Controlling Safety Integrated Extended Functions of the SINAMICS S120 via the onboard terminals of the CU310-2 PN

SINAMICS S120

Application example · February 2014

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SINAMICS S120
Safety Integrated

Controlling Safety Integrated Extended Functions of the SINAMICS S120 via the onboard terminals of the CU310-2 PN

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1 Task

Introduction

The following safety functions according to DIN EN 61800-5-2 are currently integrated in SINAMICS S120 drives:

Table 1-1: SINAMICS S120 safety functions according to DIN EN 61800-5-2

Name	Function	Description
STO	Safe Torque Off	Safe disconnection of the torque-generating power supply to the motor. The switching on inhibited function prevents the drive unit from being switched on again. (Category 0 stop function according to EN 60204-1)
SS1	Safe Stop 1	The drive is quickly and safely stopped along the OFF3 ramp and is safely monitored. Transition to STO after 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 only used when there is a motor brake and the motor brake is connected to the power connector via the outputs. SBC always responds in conjunction with STO or when internal safety monitoring functions respond with safe pulse cancellation.
SS2	Safe Stop 2	The drive is quickly and safely stopped along the OFF3 ramp and is safely monitored. Transition to SOS after a delay time has expired; the drive remains in closed-loop control. (Category 2 stop function according to EN 60204-1) Not available for safety functions without encoder.
SOS	Safe Operating Stop	This function serves to safely monitor the standstill position of a drive; the drive remains in closed-loop control. Not available for safety functions without encoder.
SLS	Safely Limited Speed	The drive speed is safely monitored. Parameterizable shutdown response when the limit value is violated.
SSM	Safe Speed Monitor	Safely displays when the speed falls below a speed limit (n < nx).
SDI	Safe Direction	The direction of motion (positive and negative directions) is safely monitored. Parameterizable shutdown response when moving in the direction that has not been enabled.
SLP	Safely Limited Position	The positioning range of a drive is safely monitored; corresponds to safety-relevant software limit switches. Parameterizable shutdown response when position limits are violated. Not available for safety functions without encoder.

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In addition to the functions defined in standard DIN EN 61800-5-2, the following safety functions are also available in SINAMICS S120.

Table 1-2: SINAMICS S120 safety functions not specified by DIN EN 61800-5-2

Name	Function	Description
SP	Safe Position	The safety-relevant position values of the SINAMICS S120 are transferred to a higher-level fail-safe control system (F-CPU) using a PROFIsafe telegram. For safety functions without encoder, these are only available with some restrictions.
SBT	Safe Brake Test	Using this function, the holding torque of up to 2 (holding) brakes can be tested. In conjunction with the SBC function, a safety-relevant brake can be implemented. Not available for safety functions without encoder.

The implementation of safety concepts is facilitated significantly through the use of drive-integrated safety engineering and its use also simplifies the verification of the required safety category for a machine.

The user is also supported by the Safety Evaluation Tool.

In the following application example, the drive-integrated safety functions are controlled via the onboard terminals of the CU310-2.

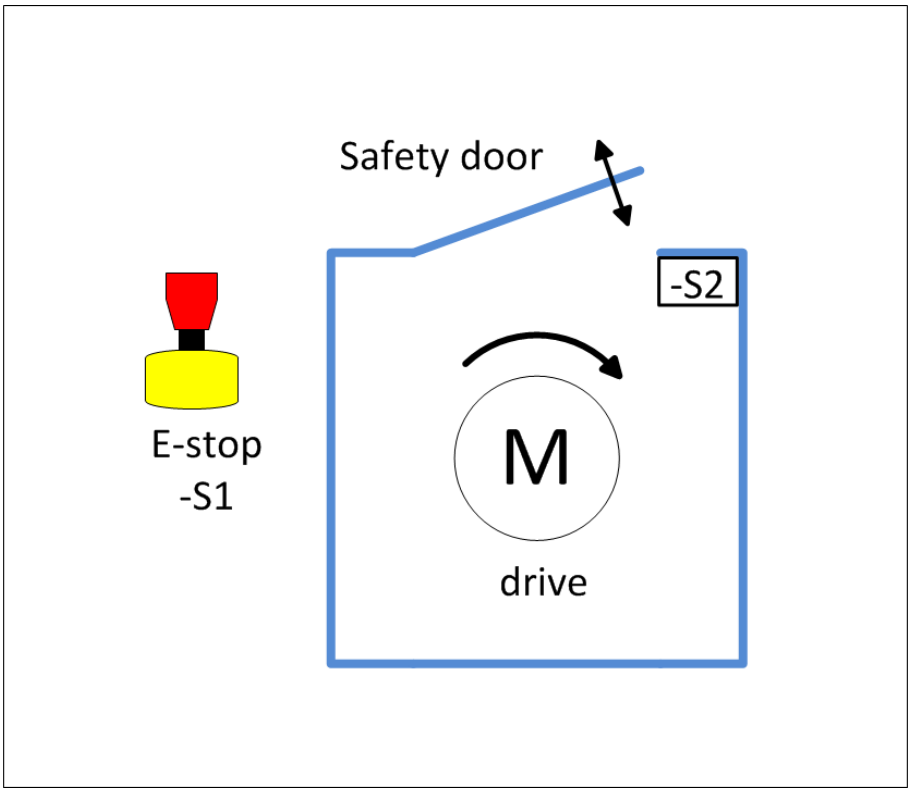
Other versions for the control of the drive-integrated safety functions when using a TM54F terminal expansion module, as well as the control via PROFIsafe are described in further application examples.

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Overview of the automation task

The following diagram provides an overview of the automation task

Fig. 1-1: Concept of the safety functions



The following safety functions are used as basis for further consideration.

Table 1-3: Safety functions of the application example

Safety function	Description	Response
SF1	Actuation of the Emergency Stop button	SS1: Fast stopping of the drive →with subsequent pulse cancellation
SF2	When the protective door is open, it is not permissible that the drive exceeds the velocity/speed configured by the user.	SLS: Monitoring of the drive speed.

Description of the automation task

In this example, safety functions SS1 and SLS should be controlled via the F-DIs of the CU310-2.

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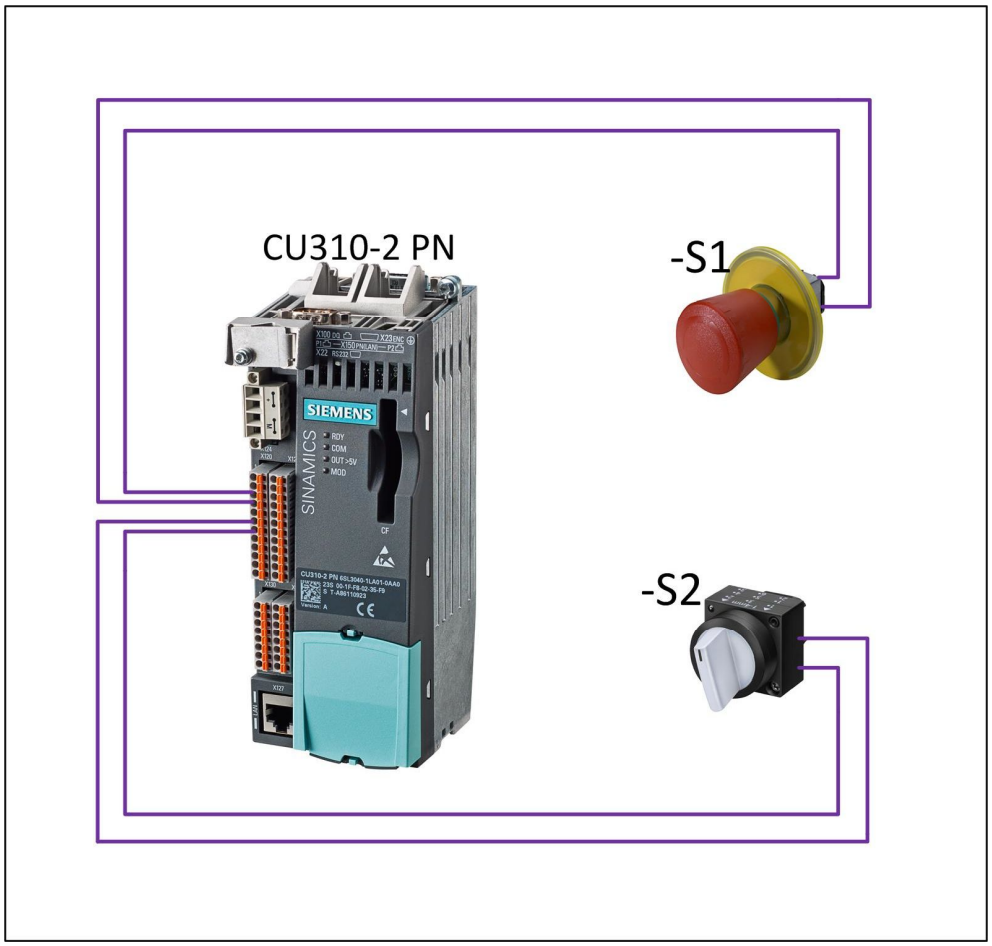
2 Solution

2.1 Overview of the overall solution

Schematic

The following schematic diagram shows the most important components of the solution:

Fig. 2-1: Relative components of the safety functions



This particular application example shows the control of safety functions SS1 and SLS via the integrated F-DIs of the CU310-2 PN.
3 F-DIs are available, of which one F-DI is used for SS1 and one for SLS. The third fail-safe input is not used in this particular example.

The S120 drive line-up used comprises a Control Unit
CU310-2 PN, a Power Module PM340 and a 1FK7 servomotor with incremental Drive-CLiQ encoder.

Design

This application example is based on the SINAMICS S120 CU310-2 PN training case (6A61067-1AA17-0AA0).

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Advantages

The application described here offers you the following advantages:

- Simple control of the safety functions integrated in the drive.
- Simple design using standard technology.
- The existing system can be quickly and simply expanded.
- Space-saving and favorably-priced design using integrated safety functions – additional hardware is not required.
- User-specific safety concepts can be implemented on this basis.

Limitations

This application does not contain a description of

- the safety functions of the SINAMICS S120,
- the general drive functions of the SINAMICS S120 and
- the hardware interfaces of the CU310-2

It is assumed that readers have basic knowledge of these topics.

Information on these topics can be found in the documents in the references.

