Control of the Safety Integrated Extended Functions for the CU320-2 (with FW V4.4) in conjunction with EPOS

SINAMICS S120

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SINAMICS S120
Safety Integrated

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Automation task 1

Automation solution 2

Basic principles 3

Installation 4

Configuration and project engineering 5

Commissioning the application 6

Using the application 7

References 8

History 9

Warranty and liability

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Table of contents

Warranty and liability **4**

1 Automation task **6**

2 Automation solution **9**

2.1 Overview of the complete solution 9
2.2 Description of the core functions 11
2.3 Hardware and software components used 12

3 PROFIsafe communication **15**

4 Installation **16**

5 Configuration and project engineering **18**

5.1 Passwords 18
5.2 Preparation 19
5.3 HW configuration 21
5.4 Configuring the basic drive functions 30
5.5 Generating the standard program 38
5.6 Parameterizing the safety functions integrated in the drive 49
5.7 Configuring the F-CPU 55
5.8 Acceptance test 64

6 Commissioning the application **65**

6.1 Preconditions 65
6.2 Preparation 65
6.3 Commissioning 66

7 Using the application **69**

7.1 Overview 69
7.2 Description 70
7.3 Summary of input signals 71

8 References **72**

8.1 Related documents 72
8.2 Internet links 72

9 History **73**

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

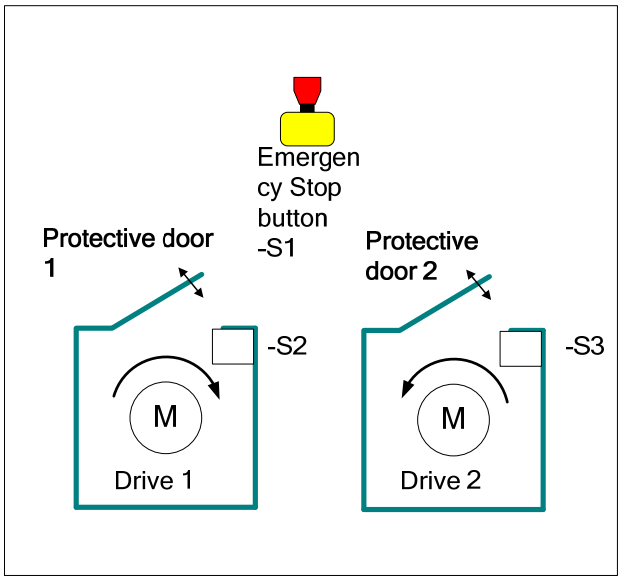
Name	Function	Description
STO	Safe Torque Off	Safe disconnection of the torque-generating power supply to the motor. The switching on inhibited function prevents the drive from restarting. (Stop function, Category 0 according to EN 60204-1)
SBC	Safe Brake Control	SBC is only used when there is a motor brake; the motor brake is connected to the power connector via 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 < nx).
SDI	Safe Direction	Safe monitoring of the direction of motion (positive and negative directions). Parameterizable shutdown response when traversing/traveling in the disabled direction.

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

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

Overview of the automation task

Fig. 1-2: Concept of the safety functions



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

Table 1-2: Safety functions of the application example

Safety function	Description	Reaction
SF1	Actuation of the Emergency Stop pushbutton	Drive 1 is stopped with immediate pulse suppression (STO). Fast stopping of drive 2 → subsequent pulse suppression (SS1).
SF2	When protective door 1 is open, drive 1 may not exceed a velocity/ speed configured by the user.	Speed monitoring at drive 1 (SLS).
SF3	When opening safety door 2, drive 2 must be quickly stopped. Drive 2 must then be held at standstill and the standstill position safely monitored.	Interrupt positioning, perform application-specific braking and, at the same time, select SOS.

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

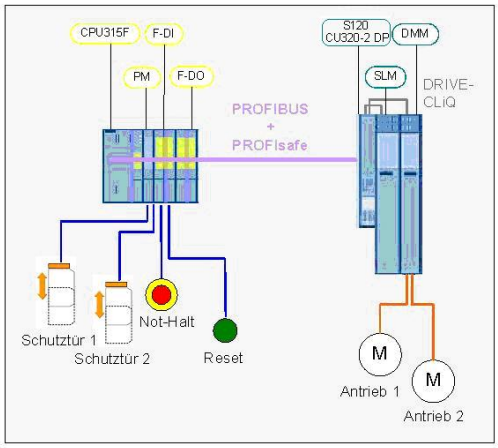
2 Automation solution

2.1 Overview of the complete solution

Schematic

The most important components of the solution are schematically shown in the following diagram:

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



This function example shows how the STO, SS1, SOS 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. Position control and motor control is carried out by a Control Unit CU320-2 DP. 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; there, they control the safety functions.

Configuration

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,
- of the general drive functions of the SINAMICS S120, and
- of the hardware interfaces of the CU320-2.

It is assumed that readers have a basic knowledge about these topics.

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

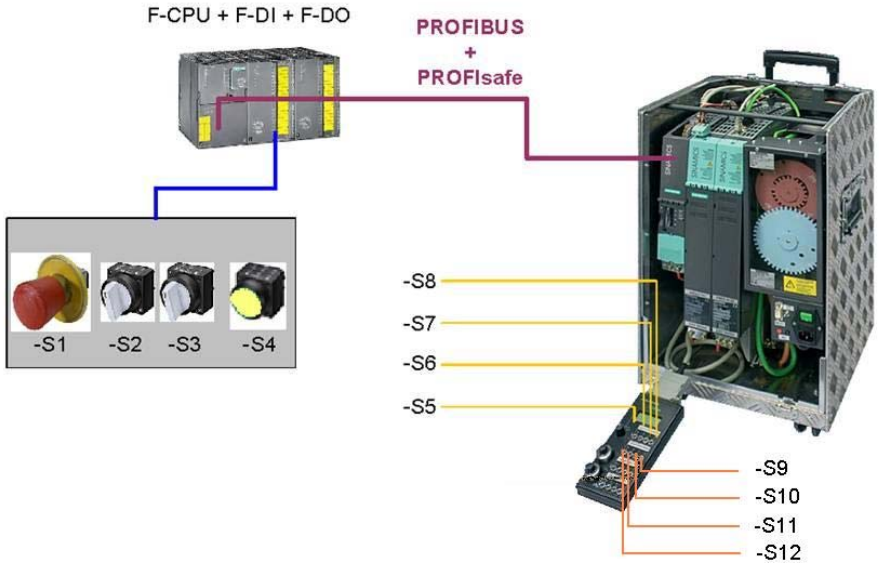
Knowledge required

It is assumed that readers have knowledge about configuring SINAMICS S120 drives with the STARTER or SIMOTION SCOUT engineering software and STEP 7.

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. The drive is switched on and switched off using these switches, traversing programs started, the test function of the safety functions initiated and active faults acknowledged.

When Emergency Stop is requested, drive 1 is stopped using the STO safety function integrated in the drive and drive 2 is stopped with SS1.

