Controlling the CU320-2 via PROFIsafe with PROFIBUS

SINAMICS S120

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SINAMICS S120
Safety Integrated

Controlling the CU320-2 via PROFIsafe with PROFIBUS

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1 Automation task

Introduction

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

Table 1-1: Overview of the safety functions of the SINAMICS S120
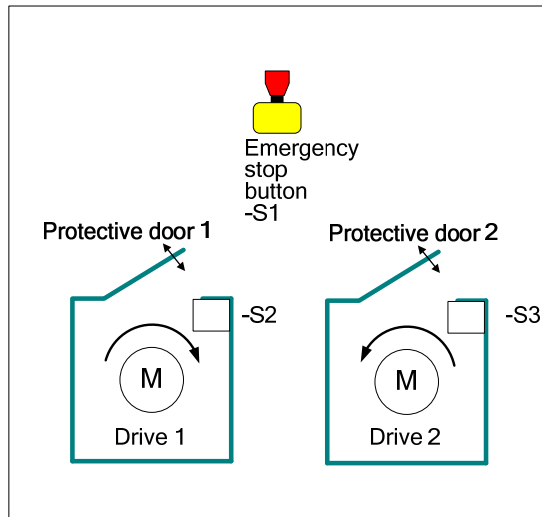
Name	Function	Description
STO	Safe Torque Off	Safe disconnection of the torque-generating energy feed to the motor. The switching on inhibited function prevents the drive from restarting. (stop function, Category 0 according to EN 60204-1)
SBC	Safe Brake Control	SBC is only used when there is a motor brake; the motor brake is connected to the power connector through the outputs. SBC always responds in conjunction with STO or when internal safety monitoring functions respond with safe pulse suppression.
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. (stop function, Category 1 according to EN 60204-1)
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. (stop function, Category 2 according to EN 60204-1) Not available for encoderless drives.
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 encoderless drives.
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 ($n < n_x$).
SDI	Safe Direction	Safe monitoring of the direction of motion (positive and negative directions). Parameterizable shutdown response when traversing in the direction that has not been enabled.

These extended safety functions can be controlled via PROFIsafe with PROFIBUS or PROFINET, as well as via a TM54F terminal expansion module.

In the current example, a SIMATIC F-CPU uses the PROFIsafe telegram with PROFIBUS to control the safety functions.

Overview of the automation task

Fig. 12: 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	Reaction
SF1	Actuation of the Emergency Stop button	Fast stopping of drive 1 and drive 2 → after pulse suppression (SS1).
SF2	When protective door 1 is open, drive 1 must not exceed a velocity/speed configured by the user.	Speed monitoring at drive 1 (SLS).
SF3	When protective door 2 is open, drive 2 must not exceed a velocity/speed configured by the user.	Speed monitoring at drive 2 (SLS).

The extended safety functions integrated in the SINAMICS S120 drives are to be controlled via PROFIsafe with PROFIBUS.

2 Automation solution

2.1 Overview of the overall solution

Schematic

The diagram below is a schematic representation of the most important components for the solution:

Fig. 2-1: Relevant components of the safety functions
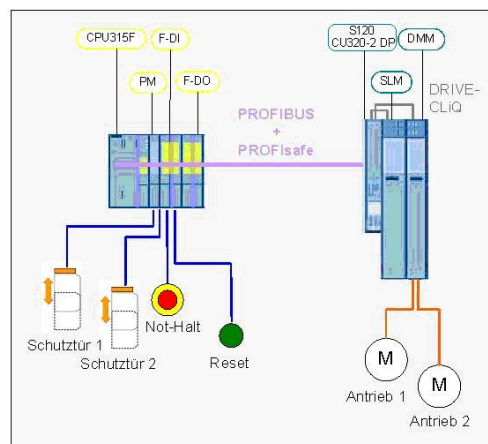
This function example shows how the SS1 and SLS safety functions are controlled via PROFIsafe with PROFIBUS at a SINAMICS S120 drive line-up.

The drive line-up in the booksize format comprises an infeed and a Double Motor Module. A Control Unit CU320-2 DP controls the motor. The extended setpoint channel is used to enter the speed setpoint. The two servomotors, which are independent of one another, are controlled from the Double Motor Module. A Smart Line Module is used as infeed.

The safety-relevant signals are sensed using fail-safe inputs of the ET200M and logically processed in the F-CPU. From the fail-safe data, the F-CPU generates a PROFIsafe telegram for each drive. These are transferred to the drives via PROFIBUS where they control the safety functions.

Design

This function example is based on the SINAMICS S120 training case (6ZB2 480-0BA00) and the SAFETY training case.

Demarcation

This application does not include a description

- of the safety functions of the SINAMICS S120,

- the general drive functions of the SINAMICS S120 and

- the hardware interfaces of the CU320-2.

Basic knowledge about these topics is required.

Information on these topics can be taken from the documents from the references.

Knowledge required

Basic knowledge about the configuration of SINAMICS S120 drives with the STARTER or SIMOTION SCOUT engineering software and STEP 7 are assumed.

2.2 Description of the core functions

Overview and description of the core functions

Fig. 2-2: Safety + SINAMICS S120 training case
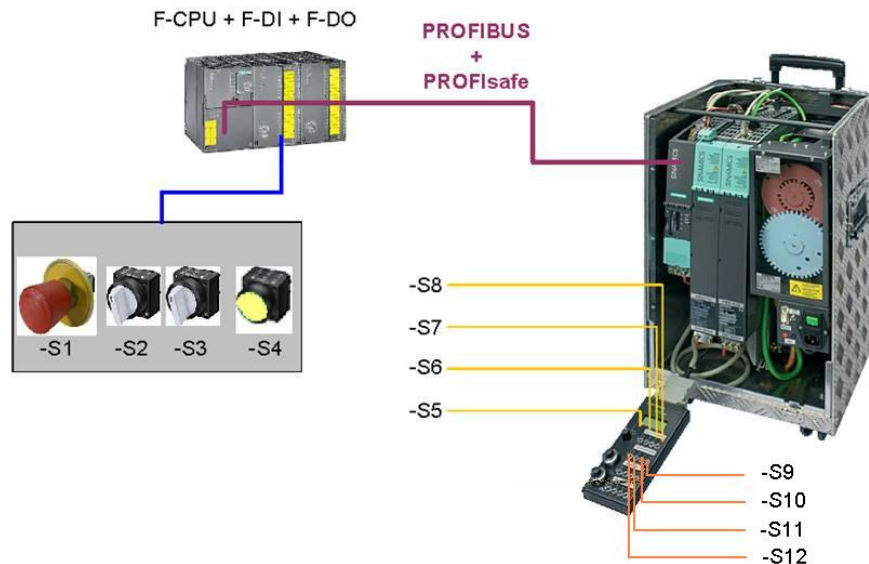
Switches -S1 to -S4 are located on a switchbox that belongs to the Safety training case. The various safety functions are selected using these switches. Switches -S5 to -S12 are located on a switchbox that belongs to the SINAMICS training case. Using these switches, the drive is switched on and switched off, different speed setpoints entered, the test function for the safety functions initiated and faults acknowledged.

When Emergency Stop (-S1) is actuated, both drives are stopped by the safety function SS1 integrated in the drive.

Each drive is assigned a protective door. If the respective protective door is opened, the speed is safely monitored against the speed/velocity limit value that has been set (SLS). The other drive is not influenced. STOP C (SS2 → SOS) at the respective drive is initiated as error response of SLS when the safety speed/velocity is exceeded.

Other versions to control the safety functions integrated in the drive using the TM54F terminal expansion module as well as control via PROFIsafe with PROFINET, are described in additional functional examples.

Advantages of this solution

The solution presented here offers you the following advantages

- Simple control of the safety functions integrated in the drive

- Simple design using standardized technology

- The existing system can be quickly and simply expanded.

- Space-saving and low-cost design using integrated safety functions – additional hardware is not required

- Complex safety concepts can be implemented on this basis.

2.3   Hardware and software components that are used

The application was created with the following components:

Hardware components

Table 2-3: SAFETY training case (essential components)

Component	Type	Order no./Ordering data	Qty	Manufacturer
SITOP power supply	SITOP SMART 120W	6EP1 333-2AA01	1	Siemens
SIMATIC S7-300 CPU	CPU 315F-2 PN/DP	6ES7 315-2FH13-0AB0	1	Siemens
	SIMATIC Micro Memory Card, 512KB	6ES7 953-8LJ20-0AA0	1	Siemens
SIMATIC S7 fail-safe input module	SM 326 F-DI 24	6ES7 326-1BK01-0AB0	1	Siemens
SIMATIC S7 fail-safe output module	SM 326 F-DO 8	6ES7 326-1BF40-0AB0	1	Siemens
SINAMICS fail-safe Terminal Module	TM54F	6SL3055-0AA00-3BA0	1	Siemens
Drive-CLiQ	Cable, gray, metal connector	6FX2002-1DC00-1AC0	1	Siemens
Protective door simulation switches S2 and S3	Toggle switch 0-I, latching, 16 mm, black	3SB2000-2AB01	2	Siemens
	Holder with solder pins	3SB2908-0AB	2	Siemens
Emergency stop command device S1	Mushroom pushbutton, red, 16 mm	3SB2000-1AC01	1	Siemens
	Holder with solder pins	3SB2908-0AB	1	Siemens
Reset button S4	Pushbutton, flat button, 16 mm, white	3SB2000-0AG01	1	Siemens
	Holder with lamp holder, lamp and solder pins	3SB2455-1B	1	Siemens
Load resistors R1 .. R8	1 kOhm 1 W	Type PO595-0 Style 0207 Power metal oxide film resistors	1	Yageo Europe
Terminals for load resistors (R1..R8)	ST 2.5-QUATTRO-TG	3038451	8	Phoenix Contact
	P-CO component connector	3036796	8	Phoenix Contact

2.3 Hardware and software components that are used

Component	Type	Order no./Ordering data	Qty	Manufacturer
Load resistor R9	SMA0207 1K2 1% TK	WID_MET_SHT_1K2_+-1%_600mW_+50ppm_0207	1	Beyschlag
Terminals for load resistor (R9)	TERMINALS_ACCESSORY_EMPTY CONNECTOR_TYPE1_GRAY	280-801	1	WAGO
	TERMINAL_4-CONDUCTOR_GRAY	280-686	1	WAGO

Table 2-4: SINAMICS training case

Component	Type	Order no./Ordering data	Qty	Manufacturer
SINAMICS training case	S120 CU320	6ZB2 480-0BA00	1	SIEMENS

Table 2-5: Additional components

Component	Type	Order no./Ordering data	Qty	Manufacturer
Control Unit	CU320-2DP	6SL3040-1MA00-0AA0	1	SIEMENS

Note	The application example was tested with the hardware components listed here. Alternatively, other components with the same function may be used. In such a case, a different parameter assignment and different wiring of the components may be required. The components shown in yellow are not relevant for this function example.

Standard software components

Table 2-6: Engineering software

Component	Type	Order no./Ordering data	Qty	Manufacturer
STEP 7	V5.5	6ES7810-4CC10-0YA5	1	Siemens
S7 Distributed Safety Programming	V5.4 SP5	6ES7833-1FC02-0YA5	1	Siemens
S7 F ConfigurationPack	V5.5 SP7	6SL3072-0AA00-0AG0	1	Siemens
STARTER	V4.2.0.0	6AU1810-1BA41-2XA0	1	Siemens
Drive ES Basic	V5.5	6SW1700-5JA00-5AA0	1	Siemens

Table 2-7: Runtime software used

Component	Type	Order no./Ordering data	Qty	Manufacturer
Sinamics	V4.4		1	Siemens
CPU	V2.6		1	Siemens

Note	The SIMOTION SCOUT can be used as an alternative to the STARTER & DRIVE ES Basic software.

Licenses

Table 2-8: Licenses

License	MLFB/order number	Note
SINAMICS LICENSE SAFETY INTEGRATED EXTENDED FUNCTIONS	6SL3074-0AA10-0AA0	per axis

File and project examples

Table 2-9: State of the application example when supplied

Component	Note
MC_FE_I_006_V20.zip	Zipped project
29056318_MC_FE_I_006_V20.pdf	This document

3 PROFIsafe communication

Each drive with configured PROFIsafe slot in the drive unit, represents an F device or F slave with fail-safe communication to the F host via PROFIBUS.

A separate PROFIsafe telegram (PROFIsafe slot) is created for each drive. This telegram is 6 bytes long for each drive. The first two bytes contain the Safety user data.

F-CPU → drive

Fig. 3-1: The following control signals are sent from the F-CPU to the drive.

PROFIdrive Safety Block 1 (F Process Data)															
Byte 0								Byte 1							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
STO	SS1	SS2	SOS	SLS	Res.	Res.	Int. Ev. ACK	Res.	SLS Limit sel.	SLS Limit sel.	Res.	SDI pos.	SDI neg.	Res.	Res.

Drive → F-CPU

Fig. 3-2: The drive returns the status of the safety functions to the F-CPU.

PROFIdrive Safety Block 1 (F Process Data)															
Byte 0								Byte 1							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Power rem.	SS1 act.	SS2 act.	SOS act.	SLS act.	Res.	Res.	Int. Ev.	Res.	SLS Limit	SLS Limit	SOS selected	SDI pos. act.	SDI neg. act.	Res.	SSM

Note	Safety functions that are integrated in the drive, but not used must be deselected using a high signal.

4 Installation

Installing the hardware

The following diagrams show the hardware structure of the application.