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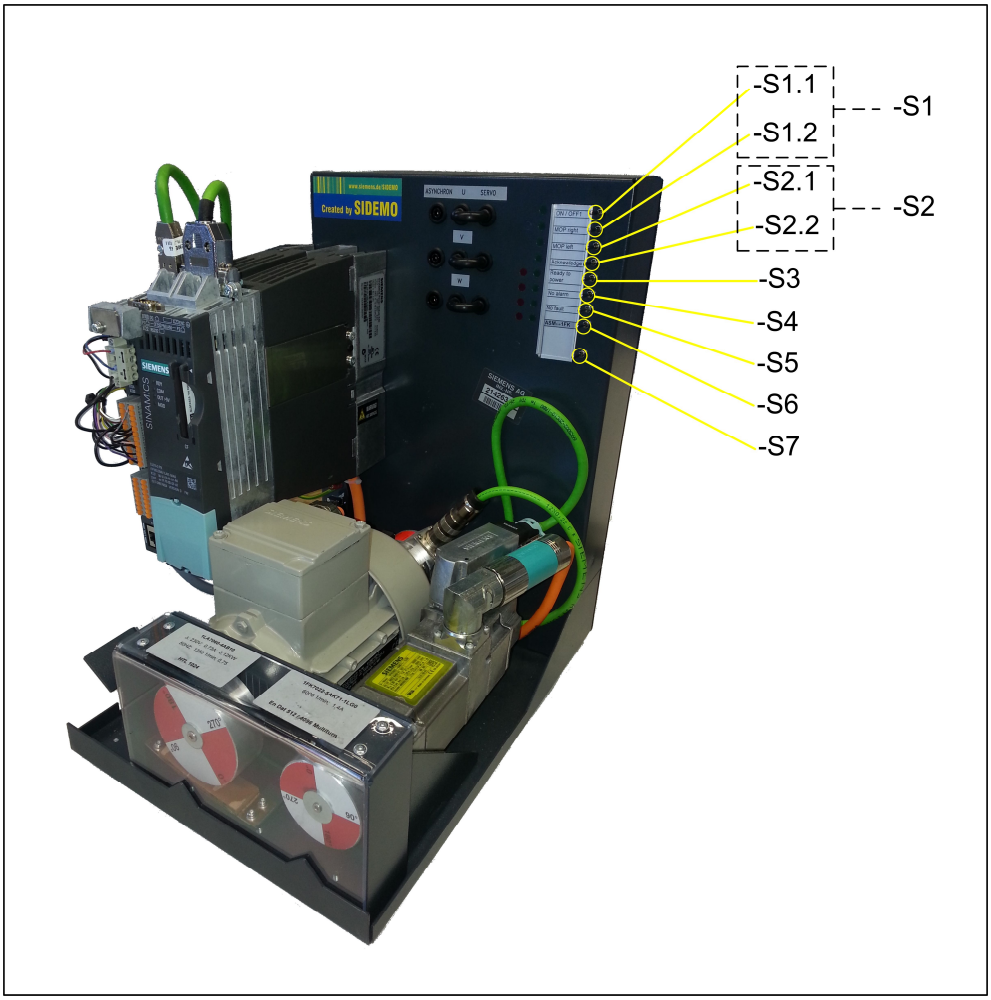
Knowledge required

It is assumed that readers have basic knowledge about engineering SINAMICS S120 drives with the STARTER or SIMOTION SCOUT engineering software.

2.2 Description of the core functionality

Overview and description of the core functionality

Fig. 2-2: SINAMICS S120 CU310-2 PN training case



The S120 drive line-up used comprises a Control Unit CU310-2 PN, a Power Module PM340 and a 1FK7022-5AK71-1LG0 servomotor with incremental Drive-CLiQ encoder. The training case also includes a 1LA7060-4AB10 induction motor, which is not used in this application example. The safety-relevant signals of the Emergency Stop pushbutton and toggle switch are connected via the fail-safe digital inputs (F-DI's) of the CU310-2 PN. When switch -S1 is actuated (switch pair -S1.1 and -S1.2), safety function SS1 is initiated, when actuating -S2 (switch pair -S2.1 and -S2.2), safety function SLS is selected. Fail-safe acknowledgment is possible using the extended alarm acknowledgment. As a consequence, all safety fault messages are acknowledged by selecting/deselecting STO (or SS1) using switch -S1.

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Note For this application example, the standard wiring of the S120 CU310-2 PN training case was adapted. The changes are presented in detail in Chapter 4.

Sequence of the core functionality

When Emergency Stop (-S1) is actuated, the drive is stopped using the SS1 safety function integrated in the drive.

The drive is assigned a protective door (-S2). If the protective door is opened, then the speed of the associated motor is safely monitored against the set speed limit value (SLS). STOP C (SS2) is initiated at the drive as SLS fault response when the safe speed is exceeded.

In this particular application example, it is not possible to acknowledge fault messages associated with safety functions in a fail-safe fashion using a switch. In this case, extended alarm acknowledgment is used where all safety fault messages are acknowledged by selecting/deselecting STO (or SS1) (-S1).

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2.3 Hardware and software components used

The application was created with the following components:

Hardware components

Table 2-1: Hardware used

Component	Qty.	Order number	Note
SINAMICS S120-CU310-2 PN training case	1	6A61067-1AA17-0AA0	
Compact Flash Card	1	6SL3054-0EG00-1BA0	
Control Unit CU310-2 PN	1	6SL3040-1LA01-0AA0	As an alternative, a CU310-2 DP can also be used.

Standard software components

Table 2-2: Software used

Component	Qty.	Order number	Note
STARTER V4.3.2.0	1	6SL3072-0AA00-0AG0	Alternatively, SIMOTION SCOUT can also be used.

Sample files and projects

The list below contains all the files and projects used in this example.

Table 2-3: Documents and files

Component	Note
MC_FE_I_017_V10.zip	Project
79722926_MC_FE_I_017_V10_en.pdf	This document

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3 Configuration and project engineering

In this chapter, you get to know how the individual components must be parameterized. STARTER is used as the engineering software for SINAMICS S120.

How the software project belonging to this application example was set-up is described step-by-step in the following sections.

Note The screenshots were generated with the "English" language setting. Display differences can occur for other language settings.

3.1 Password

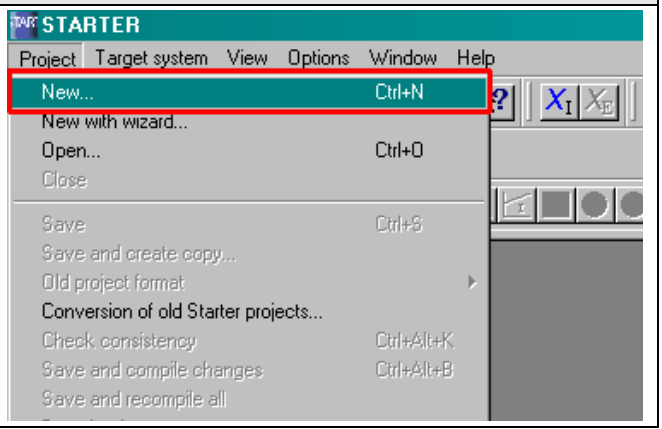
When configuring the safety functionality of SINAMICS components, safety password "1" is used for the drive.

NOTICE	**Such simple passwords must not be used in a real application as they do not provide adequate protection against authorized personnel accessing the configuration.**

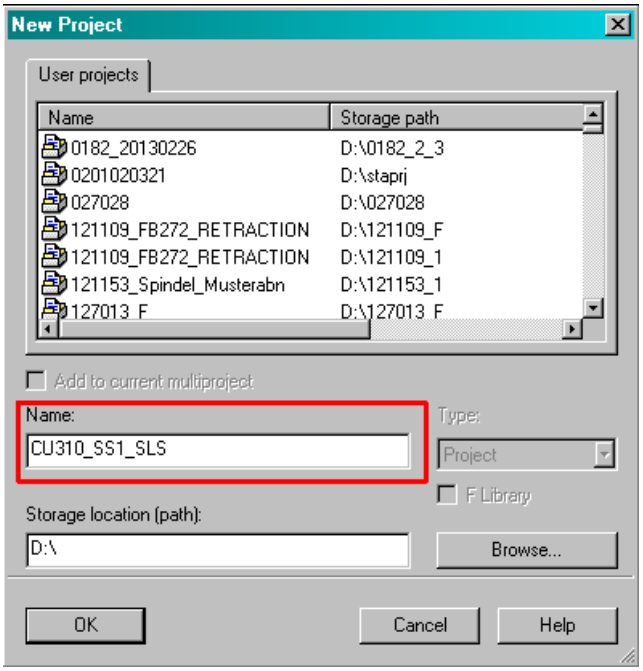
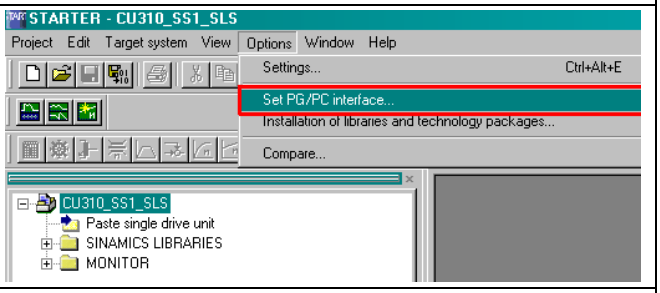
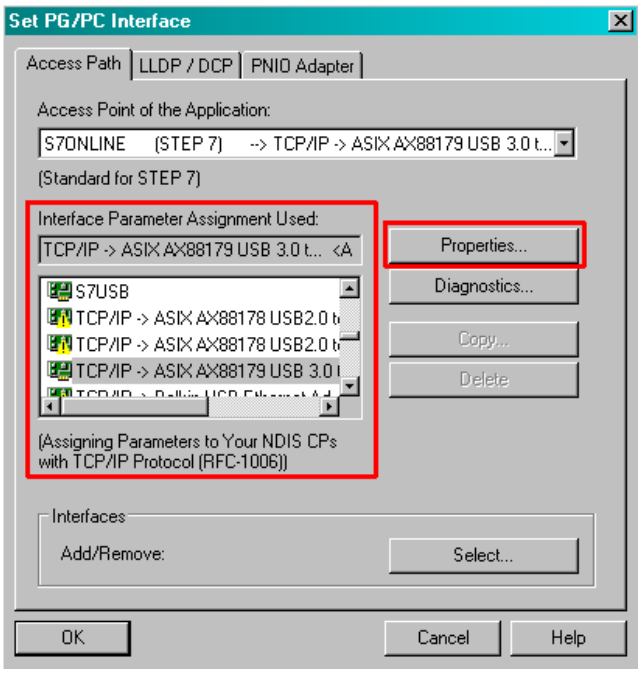
3.2 Basic commissioning of the SINAMICS drives (without safety)

Before the drive-integrated safety functions can be parameterized, the drive must be commissioned to an extent that it can be traversed.