Two switches in the SAFETY training case simulate one protective door each for drives 1 and 2. When protective door 1 is opened, the SLS function is selected for drive 1, which reduces the velocity setpoint via the external maximum velocity of EPOS. When closing protective door 1, SLS is deactivated and the reduced velocity is canceled by the application program. The drive can now be operated again with the configured velocity.

When protective door 2 is opened, drive 2 brakes using the EPOS Intermediate stop function, while SOS is selected simultaneously. The drive must come to a standstill before SOS is activated (be sure to configure the delay time correctly). When the door is closed, axis 2 restarts (the SOS function is deselected). The other drive is not influenced.

Other versions to control the safety functions integrated in the drive using the TM54F terminal expansion module as well as control using PROFIsafe with PROFINET are described in additional function 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 used

The application was created using 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

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 marked 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
SCOUT	V4.2.1.0	6AU1 810-1BA42-1XA0	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 STARTER & DRIVE ES Basic can be used as an alternative to SIMOTION SCOUT 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: Delivery state of the application example

Component	Note
MC_FE_I_009_V20.zip	Zipped project
36813720_MC_FE_I_009_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 configuration of the application.

Fig. 4-1: Overview of the hardware structure

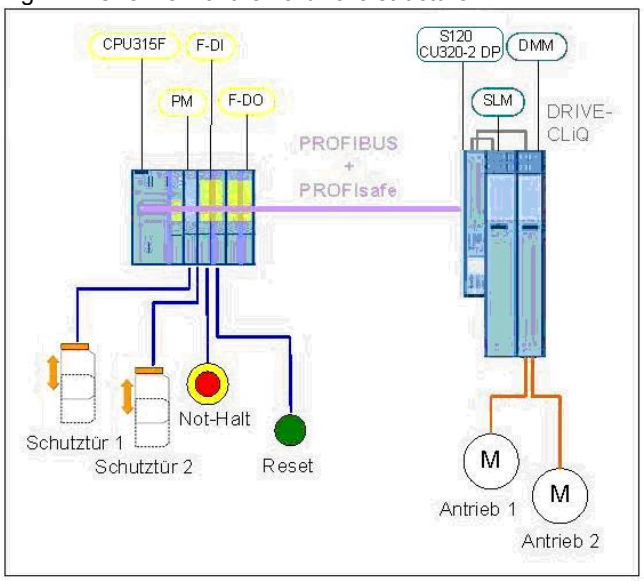


Fig. 4-2: DRIVE-CLiQ interconnection of the SINAMICS components

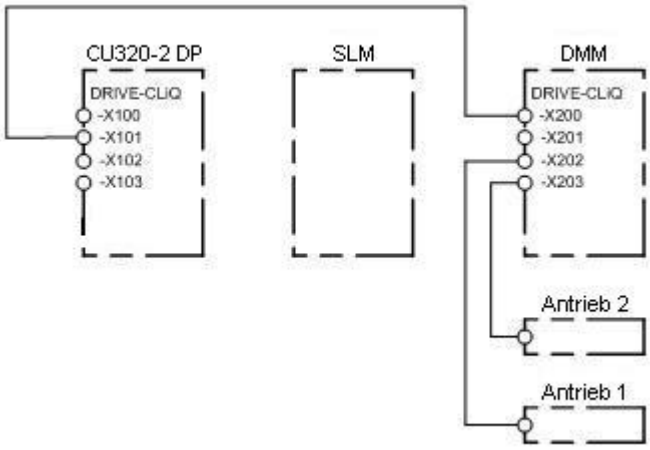
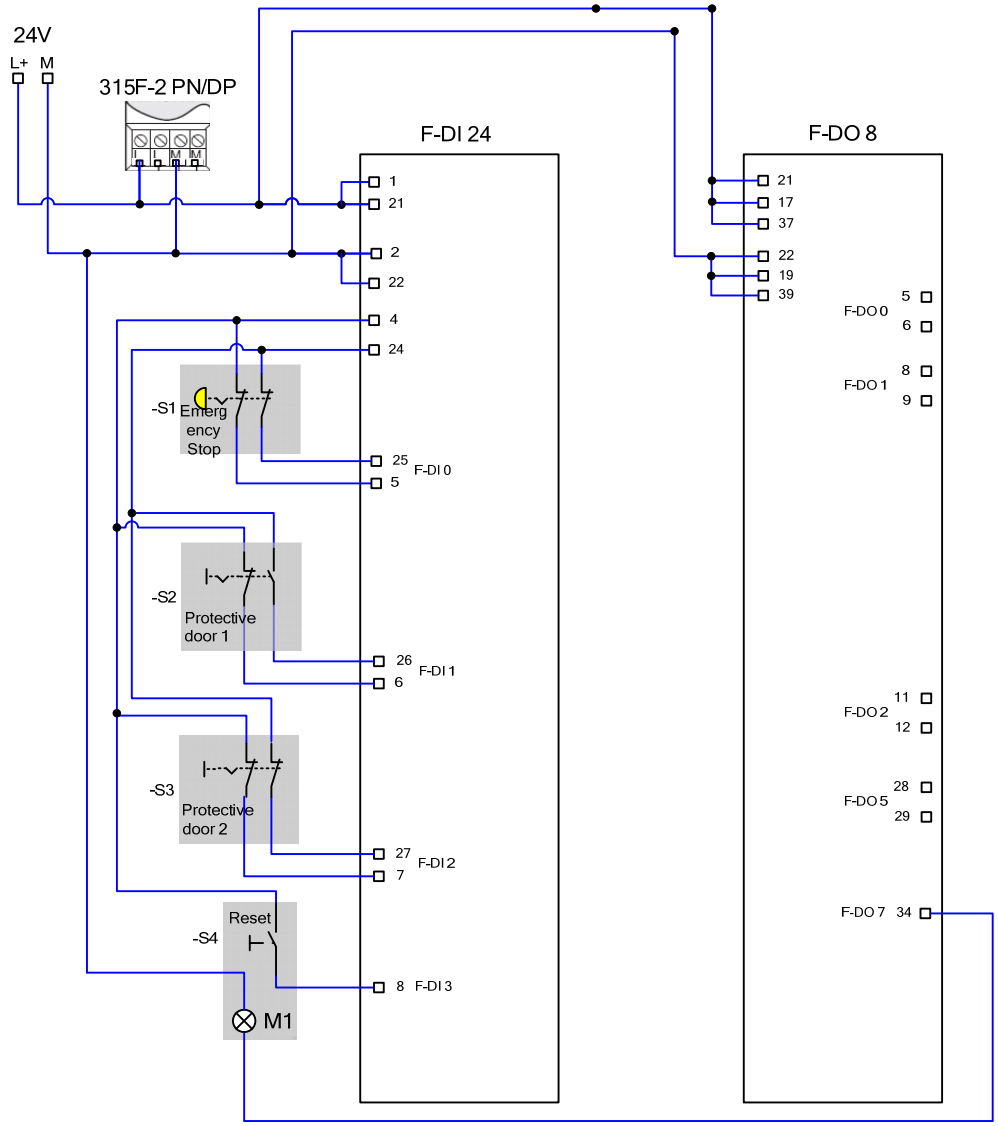


Fig. 4-3: Wiring of the control voltage at the Safety training case



5 Configuration and project engineering

In this chapter, you get to know how the individual components must be parameterized. SIMOTION SCOUT is used as the engineering software for the SINAMICS S120. STEP7 and Distributed Safety are required for programming the F-CPU.

