Safety Integrated 9

9.1 Safety Integrated overview

Safety Integrated

The safety functions integrated in the SINAMICS inverters can be parameterized intuitively using graphic screens with Startdrive that is part of TIA Portal. Most drives of the G120 family are equipped with the "Safe torque off (STO)" drive-autonomous safety function. This function is also available for Standard Control Units (without F suffix). The extended functions make available further safety functions, such as Safe Stop 1 (SS1) and Safely-limited Speed (SLS).

A brief overview of safety configuring in Startdrive follows.

9.2 Activating the safety commissioning mode

Activating the commissioning mode

Safety Integrated can be commissioned offline in the project or online directly on the drive. For the offline commissioning, you must explicitly activate the safety functions after the download. In the example, you perform both an online and an offline commissioning.

### How to activate the safety commissioning mode for online commissioning

For the online commissioning, you have already configured the drive and performed a first commissioning.

1. Double-click "Parameters" below the drive device in the project navigation. The parameters will be displayed in the working area.

2. Switch to the "Function view" tab.

3. Connect Startdrive online with the drive (🔌 Go online).

4. Activate the commissioning mode of the safety functions by clicking the ⚒ Start safety commissioning "Activate safety commissioning mode" button.
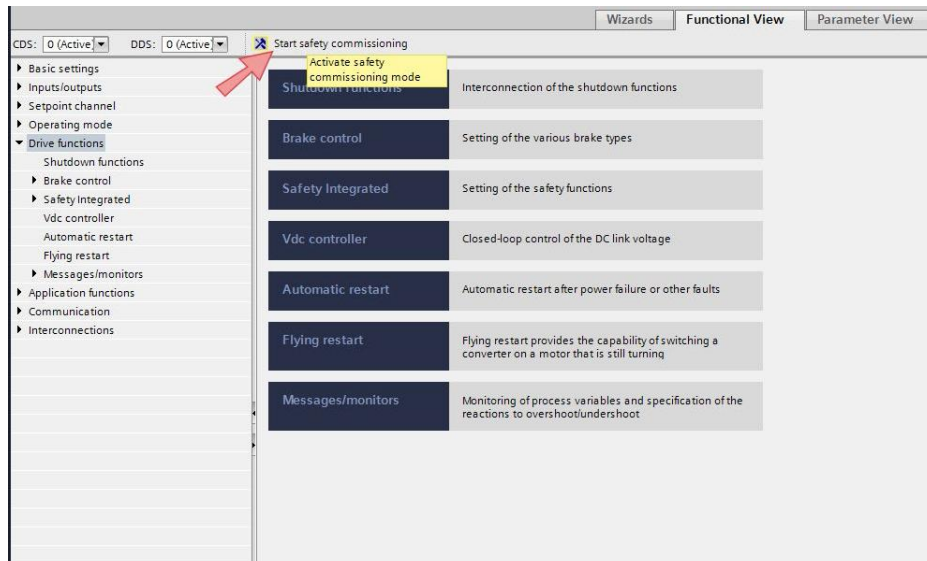
5. The safety functions are protected against unauthorized changes by a password. Enter a new password and confirm the dialog. Only with this password can the safety parameterization be re-edited.
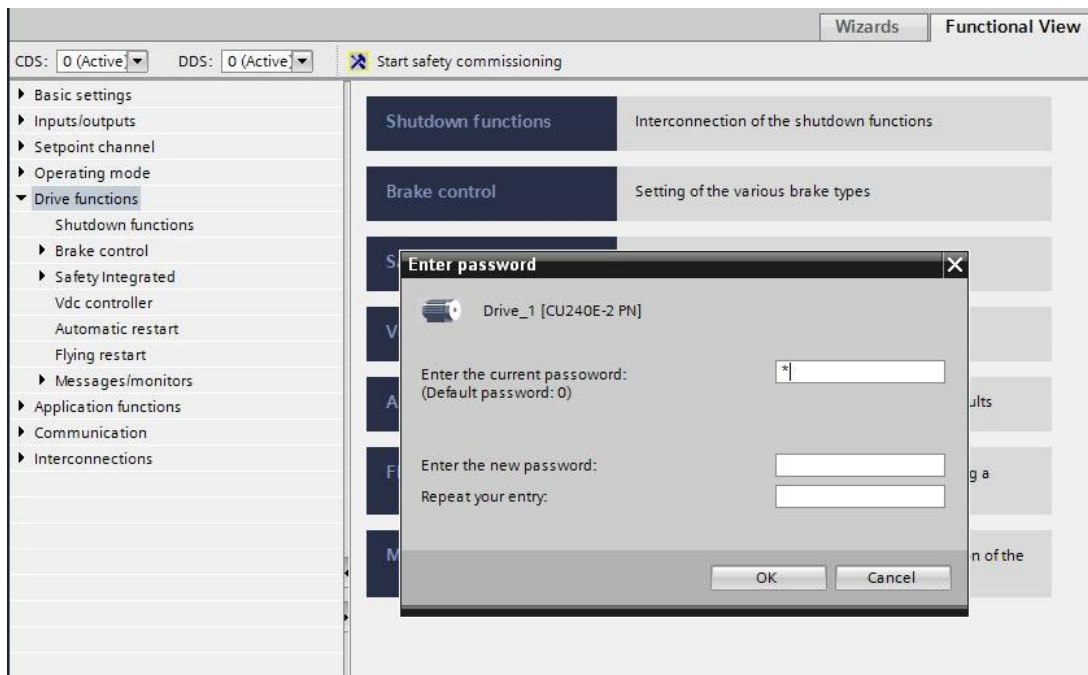
The safety commissioning can now be performed. In the next step, select the safety functionality.

9.3 Selecting the safety functionality in the Startdrive

Safety functionality

To edit the safety functions, you must first select the appropriate safety functionality.

1. Click "Selection of the safety functionality" below "Drive functions" > "Safety Integrated" in the "Function view" tab.

2. In the opened window, you can choose between "Basic functions" and "Extended functions" depending on the type of the drive device.
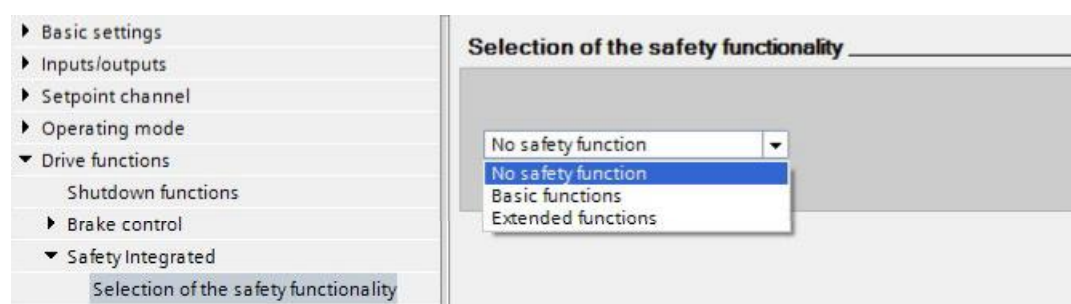

Figure 9-1   Selecting the safety functionality

3. After selecting the safety functionality, the possible safety functions are displayed in the secondary navigation and in the project window where they can be configured.