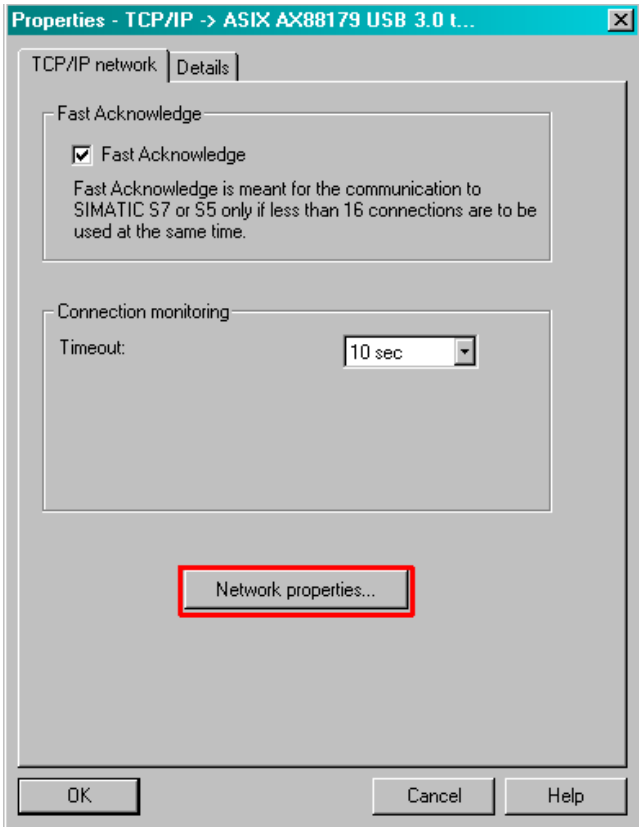
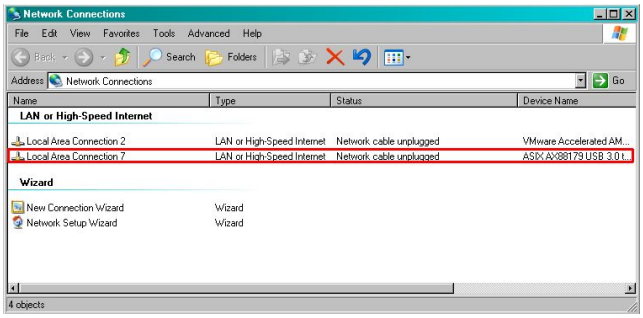
Table 3-1: Basic commissioning of a SINAMICS drive

No.	Action	Remark
1.	Open STARTER and create a new project with "Project > New".	

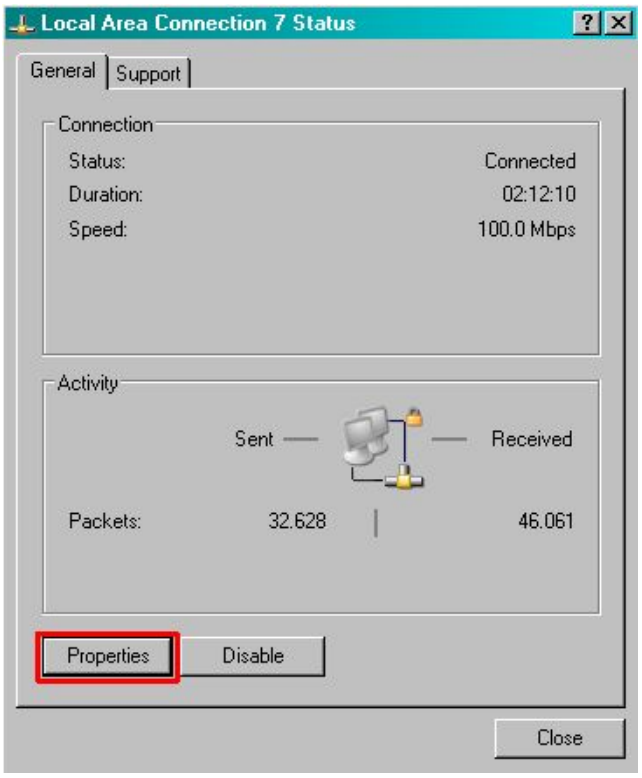
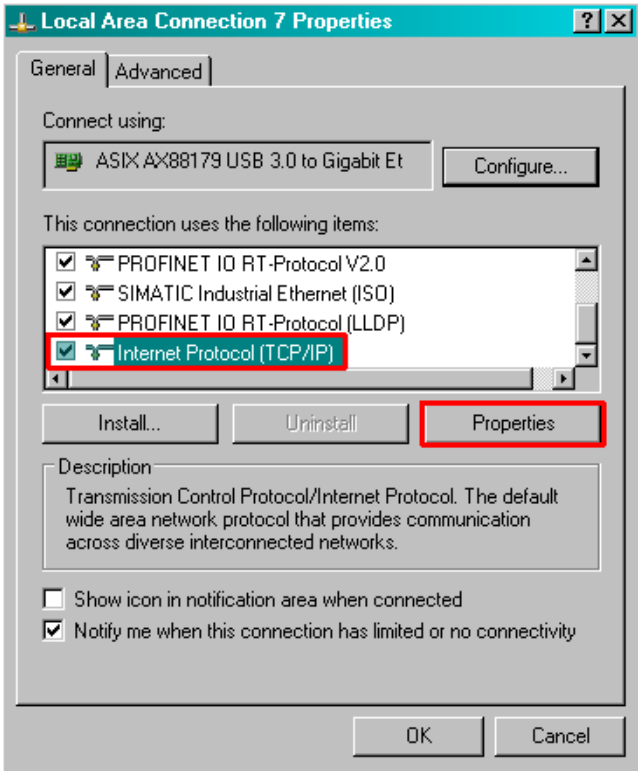
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No.	Action	Remark
2.	You can now assign an arbitrary project name.	
3.	The interface properties are defined using the menu item "Options" and "Set PG/PC Interface".	
4.	The adjacent window then opens. Select the interface with which you want to establish an online connection. Once the required interface has been selected, click on "Properties".	

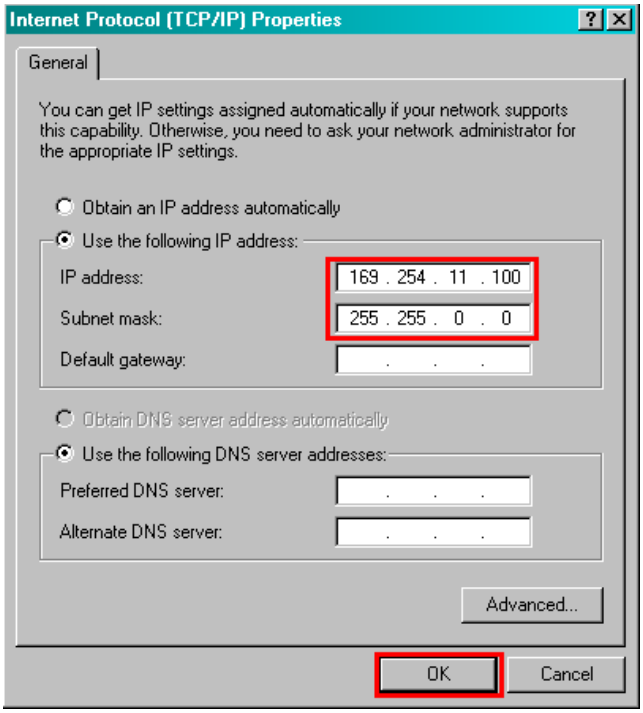
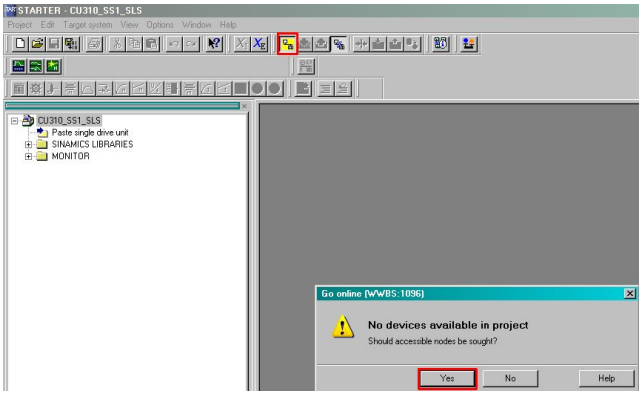
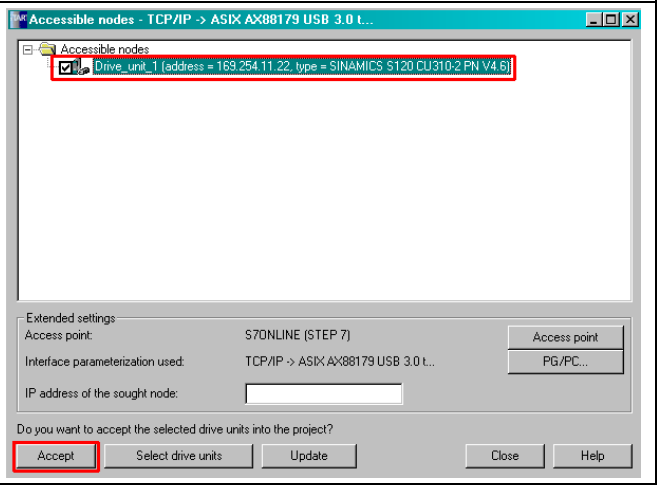
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No.	Action	Remark
5.	In the subsequent window, please click on the "Network properties" button.	
6.	Select the network connection being used and open the status window by double-clicking on the corresponding network.	

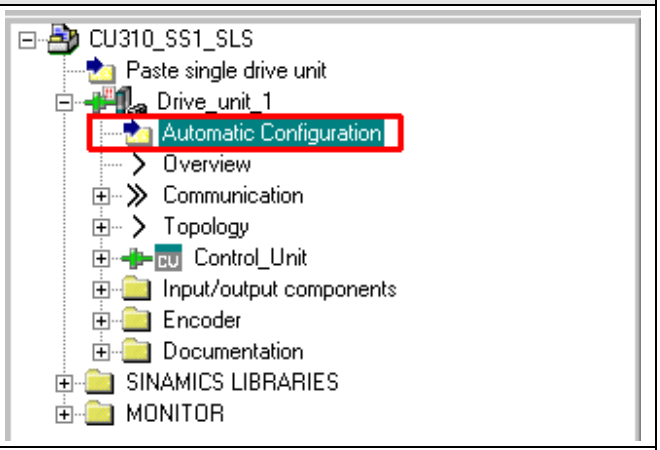
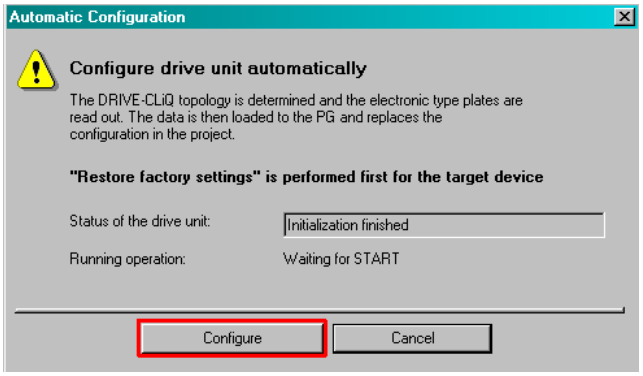
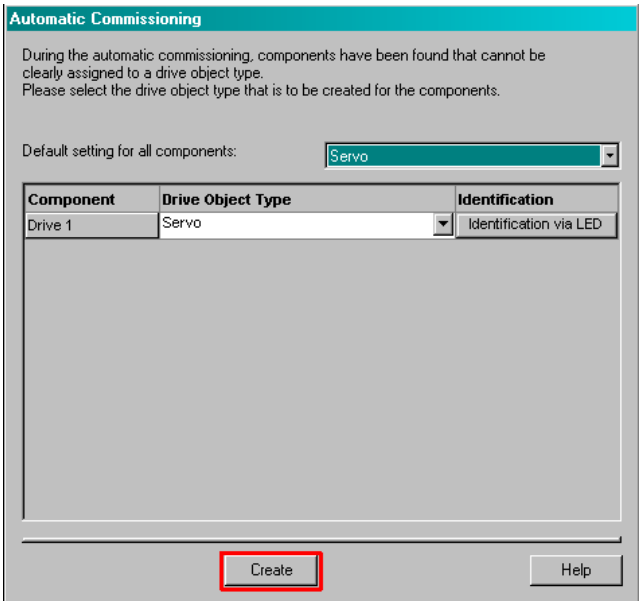
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No.	Action	Remark
7.	In the subsequent window, click on the "Properties" button.	
8.	Then select the menu item "Internet Protocol (TCP/IP)" – and press the "Properties" button.	

