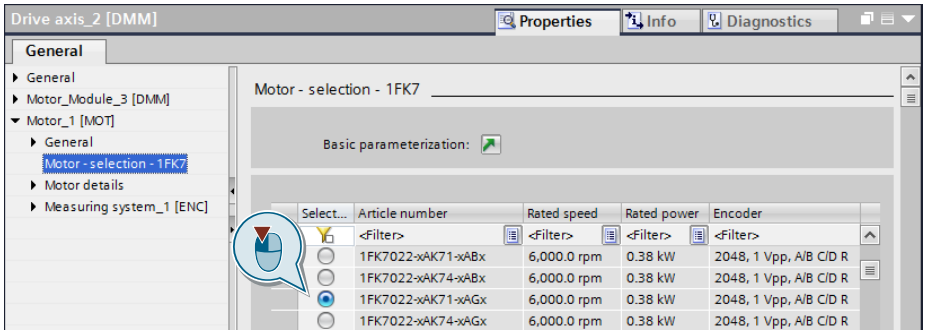
Result: The actual topology has been transferred to the project.
Since the motor encoder is connected via SMC20, the electronic nameplate of the second motor cannot be read out automatically.



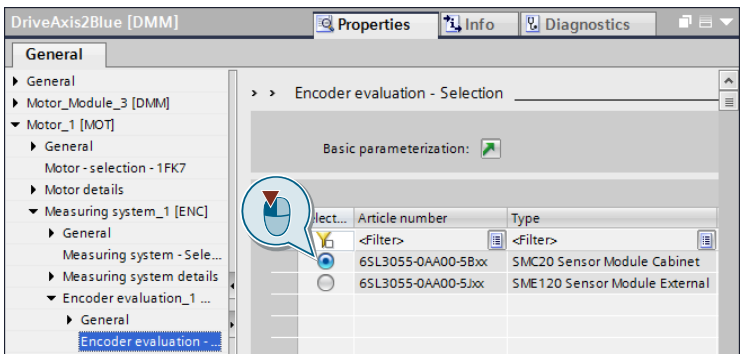
9. Select the second motor module and select the motor type in the motor module properties.



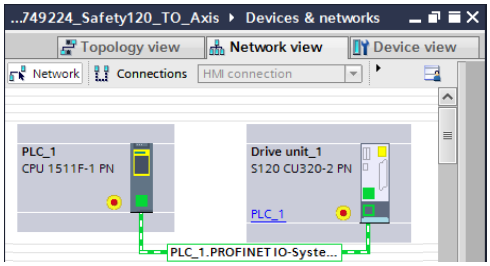
10. Then select the motor in the properties.



11. Then select SMC20 as encoder in the second motor module in the properties.



12. Connect the drive to the PLC.



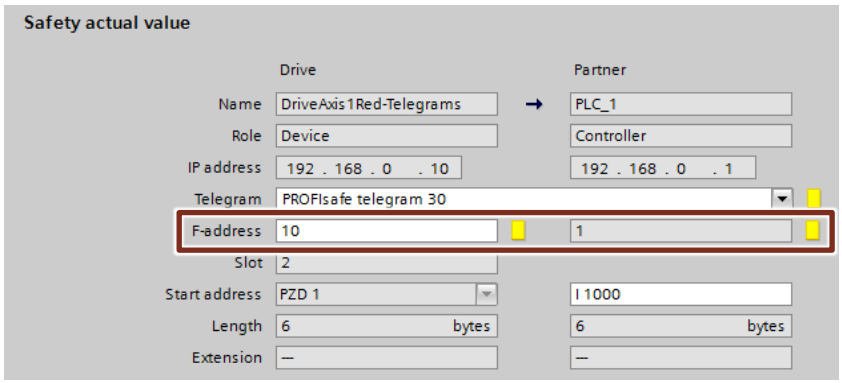
2.4.2 Configuring drive telegrams

By selecting a telegram you define the process data which are transferred between the drive and the PLC.

Follow the steps below:

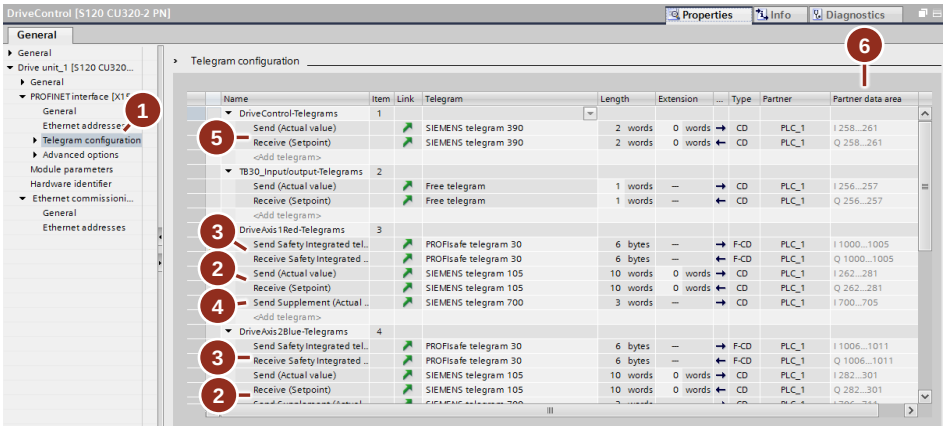
1. Select the "Telegram configuration" folder in the drive properties.
2. For the cyclic data transmission to the controller for "Send" and "Receive", select the telegram "SIEMENS telegram 105" for both axes.
3. Use "Add telegram > Safety Integrated telegram" to add the telegram "PROFIsafe telegram 30" for both axes.

   Set the F target address in the telegram configuration.



4. Add the Safety Information Channel with "Add telegram > Add Safety Integrated supplementary telegram". To do this, select the SIEMENS telegram 700 for both axes.
5. For the cyclic data transmission for "Send" and "Receive" select the telegram "SIEMENS telegram 390" for "DriveControl". The telegram is required to acknowledge errors.

6. If necessary, set the addresses of the telegrams.

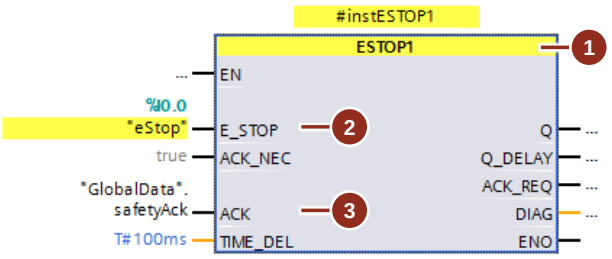


7. Save the configuration.
8. Download the configuration into the drive and save the parameters in the ROM.

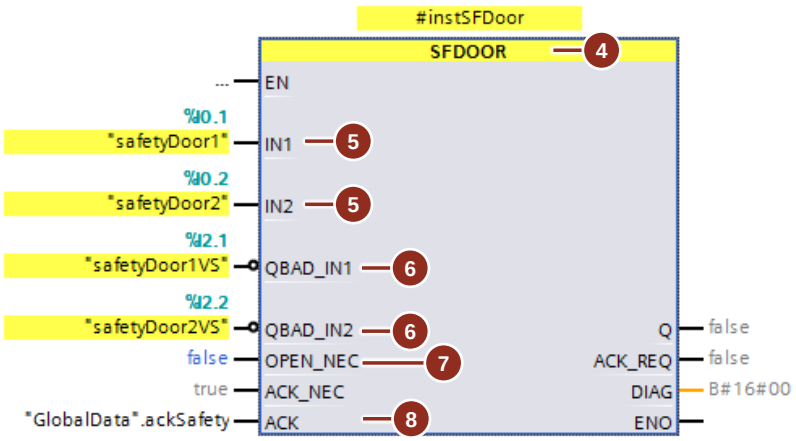
2.5 Programming basic safety functions

To control the safety functions, proceed as follows:

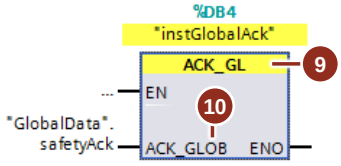
1. Open your F program and insert the instruction "ESTOP1" from the Task Card "Instructions > Safety functions" via Drag&Drop.
2. Connect the "E_STOP" input with the emergency stop mushroom pushbutton.
3. Connect the input "ACK" with the acknowledge bit.



4. Insert the instruction "SFDOOR" via Drag&Drop.
5. Connect the inputs "IN1" and "IN2" with the safety door contacts.
6. Connect the inputs "QBAD_IN1" and "QBAD_IN2" with the value status of the safety door contacts.
7. Set the input "OPEN_NEC" (opening required during start-up) to "false".
8. Connect the input "ACK" with the acknowledge bit.