4. This is the STO (Safe Torque Off) safety function for the basic functions.
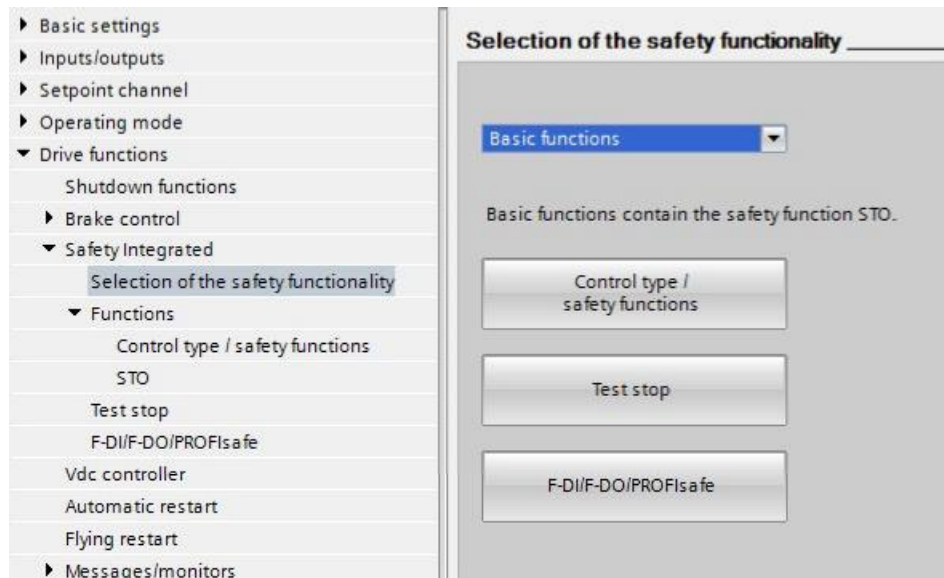

Figure 9-2   Safety functionality basic functions

5. The extended functions also contain the Safe Stop 1 (SS1), Safely-limited Speed (SLS), Safe Direction (SDI) and Safe Speed Monitor (SSM) safety functions.
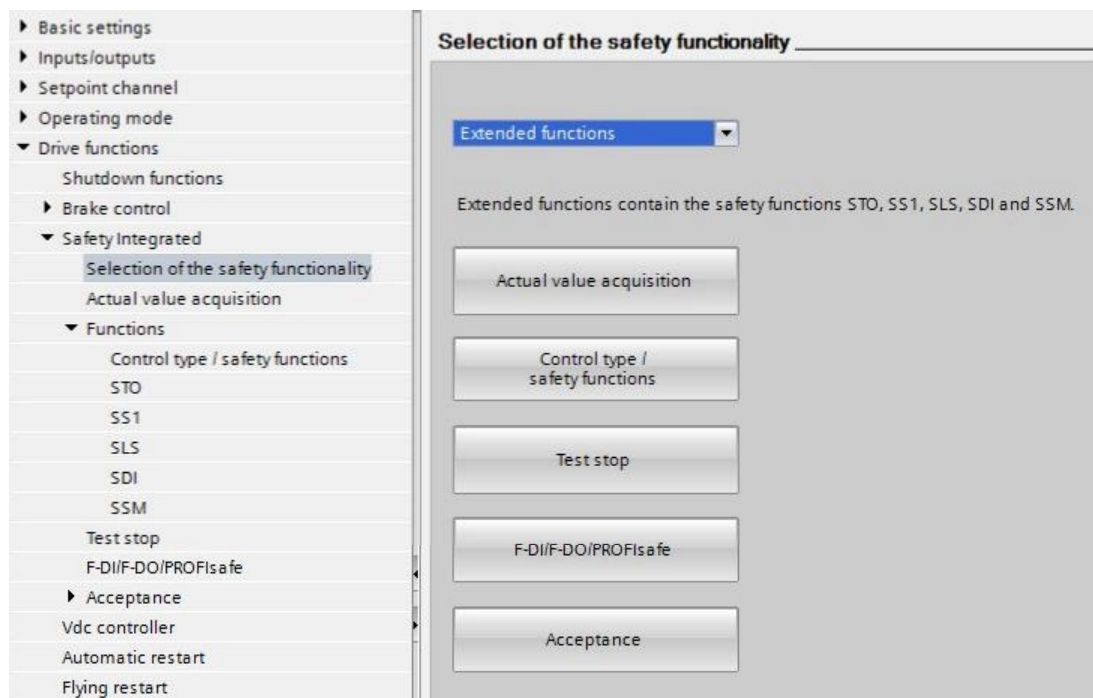

Figure 9-3   Safety functionality extended functions

The following example illustrates the commissioning of a safety function of the basic functions and one of the extended functions.

9.4 Commissioning the basic functions

9.4.1 Commissioning the Safety Integrated basic functions

Basic functions

Based on the example of a G120 CU240E-2 PN-F, commission the Safe Torque Off (STO) by means of terminals. A drive device with active STO function prevents the inadvertent starting of machine components. The safety commissioning is performed online.

Note

Prior to the safety commissioning, the drive device must be connected online with the Startdrive and the safety commissioning mode activated.

9.4.2 Commissioning basic functions with STO

STO commissioning

As first step, activate the safety functionality and then configure the Safe Torque Off (STO) safety function. The safety commissioning is performed online directly on the drive.

1. Select the "Basic functions" safety functionality in the "Function view" tab.

2. To configure the basic functions, you can display the individual screens directly via the buttons or the secondary navigation.

Note

For a structured commissioning, you should process the screens via the secondary navigation sequentially from top to bottom.

3. Click "Control type / safety functions" in the secondary navigation.

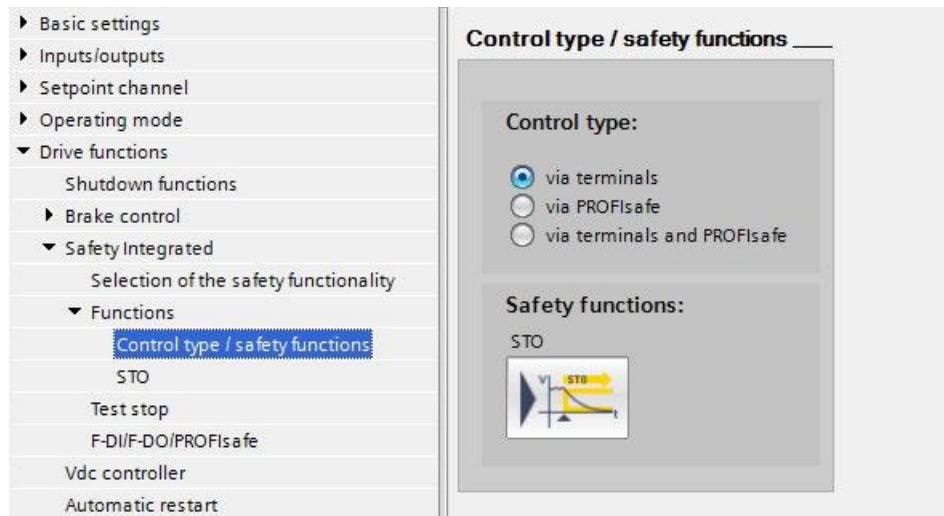4. In the opened screen, select "Via terminals" as control type.