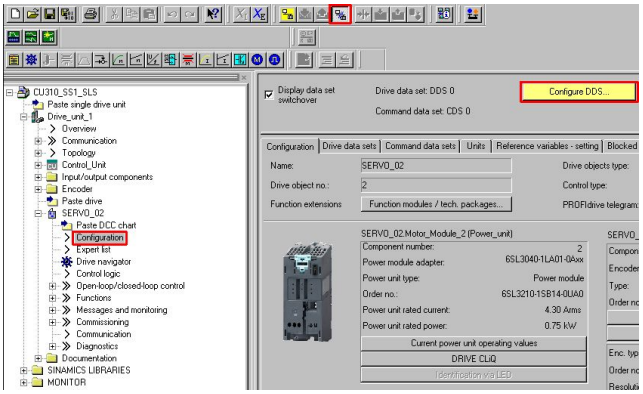
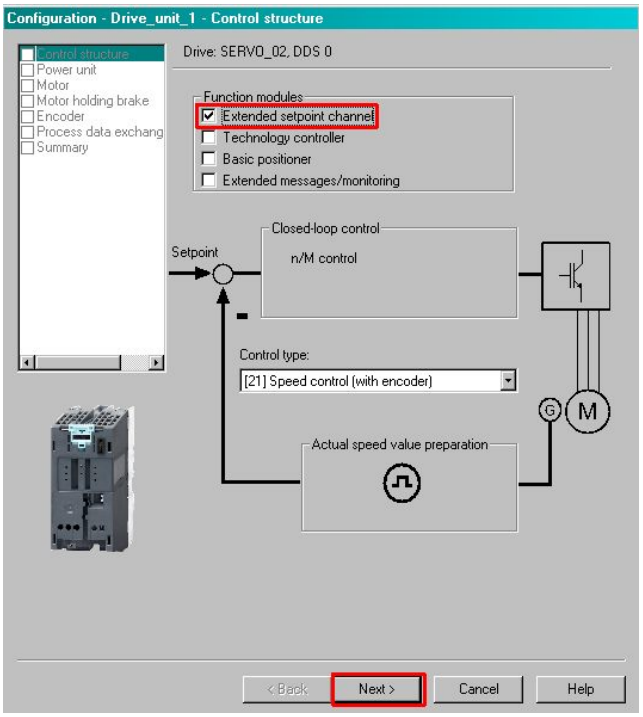
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No.	Action	Remark
9.	Enter the required IP address and the subnet mask here, for instance: • IP address: 169.254.11.100 • Subnet mask: 255.255.0.0 Click "OK" to confirm what has been entered.	
10.	A search is made for nodes/participants that can be reached in the next step; these are then added. To do this, press the "Connect to selected target devices" button and acknowledge the alarm with "Yes". A search is now made for accessible nodes.	
11.	A window is displayed with a list of all of the nodes that can be accessed. Only set the checkmark for CU310-2. The checkmark should be removed for all other nodes. Click "Accept" to confirm the selection. The node is then transferred into the project.	

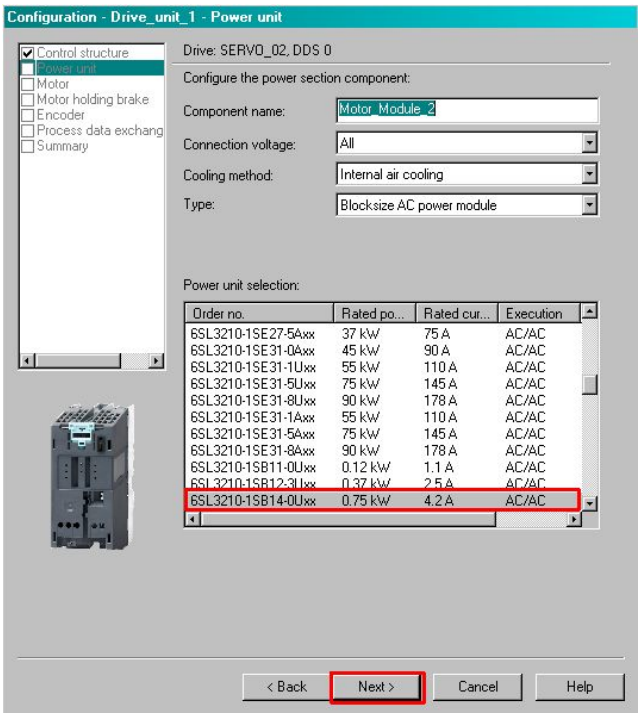
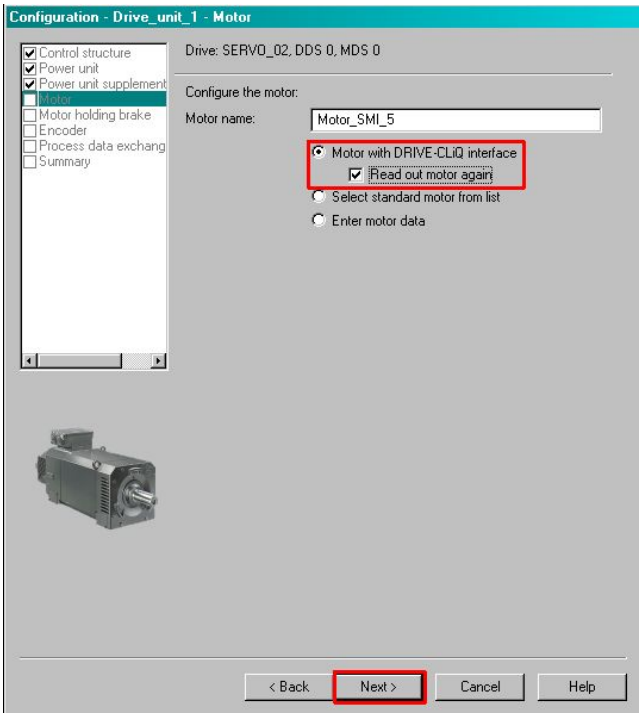
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No.	Action	Remark
12.	When you are connected online with the CU310-2, you have the option of automatically configuring the drive. To do this, press the "Automatic Configuration" button.	
13.	In the next window select the "Configure" option. The DRIVE-CLiQ nodes are then read out.	
14.	In the following window now select the "Servo" control mode for your drive. The selection is accepted by pressing the "Create" button.	

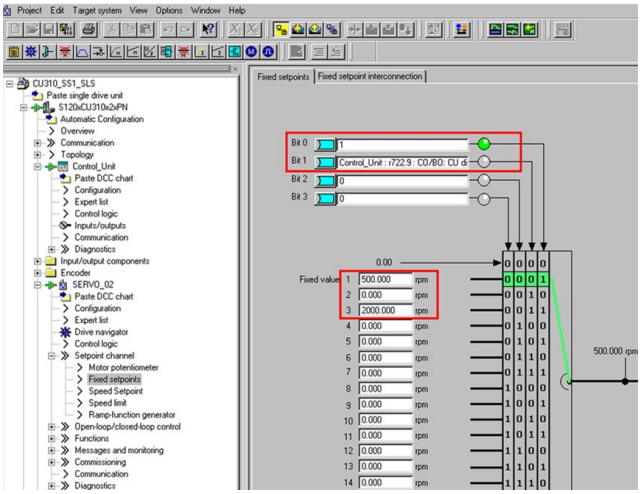
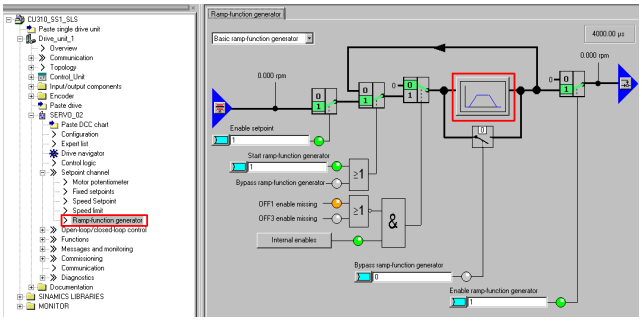
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No.	Action	Remark
15.	**Post configuring the drive** After completing the automatic configuration, go offline by pressing the "Disconnect from target device“ button. Use the "Configuration" button in the project navigator to post configure the drive. Then please click on "Configure DDS".	
16.	The extended setpoint channel is used to specify the speed of the drive. Therefore, enable the "Extended setpoint channel" function. Complete your entries by pressing "Next". **Note:** In the following, only those screen forms are described in which a change is required.	

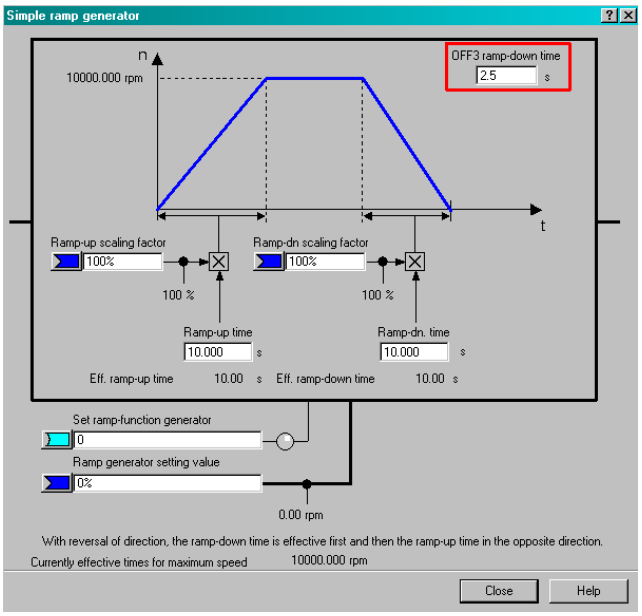
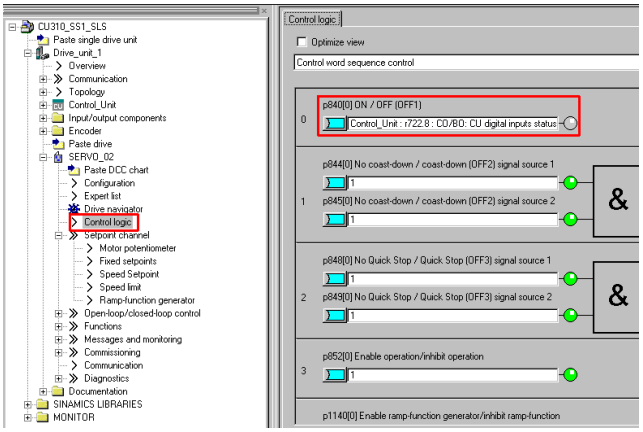
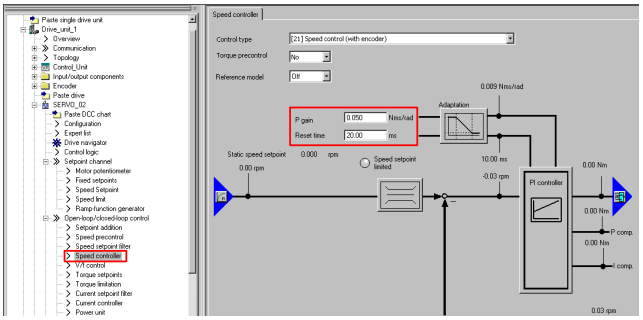
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No.	Action	Remark
17.	In a next step, select the PM340 "6SL3210-1SB14-0UA0" Power Module being used, and go to the next screen form by pressing "Next".	
18.	Since a motor with DRIVE-CLiQ interface is used, this should be read out. To do this, activate the "Read out motor again" checkbox. Press the "Next" button to acknowledge the entries that you have made. Continue with the post configuration until it has been completed.	