9. Insert the instruction "ACK_GL" via Drag&Drop.
10. Connect the input "ACK" with the acknowledge bit.
    With a positive edge at this input, each F periphery is reintegrated after a communication failure.



3 Engineering

The application example uses the function blocks from the application example "LAxisBasics" to control the axes.
"LAxisBasics - Simple control of the TO "axis" in the SIMATIC S7-1500".

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Note For the following procedures, the steps correspond to the numbers in the graphs.

3.1 Configuring the safety telegram

How to configure the safety telegram "PROFIsafe telegram 30" is described in chapter 2.4.2 under Point 3.

3.2 Configuring Safety Integrated Functions in the drive

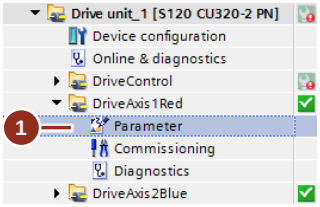
Before you configure the Safety Integrated Functions in the drive with Startdrive, the following conditions must be met:

- Commissioning of the drive is complete
- For SLS, the closed-loop controller settings should be optimized.
- The drive must not be in the "Operation" state.
- The PG/PC is connected online with the drive.

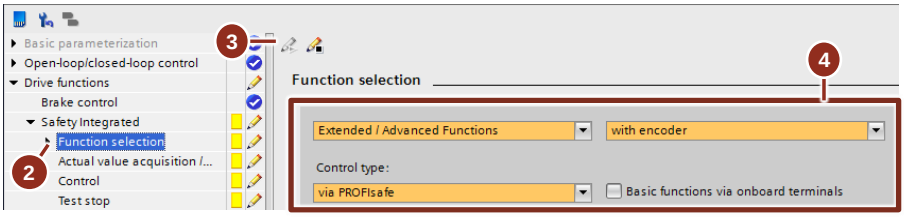
3.2.1 Configuring Safety Integrated Extended Functions

To configure the Safety Integrated Extended Functions, proceed as follows:

1. Establish an online connection to the drive and open the editor for the drive parameters.



2. Navigate to "Drive Functions > Safety Integrated > Function Selection".
3. To start the safety commissioning, click on the "Edit" button.
4. Select "Extended / Advanced Functions with encoder via PROFIsafe".



3.2.2 Actual value acquisition / mechanical system configuration

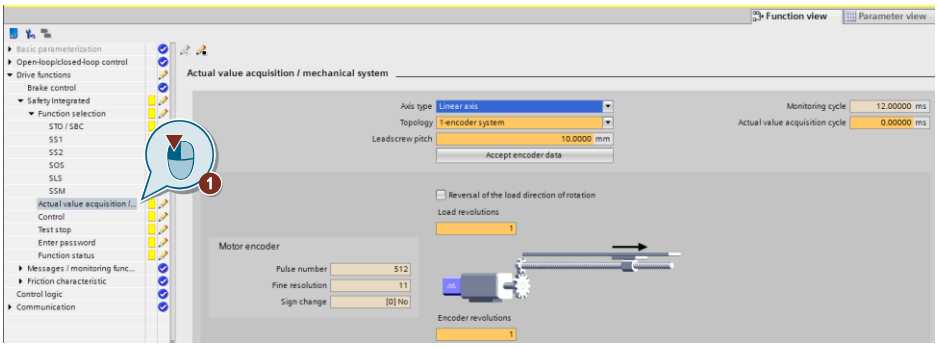
The Safety Integrated monitoring limits refer to the **load side**. After configuring the mechanical system, you can use the actual limits; further calculations are not necessary.

By default, a linear axis is set for the mechanical system. A linear axis converts a motor's rotary motion into linear motion using a leadscrew. A rotary axis can also be set; however, the application example does not use this axis type.

Due to this setting, a linear motion is assumed on the load side. As a result, all motion monitoring limits are specified in mm/min / all position monitoring settings are specified in mm.

To configure "Actual value acquisition / mechanical system", proceed as follows:

1. Navigate to "Actual value acquisition / mechanical system".
2. Configure the mechanical system as follows:
   - "Axis type" "Linear axis"
   - "Leadscrew pitch": 10 mm
   - Gear unit between load and encoder:
     "Load revolutions" 1
     "Encoder revolutions" 1

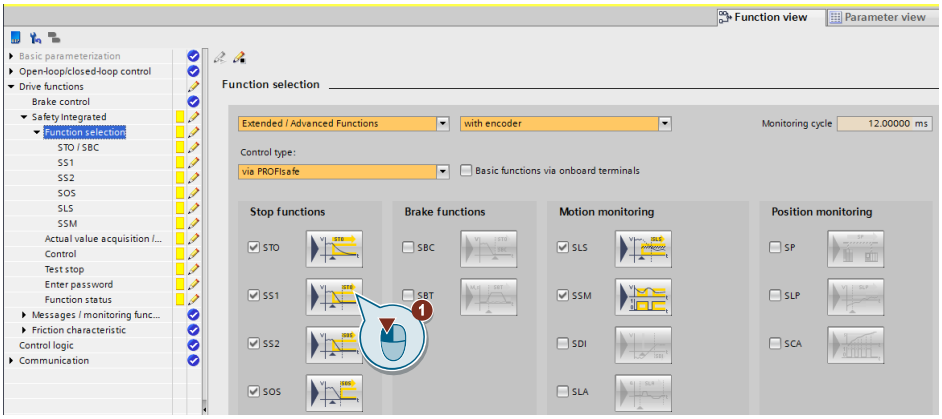


Note The "Accept encoder data" button is available online. This allows you to copy the encoder parameters from the basic system to the corresponding safety parameters.

3.2.3 Configuring Safety Integrated Function Safe Stop 1 (SS1)

To configure SS1 in the drive, proceed as follows:

1. Click on the pictogram for SS1.

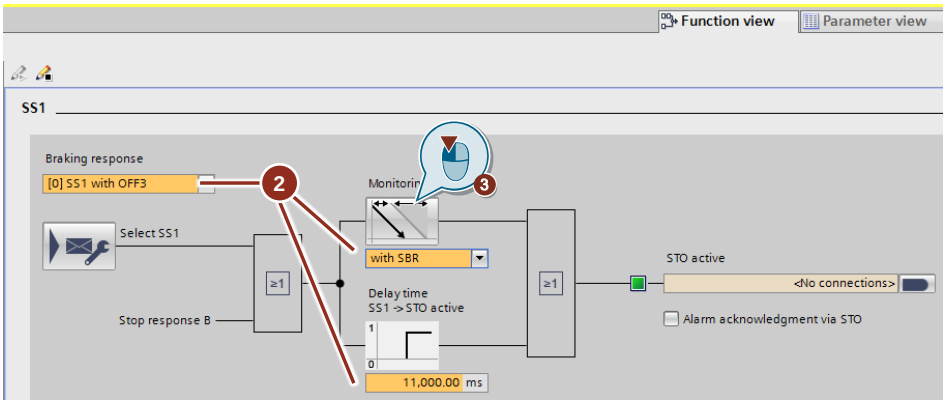


2. Parameterize SS1 as follows:
   - "Braking response": "SS1 with OFF3"
     The drive is braked with the OFF3 ramp.
   - "Monitoring": "with SBR"
     With brake ramp monitoring.
   - "Delay time SS1 -> STO active": "11000 ms"

Note

To ensure that the drive, after selecting SS1, can decelerate to a standstill before STO is activated, the selected delay time for triggering STO must be greater than the "ramp-down time (OFF3)". This enables the drive to decelerate on the OFF3 ramp from any speed of the work process before STO is activated and the drive coasts.

3. Click on the "Monitoring" icon.



4. Parameterize the braking ramp to monitor braking on the OFF3 ramp. The braking ramp should be roughly parallel to the OFF3 ramp.

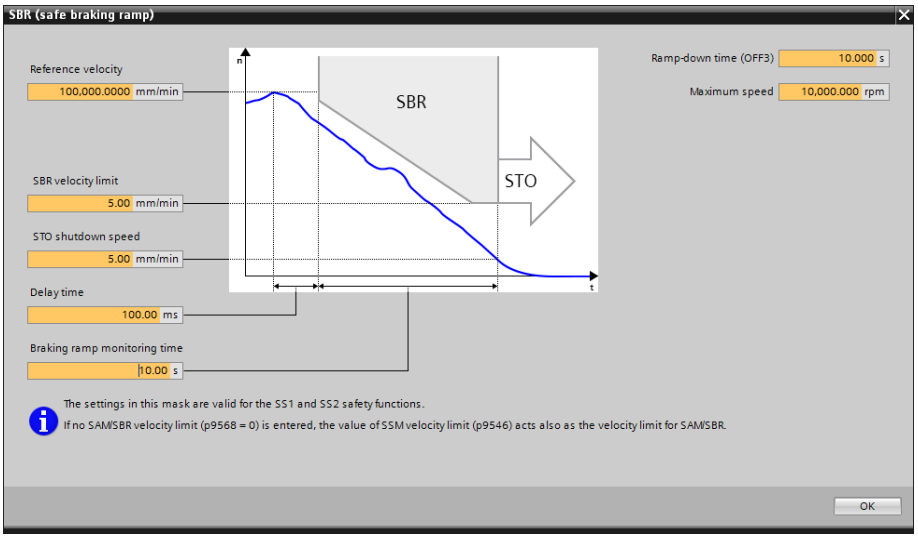
   The braking ramp's slope depends on the "reference velocity" and the "braking ramp monitoring time".