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

Note Most of the screenshots were created with the "English" language setting. For other languages, it is possible that the screenshots look slightly different.

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.

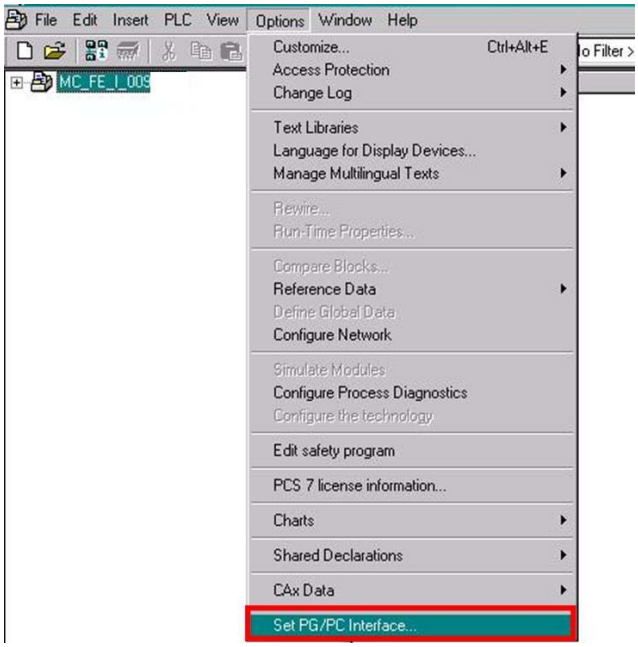
- Safety password for the F-CPU: "0"
- Safety password for SINAMICS: "1"

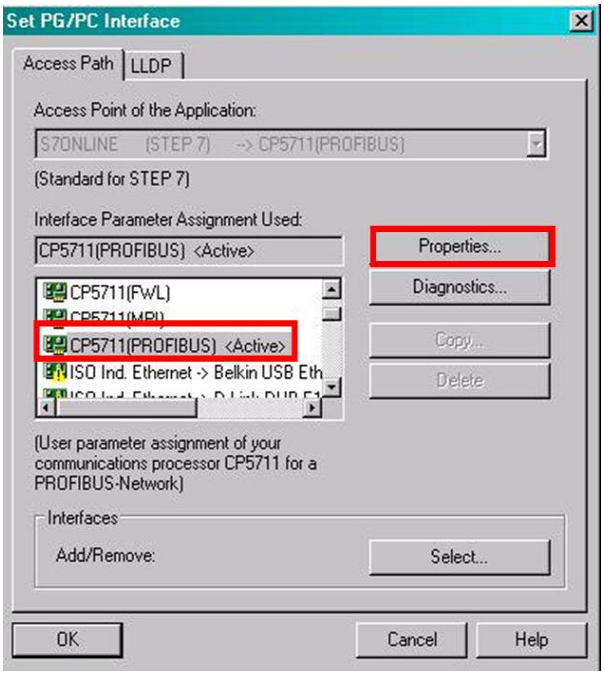
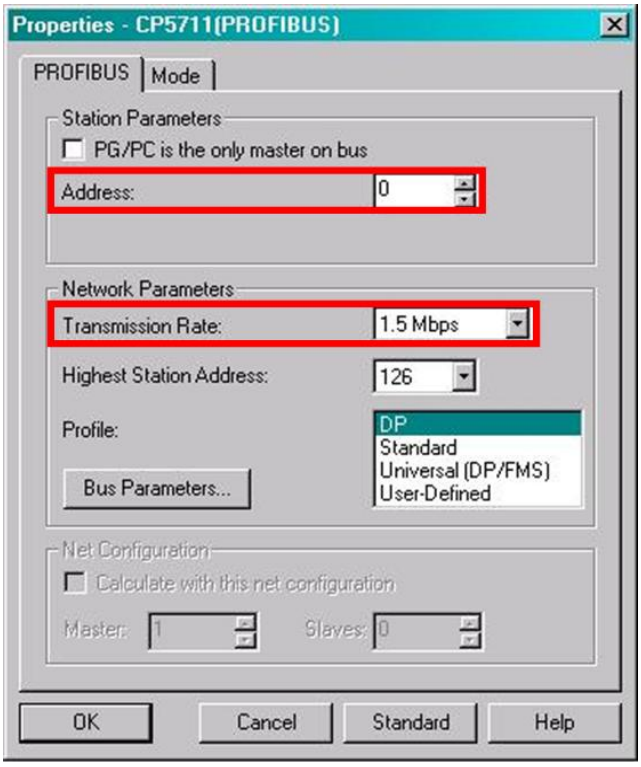
These passwords should not be used for real applications!

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 to input control word 1 (PROFIdrive data) with the exception of bit 0 (On/Off1 enable).

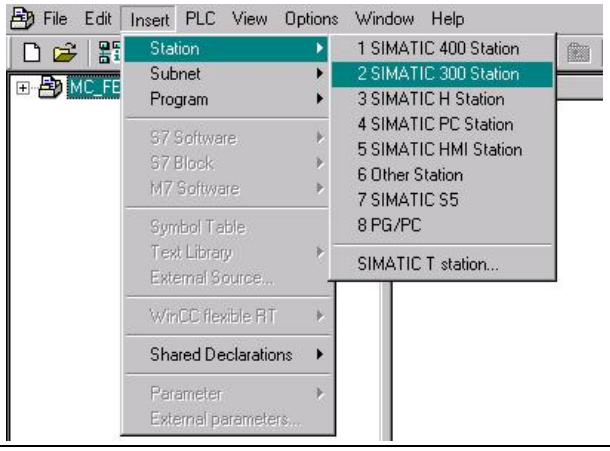
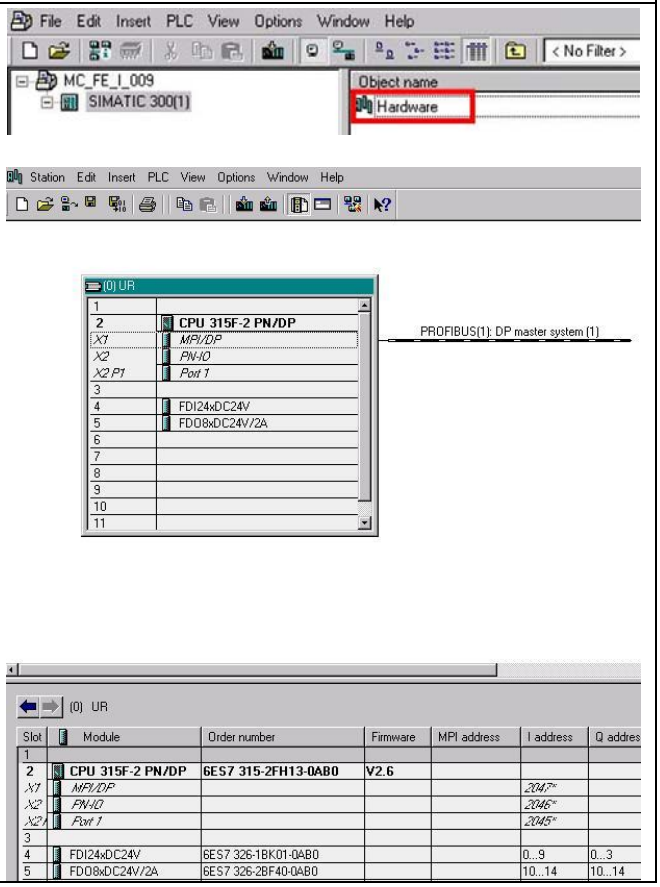
Table 5-1: Setting the interfaces and assigning the PROFIBUS address