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No.	Action	Remark
19.	The required speed setpoint is specified in the following screen form. To do this, click on "Setpoint channel > Fixed setpoints". Binary logic (bit 0-3) can be implemented here which allows a switchover to various speed setpoints. The following interconnections have been made: Bit0: „1“ Bit1: Control Unit DI9 (r722.9) The following fixed values were entered: Fixed value 1: 500 rpm Fixed value 3: 2000 rpm With the configuration made it is possible to switch over the speed setpoint using switch -S4.	
20.	From the project navigator, open the screen form "Ramp-function generator" to set the OFF3 ramp-down time. Then click on the button with the red frame.	

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No.	Action	Remark
21.	The OFF3 ramp-down time is used for braking when SS1 is selected. Set parameter (p1135) to 2.5 seconds. In this example, this means that when SS1 is selected, a drive operating at maximum speed (p1082) comes to standstill in 2.5 seconds.	
22.	In order to switch the drive on with switch -S3, the appropriate digital input is interconnected to the ON/OFF1 enable. To do this, click "Control Logic" in the project navigator. Digital input DI 8 (r722.8) is then connected to parameter p840.	
23.	Now save your configuration, go online and perform a download.	
24.	The speed controller should be set as follows, as in the following the "Safely Limited Speed" (SLS) is parameterized. A speed controller that has been sent too weak can result in alarm C01714/C30714 "Safely Limited Speed exceeded"! To do this go to the screen form "Open-loop/closed-loop control > Speed controller“. The following values were set for the speed controller: P gain = 0.05 Nms/rad Reset time = 20ms	

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No.	Action	Remark
25.	The basic commissioning of the drive has been completed. Press the "Copy RAM to ROM" button to copy from RAM to ROM.	

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3.3 Parameterization of the safety functions

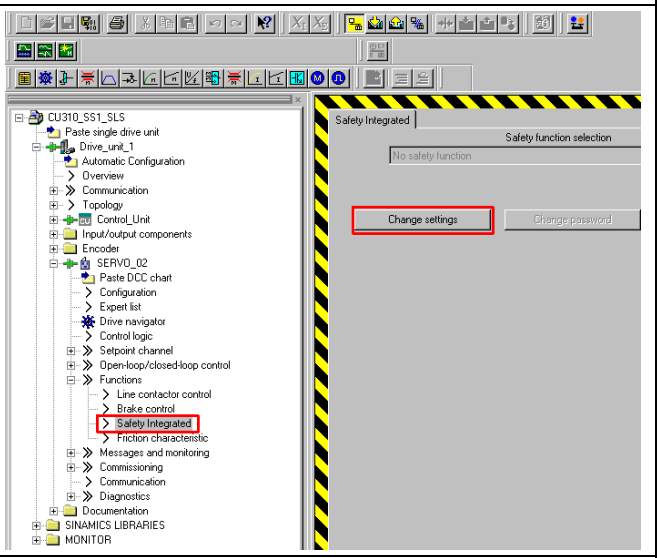
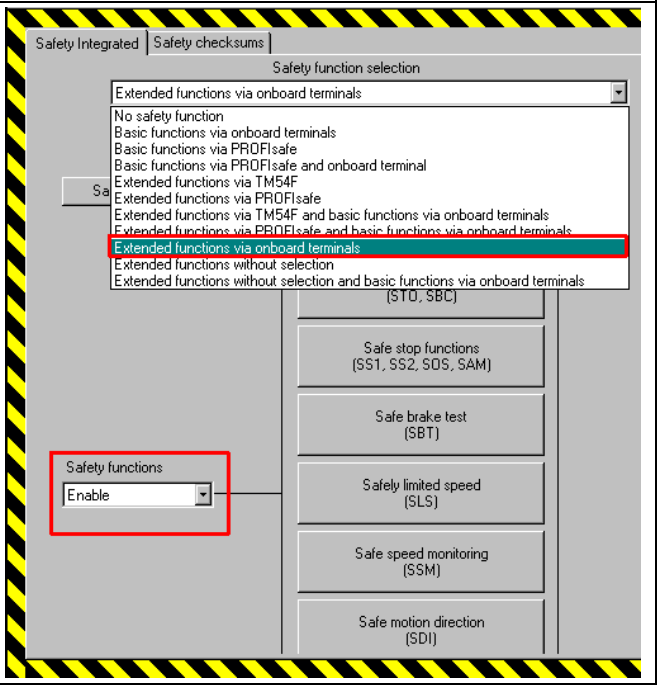
After completion of the basic commissioning, the SS1 and SLS safety functions are commissioned.

Note

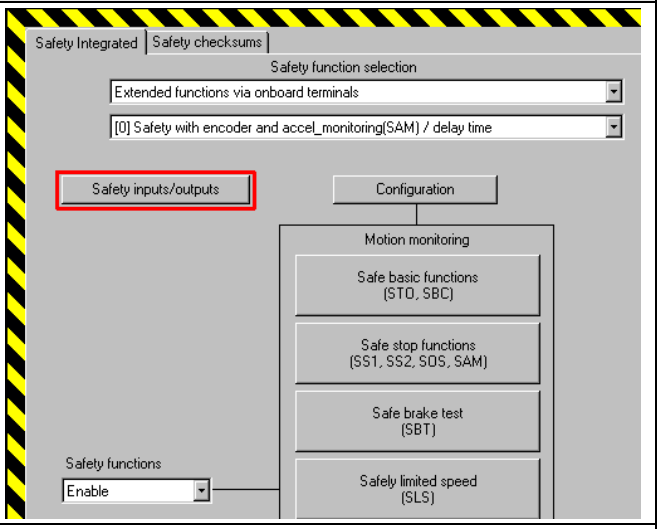
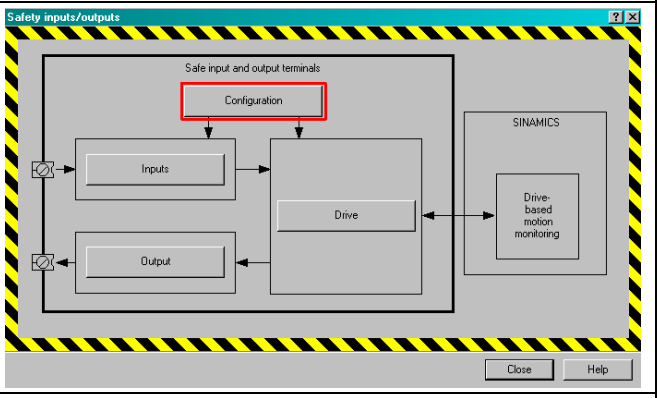
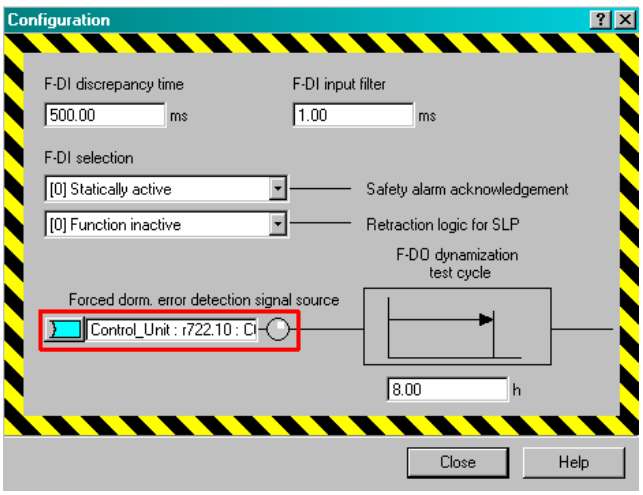
The safety functions in the drives can be configured offline as well as online.

Only those windows are described in which parameter changes are required.

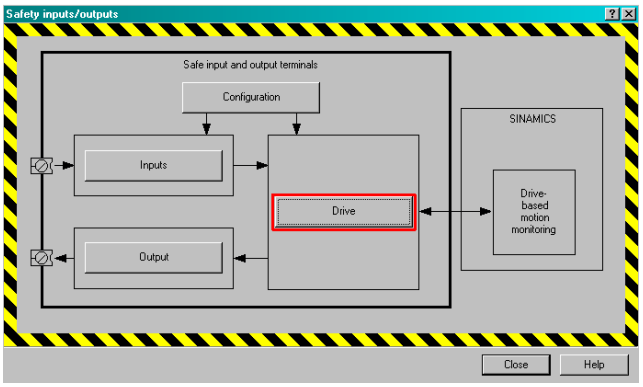
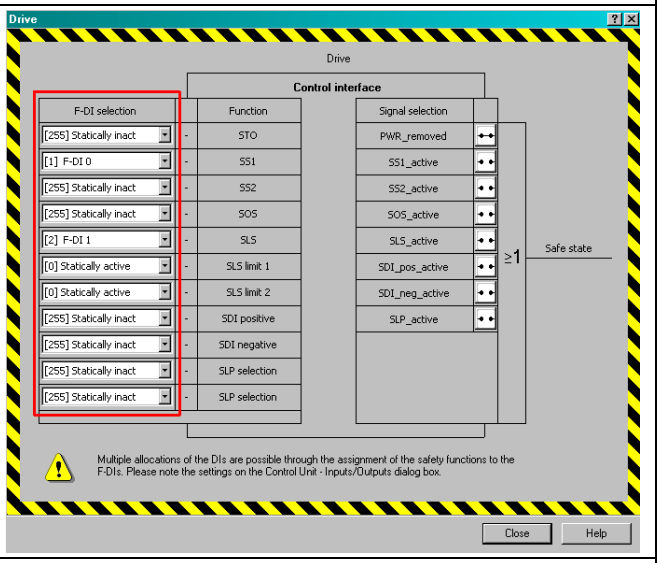
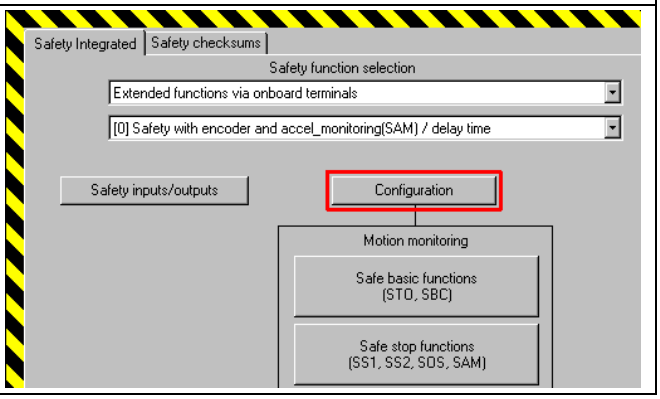
Table 3-2: Parameterizing the safety functions integrated in the drive

No.	Action	Remark
1.	In this example, the safety functions are configured online.	
2.	In the project navigator, select "Safety Integrated“, and activate safety commissioning by and pressing "Change Settings".	
3.	To control the extended safety functions via the fail-safe inputs of the Control Unit, now select the menu item "Extended functions via onboard terminals". Activate the Extended Functions by setting "Enable" for "Safety Functions".	