   The OFF3 ramp refers to the motor side. The OFF3 ramp's slope depends on the "maximum speed" and the "ramp-down time (OFF3)". This means: For lower setpoint speeds, the motor decelerates to a standstill faster than specified in the "ramp-down time (OFF3)".

   In the application example, the maximum motor speed is used for the "maximum speed". The "reference velocity" is calculated from the "maximum speed" and the mechanical system settings for leadscrew pitch (10 mm/red) and gear between load and encoder (1:1) (see Chapter 3.2.2). As a result, the same time can be used for the "braking ramp monitoring time" and the "ramp-down time (OFF3)".

   - "Reference velocity": 100,000 mm/min
   - "SBR velocity limit": 5 mm/min
   - "STO shutdown speed": 5 mm/min
   - "Delay time": 100 ms
   - "Braking ramp monitoring time": 10 s
   - "Ramp-down time (OFF3)": 10 s
   - "Maximum speed": 10,000 rpm

   Confirm your settings by clicking on "OK".

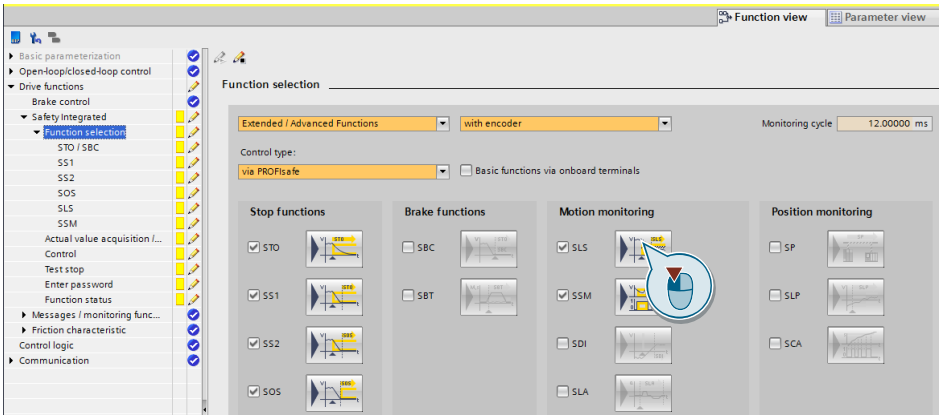


Note The large time values were chosen deliberately. Due to these values, decelerating to a standstill on the OFF3 ramp takes longer; this allows you to better analyze the signals in the trace recordings (see Chapter 3.4.3).

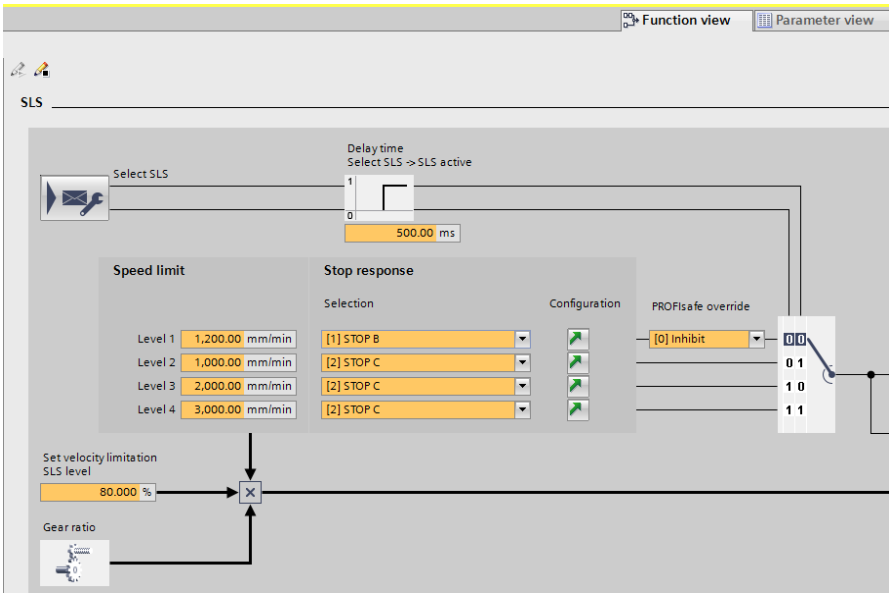
3.2.4 Configuring Safety Integrated Function Safely-Limited Speed (SLS)

To configure SLS in the drive, proceed as follows:

1. Open the parameters of the "DriveAxis1Red" drive.
2. Click on the pictogram for SLS.



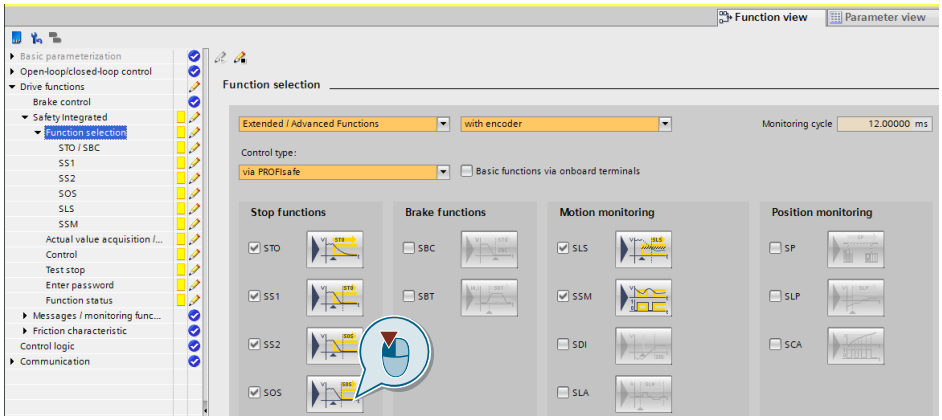
3. Configure SLS as follows:
   - "Delay time Select SLS -> SLS active": 500 ms
     If SLS is selected, the monitoring only becomes effective after the delay time has elapsed. Within this time, the actual speed must be below the (selected) limit value, otherwise the configured stop reaction is triggered.
   - "Speed limit (Level 1)": 1,200 mm/min
     1,200 mm/min = 20 mm/s
   - "Stop response (Level 1)": STOP B
     If the speed limit is exceeded, STOP B (SS1) is triggered.
   - Open the STOP B (SS1) settings by clicking on the "Configuration" button.



3.2.5 Configuring Safety Integrated Function Safe Operating Stop (SOS)

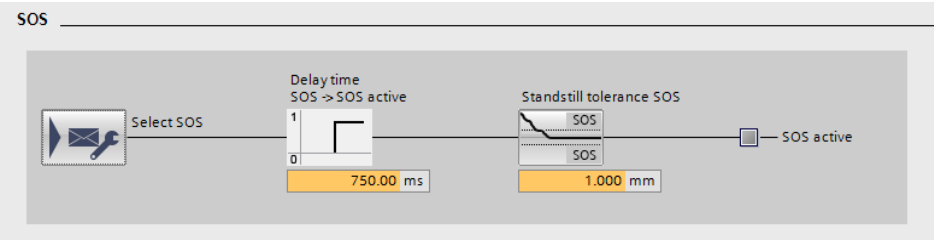
To configure SOS in the drive, proceed as follows:

1. Open the parameters of the "DriveAxis2Blue" drive.
2. Click on the icon for SOS.



3. Configure SOS as follows:

   - "Delay time SOS -> SOS active": 750 ms
     If SOS is selected, the monitoring only becomes effective after the delay time has elapsed. Within this time the motor must be stopped and remain in control.