Figure 9-4   Selecting via terminals control type

5. Click "STO" in the secondary navigation. Because the Control Unit input is permanently wired with the emergency stop, you do not need to make any further settings. If, for example, you want to interconnect the emergency stop with a signal lamp, you can use the "STO active" output.
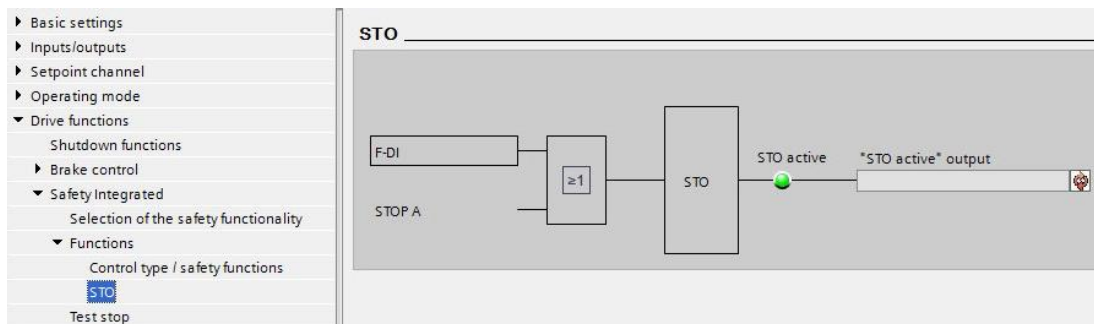

Figure 9-5   Configuring the STO basic function

This completes the configuration of STO. In the next step, configure the test stop.

9.4.3 Configuring test stop

Test stop

The test stop of the basic functions is a self-test of the inverter in order to test the circuits for the safe torque off. The test stop is restarted after each selection of the STO function and after the connection of the supply voltage (switch on). A time block monitors whether the test stop is performed regularly.

1. Click "Test stop" in the secondary navigation.

2. In the opened screen, enter the duration of the time interval in which the test stop must be performed.
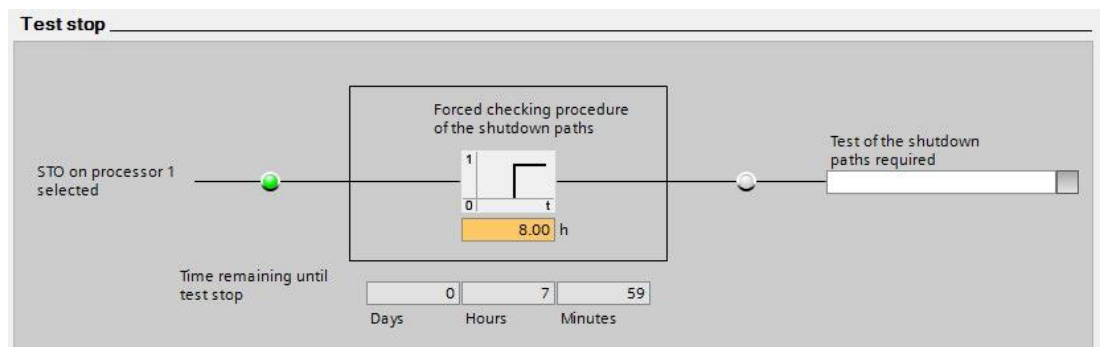

Figure 9-6   Configuring the test stop basic functions

3. You can specify the time interval. The test stop has to be executed at least once a year if SIL 2 / PL d level is required (normally determined with a risk analysis), in this case a default value of 8760 hours is suggested. Alarm A1699 occurs when the time expires

Note

The remaining time until the occurrence of the alarm A1699 is also displayed in the screen. This timer is reset for each test stop to the previously configured value.

You have now configured the test stop of the basic functions.

9.4.4 Configuring the discrepancy time and the filter time

Discrepancy/filter time

If Safety Integrated is active, the inverter checks whether the signals at both inputs always have the same signal state. Because of the technical characteristics of the sensors, brief discrepancies or signal changes between the two input signals that are not safety relevant can occur. A fail-safe logic with safe outputs connected with the SINAMICS G120 can also be used for the activation. Some such fail-safe outputs provide test pulses that can be suppressed by the filter. The discrepancy or filter time can be used to prevent a faulty initiation or discrepancy error because of transient different signal levels of the safety function.

1. Click "F-DI/F-DO/PROFIsafe" in the secondary navigation.

2. You can set the discrepancy time and the input filter time in the displayed screen. Adapt these values to the connected sensors and to the duration of the test pulses for the deployed fail-safe outputs of the fail-safe logic.
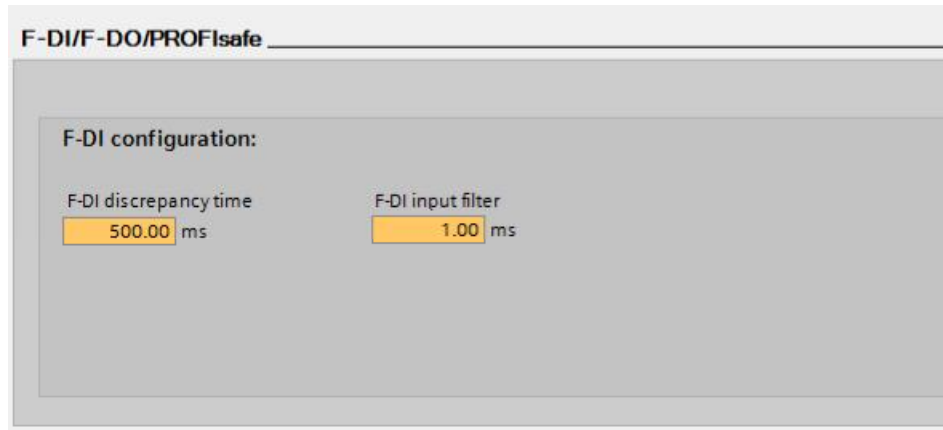

Figure 9-7   Configuring the discrepancy time and filter time basic functions

The safety commissioning is completed in the next step.

9.4.5 Completing the safety commissioning

Safety commissioning completion

To complete the commissioning, the safety parameterization must be copied to the ROM of the drive and into the project.