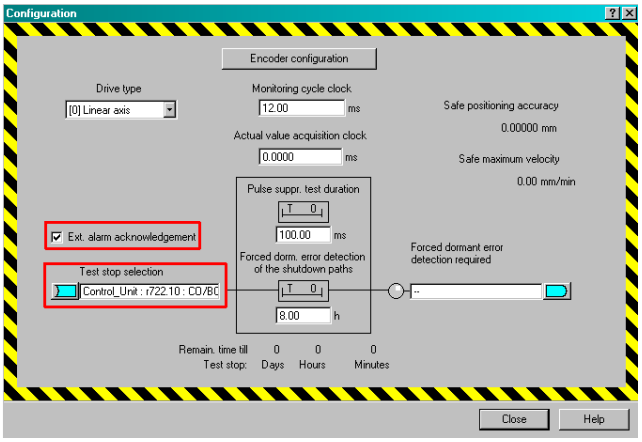
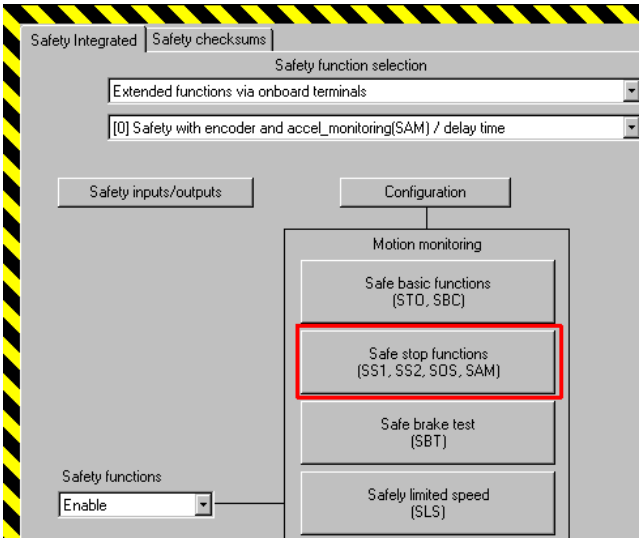
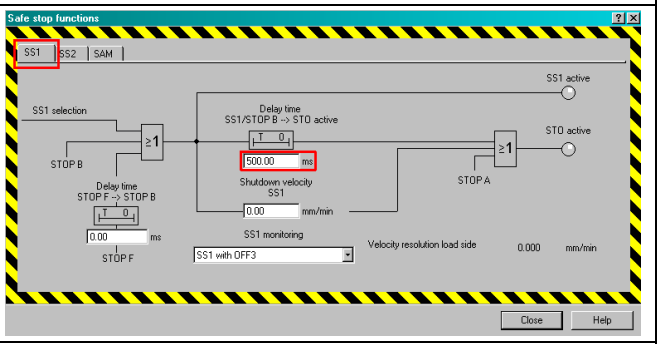
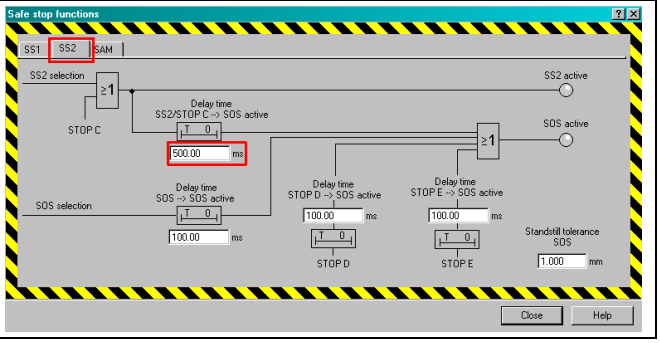
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No.	Action	Remark
4.	Once the safety functions have been activated, press the "Safety inputs/outputs" button.	
5.	The adjacent window opens. Click on the "Configuration" button here.	
6.	Here, interconnect switch -S5 (r722.10) as signal to initiate the forced checking procedure. Fail-safe acknowledgment via an F-DI is not possible in this application example.	

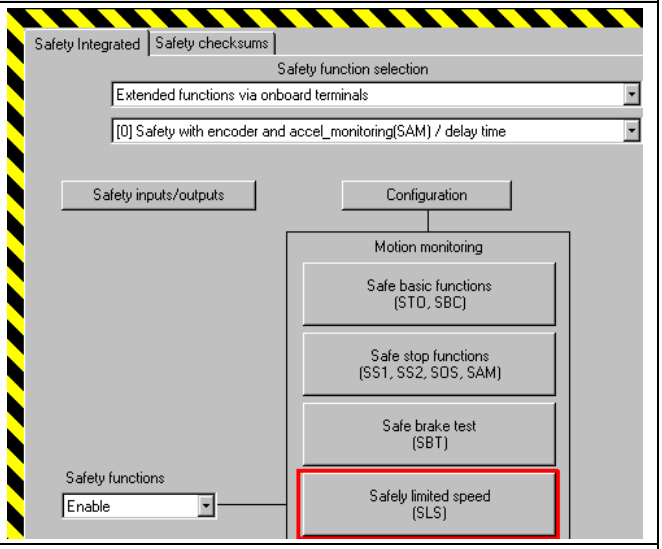
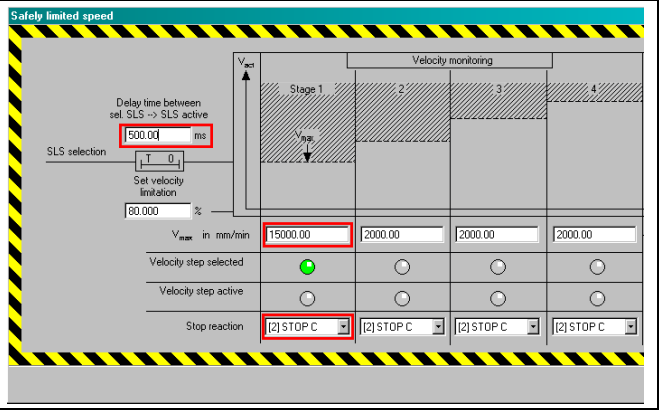
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No.	Action	Remark
7.	The screen form to assign the safety functions to the fail-safe inputs is opened using the "Drive" button.	
8.	Here, set the following values: - SS1 is interconnected with F-DI 0. - SLS is interconnected with F-DI 1. - SLS limits 1 and 2 are interconnected with a low signal ("Statically active"), so that speed level 1 is selected. All of the other safety functions are deselected using a high signal ("Statically inactive").	
9.	The safety functions still have to be configured after configuring the safety inputs/outputs. The following screen form is first opened by pressing the "Configuration" button.	

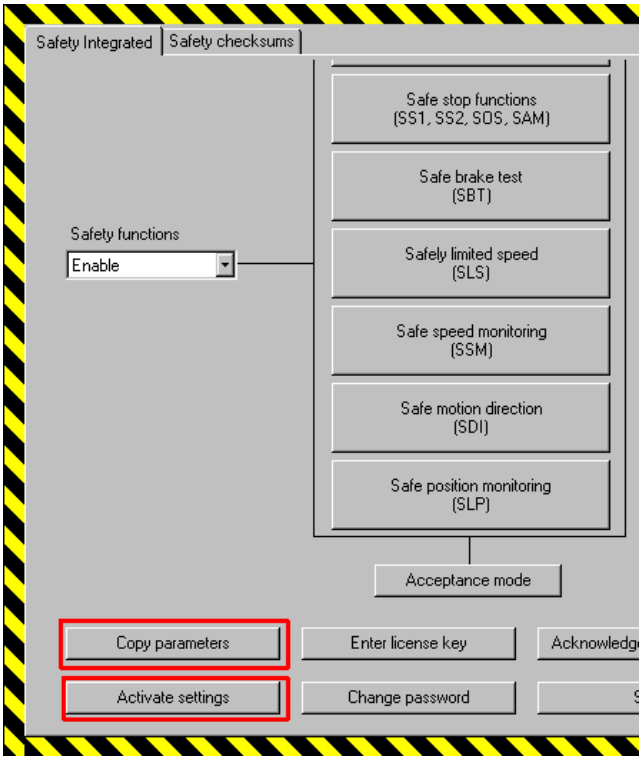
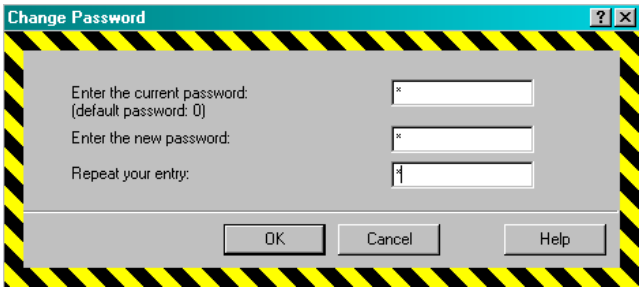
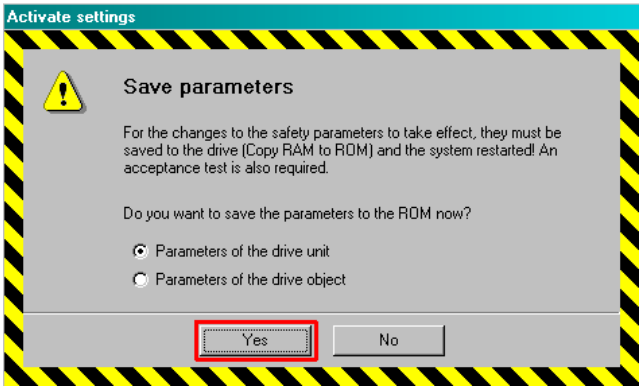
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No.	Action	Remark
10.	The extended alarm acknowledgment "Ext. alarm acknowledgement" should be selected here. Further, interconnect switch -S5 (r722.10) as signal source to select the test stop.	
11.	Please press the "Safe stop functions (SS1, SS2, SOS, SAM)" button to configure SS1 safety function.	
12.	The delay time "Delay time SS1/STOP B -> STO active" is set to 500ms in screen form SS1. This means that 500ms after selecting SS1, the subsequent state STO is initiated, independent of the drive speed.	
13.	In screen form SS2, please also change the value of the delay time "Delay time SS2/STOP C -> SOS active" to 500ms. Stop response SS2 is used when the SLS limit is exceeded.	