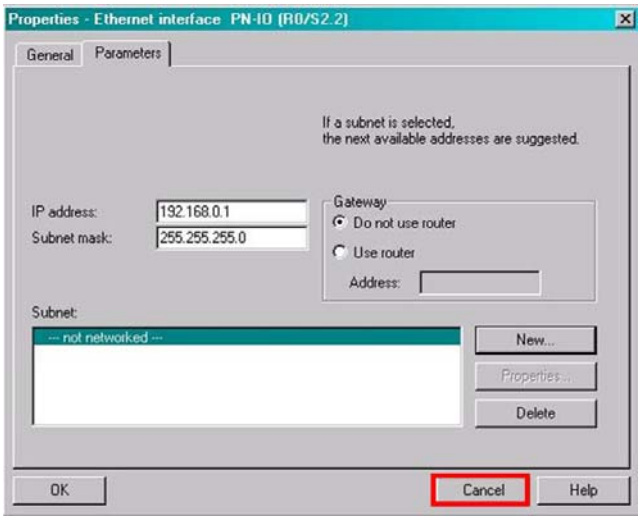
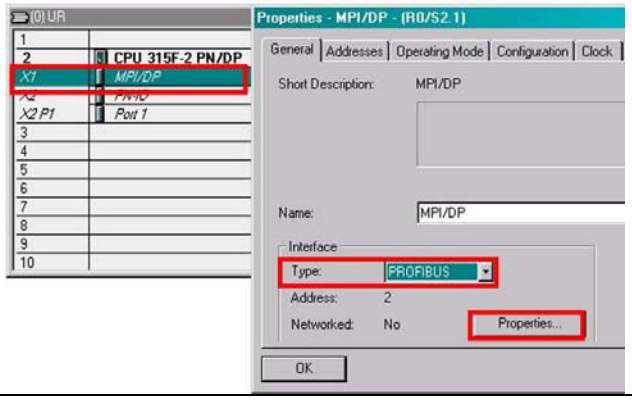
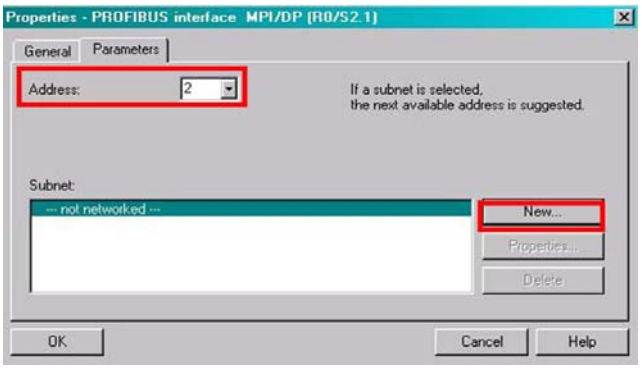
No.	Action	Remark
1.	Open the Simatic Manager in order to go online on the SIMATIC control. Then click on „Options“ → „Set PG/PC Interface“.	

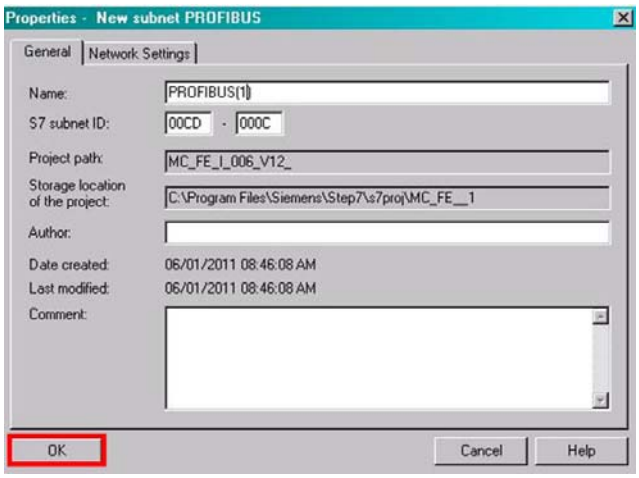
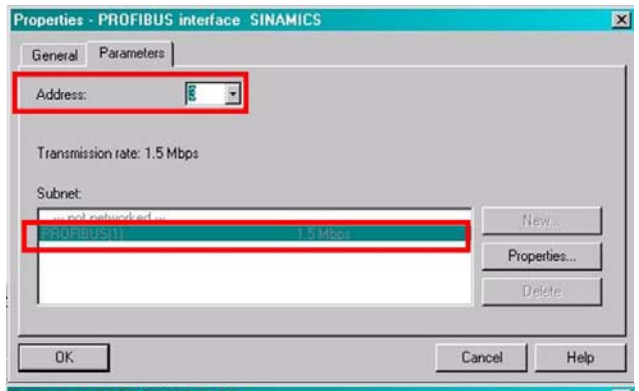
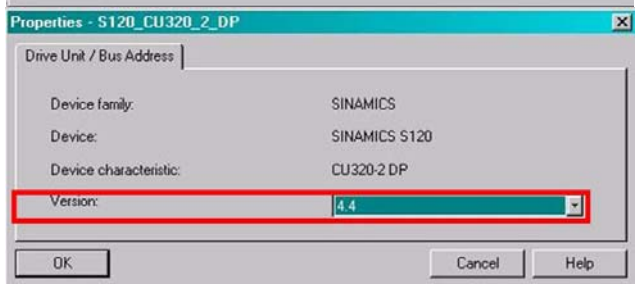
No.	Action	Remark
2.	The adapter, which is used to go online, is now selected. In this case, it is the "CP5711(PROFIBUS)" → Now click on "Properties".	
3.	The Profibus address "0" for the PG is defined here. The transmission rate is also set here. → OK	
4.	The PROFIBUS addresses of Sinamics and the F-CPU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