Fig. 4-1: Overview of the hardware structure
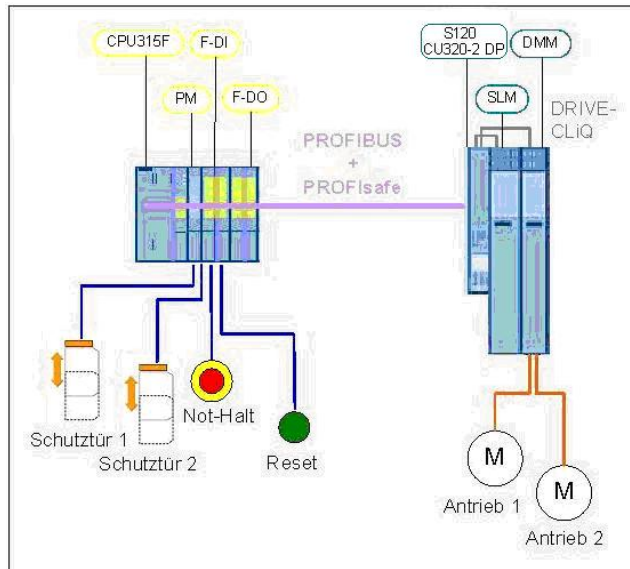
Fig. 4-2: DRIVE-CLiQ interconnection of the SINAMICS components
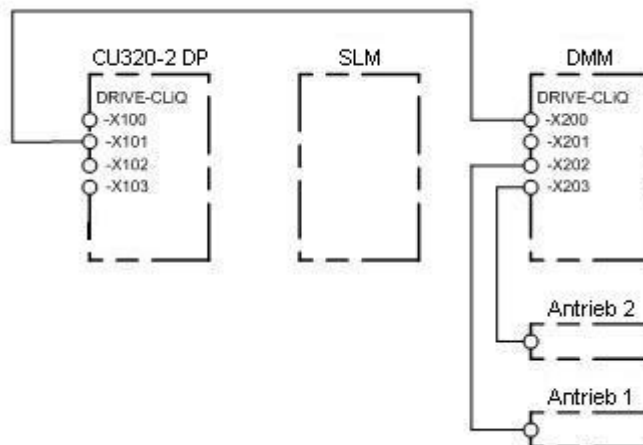
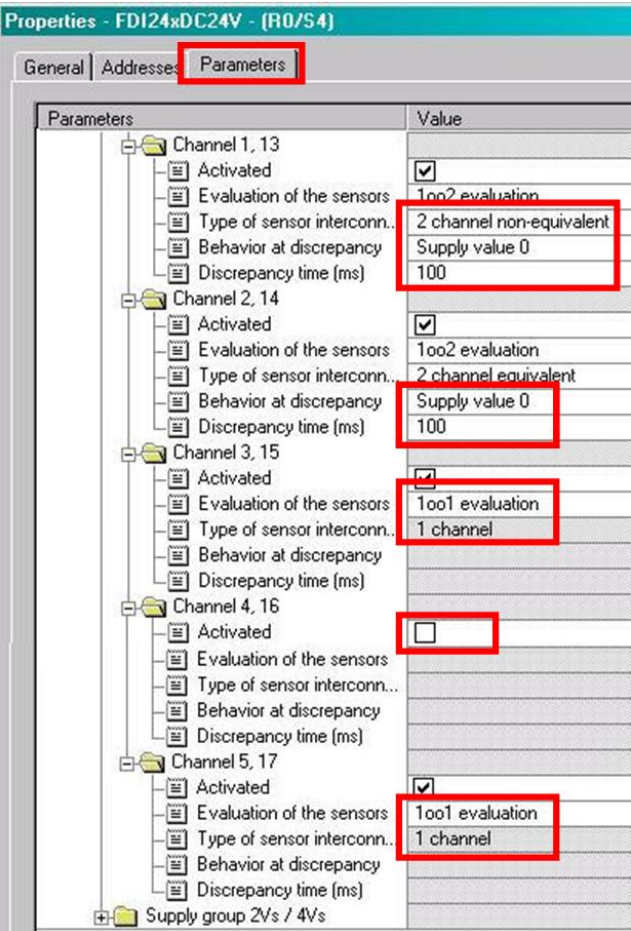Fig. 4-3: Wiring of the control voltage at the Safety training case
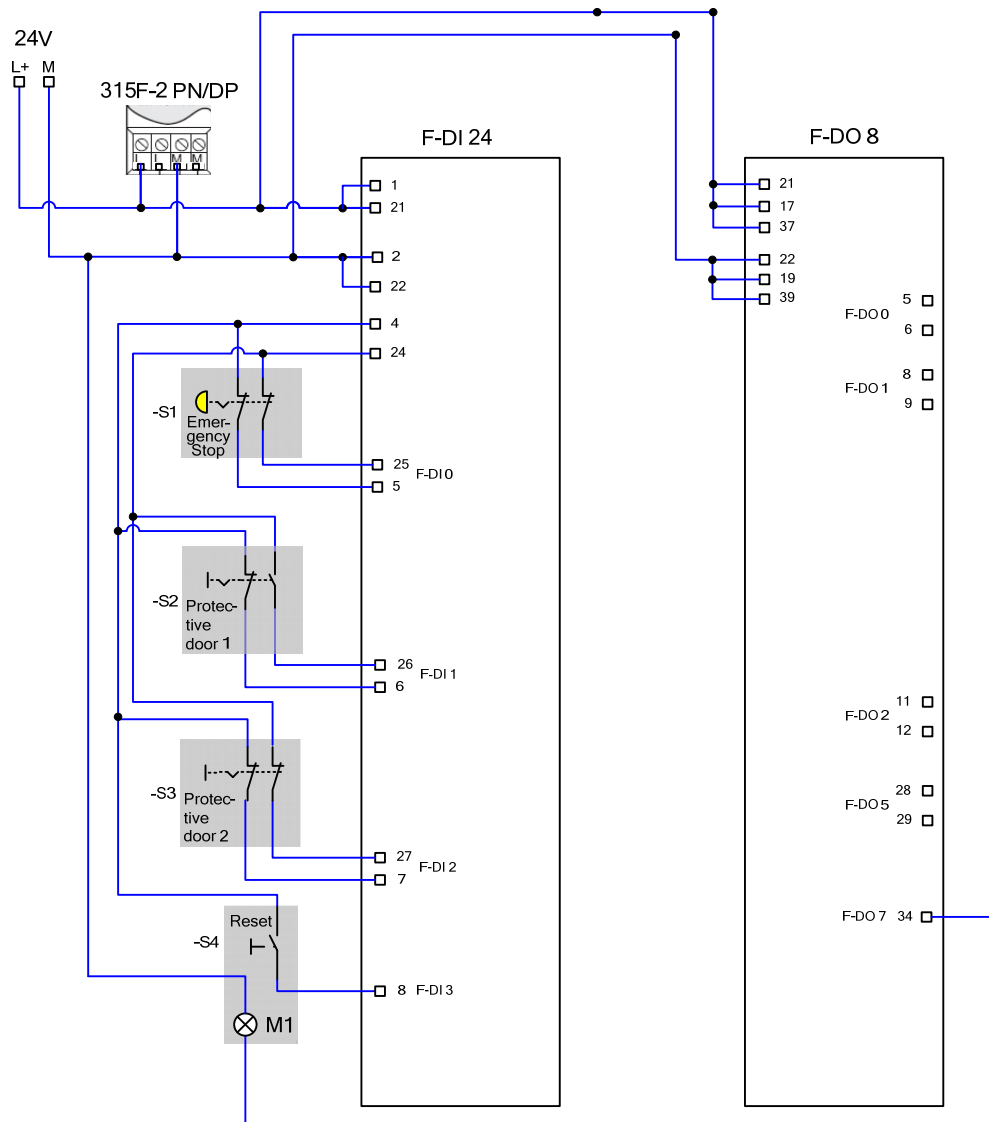
5 Configuration and project engineering

In this chapter, you get to know how the individual components must be parameterized. STARTER and DRIVE ES Basic are used as the engineering software for the SINAMICS S120. STEP7 and Distributed Safety is a prerequisite for programming the F-CPU.

How the software project belonging to this function example was created is described step-by-step in the following.

Note	Most of the screenshots were created with the "English" language setting. There might be some minor differences for other languages.

5.1 Passwords

For reasons of simplicity, a common safety password is used for the program and hardware on the SIMATIC components in the project. Also when configuring the Safety functionality of the SINAMICS components, one common password is used for the drives.
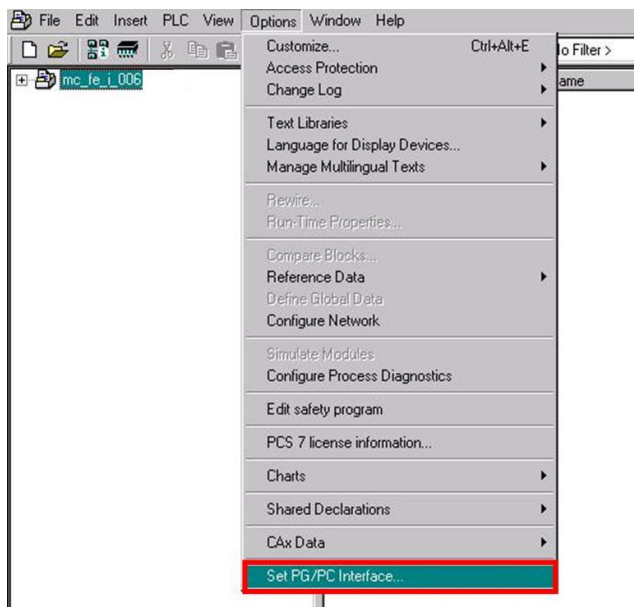
- Safety password for F-CPU: "0"

- Safety password for SINAMICS: "1"
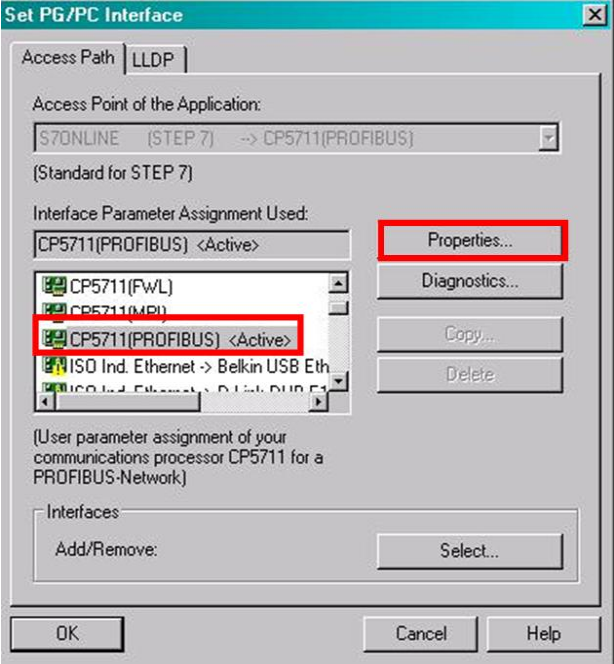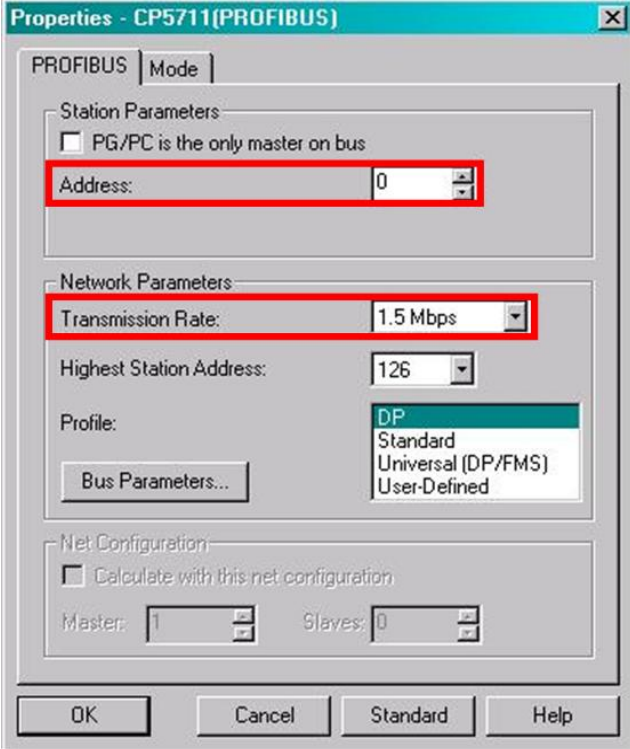
These passwords should not be used in real applications!