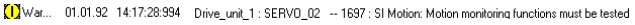
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No.	Action	Remark
14.	To be able to parameterize the SLS safety function, please press the "Safely limited speed (SLS)" button in the "Safety Integrated" screen form.	
15.	For SLS level 1, please set the value to 15000mm/min; in this example this corresponds to a speed of 1500 rpm. Now change the value of the delay time "Delay time between sel. SLS -> SLS active" to 500ms and then close the screen form by pressing "Close".	

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No.	Action	Remark
16.	The parameters must now be copied. To do this please press the "Copy parameters" button. Then click on the "Activate settings" button.	
17.	You are subsequently prompted to change the password. The default password is "0". Change the password to "1".	
18.	Data is copied from RAM to ROM when pressing the "Yes" button.	
19.	Then go offline.	
20.	Now please carry out a power on reset of the Control Unit.	POWER OFF/ON
21.	Now go online again.	

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No.	Action	Remark
22.	Load the configuration into the PG and please save it.	
23.	The adjacent message indicates that a test stop is required for the safety functions in the drive. This involves an alarm, i.e. the drives can be switched-on and operated. In this example, -S5 can be used to execute the test stop.	

3.4 Acceptance test

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To verify safety-relevant parameter assignments/configurations, when the machine is first commissioned, and also when safety-relevant parameters are changed, an acceptance test must be performed. The acceptance test must be appropriately documented. The acceptance reports must be appropriately stored and archived. This involves specifications laid down in the machinery directive.

The acceptance test must be carried out after parameterization has been completed and a power on reset.

You can find information about the acceptance test, the acceptance report and an example of a corresponding acceptance report in the "Function Manual SINAMICS S120 Safety Integrated" (FHS) /1/ in the Chapter Acceptance test and acceptance report.

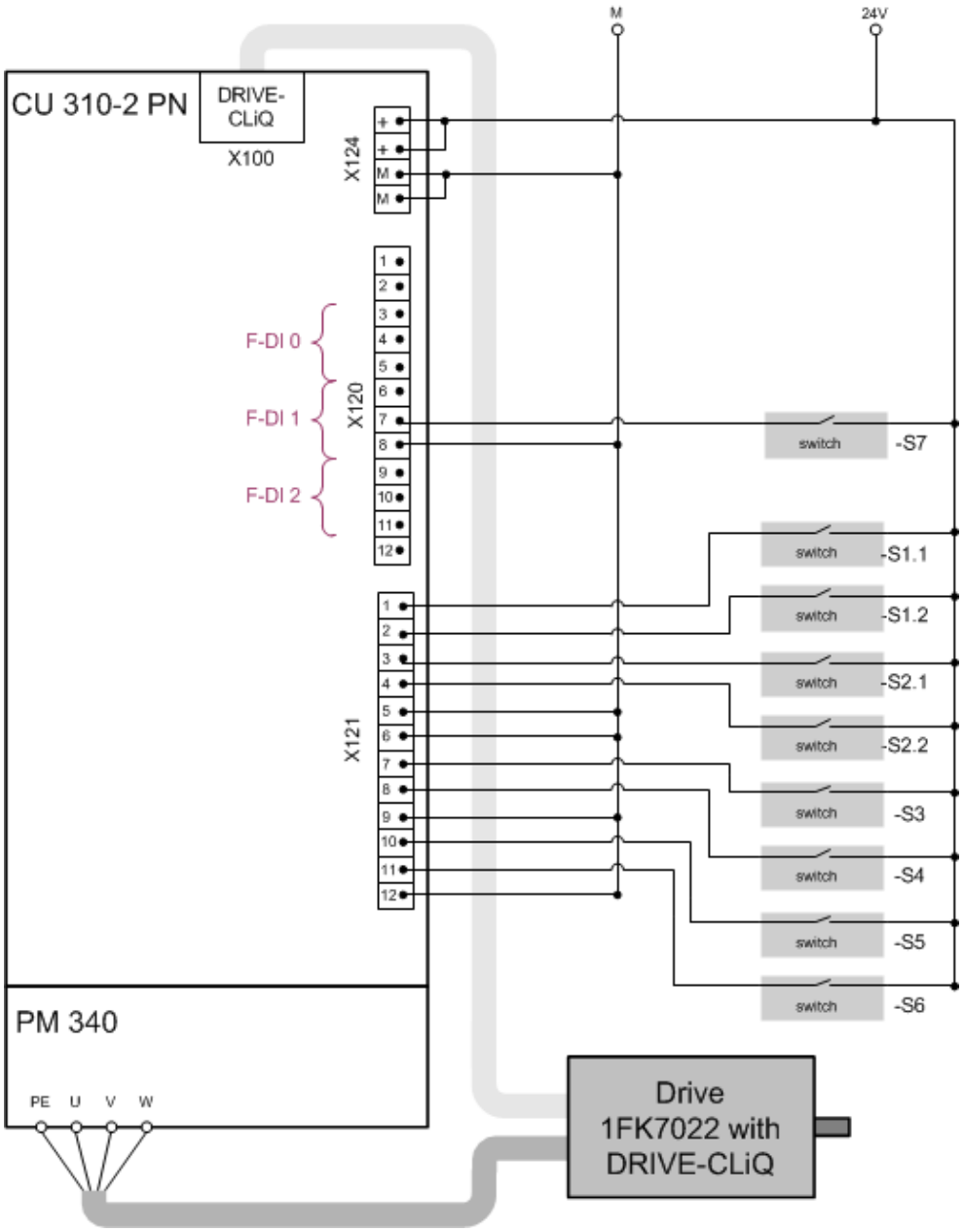
A script has been generated to simplify handling the acceptance test; this script is available at no charge in the PRODIS entry 52248627 (link only available in the SIEMENS Intranet) that can be downloaded by authorized personnel. This script conveniently guides the user step by step through the acceptance test.

4 Installation

Hardware installation

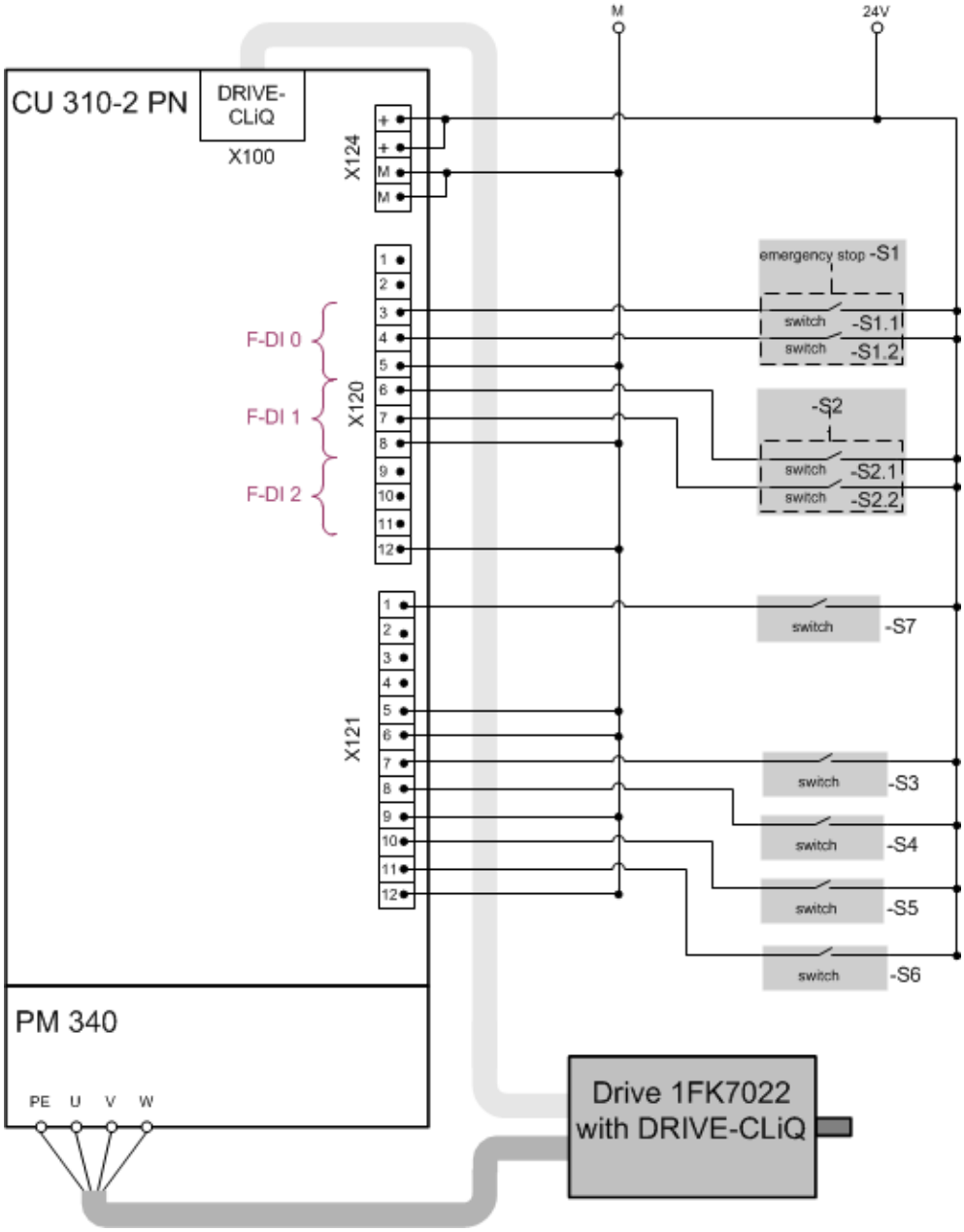
The following diagrams show the hardware configuration of the application.

Figure 4-1: Original wiring of the SINAMICS S120-CU310-2 PN training case



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Figure 4-2: Adapted wiring of the SINAMICS S120-CU310-2 PN training case



The fail-safe digital inputs are not used in the original wiring of the S120-CU310-2 PN training case. The original wiring can be taken from Fig. 4-1.
The wiring must be modified in order to be able to use the two safety functions (SS1 and SLS). The toggle switches (-S1.1 and -S1.2) are connected at the channels of the F-DI 0. An Emergency Stop switch -S1 is implemented using these two switches. Further, toggle switches (-S2.1 and -S2.2) are connected at the channels of the F-DI 1 in order to be able to implement switch -S2. Toggle switch -S7 was connected to input X121.0; however, in this application example it is not used. Now, only inputs X120.5 and X120.12 have to be connected to ground M. This means that two fail-safe inputs are available for the application example.