1. Click the ⚒ End safety commissioning button to exit the safety commissioning mode.

2. Click "Yes" to confirm the opened dialog. The drive parameters are copied from RAM to ROM.
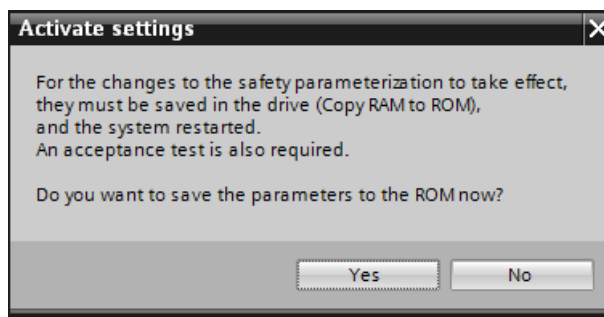

Figure 9-8   Safety commissioning: Copy RAM to ROM

3. Close the online connection to the drive device.

4. Click the "Load from device (software)" button in the toolbar to save the safety parameterization in the Startdrive project.

5. Switch the drive device Off and On so that the safety commissioning in the drive device acts.

This completes the safety commissioning.

9.5 Commissioning extended functions

9.5.1 Commissioning Safety Integrated extended functions

Extended functions

Based on the example of a G120 CU240E-2 PN-F drive device and a higher-level SIMATIC S7-1500 CPU 1516F-3 PN/DP controller, commission the Safely-limited Speed (SLS) safety function by means of PROFIsafe.

You have already included the controller and the drive device, and configured the communication in the project. The safety commissioning is performed offline in the Startdrive, and after the download safety is activated in the drive device.

9.5.2 Configuring SLS

Safety function and actual value acquisition

As first step, activate the safety functionality and then configure the actual value acquisition.

1. Select the "Extended functions" safety functionality in the "Function view" tab.

2. To configure the extended functions, you can display the individual screens directly via the buttons or the secondary navigation.

Note

For a structured commissioning, you should process the screens via the secondary navigation sequentially from top to bottom.

3. Click "Actual value acquisition" in the secondary navigation.

4. For safety functions without encoders, the pole pair number of the motor is included in the conversion from the motor side to the load side. You must first configure them.
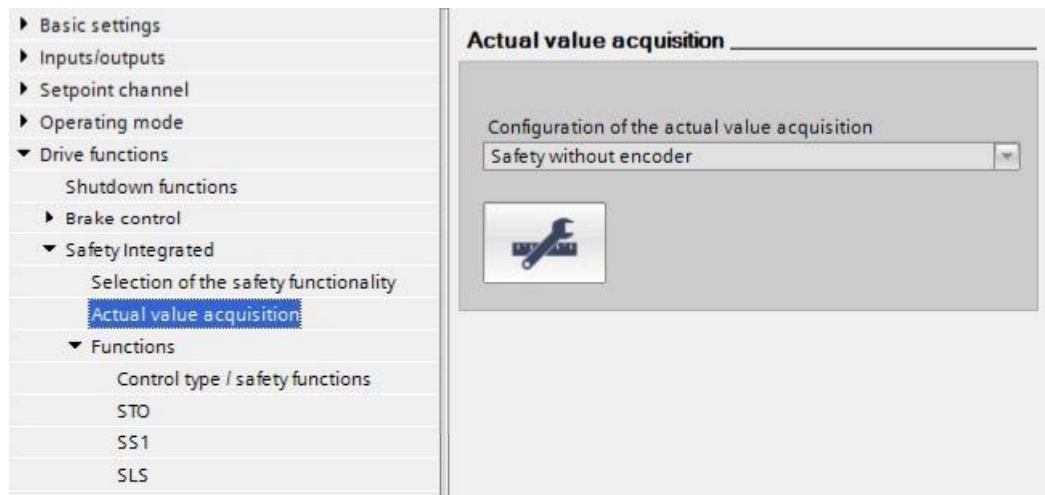

Figure 9-9   Actual value acquisition extended functions

5. Click the "Actual value acquisition configuration" button.

6. The pole pair number of the motor is displayed grayed-out in the opened dialog. This value must be considered for the input of the gear ratio. No mechanical gearbox is used in the example. Consequently, the gear ratio consists only of the pole number (2 in the example).
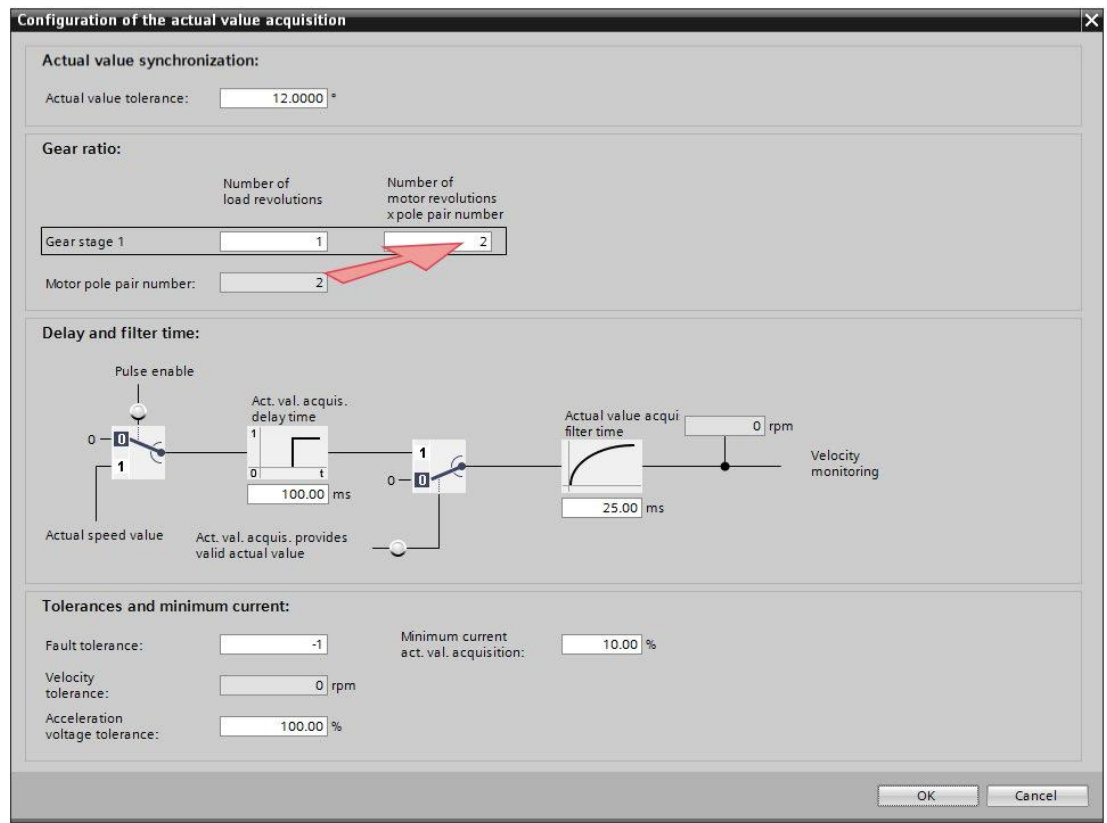

Figure 9-10   Actual value acquisition pole pair number configuration extended functions

7. Click "OK" to confirm.

This completes the configuration of the actual value acquisition. In the next step, configure the safety function.