5.2   Preparation

The PROFIBUS interfaces of the F-CPU and SINAMICS S120 are used in this application example for programming, for the exchange of fail-safe signals (PROFIsafe data) and for entering control word 1 (PROFIdrive data) with the exception of bit 0 (on/off1 enable).
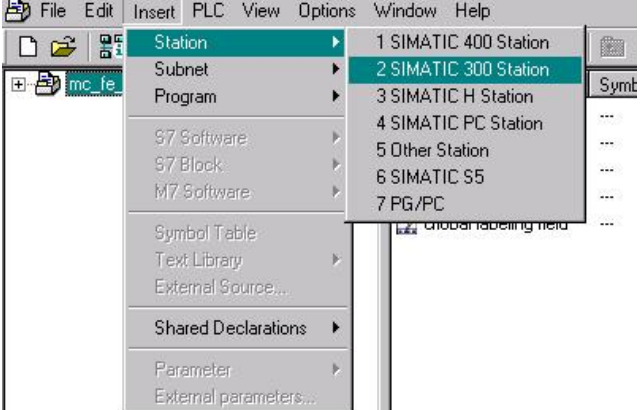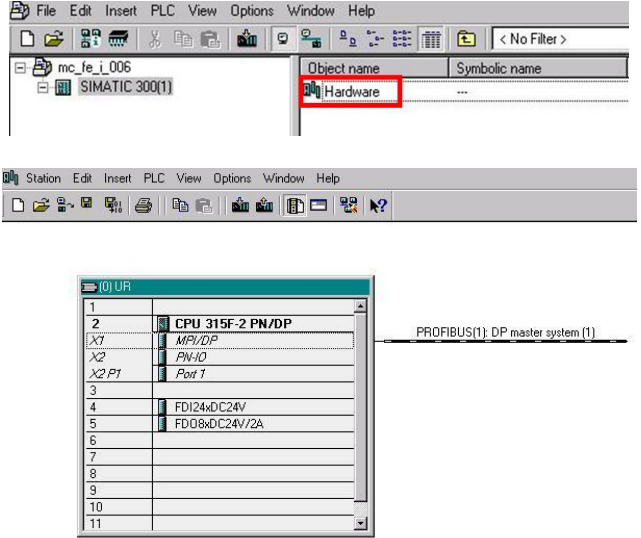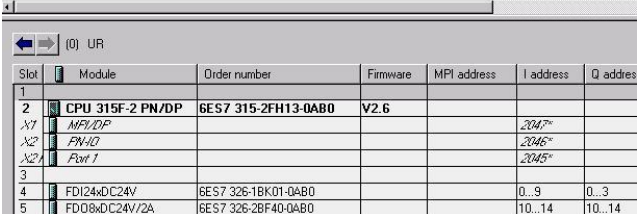
Table 5-1: Setting the interfaces and assigning the PROFIBUS address
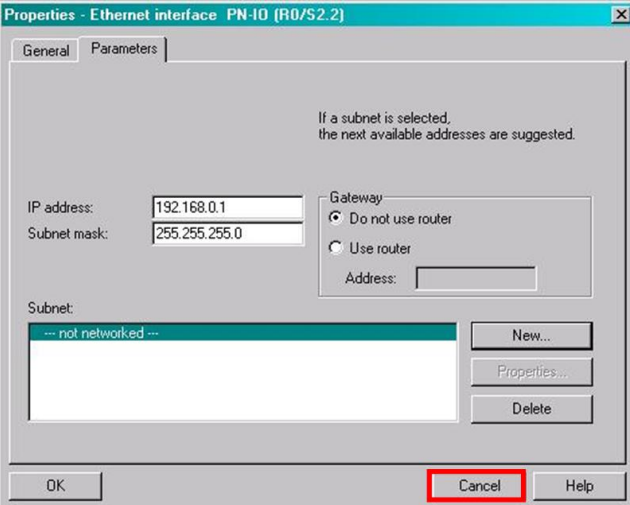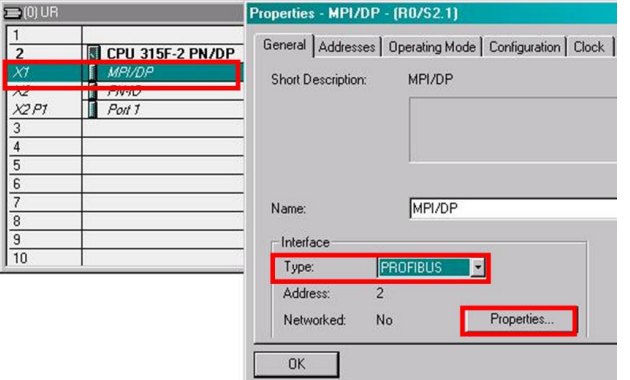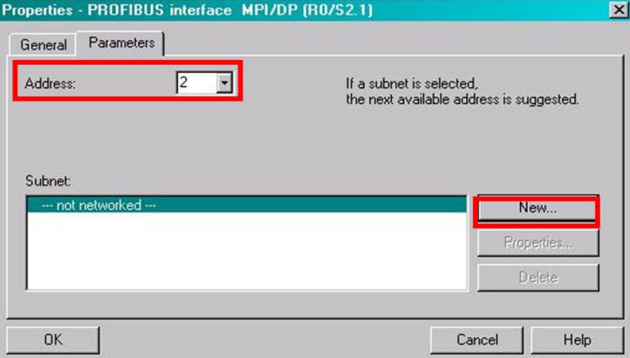
No.	Action	Remark
1.	Open the Simatic Manager to go online on the SIMATIC control. Then click on "Options" → "Set PG/PC Interface".	

No.	Action	Remark
2.	The adapter is now selected which is used to go online. In this case, it is the "CP5711(PROFIBUS)" → Now click on "Properties".	
3.	The Profibus address "0" for the PG is defined here. The transmission rate is also set here. → OK	
4.	The PROFIBUS addresses of the SINAMICS and the F-CPU will be defined later.	

5.3 HW configuration
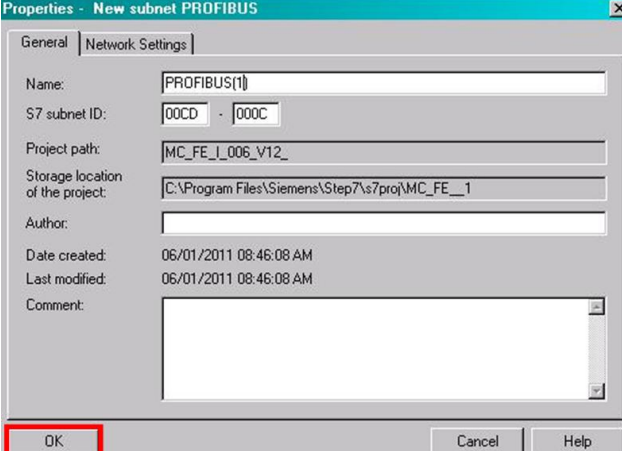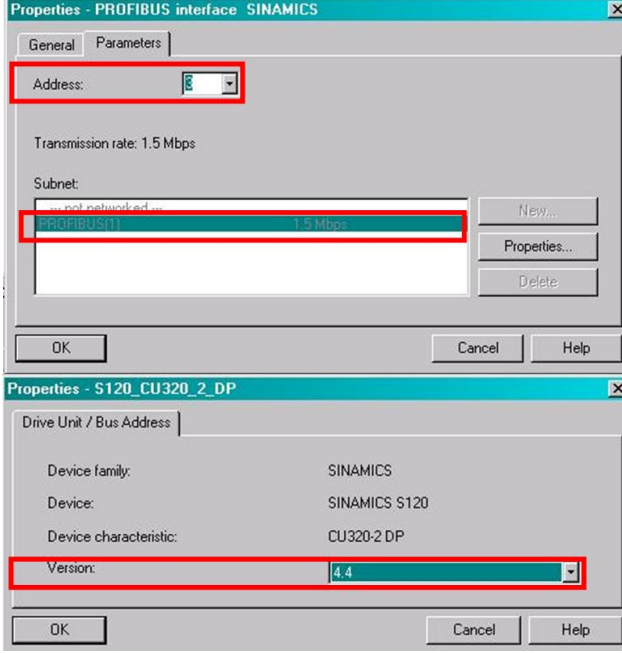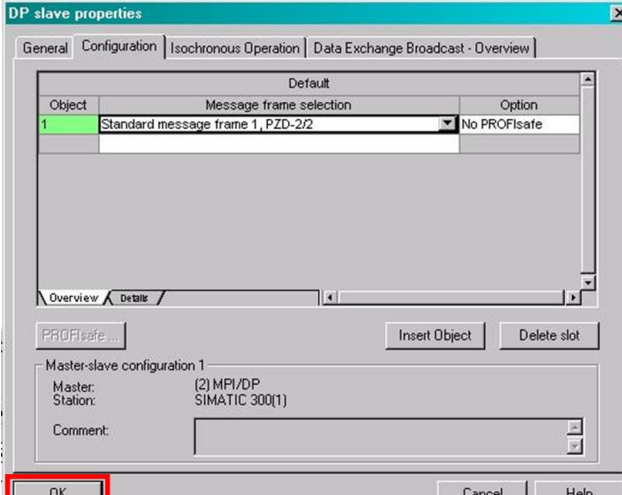
Table 5-2: HW configuration
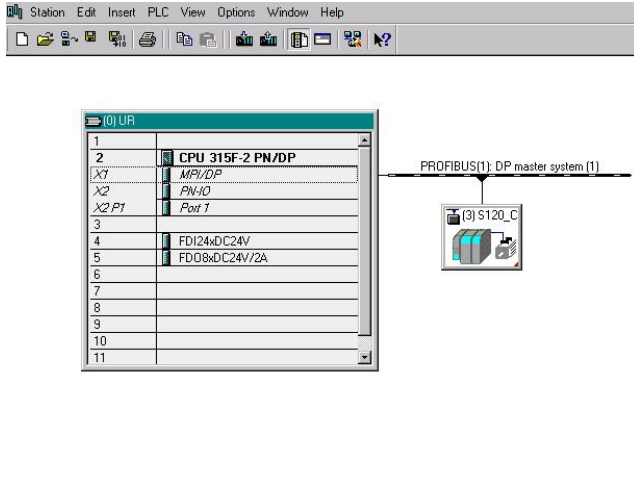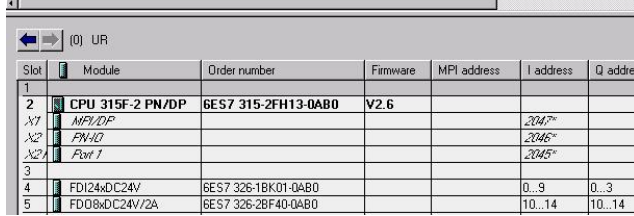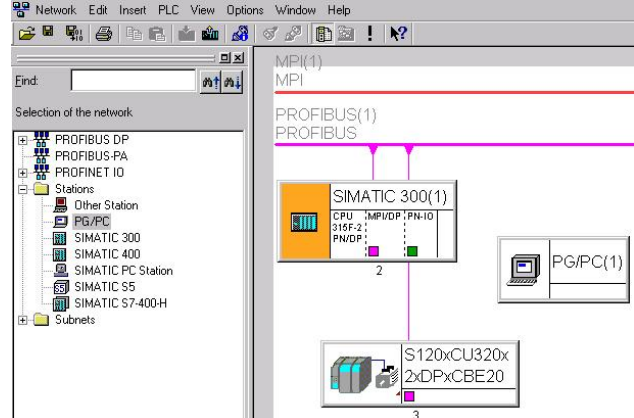
No.	Action	Remark
1.	In the SIMATIC Manager, insert a SIMATIC 300 station into the project.	
2.	Double click on "Hardware". Completely create and parameterize the station in HW Config. To do this, drag the modules contained in the parts list of Chapter 2.3 from the catalog window and drop them into the configuration window.	

No.	Action	Remark
3.	The adjacent window is displayed when inserting the F-CPU. Simply close this with "Cancel".	
4.	Then double-click on "MPI/DP" and select "PROFIBUS" in the following window and then click on "Properties".	
5.	The adjacent window opens. Here, select PROFIBUS address "2" and then click on the "New" button.	