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5 Commissioning the application

Until now, the configuration of the application example has been described step-by-step. The following steps must be observed if the project example is to be loaded directly to the hardware.

5.1 Preconditions

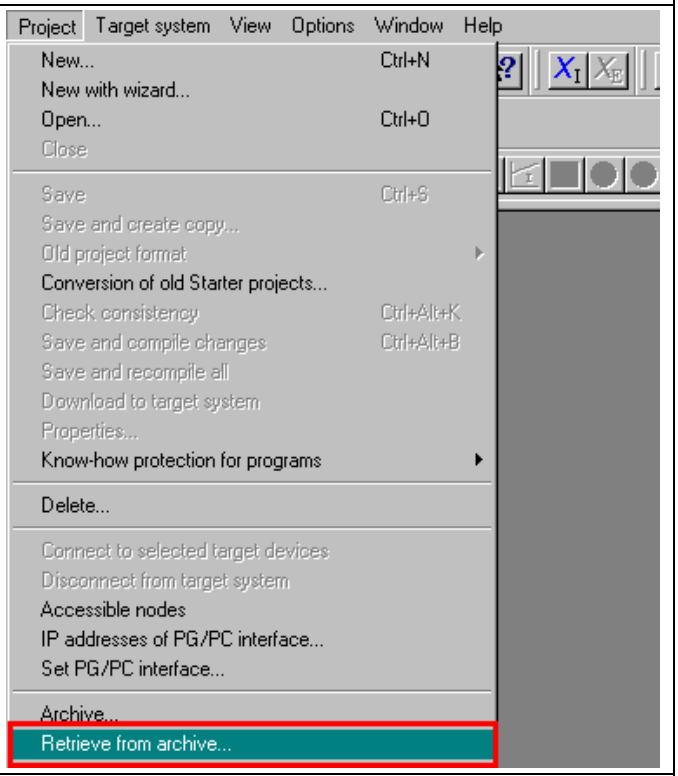
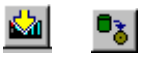
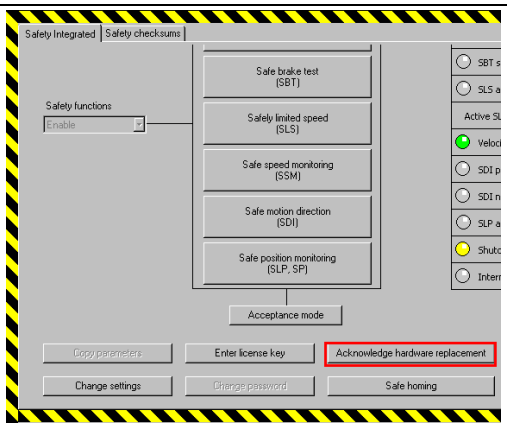
Preconditions for operation

- The motor is connected to the PM340 Power Module and the Drive-CLiQ cable of the encoder is inserted in the Drive-CLiQ port of the CU310-2.
- The wiring of the F-DIs of the training case is modified according to Chapter 4.
- The components are supplied with 24V DC.
- The infeed is connected to the line supply.

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5.2 Commissioning

Table 5-1: Commissioning the SINAMICS drive

No.	Action	Remark
1.	First start the Starter engineering system.	
2.	Dearchive and open the supplied project.	
3.	Now go online with STARTER.	
4.	Then reset the SINAMICS S120 to the factory settings.	
5.	Now perform a download and copy RAM to ROM.	
6.	When using the extended safety functions, the hardware replacement must be acknowledged after the download. To do this, please press the "Acknowledge hardware replacement" button.	

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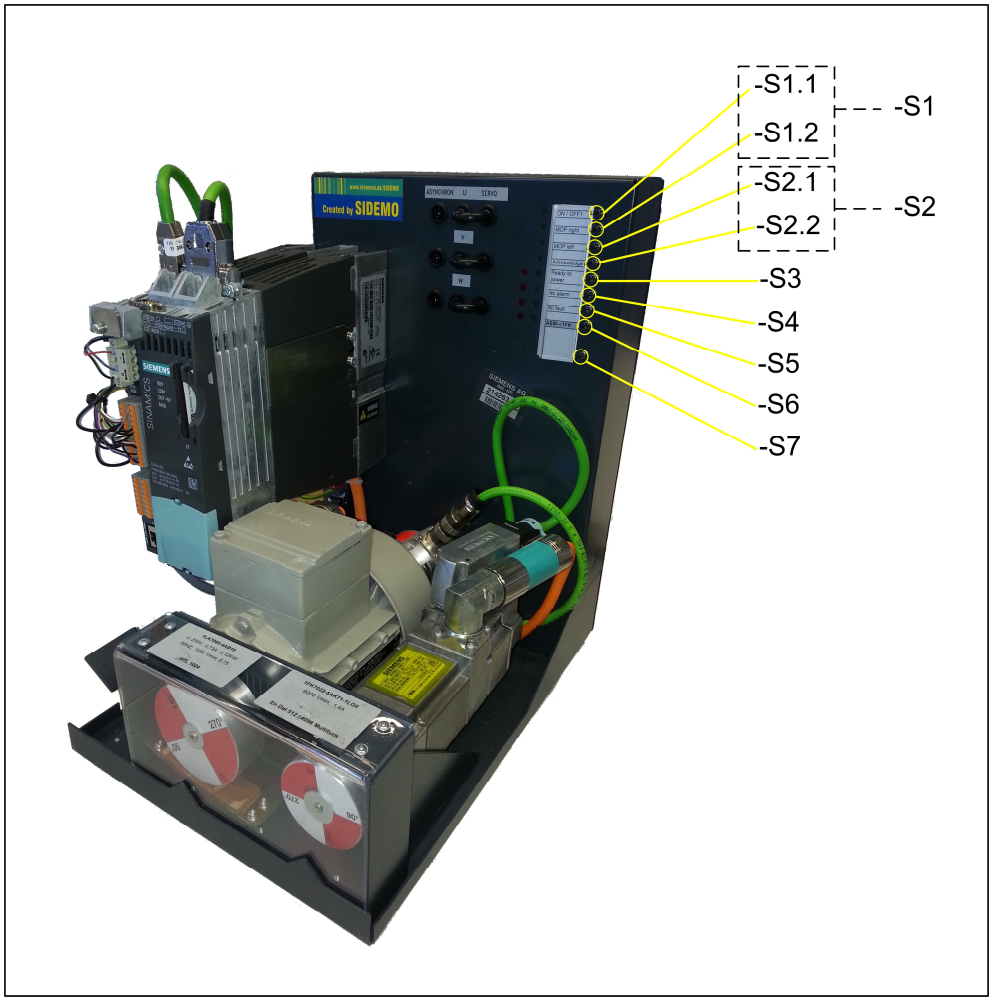
No.	Action	Remark
7.	Then copy from RAM to ROM. Then go offline.	
8.	Now carry out a power-on reset.	POWER OFF/ON
9.	To complete the installation, go back online, load the configuration into the PG and save it.	

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6 Operating the application

6.1 Overview

Fig. 6-1: Overview diagram showing how to operate the application



The SS1 safety function is controlled using switch -S1 (switch pair -S1.1 and -S1.2). The SLS safety function is selected and/or deselected using switch -S2 (switch pair -S2.1 and -S2.2). The drive is switched-on and/or switched-off using switch -S3. Switch -S4 is used to toggle between two speed setpoints. The test stop (also known as forced checking procedure) of the safety functions can be executed using -S5 as soon as the test stop alarm (A1697) is active.
In this particular application example, switches -S6 and -S7 are not used. The extended alarm acknowledgment is possible by selecting/deselecting switch -S1 as this can be used to select and deselect STO (or SS1).

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6.2 Description of function

Switching on/switching off

The drive is switched on (OFF1) using switch -S3 and a speed setpoint of 500 rpm entered.

Speed levels

The speed setpoint is increased to 2000 rpm by pressing switch -S4.

Emergency Stop

If, while the motor is rotating, switch -S1 is actuated (low signal), then safety function SS1 is activated. The drive is braked along the OFF3 ramp and STO is subsequently activated.

Protective door

Switch -S2 simulates a protective door. As long as switch -S2 is not actuated (high-level), the protective door is closed. In this particular case, the drive can be operated at any speed. If switch -S2 is actuated (low signal), then this corresponds to the protective door being opened. Safety function SLS is selected. After a configurable time has elapsed, the speed is safely monitored against a limit value (in this case, 1500 rpm). For an active SLS level, the corresponding stop response STOP C is initiated when this limit value is exceeded. This means that the drive is braked along the OFF3 ramp, and after a configurable delay time has elapsed, standstill (zero speed) is monitored using the SOS safety function. In this particular case, the drive remains in the closed-loop controlled mode. Safety messages C01714 and C30714 are output.

Fail-safe acknowledgment

In this particular example, fail-safe acknowledgment is possible using the extended alarm acknowledgment. With the extended alarm acknowledgement, all safety alarms are acknowledged when STO (or SS1) is deselected. In this particular example, this is possible using switch -S1.

Test stop

A test stop can be carried out using button -S5.

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6.3 Summary of input signals

Table 6-1: SINAMICS digital inputs

Digital input	Switch	Description
DI 8	-S3	Switch on/switch off drive (ON/OFF1) with speed setpoint = 500rpm
DI 9	-S4	Switching over the speed setpoints
DI 10	-S5	Test stop selection

Table 6-2: Fail-safe SINAMICS inputs

Digital input	Switch	Component	Description
F-DI 0	-S1 (-S1.1 and -S1.2)	Emergency Stop button	SS1
F-DI 0	-S1 (-S1.1 and -S1.2)	-	Fail-safe acknowledgment
F-DI 1	-S2 (-S2.1 and -S2.2)	Protective door	SLS

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7 References

7.1 Related documents

This list does not claim to be complete and only provides a selection of suitable references.

Table 7-1: Related documents

	Topic	Title
/1/	SINAMICS S120 Safety Integrated	SINAMICS S120 Safety Integrated Function Manual Edition 01/2013 MLFB: 6SL3097-4AR00-0AP4
/2/	SINAMICS S120 Manual	SINAMICS S120 AC Drive Manual 01/2013 Edition MLFB: 6SL3097-4AL00-0AP3
/3/	SINAMICS S120 List Manual	SINAMICS S120/S150 List Manual Edition 01/2013 MLFB: 6SL3097-4AP00-0AP4
/4/	SINAMICS S120 Function Manual	SINAMICS S120 Function Manual 01/2013 Edition MLFB: 6SF3097-4AB00-0AP3

7.2 Internet links

This list does not claim to be complete and only provides a selection of suitable information.

Table 7-2: Internet links

	Topic	Title
\1\	Reference to the article	http://support.automation.siemens.com/WW/view/en/79722926
\2\	Siemens Industry Online Support	http://support.automation.siemens.com

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8 Contact persons

Siemens AG

Industry Sector
I DT MC PMA APC
Frauenauracher Strasse 80
D - 91056 Erlangen, Germany
E-mail: safety.team.motioncontrol.i-dt@siemens.com

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9 History

Table 9-1: History

Version	Date	Revision
V1.0	02/2014	First Edition

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