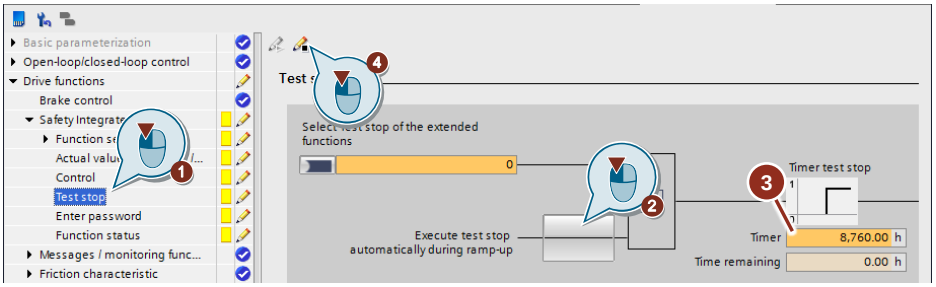


   - "Standstill tolerance SOS": 1mm
     Once the motor has been stopped, the configured tolerance must not be exceeded. If the standstill tolerance is exceeded, STOP B is activated in the drive, followed by STOP A.

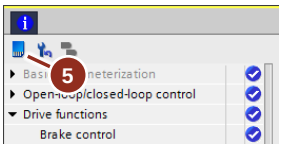
3.2.6 Configuring the test stop

Proceed as follows to configure the test stop:

1. Navigate to "Test stop".
2. Close the switch by clicking on the button.
   → The test stop is performed automatically each time the drive is restarted.
3. Set the time interval for performing dynamization and testing of the drive-integrated safety motion monitoring functions. To maintain the guaranteed failure probability of the safety functionality of the SINAMICS, the test stop must be performed at least once a year (8760 hours).
4. To end the safety commissioning, click on "Stop processing".



5. To save the parameters in the ROM, click on "Safe the data of all drive objects retentively".



6. Switch the drive off and back on.

3.3 Controlling and evaluating Safety Integrated Functions

The SINAMICS Safety Integrated Functions are controlled via PROFIsafe. The "LDrvSafe" library provides failsafe function blocks (FBs) and PLC data types for this purpose, depending on the PROFIsafe telegram used (30, 31, 901, 902, 903) for simple control and evaluation of the Safety Integrated Functions.

In the user program, the FBs and PLC data types are used for the configured PROFIsafe telegram 30.

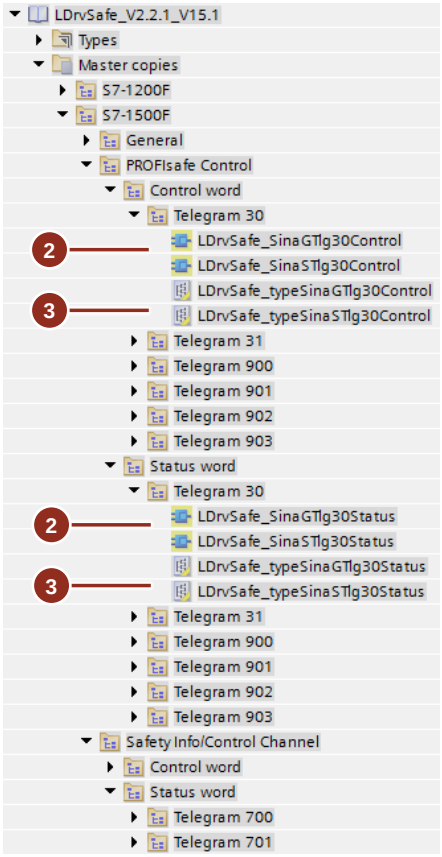
Note Further information on the function blocks of the "LDrvSafe" library can be found in the application example "SIMATIC - Fail-safe LDrvSafe library for controlling Safety Integrated Functions of the SINAMICS drive family".

https://support.industry.siemens.com/cs/ww/en/view/109485794

To control and evaluate the Safety Integrated Functions, proceed as follows:

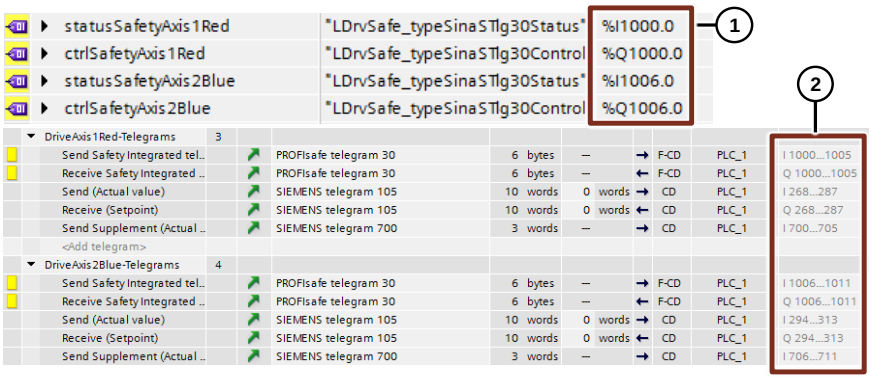
Inserting library elements

1. Open the library "LDrvSafe".
2. Insert the following FBs from the library into the folder "Program blocks" via Drag&Drop:
   - "LDrvSafe_SinaSTlg30Control"
   - "LDrvSafe_SinaSTlg30Status"
3. Add the following PLC data types from the library to the "PLC data types" folder, using Drag&Drop:
   - "LDrvSafe_typeSinaSTlg30Control"
   - "LDrvSafe_typeSinaSTlg30Status"



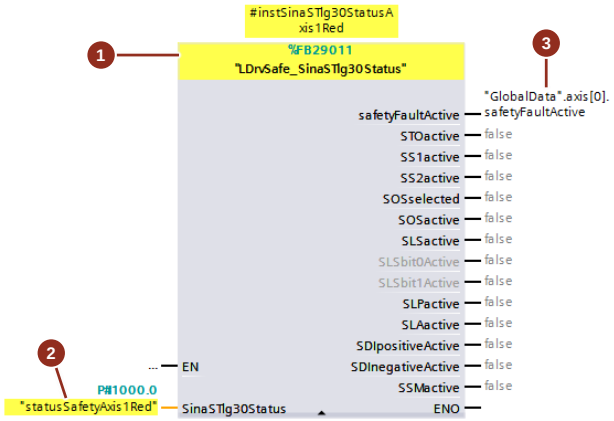
Creating tags

1. Open the tag table.
2. Create two tags per drive with the PLC data types "LDrvSafe_typeSinaSTlg30Control" and "LDrvSafe_typeSinaSTlg30Status". The start addresses of the tags (1) **must** be the same as the start address (2) of the corresponding telegram in the hardware configuration.

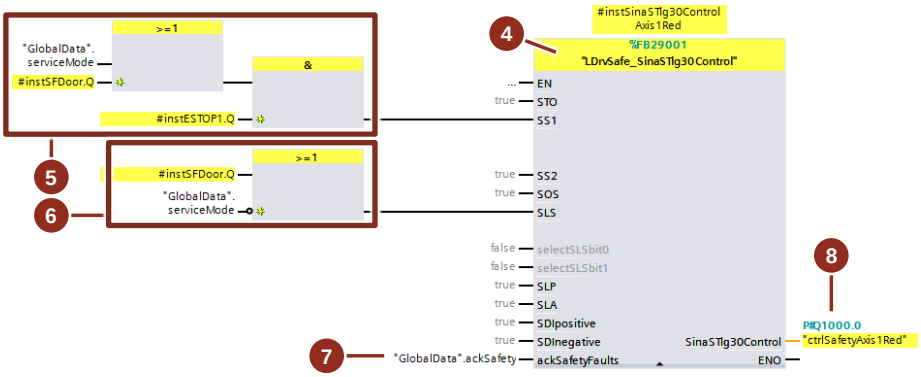


Calling library blocks

1. Insert the FB "LDrvSafe_SinaSTlg30Status" into your F program.
   This FB is used for simple evaluation of the Safety Integrated Functions of SINAMICS S via PROFIsafe telegram 30.
2. Connect the input "SinaSTlg30Status" with the tag "statusSafetyAxis1Red" defined in step 4.
3. Connect the outputs of the FBs.



4. Insert the FB "LDrvSafe_SinaSTlg30Control" into your F program.
   This function block is used for simple controlling of the Safety Integrated Functions of SINAMICS S via PROFIsafe telegram 30.
5. Connect the safe signals of the FBs "ESTOP1", "SFDOOR" and "serviceMode" with the Safety Integrated Function SS1 at the block input.
6. Connect the safe signal of the FBs "SFDOOR" and "serviceMode" with the Safety Integrated Function **SLS** at the block input.
7. Connect the acknowledgement bit with "ackSafetyFaults" at the block input.
8. Connect the output "SinaSTlg30Control" with the tag "ctrlSafetyAxis1Red" defined under point 4.



The unused safety functions (STO, SS2, SOS, SLP, SLA, SDIpositive and SDInegative) are deselected in the default setting.