5.3 HW configuration
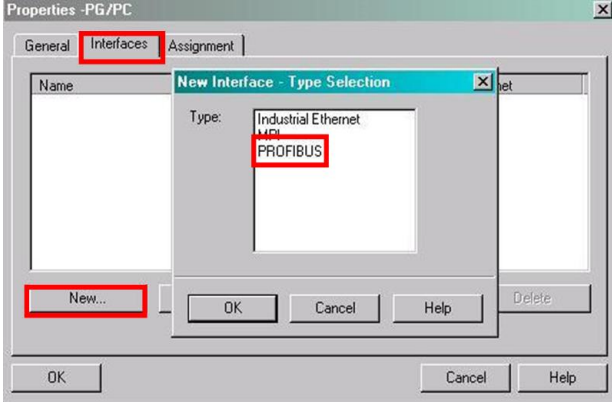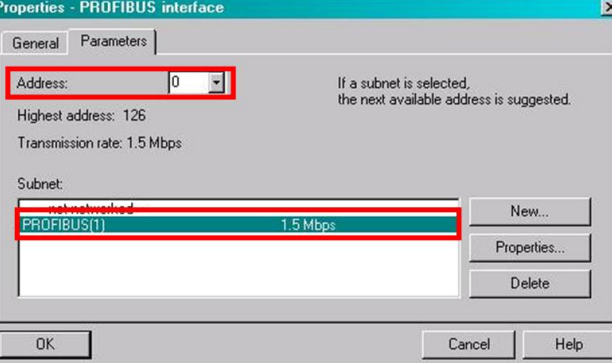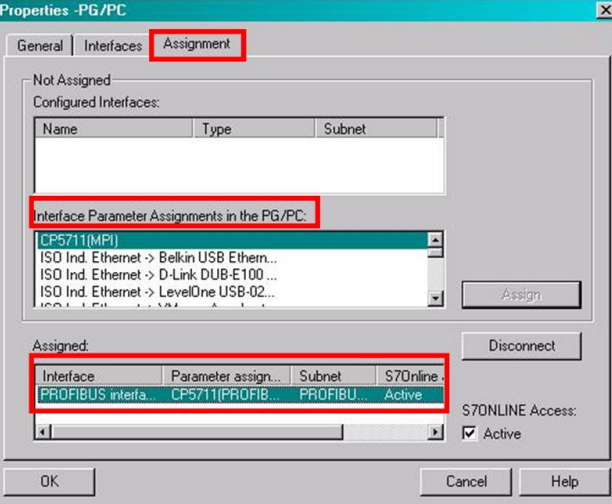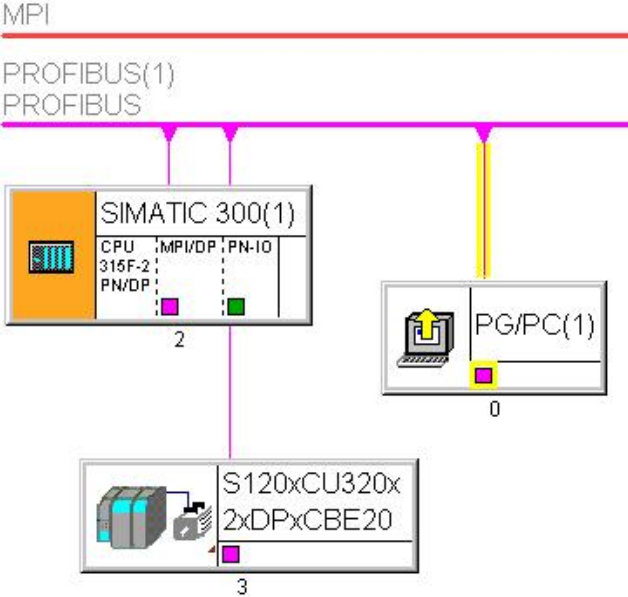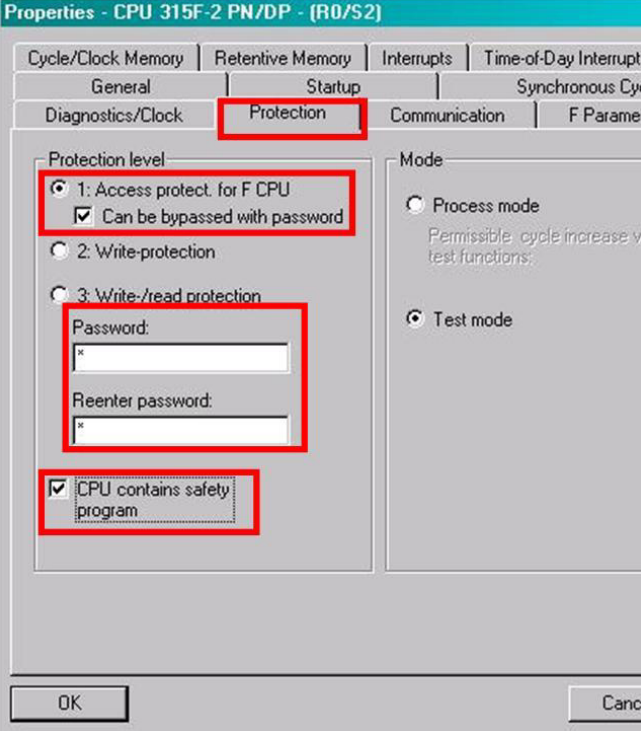
No.	Action	Remark
6.	Acknowledge with OK A PROFIBUS line is created.	
7.	When inserting the Sinamics S120 from the catalog into the configuration window, the adjacent window is displayed in HW Config. Here, PROFIBUS address "3" is selected. Also select the already created Profibus connection. → OK In the following window, select Version 4.4.	
8.	The adjacent window appears automatically and is confirmed with OK. The PROFIsafe Slot is inserted later in STARTER.	
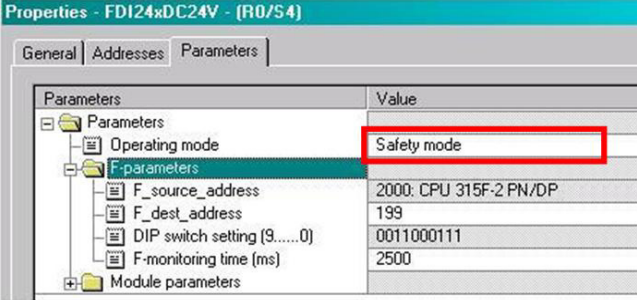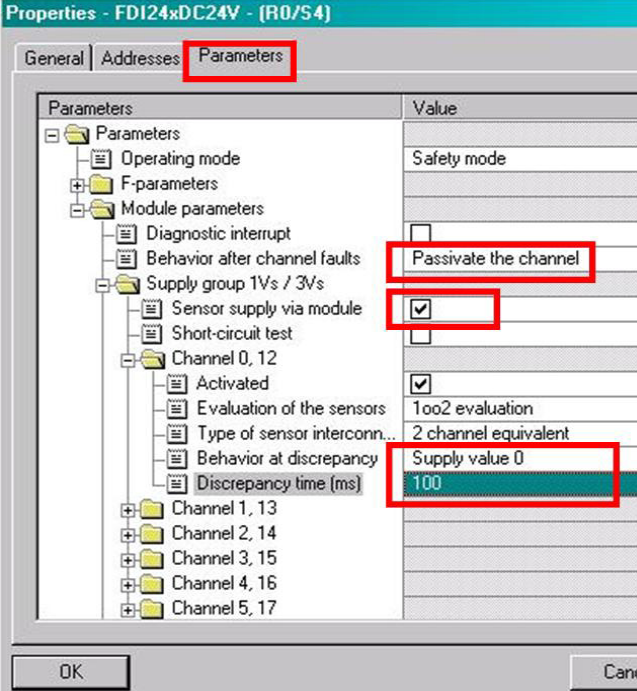
No.	Action	Remark
9.	The hardware configuration should then look like this.	
10.	Saving and compiling	
11.	Open NetPro as the programming device must be inserted. To do this, click on "Configure Network".	
12.	Drag the "PC/PG" object from the "Stations" folder and drop in the work area. The properties window opens by double-clicking on PG/PC(1).	
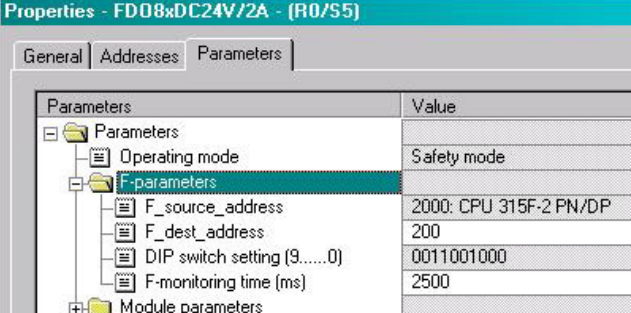
5.3 HW configuration
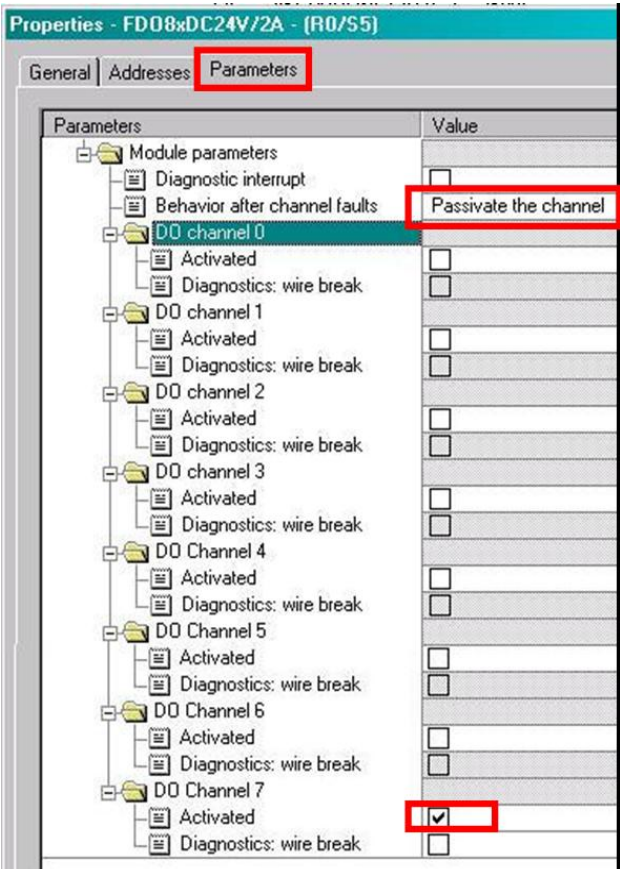
No.	Action	Remark
13.	Select the "Interfaces" tab and there, press the "New" button. Select "PROFIBUS" in the following window and confirm with "OK".	
14.	Select Profibus address "0" - and for "Subnet", select the existing PROFIBUS connection.	
15.	The interface must now be allocated on the PC/PG. In the example, the computer is equipped with the "CP5711(PROFIBUS)", and this interface should be connected to the existing PROFIBUS connection. The connection is established using the "Assign" button.	

No.	Action	Remark
16.	The PG is now available with active interface (yellow line).	
17.	Saving and compiling Then close NetPro.	
18.	**Configuring the F-CPU** Open HW Config in the SIMATIC Manager. In the properties window of the F-CPU, under the "Protection" tab, activate access protection for the F-CPU and protect using "0" as password. Activate the safety program (set the check mark for "CPU contains safety program").	

5.3 HW configuration

No.	Action	Remark
19.	**Configuring the F-DI module** Configure the PROFIsafe address using DIL switches. To do this, click on the F-DI in HW Config. Select "Safety mode".	
20.	**Configuring the F-DI module** Configuring F-DI 0 (channels 0, 12)	

No.	Action	Remark
21.	**Configuring the F-DI module** Configuring F-DI 1 (channels 1, 13) Configuring F-DI 2 (channels 2, 14) Configuring F-DI 3 (channels 3, 15) Configuring F-DI 5 (channels 5, 17)	
22.	**Configuring the F-DO module** Configure the PROFIsafe address using DIL switches. To do this, click on the F-DO in HW Config.	

5.3 HW configuration

No.	Action	Remark
23.	**Configuring the F-DO module** Configuring F-DO 7	
24.	Save and compile HW Config.	
25.	Download HW Config to the F-CPU	

5.4 Configuration of the basic drive functions
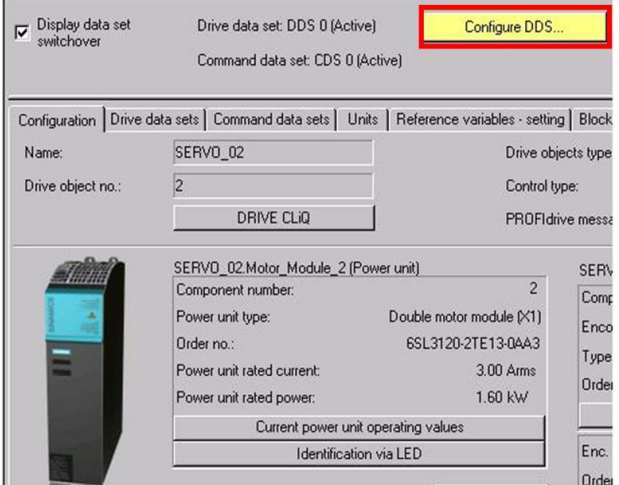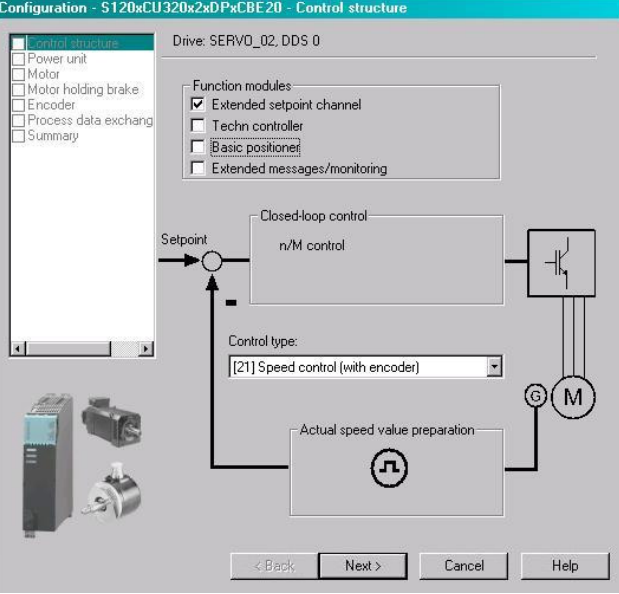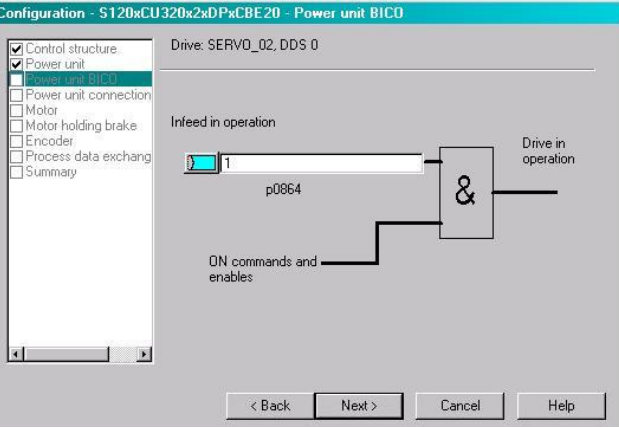
The existing hardware in the drive system must first be commissioned and the desired motion functions created.
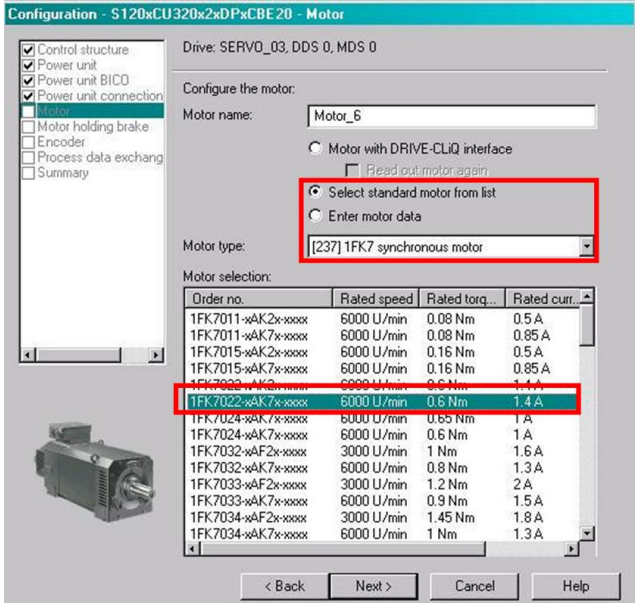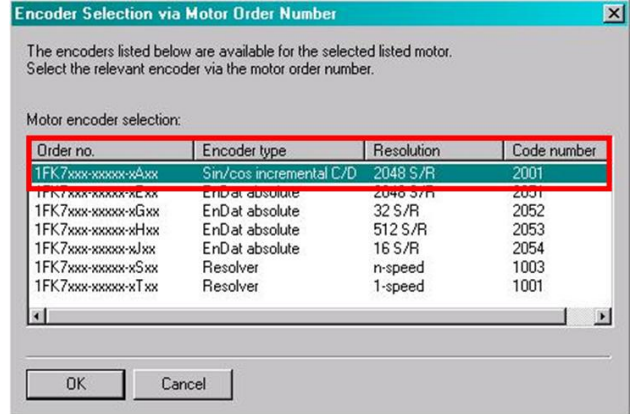
Table 5-3: Configuration of the basic functions
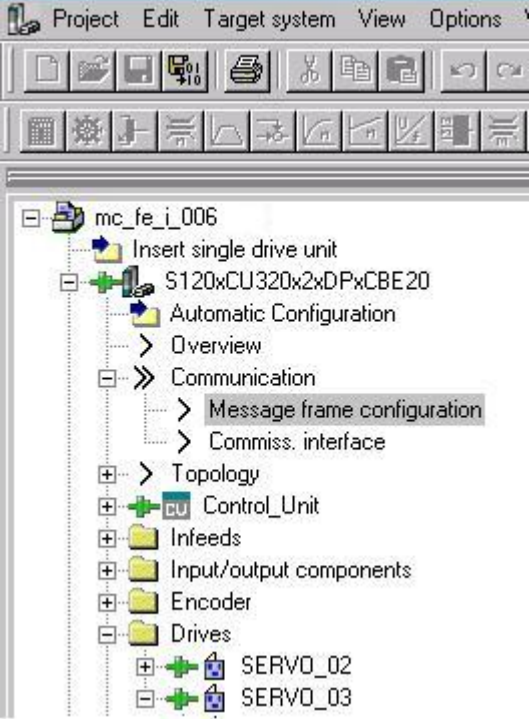
No.	Action	Remark
1.	Open STARTER from the SIMATIC project. To do this right-click on the SINAMICS in HW Config. Click on "Open Object with STARTER".	
2.	Go online.	
3.	Restoring factory settings.	
4.	Start the automatic configuration of the drives.	
5.	Select "Servo" as the drive object type and create with "Create".	
6.	Go offline	
7.	Save.	
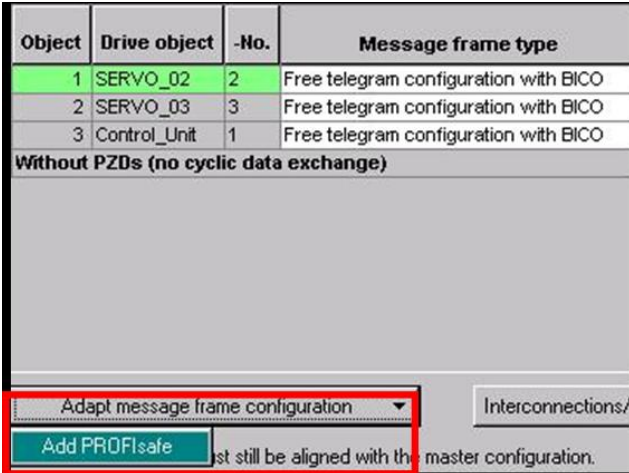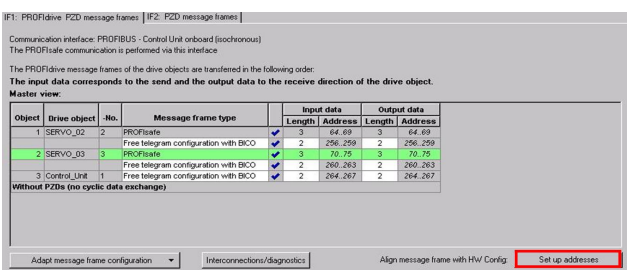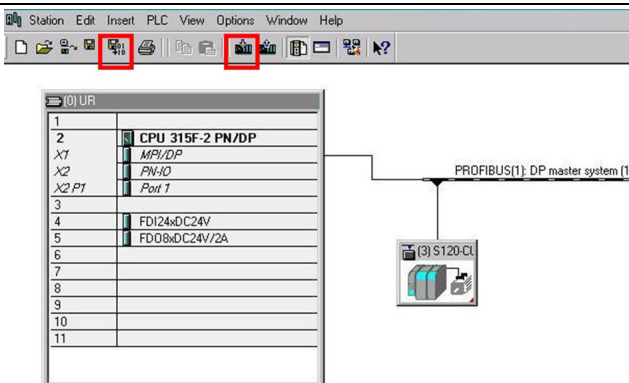
No.	Action	Remark
8.	**Post configuration of both drives** In the Project Navigated for drive 1 or drive 2 (SERVO_02 or SERVO_03), open the "Configuration" window. "Configure DDS" starts the navigated post configuration. **Note** In the following, only those screen forms are described in which a change is required.	
9.	**Post configuration of both drives** Under "Function modules" →, activate "Extended setpoint channel".	
10.	**Post configuration of both drives** A signal at "Infeed in operation" (p0864) is required for operation. Fixed binector 1 is used here in the example. **Note** In a real application, fixed binector 1 should not be used as signal for "Infeed in operation" (p0864).	
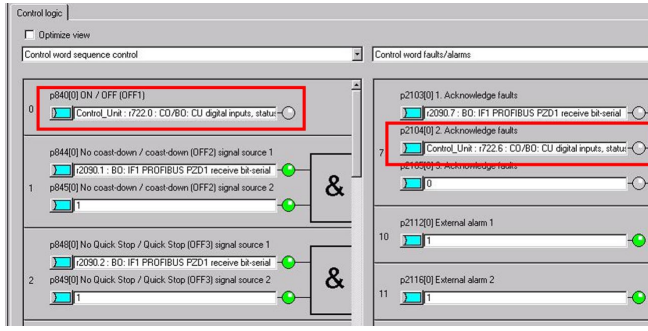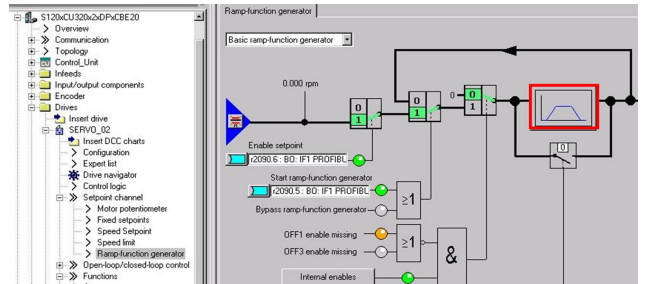
No.	Action	Remark
11.	**Post configuration, drive 2** The second drive does not have a Drive-CLiQ encoder; the motor must be manually selected. In the example, an 1FK7022 - 5AK71 - 1AG0 motor is being used.	
12.	**Post configuration, drive 2** Just like the motor, the encoder must also be manually selected. The is also realized using the type number (MLFB). Here in the example, an incremental encoder with the identification code letter A is selected.	
13.	**Note** The reason for the following steps is the automatic calculation of the motor parameters.	
14.	Go online.	
15.	Download.	
16.	Copy from RAM to ROM.	
17.	Upload.	
18.	Offline.	