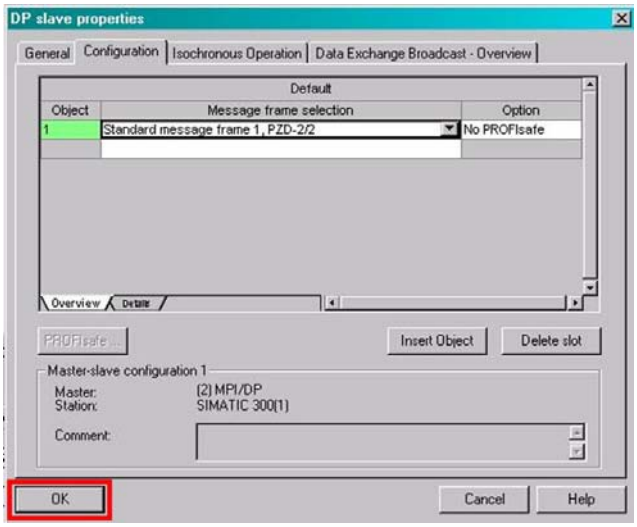
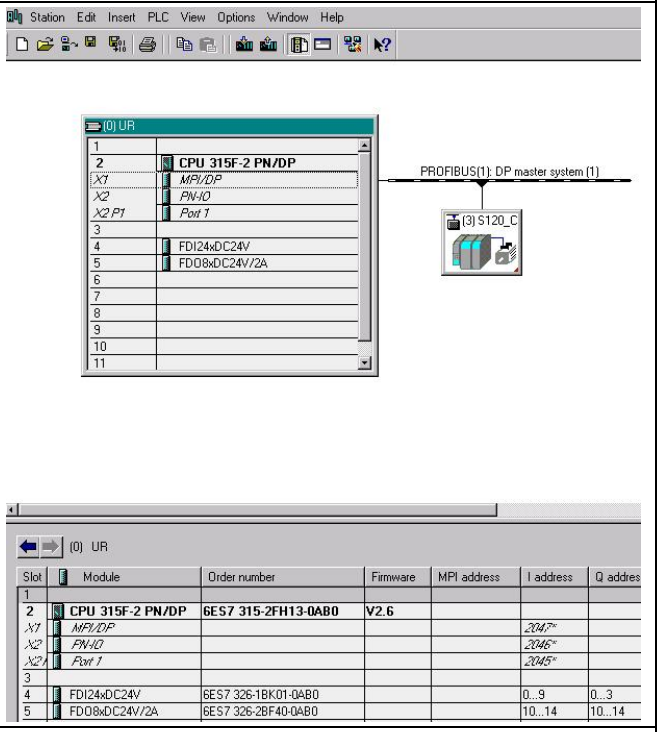
5.3 HW configuration

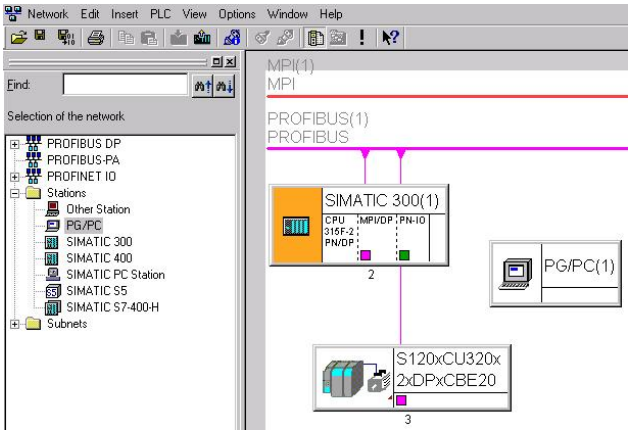
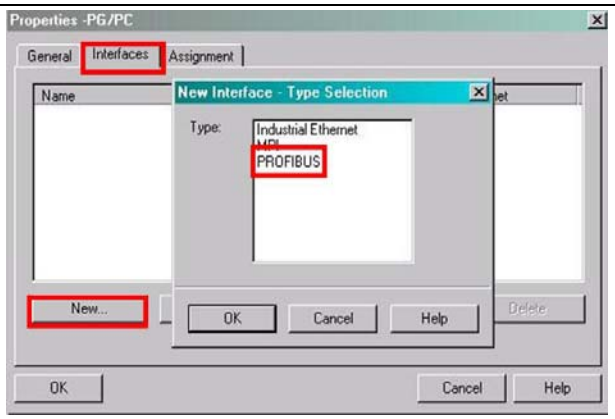
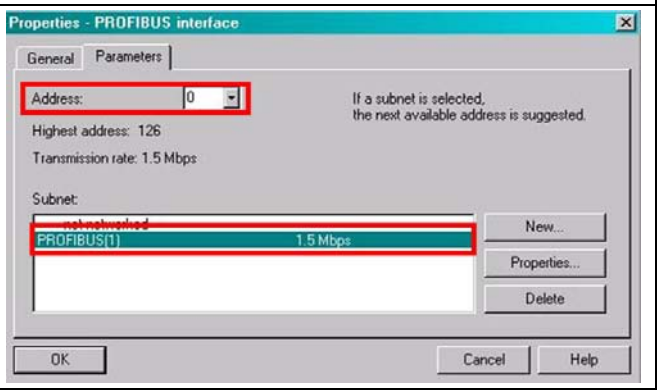
Table 5-2: HW configuration

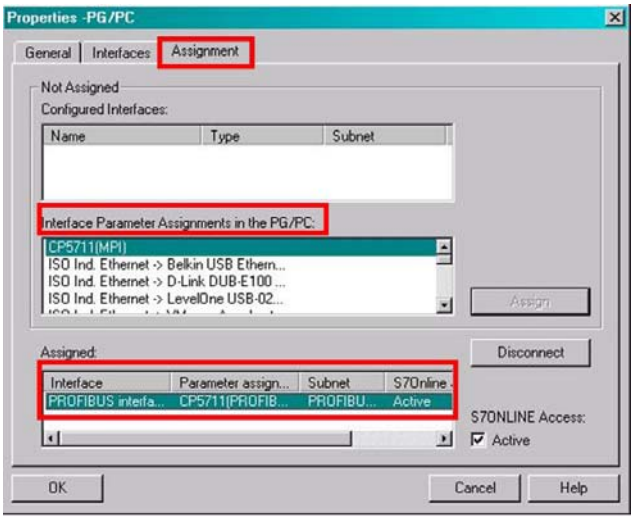
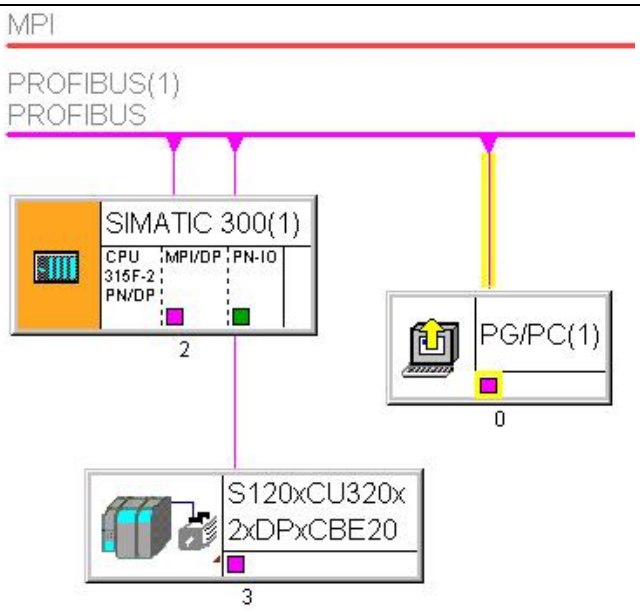
No.	Action	Remark
1.	In the SIMATIC Manager, insert a SIMATIC 300 station into the project.	
2.	Double click on "Hardware". Completely create and parameterize the station in HW Config. To do this, drag the modules contained in the parts list of Chapter 2.3 from the catalog window and drop them into the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