9. Repeat steps 1 - 8 for the second axis and connect the safe signal of the FBs "SFDOOR" and "serviceMode" with the Safety Integrated Function **SOS** at the block input in step 6.

3.4 Responding to a selected Safety Integrated Function

If a Safety Integrated Function SOS or SLS has been selected, the controller of the drive must react accordingly before the delay time expires, before the drive carries out a stop reaction autonomously.

Note

This document and example project describe the response to the Safety Integrated Functions SOS and SLS. The recommendations for the other Safety Integrated Functions can be found in the chapter "Safety Functions in the Drive" of the function manual "S7-1500 Motion Control V4.0 in the TIA Portal V15":

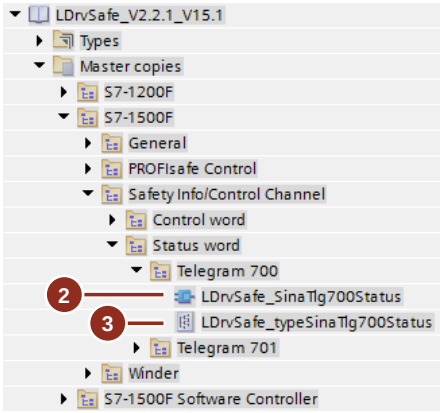
https://support.industry.siemens.com/cs/ww/en/view/109749262/102819887115

3.4.1 Reading out the Safety Information Channel

The Safety Information Channel must be monitored cyclically in the standard user program. In chapter 3.1 the SIEMENS telegram 700 has already been added for both drives. This section describes how the data can be read out, monitored and reacted to in the user program for the selected Safety Integrated Function.

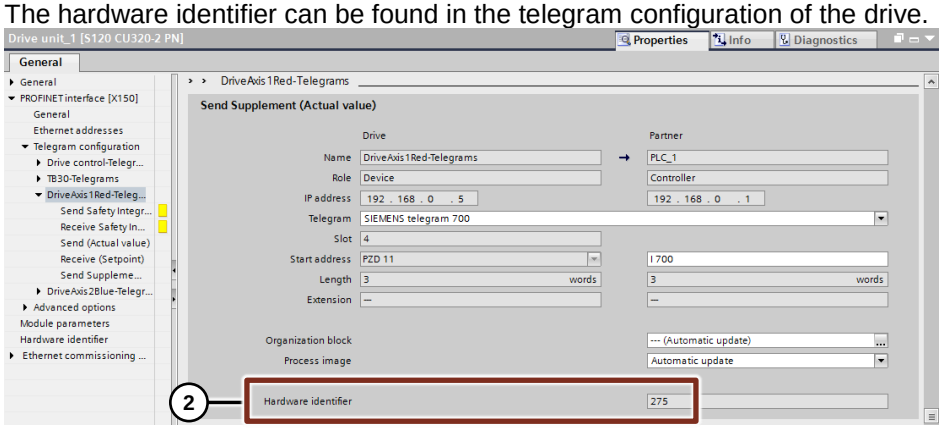
Inserting library elements

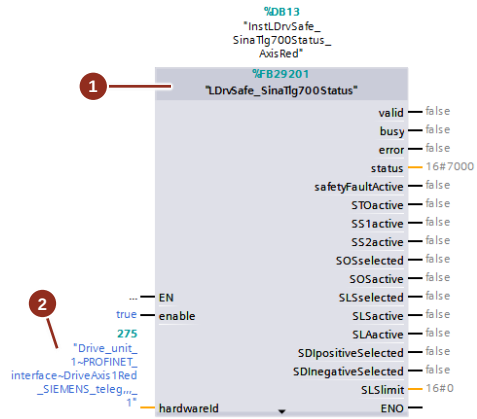
1. Open the library "LDrvSafe".
2. Insert the FB “LDrvSafe_SinaTlg700Status” from the library into the folder "Program blocks" via Drag&Drop.
3. Add the PLC data type “LDrvSafe_typeSinaTlg700Status” from the library to the "PLC data types" folder, using Drag&Drop.



Calling library blocks

1. Insert the FB "LDrvSafe_SinaTlg700Status" into your standard user program. This FB is used for simple evaluation of the Safety Information Channel.
2. Connect the input "hardwareId" with the hardware identifier of the SIEMENS telegram 700.
   The hardware identifier can be found in the telegram configuration of the drive.





3. Repeat steps 1 and 2 for the second axis.
4. Download the PLC project to the controller.

3.4.2 Detection of a selected Safety Integrated Function

The status word "S_ZSW1B" of the Safety Information Channel indicates whether the Safety Integrated Function is selected and/or active. In the user program, the "Selected" bits of the configured Safety Integrated Functions must be monitored and responded to.

3.4.3 Possible reactions

Each Safety Integrated Function requires a different reaction. For the Safety Integrated Functions SOS and SLS described here, the reaction can consist of either replacing the motion task or changing the speed override. Select a suitable procedure according to your application.

Replacing motion task

An active motion task can be replaced by a new Motion Control instruction. The active Motion Control instruction is aborted (CommandAborted = True) and can no longer be continued. The replacing Motion Control instruction can also be replaced after deselecting SOS or SLS by restarting the original Motion Control instruction.

An active speed specification with the Motion “MC_MoveVelocity” Motion Control instruction can, for example, be replaced by another Motion Control instruction with the speed limit from the Safety Information Channel.

Stopping the drive can be implemented with the MC_Halt motion control instruction.

Adapting the velocity override of the technology object

The tag <TO>.Override.Velocity is a percentage correction (0.0 to 200%) of the specified velocity, for example the target velocity of a Motion Control instruction. This usually has the value 100.0%. Reducing the override reduces the speed but does not abort the Motion Control instruction. If the Safety Integrated Function is no longer selected and the F periphery has been acknowledged, the override can be reset again. The Motion Control instruction is then continued with the specified target velocity.

An override change is effective immediately and is followed with the dynamic settings effective on the Motion Control instruction.

Pausing an active Motion Control instruction can be realized by setting 0.0.

3.5 Changing the velocity setpoint for SLS

If the safety door is opened in service mode in the included example project, the safety program selects SLS. The drive should then run at reduced speed. To do this, the target speed must be reduced in the user program as soon as SLS is selected. This is the only way to ensure that the axis is decelerated in good time before the drive signals “SLS enabled” after a delay time.

After deselecting SLS, the drive is to be accelerated to the original speed after acknowledging the F peripherals.

If automatic mode is active and the safety door is open, the FB "LDrvSafe_SinaSTlg30Control" selects SLS. The drive must now be decelerated to the speed limit within the set delay time.

Response in the user program

In the user program, monitor the "SLSselected" bit of the FB "LDrvSafe_SinaTlg700Status”. In "SLSlimit" the effective speed limit is transferred.

In the user program, react within the configured delay time as described in 3.4.3. Depending on the application, for example, the current motion control instruction can be replaced or adapted to the velocity override.

In the following example, the velocity override is reduced according to the transferred SLS velocity limit when SLS is selected.

Figure 3-1 Reduction of the velocity override

```
// Set slow speed, if door is open and service mode active
IF "GlobalData".serviceMode AND
    "InstLDrvSafe_SinaTlg700Status_AxisRed".SLSselected
THEN
    // convert percentage to mm/min
    #tempVelocity := "InstLDrvSafe_SinaTlg700Status_AxisRed".SLSlimit / (#NORMALIZATION_FACTOR / "Axis1Red".Actor.DriveParameter.ReferenceSpeed) * 10;
                                                                        16#40000000 / DWord

    // convert mm/min to mm/s
    #tempVelocity := #tempVelocity / 60;

    // reduce velocity to make sure speed limit is not exceeded
    #tempVelocity *= 0.95;

    // calculate velocity override to match calculated velocity
    "Axis1Red".Override.Velocity := (100.0 * #tempVelocity) / "LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.jogVelocity;
ELSE
    "Axis1Red".Override.Velocity := 100.0; // reset velocity override if SLS is no longer selected
END_IF;
```

NOTICE	Ensure that the closed-loop controller settings have been optimized for the used drives. Otherwise the SLS stop reaction may be triggered due to speed fluctuations. In the example in Figure 3-1, the speed limit was additionally calculated with a factor of 0.95 as the reference speed.

3.6 Stopping the drive with SOS

If Safe Operating Stop (SOS) has been selected, the drive must be stopped within the SOS delay time. The drive then remains in closed-loop operation and standstill monitoring is active. This means that protected machine areas can be entered by service personnel without the machine having to be switched off.

If automatic mode is active and the safety door is open, SOS is selected by the FB "LDrvSafe_SinaSTlg30Control". The drive must now be stopped within the set delay time.