5.4 Configuration of the basic drive functions
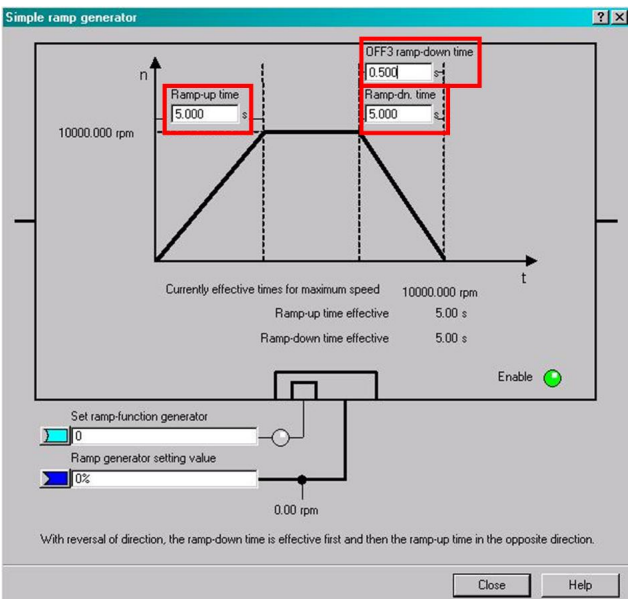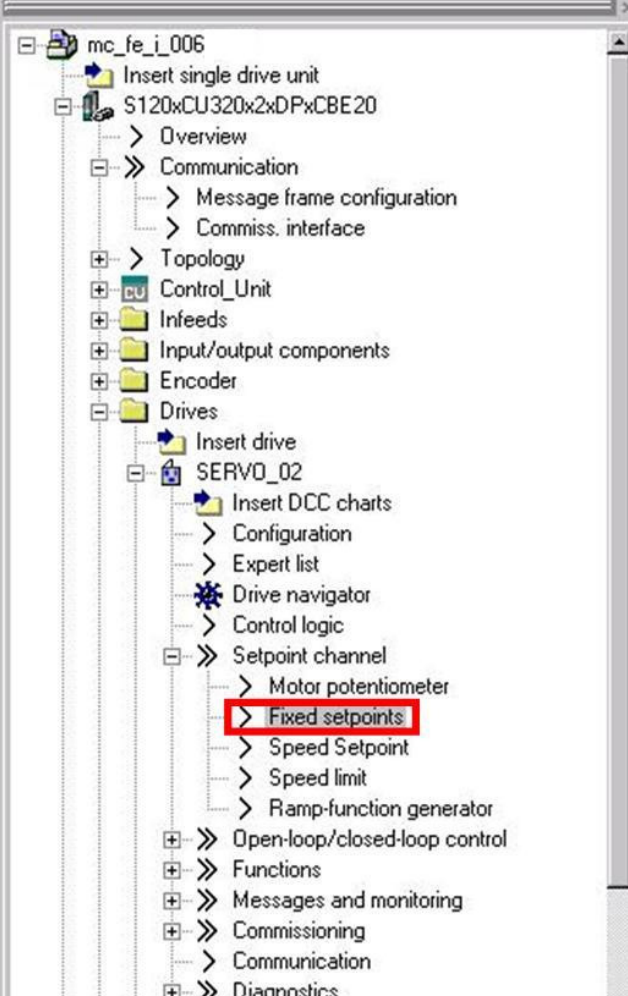
No.	Action	Remark
19.	**Telegram configuration** The telegram configuration can be found under "Communication" and then "Message frame configuration".	
20.	**Telegram configuration** Standard telegram 1 should be selected for both drives. Then switch back to "Free telegram configuration with BICO". The reason for this is the automatic pre-assignment of the PROFIdrive control words. However, adjustments are needed, which are only possible for free telegram configuration.	

No.	Action	Remark
21.	**Telegram configuration** Using the "Adapt message frame configuration" button, for both drives create a PROFIsafe slot.	
22.	**Telegram configuration** Then, transfer the configuration to HW Config. To do so, click on "Set up addresses". The telegram configuration should now look same as shown in the diagram.	
23.	**Telegram configuration** In the Simatic Manager, HW Config should be again saved, compiled and downloaded again.	
24.	**Note** In the HW Config in the Simatic Manager, the telegram selection was automatically entered. The specified address can be changed here.	

5.4 Configuration of the basic drive functions

No.	Action	Remark
25.	**Configuration of both drives** If a Single Line Module is used for 230V 1AC (included in the training cases), the DC link parameters must be adapted. **Note** Since the 5 kW SLM has no DRIVE-CLiQ interfaces, it is not necessary to configure the infeed.	p0210: 345V p1248[0]: 240V p1244[0]: 401V See also FAQ ID: 27038754
26.	**Configuration of both drives** In STARTER under the item "Control logic", in the drive, interconnect the ON/OFF1 enable with digital input 0. In the control word "faults/alarms", interconnect parameter p2104[0] "2.Acknowledge faults" with digital input 6.	
27.	**Configuration of both drives** Under the item "Setpoint channel" and then "Ramp-function generator", click on the button in the red frame.	

No.	Action	Remark
28.	**Configuration of both drives** For SS1, the OFF3 ramp-down time (p1135) is used for deceleration. The following values were set: - Ramp-up time (p1120[0]) = 5s - OFF3 ramp-down time (p1135[0]) = 0.5s - Ramp-down time (p1121[0]) = 5s	
29.	**Configuration of drive 1** Specify speeds for normal operation and for the SLS safety function. Under the item "Setpoint channel" →, click on "Fixed Setpoints".	

5.4 Configuration of the basic drive functions

No.	Action	Remark
30.	**Configuration of drive 1** Bits 0 to 1 are used to select the various speed setpoints. The following interconnections have been made: Bit0: Control Unit DI 1 Bit1: Control Unit DI 2 Bit2: 0 Bit3: 0 The following fixed values were entered: Fixed value 1: 20 rpm Fixed value 3: 800 rpm Fixed setpoint active, p1024 is interconnected with p1070 main setpoint.	

No.	Action	Remark
31.	**Configuration of drive 2** Specify speeds for normal operation and for the SLS safety function. Under the item "Setpoint channel" →, click on "Fixed Setpoints".	
32.	**Configuration of drive 2** The following interconnections have been made: Bit0: Control Unit DI 1 Bit1: Control Unit DI 2 Bit2: 0 Bit3: 0 The following fixed values were entered: Fixed value 1: 33 rpm Fixed value 3: 333 rpm Fixed setpoint active, p1024 is interconnected with p1070 main setpoint.	
33.	Save the project.	

5.4 Configuration of the basic drive functions
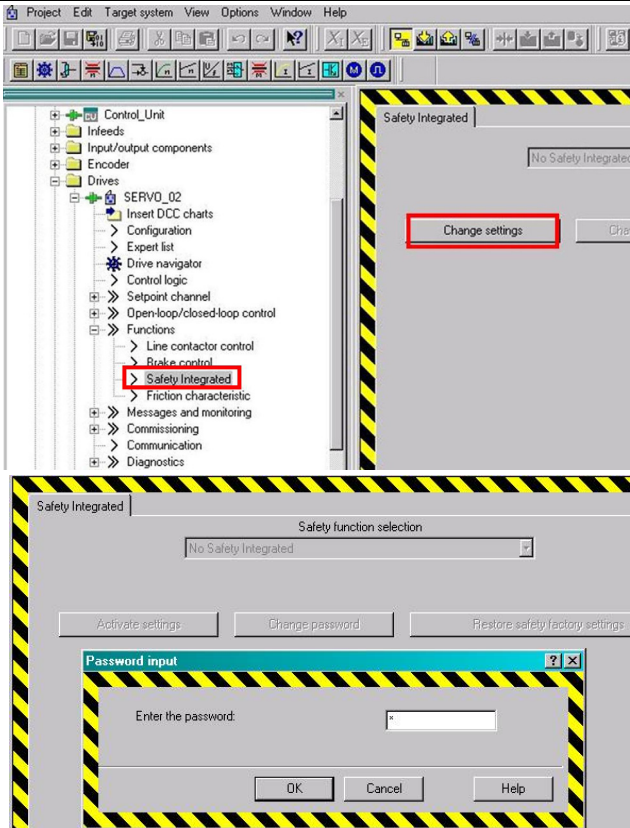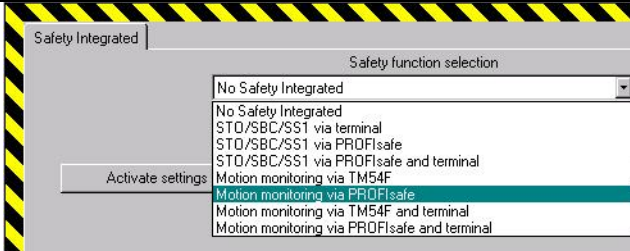
No.	Action	Remark
34.	Go online.	
35.	Load the project into the target device.	
36.	Copy from RAM to ROM.	