9.5.3   Configuring the control type and the SLS

Configuring the control type and the SLS

Now configure the control type and the SLS safety function.

1. Select "PROFIsafe" as control type and insert the PROFIsafe telegram.

2. Click "Control type / safety functions" below "Functions" in the secondary navigation.

3. You must enable the associated SLS safety function. Select "Enable" in the selection list in front of the required safety function. The other safety functions also enabled but not deployed are deactivated later in the safety program.
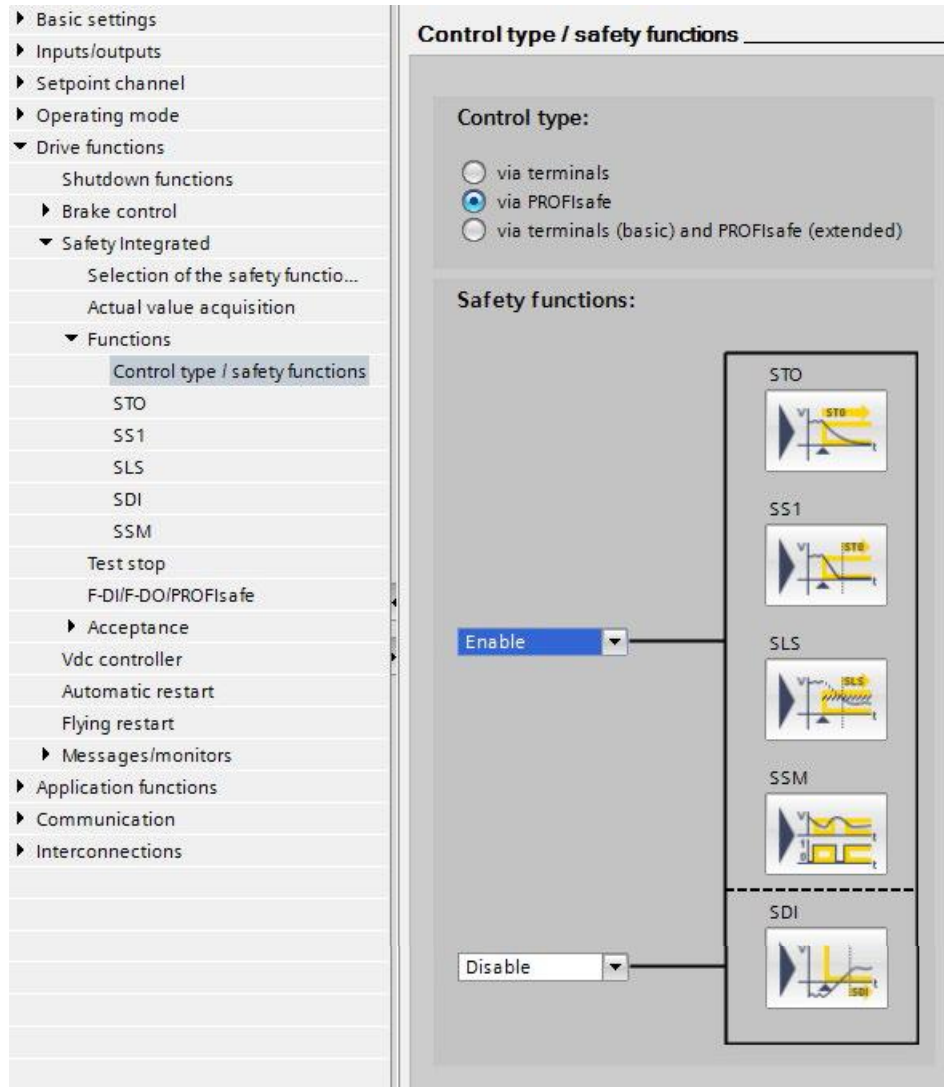

Figure 9-11   Extended functions: Enable PROFIsafe control type and safety function

4. Click "SLS" in the secondary navigation.

5. Select the monitoring mode. In the example, safety without encoder with a braking ramp ("with SBR" in the example) is selected.

6. For SLS via PROFIsafe, you can select as many as four monitoring levels. Only level 1 is used in the example. Enter a value for the maximum speed (500 rpm in the example) and the "stop response" when the monitoring is triggered (STOP A in the example, which is equal to STO).
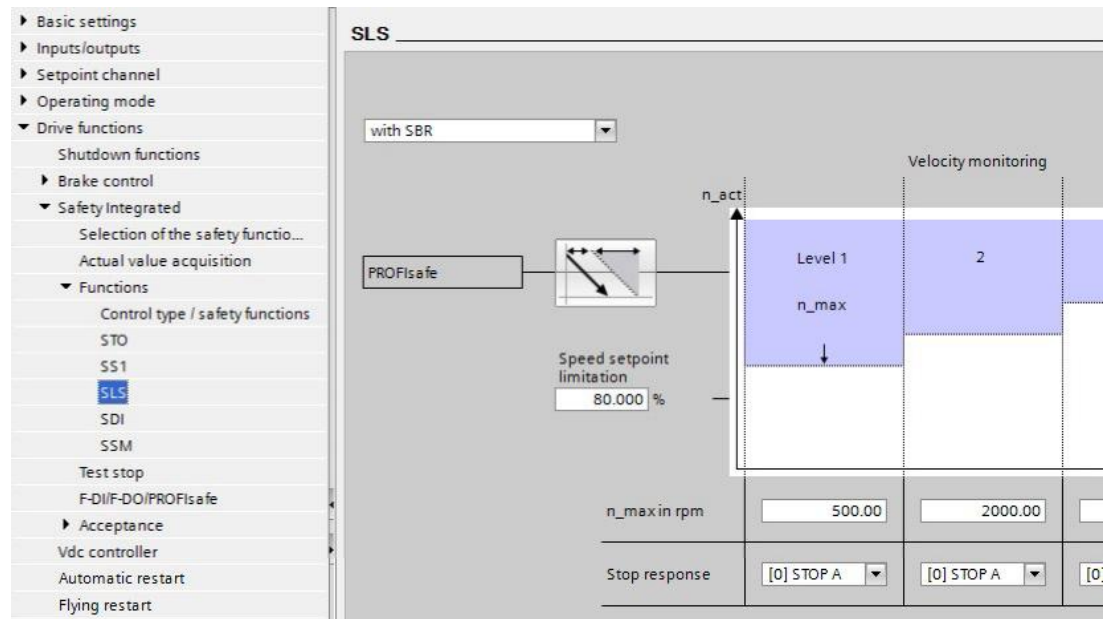   Leave the other parameters at their standard values.

Figure 9-12   Extended functions: Configure SLS

This completes the configuration of SLS. In the next step, configure the test stop.

9.5.4   Configuring a test stop (forced checking procedure)

Test stop

The test stop (forced checking procedure) of the extended functions is a self test of the inverter that tests its circuits for monitoring the speed and for the safe torque shutdown. A time block monitors whether the test stop is performed regularly. The test stop is started with a freely selected signal.