Response in the user program

In the user program, monitor the "SOSselected" bit of the FB "LDrvSafe_SinaTlg700Status". After decelerating the drive to standstill, it must remain in control (MC_Power.Enable = true). Otherwise the motor may move and the standstill monitoring activates STOP B followed by STOP A.

In the user program, react within the configured delay time as described in 3.4.3. Depending on the application, the drive can, for example, be stopped by the Motion Control instruction MC_Halt or the velocity override set to 0.0.

In the following example, the velocity override is set to 0.0 if SOS is selected.

Abbildung 3-2 Stopping the drive if SOS is selected

```
// Halt axis if door is open and service mode active
IF "GlobalData".serviceMode AND
    "InstLDrvSafe_SinaTlg700Status_AxisBlue".SOSselected THEN
    "Axis2Blue".Override.Velocity := 0.0; // set velocity override to 0 if SOS is selected
ELSE
    "Axis2Blue".Override.Velocity := 100.0; // reset velocity override if SOS is no longer selected
END_IF;
```

3.7 Testing Safety Integrated Functions

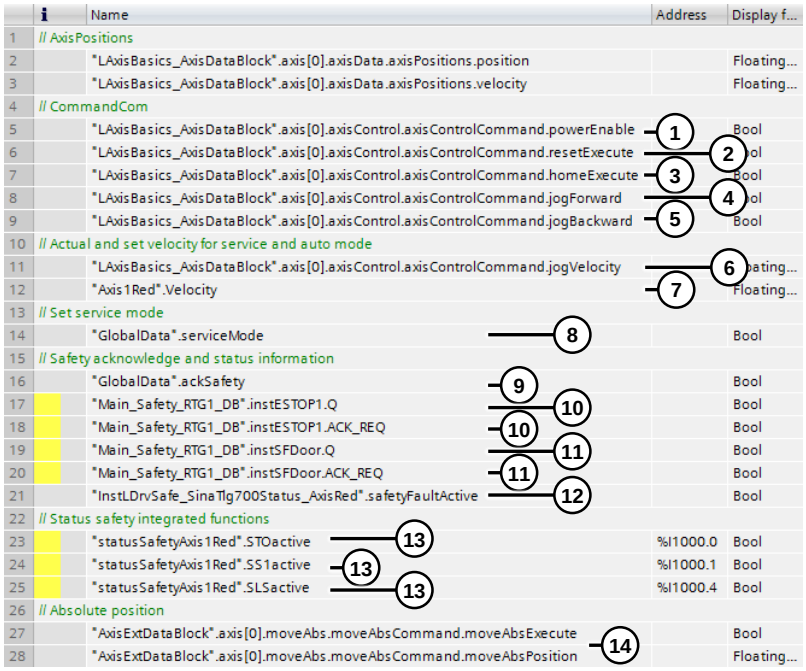
Note The "LAxisBasics" library is used to move the axes in the application example.

https://support.industry.siemens.com/cs/ww/en/view/109749348

Monitoring table

You can control the application example via the watch table "WatchTableAxis1Red".

Figure 3-3: "WatchTableAxis1Red" watch table



	Name	Address	Display f...
1	// AxisPositions		
2	"LAxisBasics_AxisDataBlock".axis[0].axisData.axisPositions.position		Floating...
3	"LAxisBasics_AxisDataBlock".axis[0].axisData.axisPositions.velocity		Floating...
4	// CommandCom		
5	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.powerEnable		Bool
6	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.resetExecute		ool
7	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.homeExecute		Bool
8	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.jogForward		ool
9	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.jogBackward		Bool
10	// Actual and set velocity for service and auto mode		
11	"LAxisBasics_AxisDataBlock".axis[0].axisControl.axisControlCommand.jogVelocity		oating...
12	"Axis1Red".Velocity		Floating...
13	// Set service mode		
14	"GlobalData".serviceMode		Bool
15	// Safety acknowledge and status information		
16	"GlobalData".ackSafety		Bool
17	"Main_Safety_RTG1_DB".instESTOP1.Q		Bool
18	"Main_Safety_RTG1_DB".instESTOP1.ACK_REQ		Bool
19	"Main_Safety_RTG1_DB".instSFDoor.Q		Bool
20	"Main_Safety_RTG1_DB".instSFDoor.ACK_REQ		Bool
21	"InstLDrvSafe_SinaTlg700Status_AxisRed".safetyFaultActive		Bool
22	// Status safety integrated functions		
23	"statusSafetyAxis1Red".STOactive	%I1000.0	Bool
24	"statusSafetyAxis1Red".SS1active	%I1000.1	Bool
25	"statusSafetyAxis1Red".SLSactive	%I1000.4	Bool
26	// Absolute position		
27	"AxisExtDataBlock".axis[0].moveAbs.moveAbsCommand.moveAbsExecute		Bool
28	"AxisExtDataBlock".axis[0].moveAbs.moveAbsCommand.moveAbsPosition		Floating...

You can use the watch table to perform the following functions:

- Switch on the axis (1).
- Acknowledge error (2).
- Reference axis (Homing) (3).
- Move the axis forwards (4) and backwards (5) in jog mode.
- Specify speed for the service mode (6) and monitor actual speed (7).
- Activate service mode (TRUE) / activate automatic mode (FALSE) (8).
- Acknowledge emergency stop (9).
- Observe the output signals of the "ESTOP1" instruction (10).
- Observe the output signals of the "SFDOOR" instruction (11).
- Observe internal event (PROFIsafe) of the axis (12).
- Observe the status of the Safety Integrated Functions (PROFIsafe) (13).
- Absolute positioning of the axis (14).

3.7.1 Start drive via watch table

The axis must be in motion so that the behavior of the Safety Integrated Functions can be observed and analyzed.

To rotate the axis in jog mode, proceed as follows.

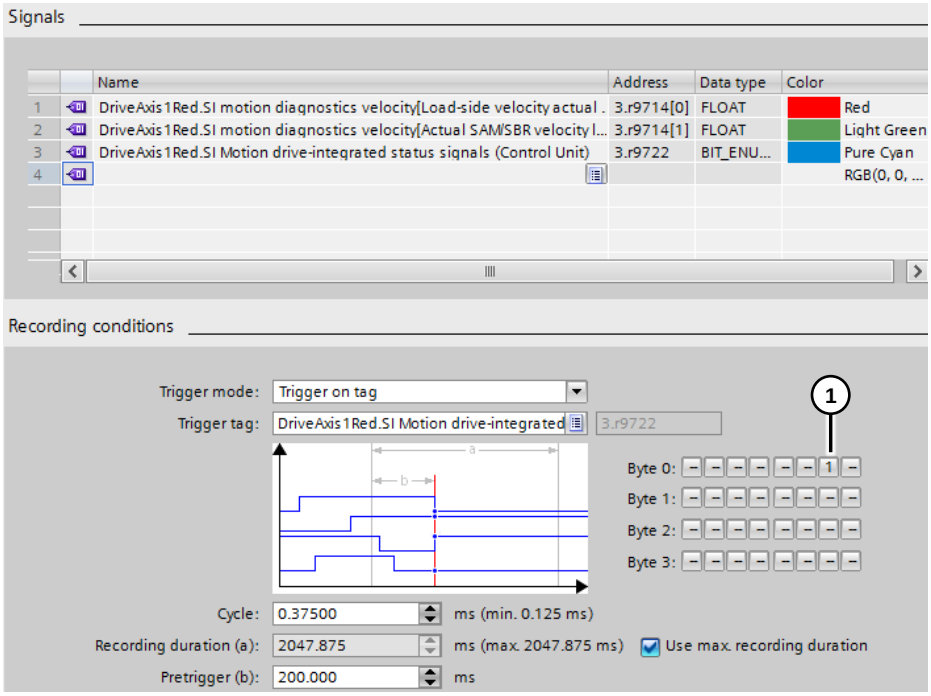
1. Unlock the emergency stop mushroom pushbutton and close the safety door.
2. Open the watch table "WatchTableAxis1Red" (Figure 3-3) or "WatchTableAxis2Blue" and activate "Monitor all".
3. Acknowledge the emergency stop by setting the tag "ackSafety" (9) to "TRUE". Then set "ackSafety" (9) back to "FALSE".
   The status of the parameter outputs "Q" of the safety instructions "ESTOP1" (10) and "SFDOOR" (11) becomes "TRUE".
   The status of the "safetyFaultActive" bit of both axes becomes "FALSE".
4. If there are errors on the axes, set the tag "resetExecute" (2) to "TRUE". Then set "resetExecute" (2) back to "FALSE".
5. Switch on the axes by setting the tag "powerEnable" (1) to "TRUE".
6. Start the motor by setting the tag "jogForward" (4) or "jogBackward" (5) to "TRUE".