5.5 Parameterizing the safety functions integrated in the drive
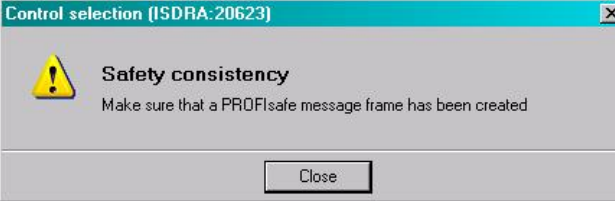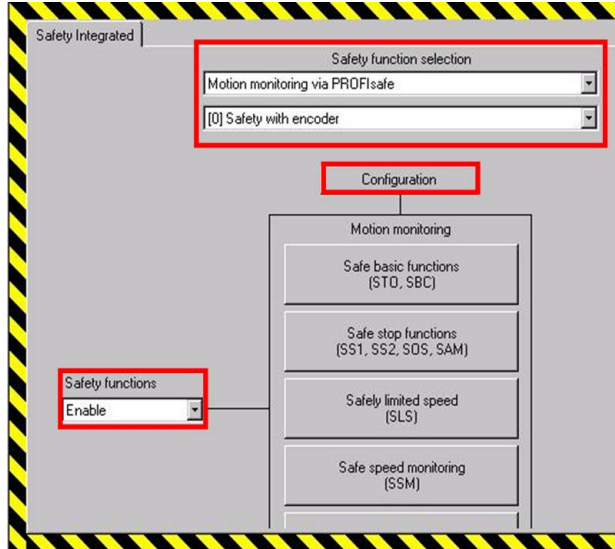
Notes	• The safety functions are configured on the drives online.
	• Only the windows are described in which parameter changes are required.
	• In this example, the following safety functions are used: SS1 and SLS.
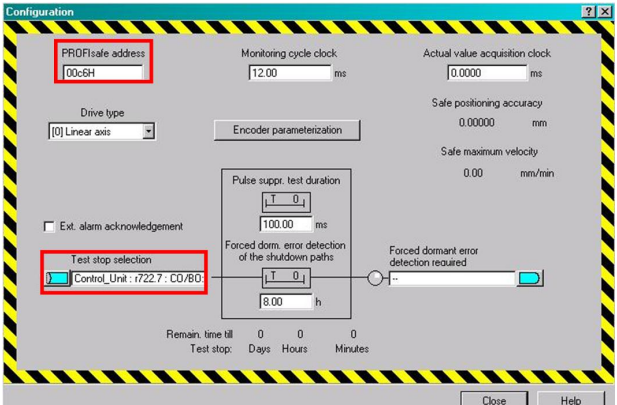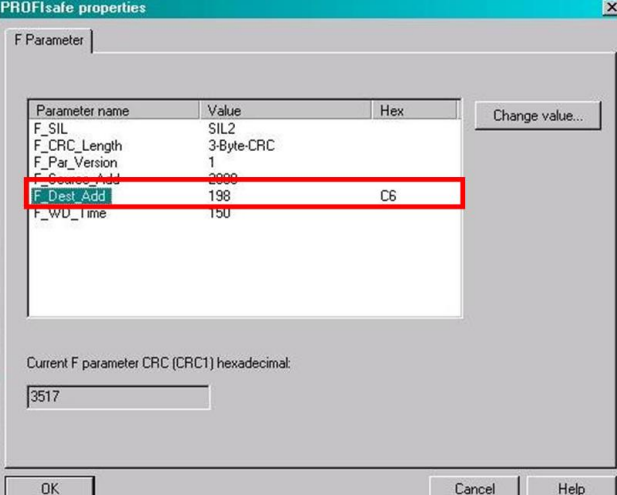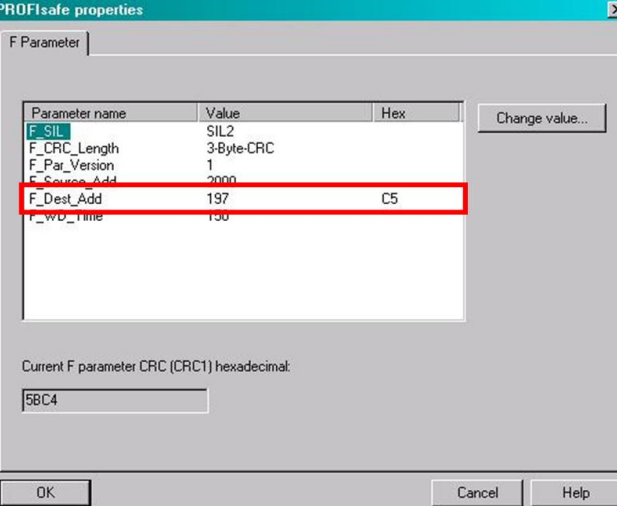
Table 5-4: Parameterizing the safety functions integrated in the drive

No.	Action	Remark
1.	Go online with STARTER.	
2.	**Configuration of both drives** For the drives, open the "Safety Integrated" window under the item "Functions". In order to change the settings in the Safety screen form, click on "Change settings". A password is now required. The default password for the first commissioning is "0".	
3.	**Configuration of both drives** Switchover the control selection to "Motion monitoring via PROFIsafe".	

5.5 Parameterizing the safety functions integrated in the drive

No.	Action	Remark
4.	**Configuration of both drives** Close the message with "Close".	
5.	**Configuration of both drives** "Safety Integrated" window The following are configured in the example: Select control with "Motion Monitoring via PROFIsafe" and "Safety with encoder" Set "Safety functions" to "Enable". Then click on "Configuration".	
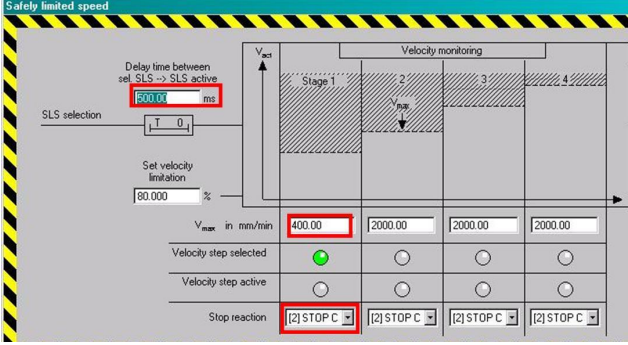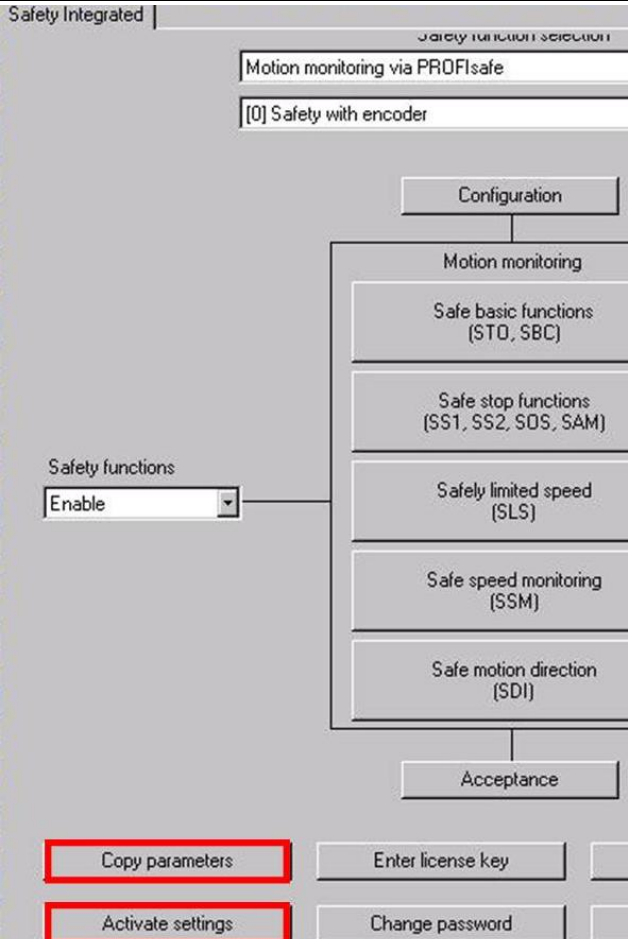
No.	Action	Remark
6.	**Configuration of both drives** "Configuration" window The following have to be configured in the example: PROFIsafe address with C6hex for drive 1 and PROFIsafe address with C5hex for drive 2. The PROFIsafe addresses can read-out from the HW Config under the PROFIsafe properties. Interconnect the signal source of the test stop with DI7 of SINAMICS.	

5.5 Parameterizing the safety functions integrated in the drive

No.	Action	Remark
7.	**Configuration of both drives** "Safe stop functions" window The following values were entered for the example: Delay time SS1→ STO active = 500 ms Delay time STOP C/SS2 →SOS active = 500 ms	
8.	**Configuration of drive 1** "Safely-Limited Speed (SLS)" window The velocity limit for level 1 is 250 mm/min. When this limit is exceeded, the STOP C stop response configured here is initiated. Within the delay time "Delay Time Delay time between sel. SLS → SLS active" (p9551), the drive speed must be below the limit n_max. Entered in the example: Delay time SLS → SLS active: 500ms N_max for level 1: 250 mm/min for drive 1	

No.	Action	Remark
9.	**Configuration of drive 2** "Safely-Limited Speed (SLS)" window The velocity limit for level 1 is 400 mm/min. When this limit is exceeded, the STOP C stop response configured here is initiated. Within the delay time "Delay Time Delay time between sel. SLS → SLS active" (p9551), the drive speed must be below the limit n_max. Entered in the example: Delay time SLS → SLS active: 500ms N_max for level 1: 400 mm/min for drive 2	
10.	**Configuration of both drives** The parameters must now be copied. To do this, click on the "Copy parameters" button. Then click on "Activate settings".	

5.5 Parameterizing the safety functions integrated in the drive

No.	Action	Remark
11.	**Configuration of both drives** You will now be prompted to assign a new password. To do this, e.g. set the password to "1".	Password input dialog: Enter the current password: (default password: 0) Enter the new password: Repeat your entry: OK Cancel Help
12.	**Configuration of both drives** The parameters of the drive device are now copied to ROM. Confirm with "Yes".	Activate settings — Save parameters After activation of the safety parameterization, this should als to the drive (Copy RAM to ROM). An acceptance test is also Do you want to save the parameters to the ROM now? ⦿ Parameters of the drive unit ○ Parameters of the drive object Yes No
13.	Go offline	
14.	Then perform a power-on reset of the Control Unit.	POWER OFF/ON
15.	Go online.	
16.	Load the configuration into the PG.	
17.	Save the project.	
18.	These messages indicate that a test stop of the safety functions in the drives is required. Here, they involve alarms, i.e. the drives can be switched-on and operated. In this example, the test stop can be executed using switch -S9.	Warning S120xCU320x2xDPxCBE20 : SERVO_02 1697 : SI Motion: Motion monitoring functions must be tested Warning S120xCU320x2xDPxCBE20 : SERVO_03 1697 : SI Motion: Motion monitoring functions must be tested

5.6 Configuring the F-CPU

In this example, in OB1, the required enable signals (except bit 0 for OFF1/ON enable) are only set in control word 1 for drives 1 and 2.
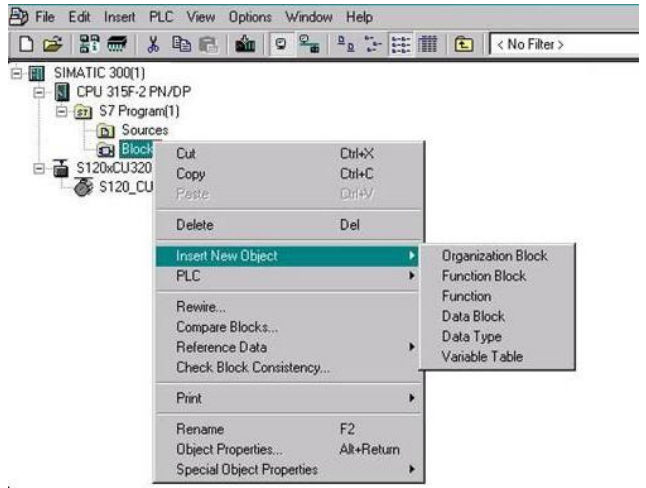
The safety program was consciously selected to be as simple as possible. In this particular case, the main task of the safety program is to generate the PROFIsafe control words for the drives from the signals at the F-DIs. These are transferred to the drives using the PROFIdrive telegrams where they control the safety functions. The blocks required for the safety program must first be created.