1. Click "Test stop" in the secondary navigation.

2. In the opened screen, use "Test stop selection" to interconnect a signal or a bit of a control word in order to start the test stop. In the example, digital input DI1 (r722.1) is interconnected.

3. You can specify the time interval. The test stop has to be executed at least once a year if SIL 2 / PL d level is required (normally determined with a risk analysis), in this case a default value of 8760 hours is suggested. Alarm A1699 occurs when the time expires.

Note

The test stop of the extended functions includes the test of the basic functions (STO). Consequently, you should set the two timers to the same value.
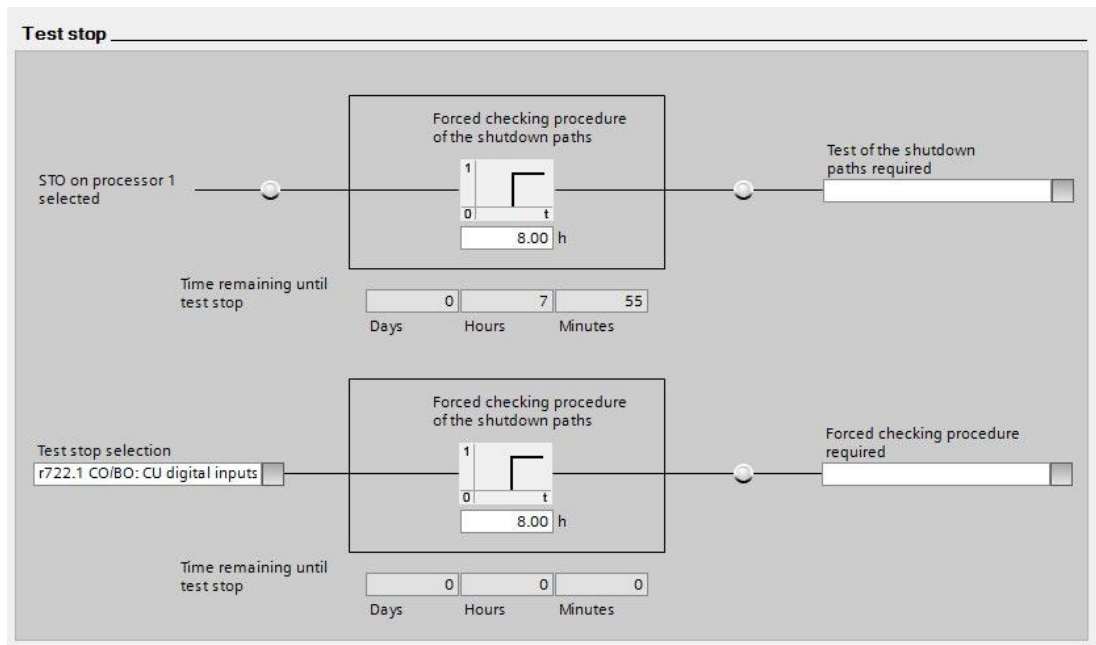

Figure 9-13   Extended functions: Configure test stop

Leave the other parameters at their default settings. You have now configured the test stop of the extended functions.

9.5.5 Configuring PROFIsafe

PROFIsafe

In the example, Safety Integrated via PROFIsafe is configured. For the fail-safe communication between the controller and the drive, a PROFIsafe telegram must be added and the PROFIsafe address entered.

1. Click "F-DI/F-DO/PROFIsafe" in the secondary navigation.

2. The PROFIsafe address of the drive is displayed in the opened screen (0x5 in the example). You can change it offline. The PROFIsafe address corresponds to the F address (F_Dest_Add).

Note

The PROFIsafe address can be changed in this screen as of SINAMICS V4.7 or Startdrive V13 SP1.

3. Click the "Telegram configuration" button to open the telegram configuration in the details view. "Cyclic data exchange" is displayed in the "Properties" tab in the details view footer.

4. Click <Add telegram> below the actual value and the setpoint in the table, and select "Add safety telegram" in the opened context menu.
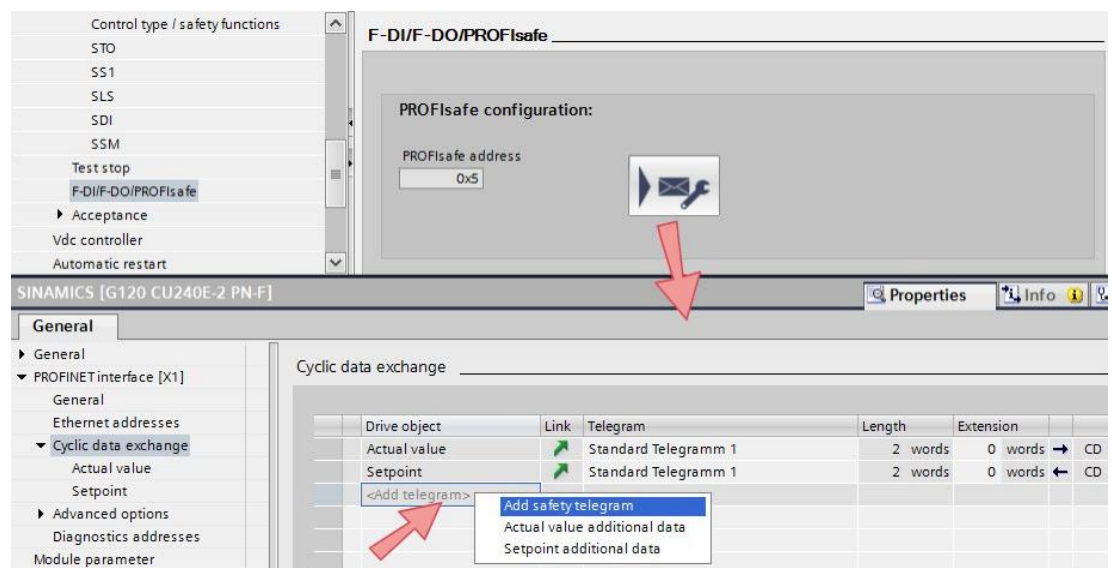
Figure 9-14   Configuring a PROFIsafe telegram

5. The PROFIsafe telegram 30 is added in this example (further ones are available, e.g.900).

Figure 9-15   PROFIsafe telegram 30

6. Also check the "F address" in the "Safety setpoints" and "Safety actual values" fields in the same screen. It is used for the safety configuring and corresponds to the PROFIsafe address for the safety commissioning. Address 0x5 is used in the example.

Figure 9-16   Configuring the PROFIsafe address (F address)

The PROFIsafe telegram is now configured. The safety commissioning is completed in the next step.

9.5.6 Completing the safety commissioning

Activating safety

To complete the commissioning, the safety parameterization must be loaded into the drive device and activated.