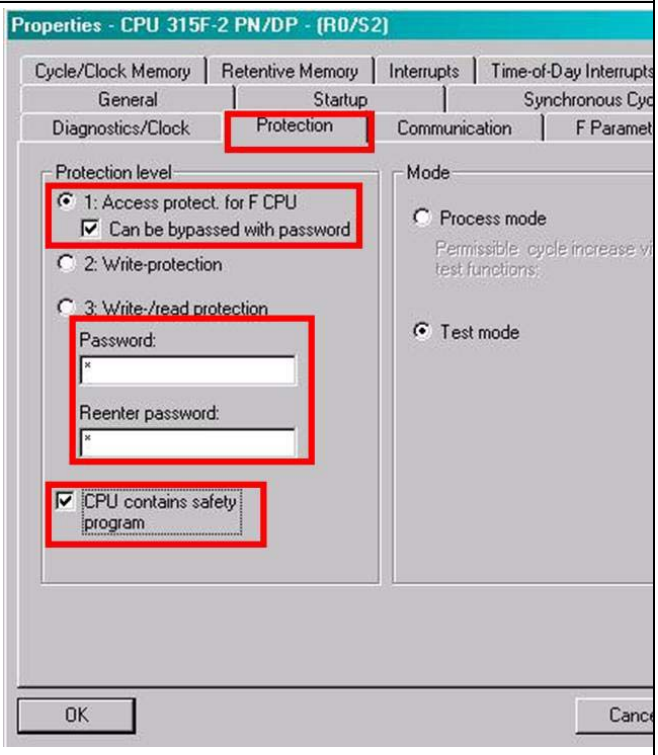
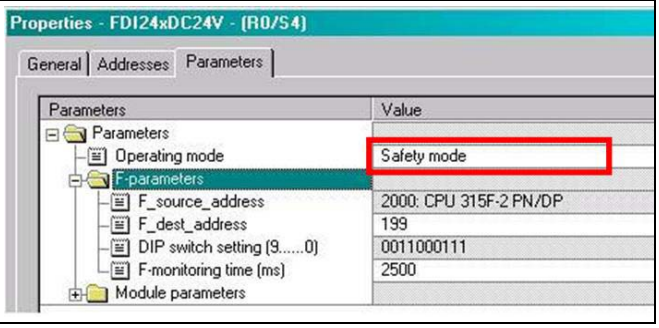
No.	Action	Remark
3.	When inserting the F-CPU, the adjacent window is displayed. Simply close this with "Cancel".	
4.	Then double-click on "MPI/DP" and select "PROFIBUS" in the following window - and then click "Properties".	
5.	The adjacent window opens. PROFIBUS address "2" is selected here, and then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

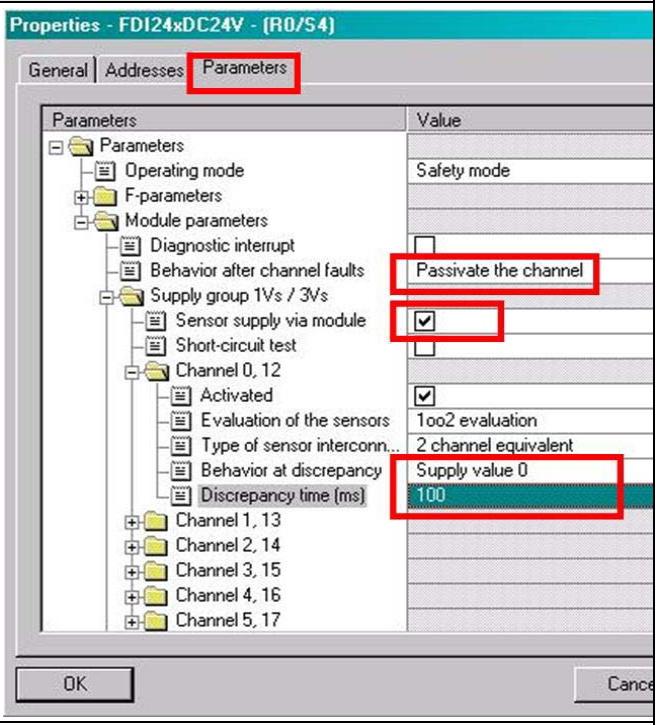
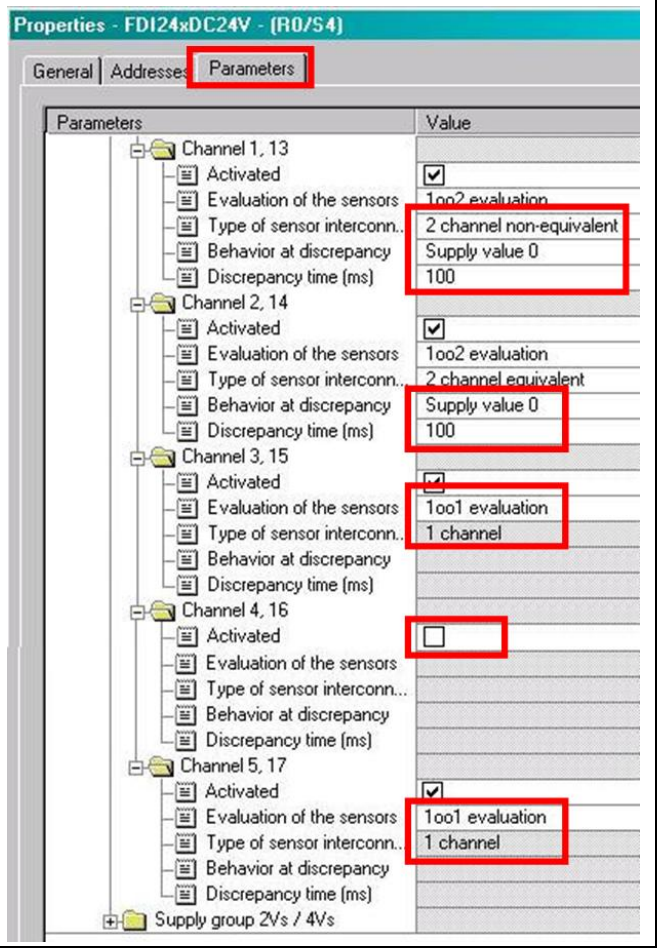
No.	Action	Remark
6.	Acknowledge with OK A PROFIBUS line is now created.	
7.	When inserting the Sinamics S120 from the catalog into the configuration window, the adjacent windows appear in HW Config. PROFIBUS address "3" is selected here. Also select the Profibus connection that has already been created. → OK In the following window, select Version 4.4.	 