Caution	**It is not permissible that the program is used for a real application in this form.**

You start with the F-Call block. This is required to call the safety program. To do this, a function (in this case, FC1) must be inserted in the block folder using the F-Call programming language. Cyclic interrupt OB35 is required to cyclically call the safety program.
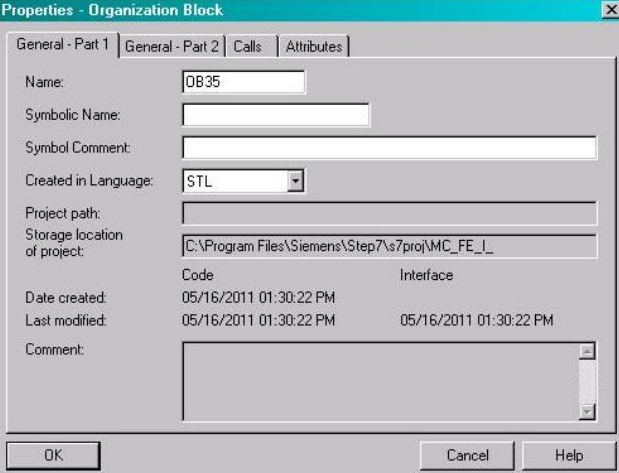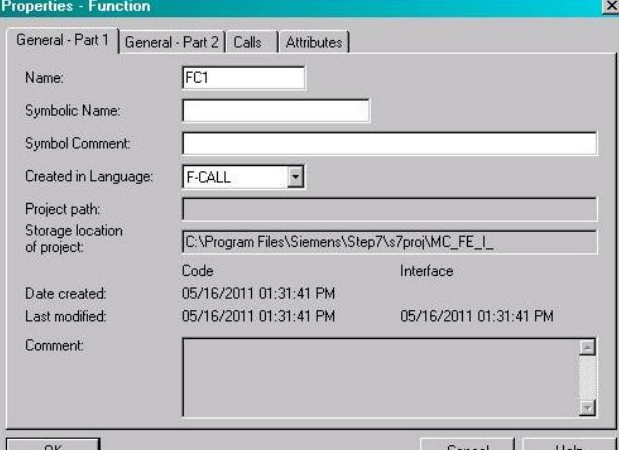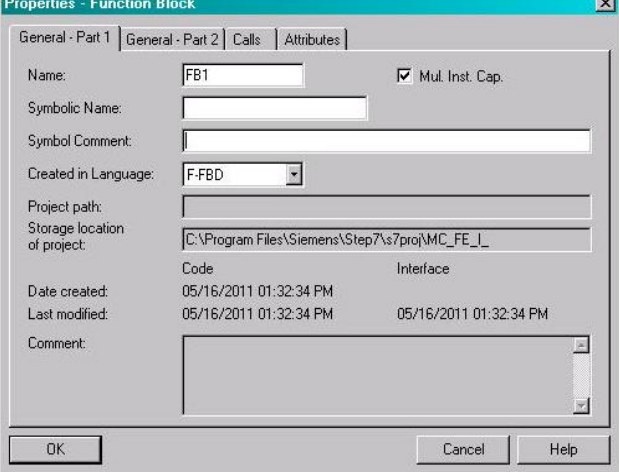
In this example, the actual safety program is executed in a function block (here, FB1); this means that FB 1 must now be inserted with the programming language F-LAD (corresponds to F-KOP (DE)) or F-FBD (corresponds to F-FUP (DE)).

Table 5-5: Configuring the F-CPU
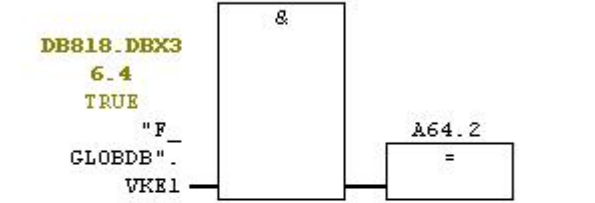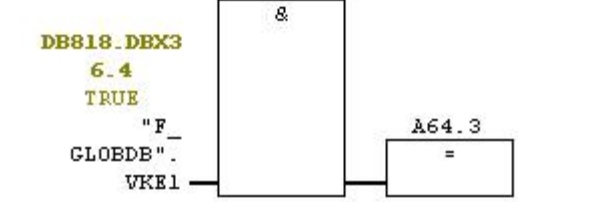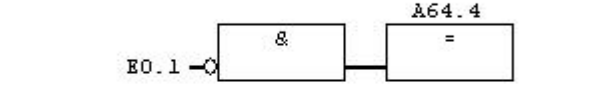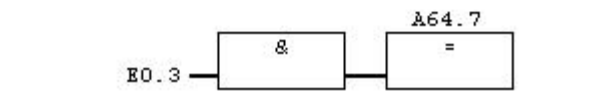
No.	Action	Remark
1.	To insert blocks, right-click on "Blocks" → "Insert New Object".	
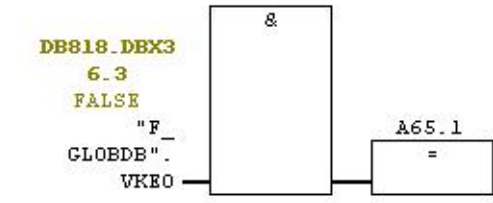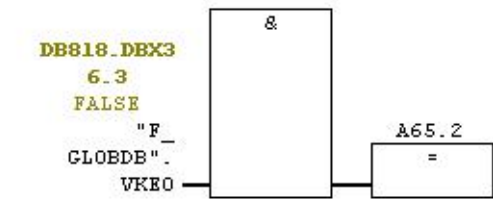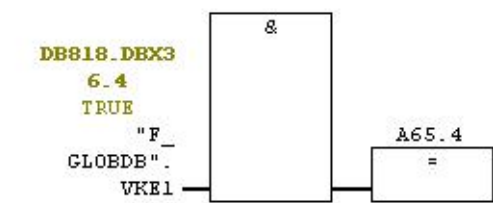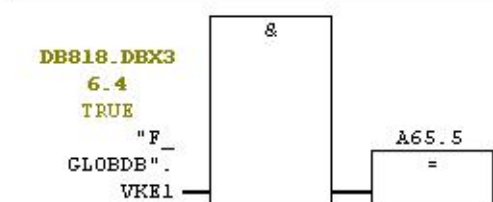
No.	Action	Remark
2.	Create OB35 using the STL programming language (corresponds to AWL (DE)).	
3.	Create the FC1 using the F-CALL programming language. FC1 is the gateway to the safety program.	
4.	Create FB1 with the programming language F-FBD (corresponds to F-FUP (DE)). The safety program is written to FB1.	
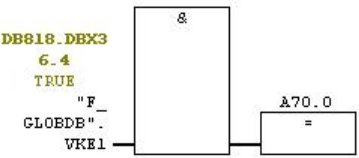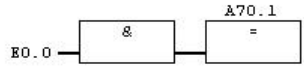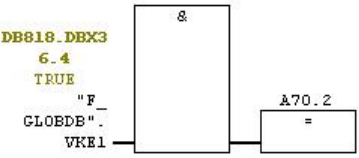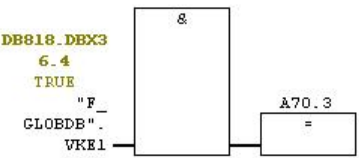
No.	Action	Remark
5.	**OB1** All enable signals are permanently written to the STW. **Note** The address of the output word can be seen in Chapter 5.4 for the telegram configuration.	OB1 : "Main Program Sweep (Cycle)" Comment: Network 1: Assign dummy control word Comment: L 1150 // 1150 = 47E T AW 256 T AW 260
6.	**OB35** Calls the safety program	OB35 : "Cyclic Interrupt" Comment: Network 1: Open Safety-Program Comment: CALL FC 1
7.	**FB1** **Drive 1** Network 1: Acknowledge faults using -S4. **Note** FB219 can be found in FB1 in the folder "Libraries" → "Distributed Safety" → "F-Application Blocks". Network 2: STO is permanently deselected with a fail-safe VKE1. Network 3: -S1 is interconnected with SS1 on PROFIsafe STW 1.	FB1 : Safety-Program Comment: Network 1: Reintegration of all components Comment: DB219 / FB219 F_: Global Acknowledgement of all F-I/O of a RTG "F_ACK_GL" — EN; E0.3 — ACK_REI_GLOB; ENO — Network 2: PROFIsafe Drive 1 STO Comment: DB818.DBX36.4 TRUE "F_GLOBDB".VKE1 & — A64.0 = Network 3: PROFIsafe Drive 1 SS1 Comment: E0.0 — & — A64.1 =
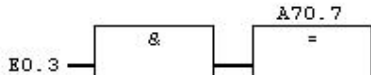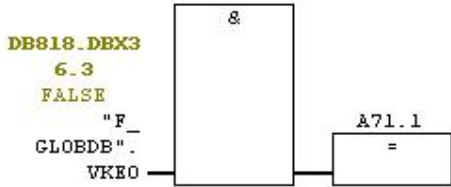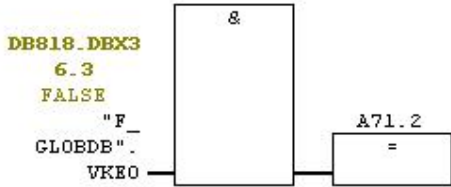
No.	Action	Remark
8.	**FB1** **Drive 1** Network 4: SS2 is permanently deselected with a fail-safe VKE1. Network 5: SOS is permanently deselected with a fail-safe VKE1. Network 6: -S2 is interconnected with SLS on PROFIsafe STW 1. Inversion is necessary, as -S2 is connected as NO/NC contact. Network 7: -S4 is interconnected with the fail-safe acknowledgment on PROFIsafe STW 1.	**Network 4**: PROFIsafe Drive 1 SS2 Comment: DB818.DBX36.4 TRUE "F_GLOBDB".VKE1 — & — A64.2 = **Network 5**: PROFIsafe Drive 1 SOS Comment: DB818.DBX36.4 TRUE "F_GLOBDB".VKE1 — & — A64.3 = **Network 6**: PROFIsafe Drive 1 SLS Comment: E0.1 —O & — A64.4 = **Network 7**: PROFIsafe Acknowledgement Comment: E0.3 — & — A64.7 =
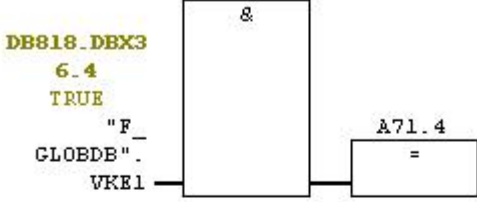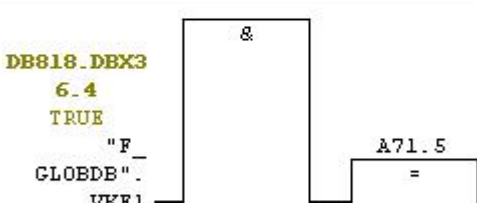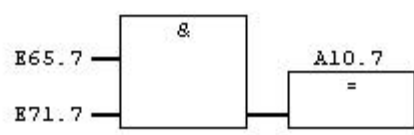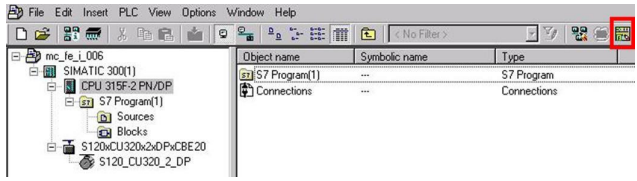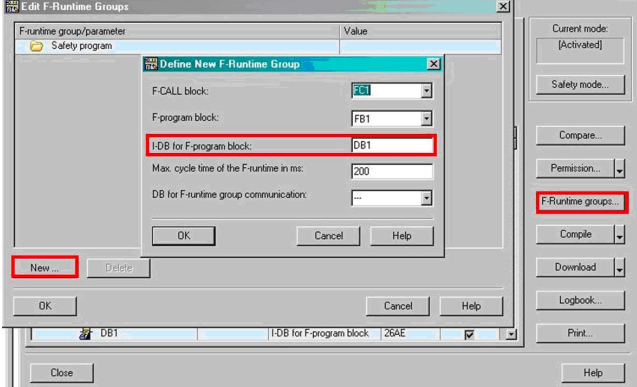
No.	Action	Remark
9.	**FB1** **Drive 1** Networks 8 and 9: The fail-safe VKE0 is interconnected on A65.1 and A65.2; this means that SLS level 1 is permanently selected. Networks 10 and 11: The fail-safe VKE1 is interconnected on A65.4 and A65.5; this means that SDI is permanently deselected in the positive and negative directions.	**Network 8** : PROFIsafe Drive 1 SLS stage Bit 0 Comment: DB818.DBX3 6.3 FALSE "F_GLOBDB".VKE0 — & — A65.1 = **Network 9** : PROFIsafe Drive 1 SLS stage Bit 1 Comment: DB818.DBX3 6.3 FALSE "F_GLOBDB".VKE0 — & — A65.2 = **Network 10** : PROFIsafe Drive 1 SDI positive Comment: DB818.DBX3 6.4 TRUE "F_GLOBDB".VKE1 — & — A65.4 = **Network 11** : PROFIsafe Drive 1 SDI negative Comment: DB818.DBX3 6.4 TRUE "F_GLOBDB".VKE1 — & — A65.5 =
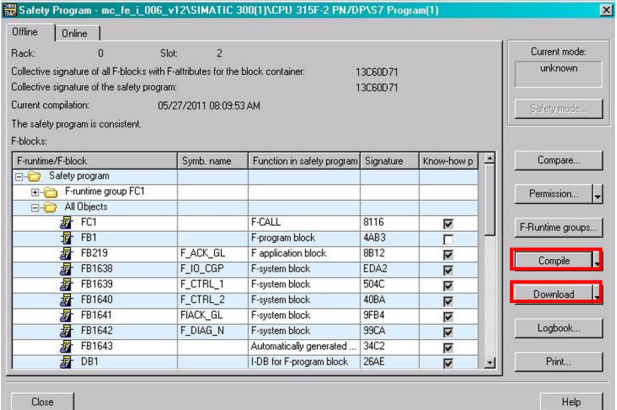
5.6 Configuring the F-CPU

No.	Action	Remark
10.	**FB1** **Drive 2** Network 12: STO is permanently deselected with a fail-safe VKE1. Network 13: -S1 is interconnected with SS1 on PROFIsafe STW 2. Network 14: SS2 is permanently deselected with a fail-safe VKE1. Network 15: SOS is permanently deselected with a fail-safe VKE1.	

No.	Action	Remark
11.	**FB1** **Drive 2** Network 16: -S3 is interconnected with SLS on PROFIsafe STW 2. Network 17: -S4 is interconnected with the fail-safe acknowledgment on PROFIsafe STW 2. Networks 18 and 19: The fail-safe VKE0 is interconnected on A71.1 and A71.2; this means that SLS level 1 is permanently selected.	**Network 16** : PROFIsafe Drive 2 SLS Comment: E0.2 — [&] — A70.4 [=] **Network 17** : PROFIsafe Acknowledgement Comment: E0.3 — [&] — A70.7 [=] **Network 18** : PROFIsafe Drive 2 SLS stage Bit 0 Comment: DB818.DBX36.3 FALSE "F_GLOBDB".VKE0 — [&] — A71.1 [=] **Network 19** : PROFIsafe Drive 2 SLS stage Bit 1 Comment: DB818.DBX36.3 FALSE "F_GLOBDB".VKE0 — [&] — A71.2 [=]

No.	Action	Remark
12.	**FB1** **Drive 2** Networks 20 and 21: The fail-safe VKE1 is interconnected at A71.4 and A71.5; this means that SDI is permanently deselected in the positive and negative directions. Network 22: Control of the signal lamp in -S4 for the SSM feedback signal.	
13.	**Generating the safety program** Click on this button to generate the safety program.	
14.	**Creating a new F-runtime group** Here, the safety program (FB1) is assigned to FC1 and the associated I-DB is defined. For this purpose, click on the button "F-Runtime groups" → "New" and specify an I-DB.	