1. Save the project and select "Load to device" in the context menu of the drive device.

2. Connect Startdrive online to the drive unit (🔶 Go online).

3. Activate the commissioning mode of the safety functions.

4. A password protects the safety functions against unauthorized changes. Enter a new password and confirm the dialog.

Figure 9-17   Activating Safety Integrated in the drive

5. Click the 🔧 End safety commissioning button to exit the safety commissioning mode.

6. Click "Yes" to confirm the opened dialog. The drive parameters are copied from RAM to ROM.

7. Close the online connection to the drive device.

8. Click "Load from device (software)" in the context menu of the drive device in the project navigation to save the safety parameterization in the Startdrive project.

9. Switch the drive device Off and On so that the safety commissioning in the drive device acts.

This completes the safety commissioning.

9.5.7 Safety program and F-runtime group

Safety program

To use the safety functions of the SINAMICS drive device in conjunction with an F-CPU, you must create the safety programs. For each F-peripheral of the SIMATIC S7-1500F CPU, an F-block with the associated instance DB and an F-runtime group are created automatically during the configuring so that you can begin immediately with programming the safety program.

To display the F-runtime group, proceed as follows:

1. Click "Safety Administration" below the SIMATIC CPU in the project navigation. In the working area, you can use the secondary navigation to access the individual functions of the Safety Administration.
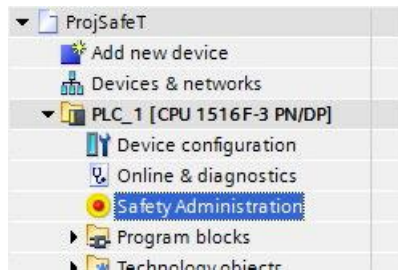

Figure 9-18   Safety Administration for SIMATIC CPU

2. Click "F-runtime group" to display the automatically created F-blocks. The F-peripheral DB contains tags that you can evaluate in the safety program. The F-runtime group consists of an F-OB that calls the main safety block in which the safety functions are programmed.
This example does not require any change to be made to the F-runtime group.
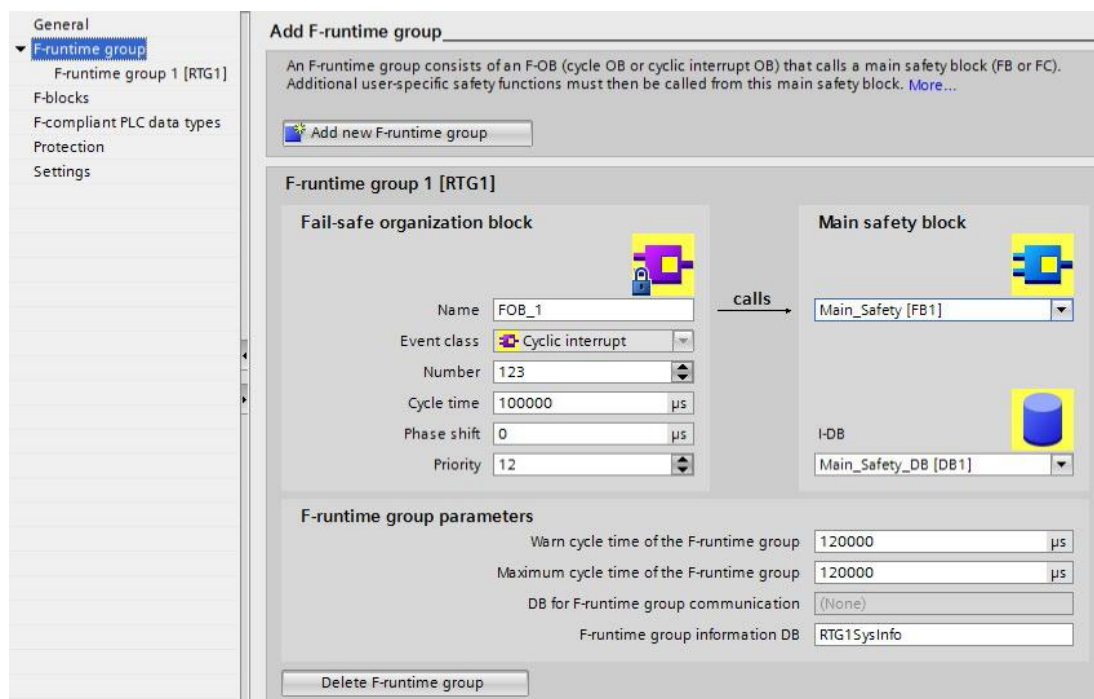

Figure 9-19   F-runtime group for safety programs

In the next step, program the main safety block.

9.5.8   Programming the main safety block

Main safety block

In the main safety block, the F-peripheral is acknowledged and re-integrated concurrently in the F-runtime group. The superfluous safety functions are deselected and the deployed safety functions are selected. In the example, the main safety block is programmed in F-FBD.

Note

Further information about the general programming and about the F-peripheral is contained in the online help of the TIA Portal.

1. Create in the project navigation under "PLC tags" a new tag table with the following tags
   (the byte number is chosen as example, by respecting the bit positions in the telegram):
   – STO (%Q1.0)
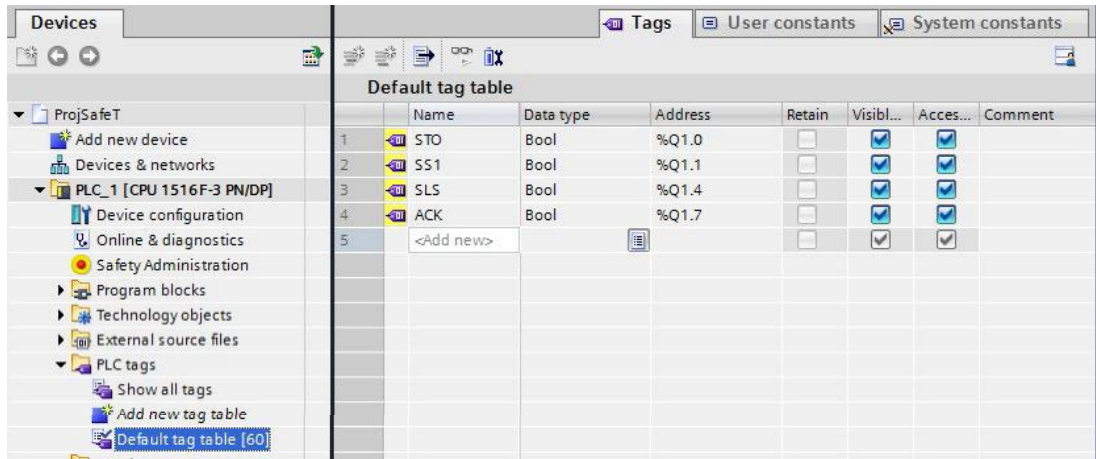   – SS1 (%Q1.1)
   – SLS (%Q1.4)
   – ACK (%Q1.7)

Figure 9-20   Creating tags for the safety program

Note

The addresses of the tags result from the PROFIsafe control word and are used for the selection or deselection of the safety functions. To improve clarity, the tag names correspond to the name of the safety function.