Alternatively, the axis can also be moved absolutely to the position "moveAbsPosition" with the tag "moveAbsExecute" (14).

3.7.2 Testing Safety Integrated Function Safe Stop1 (SS1)

To test SS1, proceed as follows:

1. Open the trace "Trace1Axis1RedSS1" in the drive. The trace records the speeds and status signals of the drive. The trace is triggered when SS1 is selected. SS1 corresponds to bit 1 (1) of the drive's status signals.



2. Start the trace recording.
3. Start the motor as described in chapter 3.7.1.

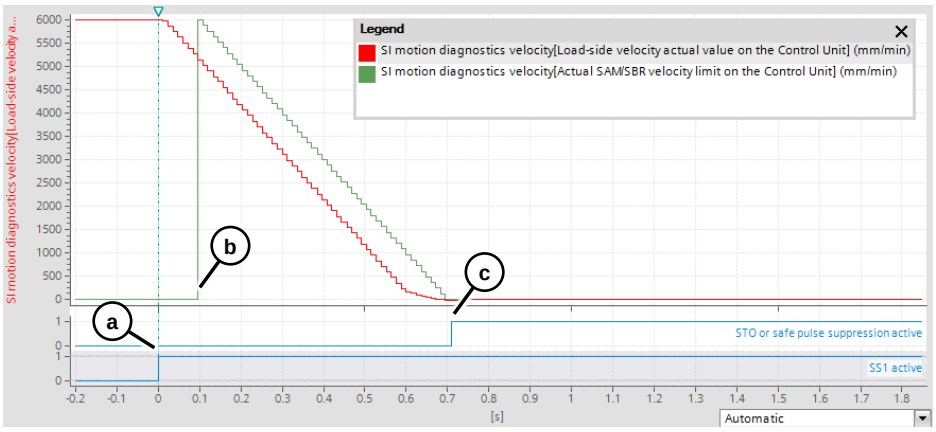
4. Activate automatic mode by setting the tag "serviceMode" (8) to "FALSE" in the observation table. (SS1 is only triggered in automatic mode when the safety door is opened).
5. To trigger SS1, press the emergency stop mushroom pushbutton or open the safety door in automatic mode.

   The trace shows the following:

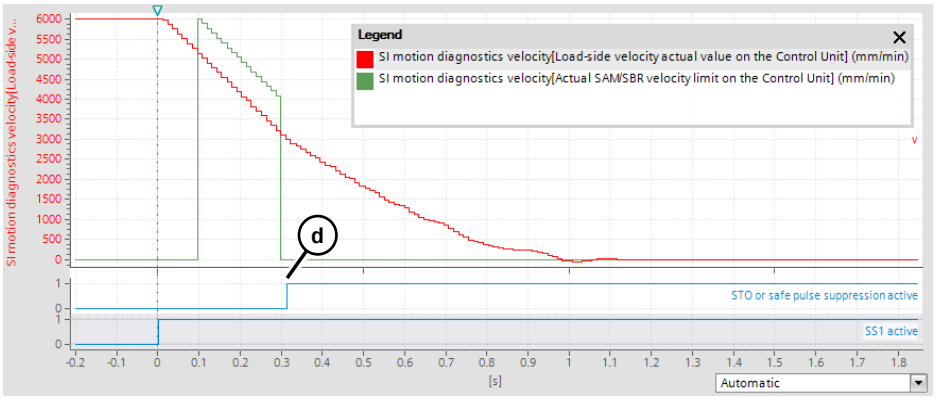
   a. As soon as SS1 is active, the drive is braked at the OFF3 ramp.

   b. After the delay time has elapsed, monitoring of the brake ramp is activated. It is monitored that the motor does not exceed the set brake ramp (SBR) during braking.

   c. STO is triggered if the braking speed falls below the STO switch-off speed.



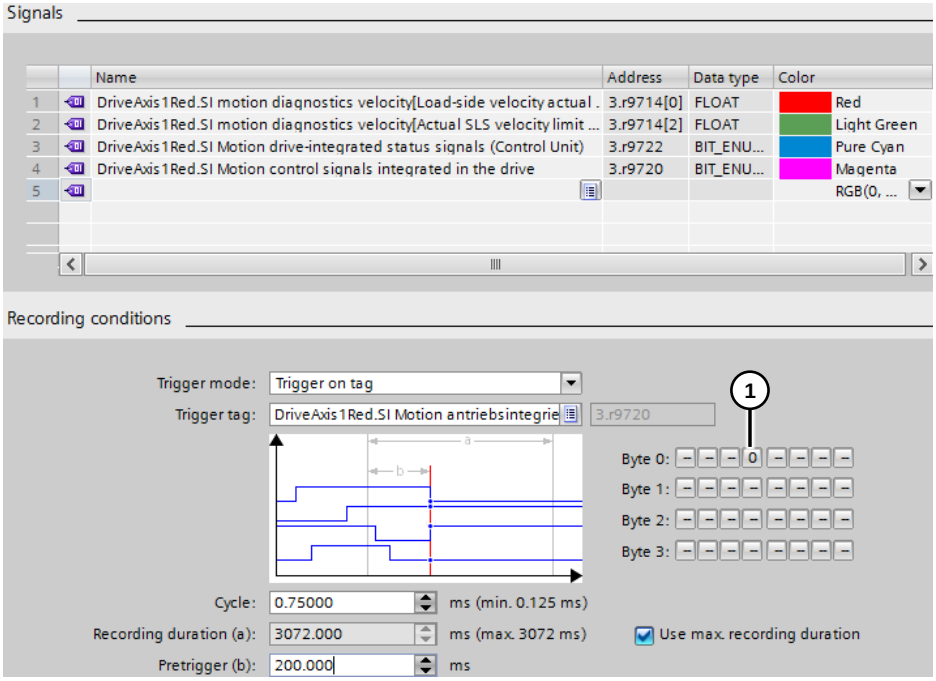
   d. STO can also be triggered beforehand by the expiration of the "Delay time SS1->STO".
   In the example, the delay time has been reduced to 300 ms.
   The drive then coasts down.



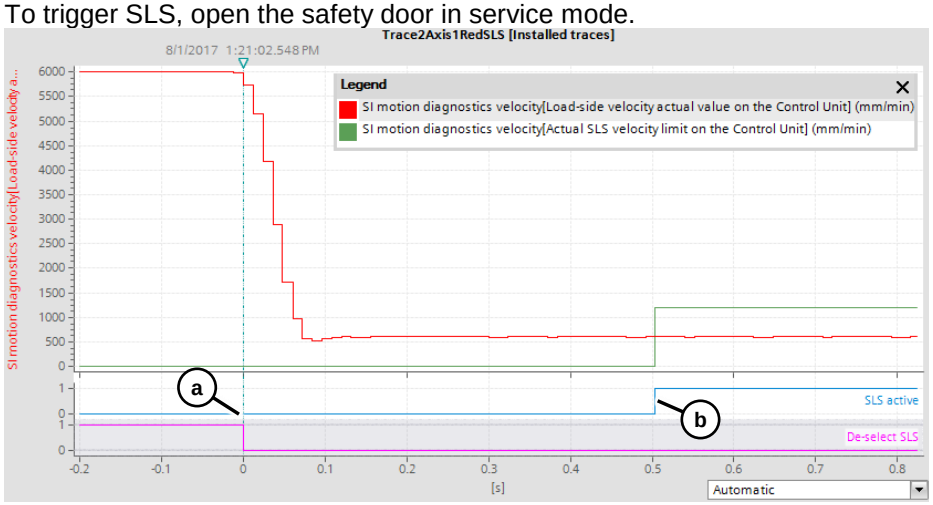
3.7.3 Testing Safely-Limited Speed (SLS)

To test SLS, proceed as follows:

1. Open the trace "Trace2Axis1RedSLS" in the drive. The trace records the speeds, status signals and control signals of the drive. The trace is triggered on SLS. SLS corresponds to bit 4 (1) of the drive's control signals.



2. Start the trace recording.
3. Start the motor as described in chapter 3.7.1.
4. Activate service mode by setting the tag "serviceMode" (8) to "TRUE" in the watch table. (SLS is only triggered in service mode when the safety door is opened).
5. To trigger SLS, open the safety door in service mode.