No.	Action	Remark
15.	Then generate the safety program and load into the F-CPU. In addition, load the standard blocks into the F-CPU.	

Note	We recommend that blocks OB82 and OB86 are also integrated in order to tolerate the failure of the I/O (e.g. the drives for a power on reset) without the F-CPU going into the STOP operating state.

5.7 Acceptance test

To verify safety-oriented parameters, an acceptance test must be performed after the machine has been commissioned for the first time and also after changes are made to safety-related parameters. The acceptance test must be appropriately documented. The acceptance reports must be adequately stored and archived.

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

Information about the acceptance test, the acceptance report and an example of an appropriate acceptance report is provided in the "Function Manual SINAMICS S120 Safety Integrated" (FHS) in the Chapter "Acceptance test and acceptance report".

To simplify the handling of the acceptance test, an application has been created, which can be ordered free of charge by your local SIEMENS partner. This application takes the user step-by-step in a user-friendly fashion through the acceptance test.

6 Commissioning the application

Up until now, the configuration of the application example was described step-by-step. The following steps should now be followed if the sample project is to be directly downloaded to the hardware.

All of the components (S7-F-CPU and SINAMICS S120) should first be generally reset or reset to factory settings.

6.1 Preconditions

Preconditions for operation
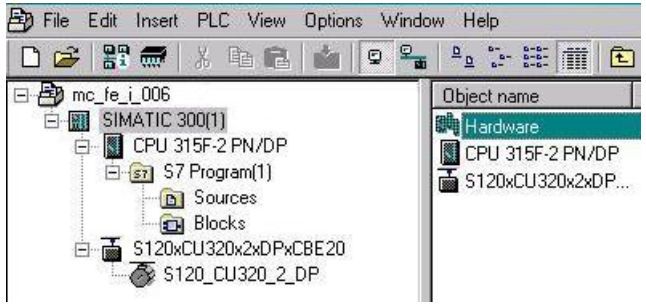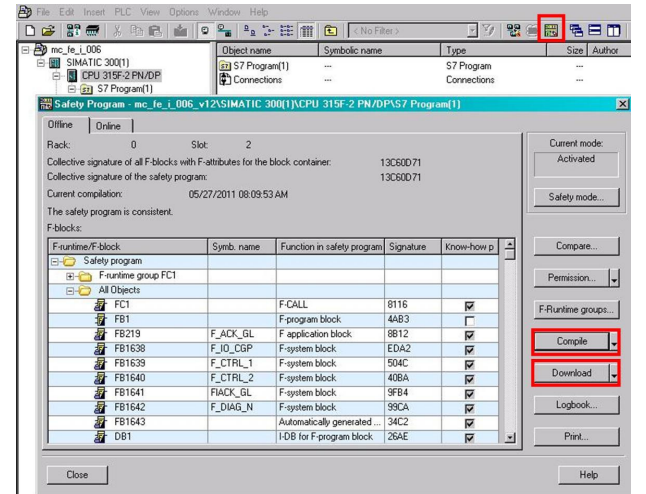
- The SIMATIC components have been mounted and connected with one another. The PROFIsafe addresses of the fail-safe input and output modules must be set using the DIL switch; see Chapter 5.4.

- All components have been connected as specified in Chapter 4.

- The DRIVE-CLiQ topology of the SINAMICS components has been maintained.

- The motor is connected to the Motor Module using a power cable.

- The Motor Module is correctly connected with the infeed (DC link and 24 V DC control voltage).

- The infeed is connected to the line supply.

- The components are supplied with 24 V DC.

6.2 Preparation

(see chapter 5.2 Preparation)
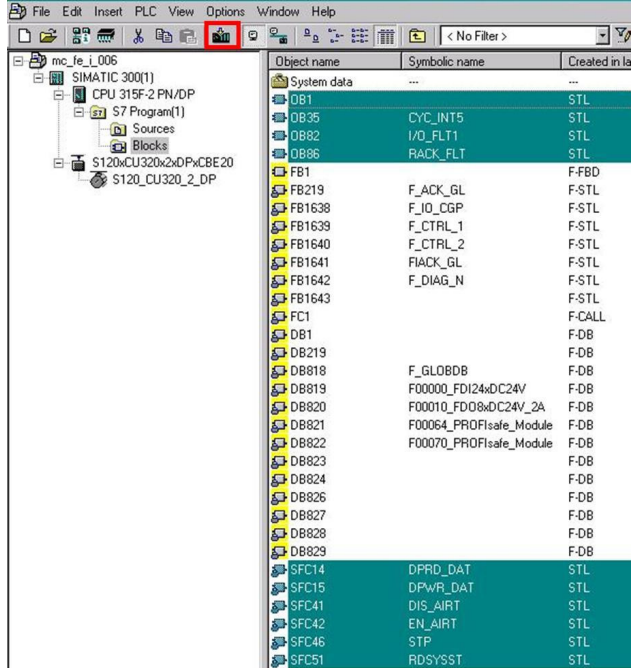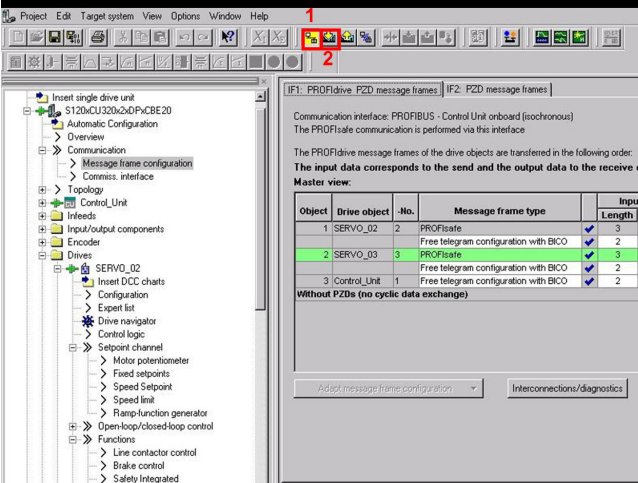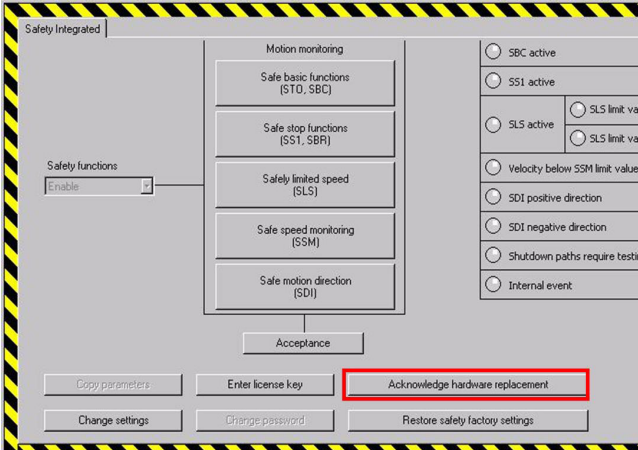
6.3 Commissioning

Table 6-1: Commissioning the application example

No.	Action	Remark
1.	**Loading the configuration of the F CPU** The HW configuration of the S7-F-CPU must first be downloaded. The HW configuration is opened by double-clicking on "Hardware". Depending on the default values and the previous configuration on the F-CPU side, it may be necessary to adapt the PROFIBUS address of the PG in NetPro to download the hardware configuration of the F-CPU.	
2.	**Note** If a Safety program was previously available on the F-CPU, then this is password-protected. This must be known for the download. If it is not known, then the memory card must be deleted using a suitable device (e.g. a SIEMENS PG). If the card is deleted or formatted using a card reader, the card will be destroyed.	
3.	After the HW configuration has been downloaded, the program blocks must be loaded into the F-CPU. The window to load the safety functions is first opened using the "yellow" button in the function bar. The download is then initiated from this window using the "Download" button. The safety program must have previously been generated ("compiled").	

No.	Action	Remark
4.	The remaining (non-safety-related) blocks are then loaded normally.	
5.	**Loading the SINAMICS S120 configuration** You can download the configuration directly to the SINAMICS S120. To do so, first go online and then perform a download.	
6.	Now, for each series commissioning, the new serial numbers must be transferred to the Safety configuration. This is carried out using "Acknowledge hardware replacement" in the Safety screen form of both drives.	

No.	Action	Remark
7.	The backup procedure from RAM to ROM must then be initiated for SINAMICS and a restart carried out (power on reset).	

7 Using the application

7.1 Overview

Fig. 7-1: Operator controls of the application example
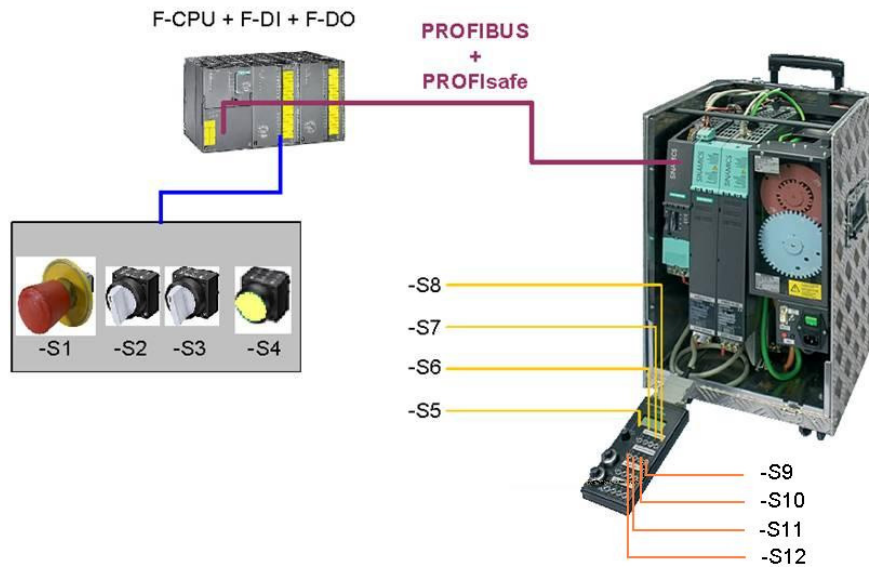
Switches -S1 to -S4 are located on a switchbox that belongs to the Safety training case. The various safety functions can be selected using the switches.

Switches -S5 to -S12 are located on a switchbox that belongs to the SINAMICS training case. Using these switches, the drives are switched on and switched off, different speed setpoints entered, the test function for the safety functions started and faults acknowledged.

7.2   Description

Reintegration

> The drives have to be reintegrated after a power OFF/ON. All of the alarm messages are acknowledged by pressing pushbutton -S4, and the signal lamp in -S4 is lit.

Switching-on/switching-off

> The Emergency Stop button S1 must be released in order to be able to operate the drives. Both drives are switched-on (OFF 1) using switch -S5.

Speed steps

> Switch -S6 can be used to changeover between speed setpoint 0 and 20 rpm (drive1) or 0 and 33 rpm (drive2). If switch -S7 is also actuated, then the speed increases up to 800 rpm (drive 1) and 333 rpm (drive 2).

Acknowledging alarms

> Alarms present on the SINAMICS system can be acknowledged using -S10. The Safety alarms are the exception in this case, as they must be acknowledged in a fail-safe fashion using -S4. Cyclic test stop for the safety functions is activated using -S9.

Protective door 1

> When protective door 1 is closed (switch -S2), drive 1 rotates with a maximum of 800 rpm. If the first speed stage is selected, then the motor rotates with 20 rpm. If protective door 1 is now opened, nothing happens, as the speed limit was parameterized with 25 rpm.

Protective door 2

> A closed protective door 2 (switch -S3) results in a maximum setpoint speed of 333 rpm for drive 2. If the first speed stage is selected, the motor rotates with 33 rpm. If protective door 2 is now opened, nothing happens, as the speed limit was parameterized with 40 rpm.

Fault simulation

> With protective door 1 or 2 open, if the second speed setpoint of 800 rpm (drive 1) or 333 rpm (drive 2) is selected, then this results in an SLS limit value violation and the relevant drive is stopped with an internal SS2 (STOP C); after the delay time has expired, STOP C → SOS" (in the example 500 ms) is switched to SOS. The other drive is not affected by this.

7.3 Summary of input signals

Table 7-2: Sinamics digital inputs

Digital input	Switch	Component	Description
DI 0	-S5	Drive 1 / drive 2	Switching-on/switching-off
DI 1	-S6	Drive 1 / drive 2	Changeover speed setpoint (fixed setpoint) bit 0
DI 2	-S7	Drive 1 / drive 2	Changeover speed setpoint (fixed setpoint) bit 1
DI 6	-S10	Drive 1 / drive 2	Acknowledge alarms
DI 7	-S9	Drive 1 / drive 2	Initiate a test stop

Fig. 7-3: Fail-safe inputs on the F-DI module

Digital input	Switch	Component	Description
F-DI 0	-S1	Emergency Stop button	Drive 1: SS1
			Drive 2: SS1
F-DI 1	-S2	Protective door 1 (for drive 1)	SLS
F-DI 2	-S3	Protective door 2 (for drive 2)	SLS
F-DI 3	-S4	Acknowledgement button	Fail-safe acknowledgement (drives 1 and 2) and depassivation (all F-slaves)

Note	The drives can only be operated when the infeed is activated and the DC link charged.

8 References

8.1 Related documents

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

Table 8-1: References

	Topic	Title
/1/	SINAMICS S120	Function Manual, Edition 01/2011
/2/	SINAMICS S120	Manual, Edition 01/2011
/3/	SINAMICS S120	List Manual, Edition 01/2011

8.2 Internet links

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

Table 8-2: Internet link reference

	Topic	Title
\1\	Reference to the article	http://support.automation.siemens.com/WW/view/de/29056318
\2\	Siemens I IA/DT Customer Support	http://support.automation.siemens.com

9 History

Table 9-1: History

Version	Date	Revision
V1.0	05/2008	First edition
V1.1	07/2009	Revision
V2.0	07/2011	Revision with SINAMICS V4.4 and STARTER 4.2