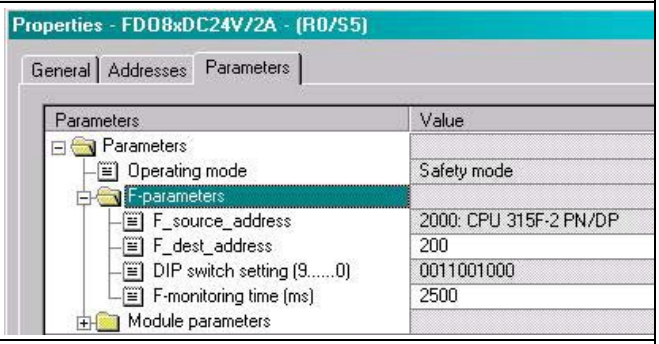
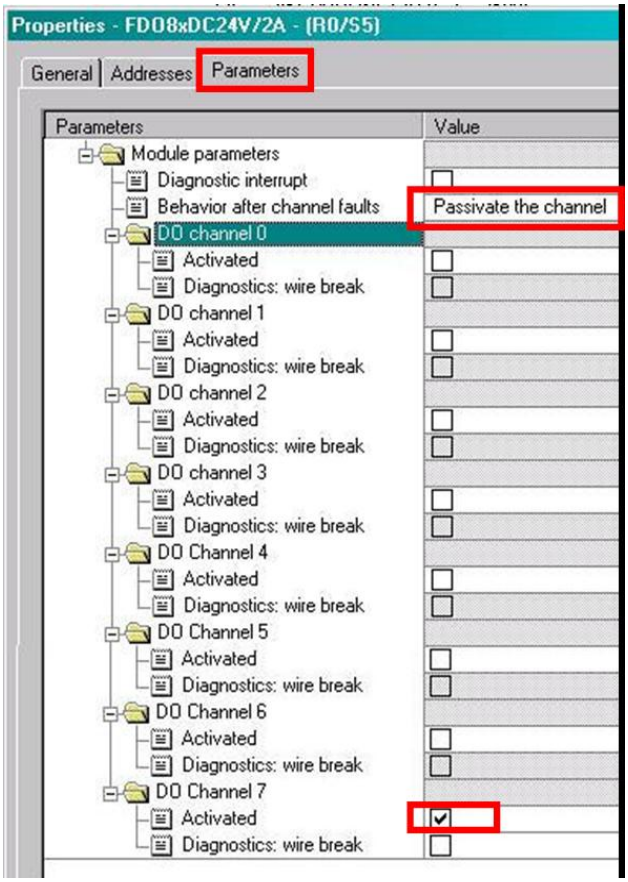
No.	Action	Remark
8.	The adjacent window appears automatically and is confirmed with OK. The PROFIsafe slot is inserted into SCOUT at a later stage.	
9.	The hardware configuration should then look like this.	
10.	Saving and compiling.	
11.	Open NetPro, as the programming device still has to be inserted. To do this, click on "Configure Network".	

No.	Action	Remark
12.	Drag the "PC/PG" object from the "Stations" folder and drop in the work area. Open the properties window by double-clicking on PG/PC(1).	
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.	

No.	Action	Remark
15.	The interface must now be assigned 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.	
16.	The PG is now available with active interface (yellow line).	
17.	Saving and compiling. Then close NetPro.	

No.	Action	Remark
18.	**Configuring the F-CPU** Open the 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 password "0". Activate the safety program (set the check mark for "CPU contains safety program").	
19.	**Configuring the F-DI module** Configure the PROFIsafe address using DIL switches. Double-click on the F-DI in HW Config to do this. Select "Safety mode".	

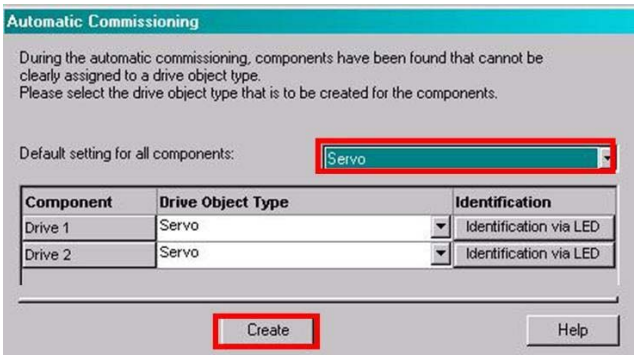
No.	Action	Remark
20.	**Configuring the F-DI module** Configuring F-DI 0 (channel 0, 12)	
21.	**Configuring the F-DI module** Configuring F-DI 1 (channel 1, 13) Configuring F-DI 2 (channel 2, 14) Configuring F-DI 3 (channel 3, 15) Configuring F-DI 5 (channel 5, 17)	

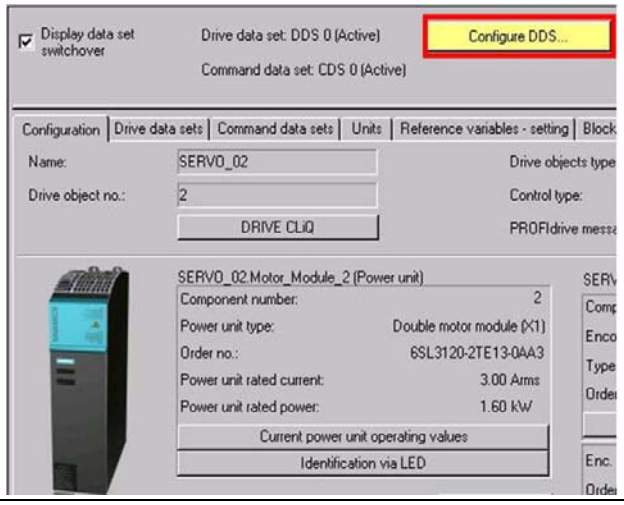
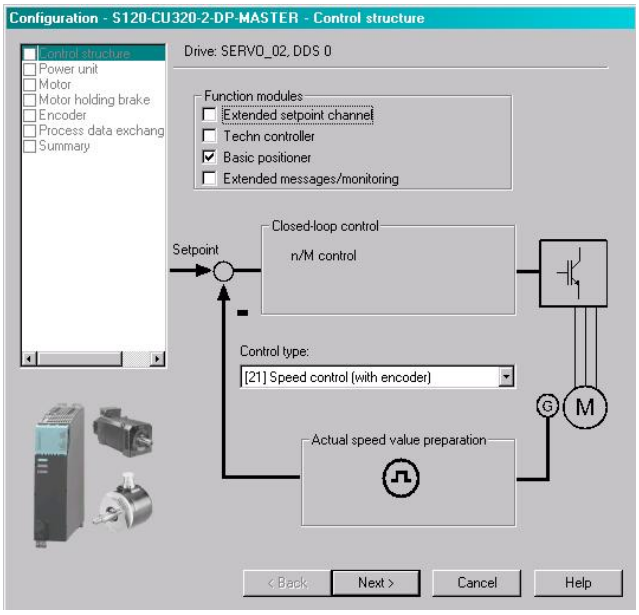
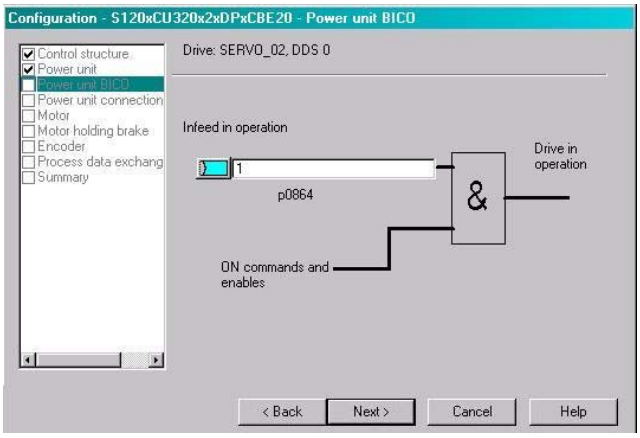
No.	Action	Remark
22.	**Configuring the F-DO module** Configure the PROFIsafe address using DIL switches. Double-click on the F-DO in HW Config to do this.	
23.	**Configuring the F-DO module** Configuring F-DO 7	
24.	Save HW Config and compile.	
25.	Download HW Config to the F-CPU	