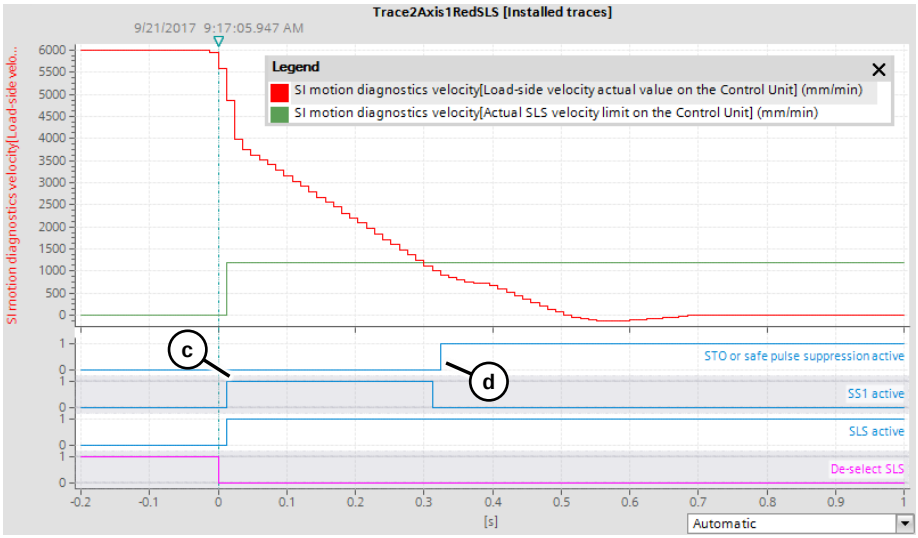
The trace shows the following:

a. SLS is selected as soon as the safety door is opened in service mode. The drive is braked to the speed limit received from the Safety Information Channel (6).

b. After the "SLS->SLS active delay time" has elapsed, SLS is activated. From this point on, the speed is safely monitored to the configured value of 20 mm/s.
If the velocity exceeds the configured value, SS1 is triggered in the application example.

c. In the following figure, the "Delay time SLS->SLS active" that was selected was too short (10 ms) After the delay time has elapsed, the actual speed is not below the configured limit value.
→ The configured stop reaction SS1 is triggered.

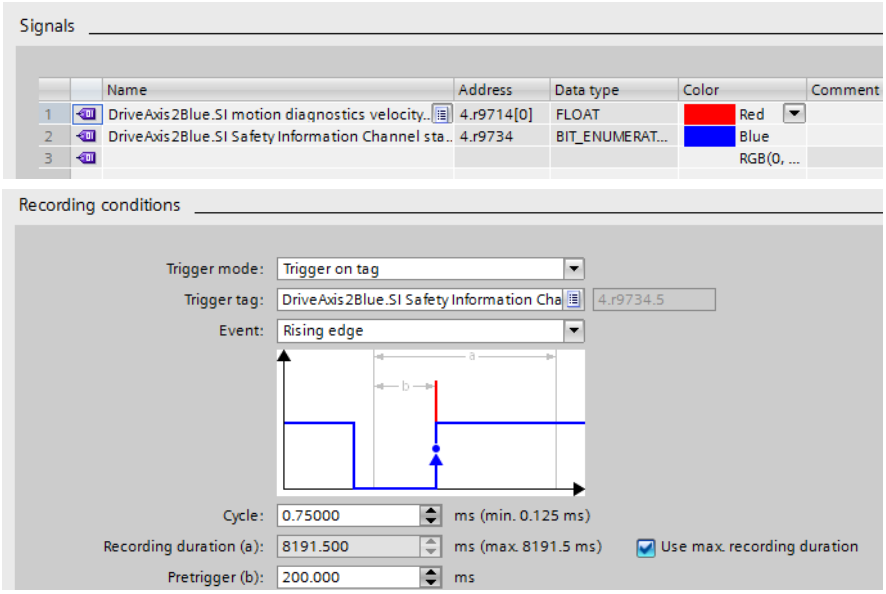
d. STO will be triggered after the "Delay time SS1->STO" (300 ms) has elapsed. The drive then coasts down.



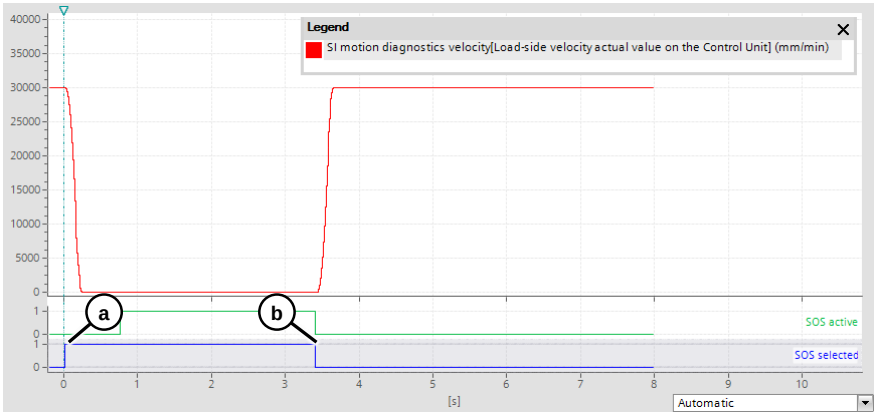
3.7.4 Testing Safe Operating Stop (SOS)

To test SOS, proceed as follows:

1. Open the trace "Trace3Axis2BlueSOS" in the drive. The trace records the speed and the Safety Information Channel status word (S_ZSW1B) of the drive. The trace is triggered by a rising edge of the status word bit 5 "SOS selected".

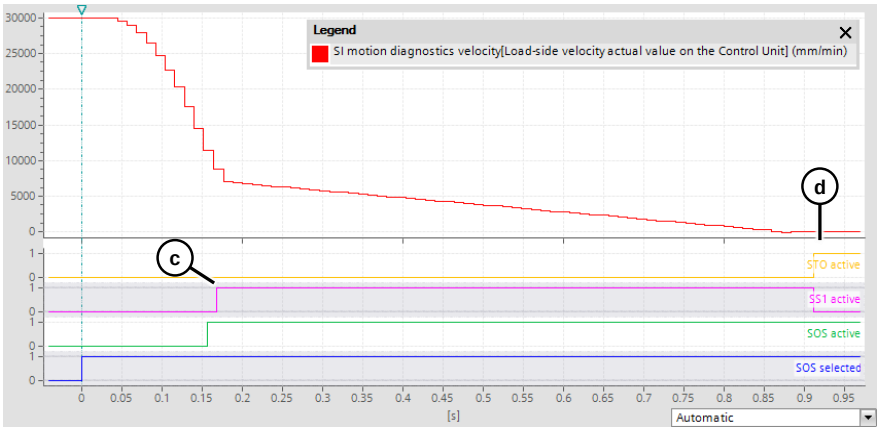


2. Start the trace recording.
3. Start the motor as described in chapter 3.7.1.
4. Activate service mode by setting the tag "serviceMode" (8) to "TRUE" in the watch table. (SOS is only triggered in service mode when the safety door is opened).
5. To trigger SOS, open the safety door in service mode.
   The trace shows the following:
   a. The drive is stopped as soon as the safety door is opened in service mode.
   b. After the safety door has been closed and the F peripherals acknowledged, the movement is continued.



   c. In the following figure, the "Delay time SOS->SOS active" that was selected was too short (150 ms) After the delay time has elapsed, the drive is not yet stopped:
   → With "SOS active" the standstill monitoring is also activated. Since the

drive has not yet been stopped, STOP B is triggered by the standstill monitoring.



d. After the drive has been stopped by STOP B, STOP A is triggered and the drive is disabled.

4 Appendix

4.1 Service and support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:
support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. Please send queries to Technical Support via Web form:
www.siemens.com/industry/supportrequest

SITRAIN – Training for Industry

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that’s tailored to the customer’s specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:
www.siemens.com/sitrain

Service offer

Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:
support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS and Android:
support.industry.siemens.com/cs/ww/en/sc/2067

4.2 Links and literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to the entry page of the application example https://support.industry.siemens.com/cs/ww/en/view/109749224
\3\	SIMATIC - Failsafe library LDrvSafe to control the Safety Integrated functions of the SINAMICS drive family https://support.industry.siemens.com/cs/ww/en/view/109485794
\4\	"LAxisBasics - Simple control of the TO "axis" in the SIMATIC S7-1500". https://support.industry.siemens.com/cs/ww/en/view/109749348
\5\	SINAMICS S120 Safety Integrated functional manual https://support.industry.siemens.com/cs/ww/en/view/109740018
\6\	SIMATIC S7-1500 S7-1500 Motion Control V4.0 in the TIA Portal V15 https://support.industry.siemens.com/cs/ww/en/view/109749262

4.3 Change documentation

Table 4-2

Version	Date	Change
V1.0	11/2017	First version
V1.1	06/2018	Upgrade to TIA Portal V15
V1.2	06/2018	Changes in the documentation
V1.3	01/2019	Small correction
V1.4	08/2019	Extension for Safety Information Channel and SOS