In the example above, the telegram addresses are individually parametrized. For more complex applications, the LDrvSafe library is available for a more convenient use (https://support.industry.siemens.com/cs/document/109485794)

Figure 9-21   PROFIsafe control word 1

2. Click "Main_Safety [FB1]" below the "Program blocks" of the project navigation. The program block opens in the editor.

3. Click the "ACK_GL" block below the "Safety functions" in the "Basic instructions" instruction window and drag-and-drop it to the program editor. A positive edge must be present as user acknowledgment at the block input.
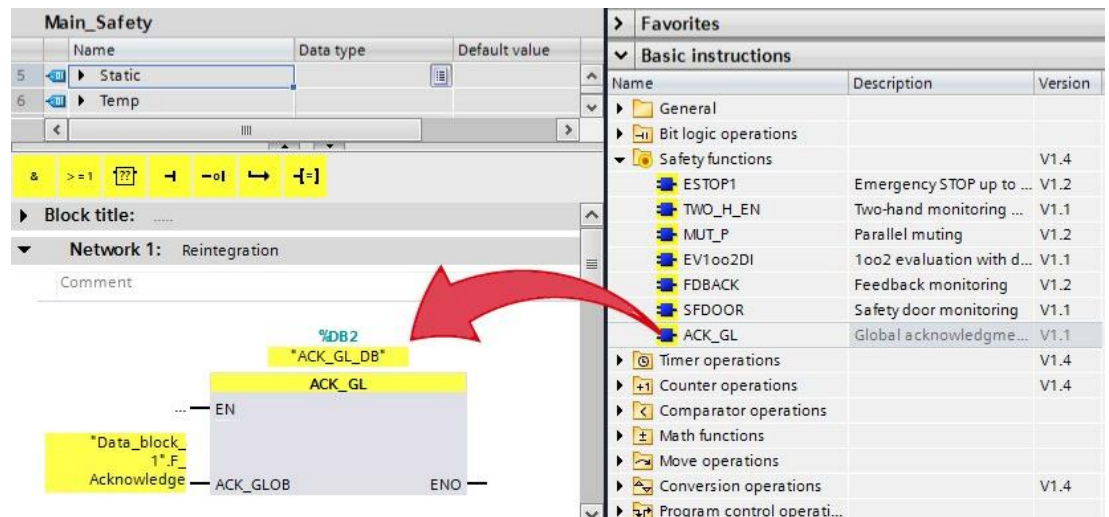

Figure 9-22   ACK_GL block: Global acknowledgment of all F-peripherals

4. Insert a new network. All safety functions other than SLS with a fail-safe "High" signal are deselected in this network. To do this, create a new static tag **vke1** of the "Bool" type with default value "true" in the block parameters table. As an alternative, typing the "true" value directly at the block interface is possible if you use the LDrvSafe library.
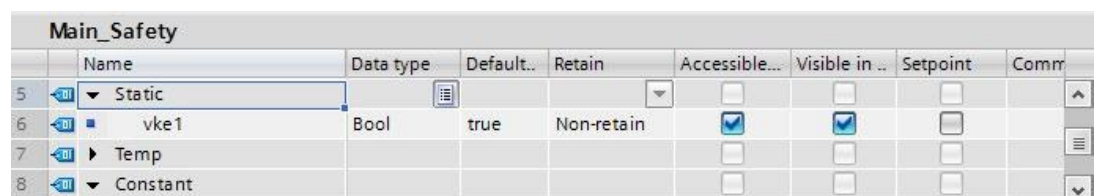

Figure 9-23   Creating a static vke1 tag for the high signal

5. Assignments of the **vke1** "High" signal at the Q1.0 and Q1.1 outputs deselect the STO and SS1 safety functions.
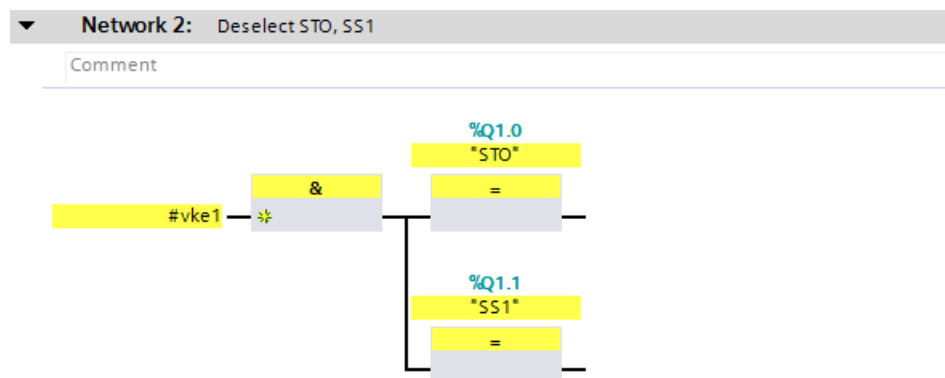

Figure 9-24   Deselecting safety functions with logical "high"

6. In a new network, the SLS safety function is deselected with "high" at the Q1.4 output, otherwise the function remains active.

Figure 9-25   Selecting/deselecting the SLS safety function

7. To reliably acknowledge the SINAMICS safety fault, the Reset pushbutton is interconnected with the acknowledge bit (Q1.7) from the PROFIsafe control word.
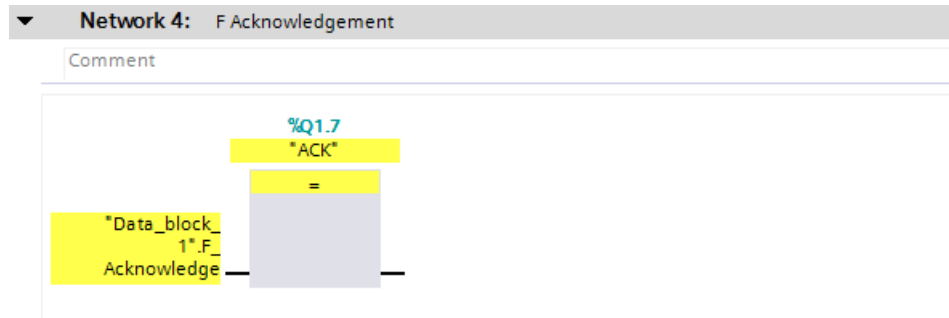

Figure 9-26   Acknowledging safety faults with the Reset pushbutton

8. Mark the CPU in the project navigation and click on "Compile" and then save the project.

The programming is complete after a fault-free compilation. It only remains to load the project to the target system.

9.6   Acceptance of the safety functions

Acceptance test

The acceptance test of the drive device is part of the acceptance test of the complete machine or system. The acceptance test checks whether the drive-integrated safety functions are set to match the configured safety function of the machine. The results of the acceptance test and the settings of the drive-integrated safety functions must be documented.

The safety commissioning and programming are completed after performing and documenting the acceptance.

Note

A procedural support for the acceptance test is provided by the Startdrive Advanced tool. An introductive video series is available here: https://sie.ag/34xSYuV