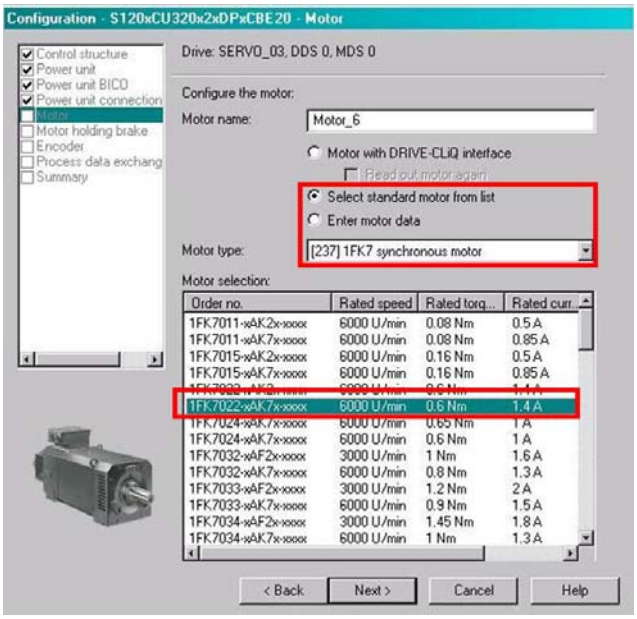
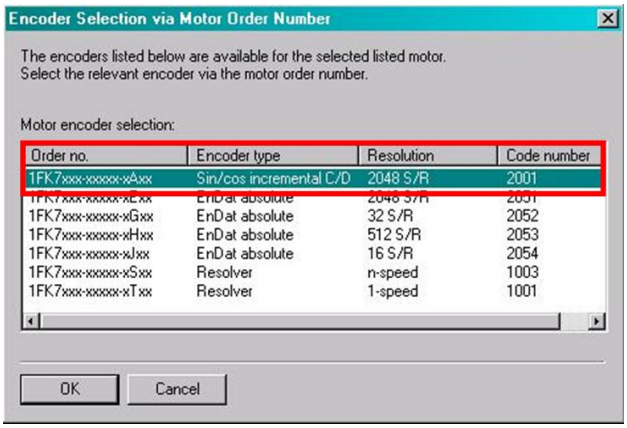
5.4 Configuring the basic drive functions

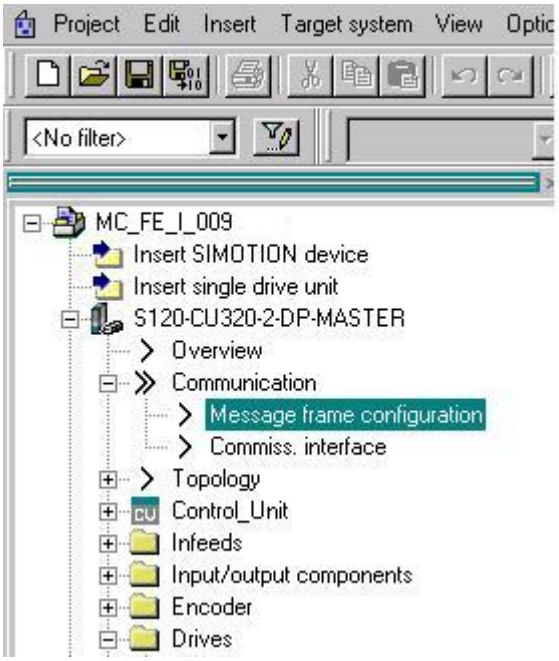
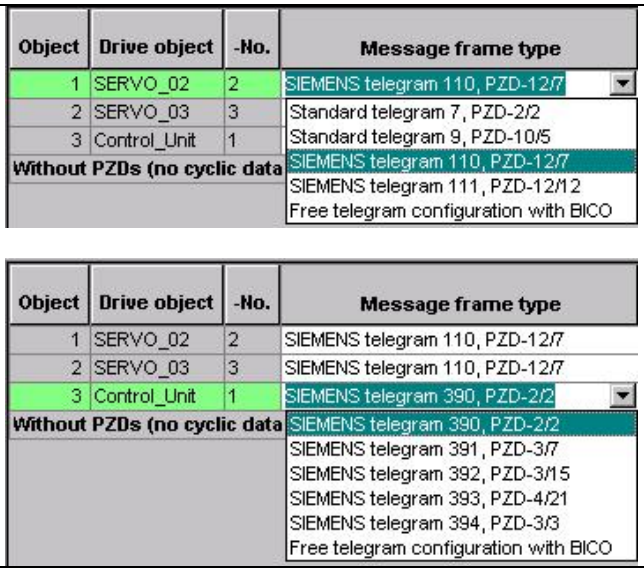
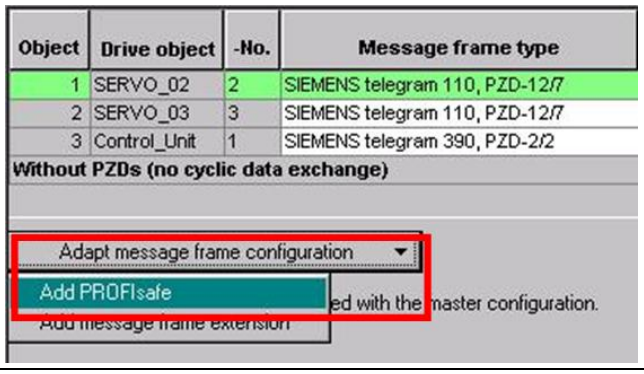
First of all, the existing hardware in the drive system must be commissioned and the desired motion functions set up.

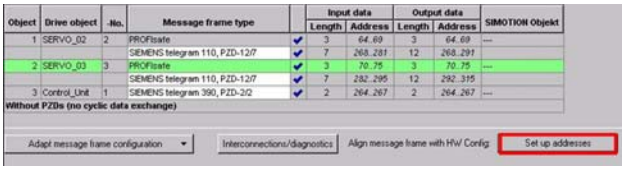
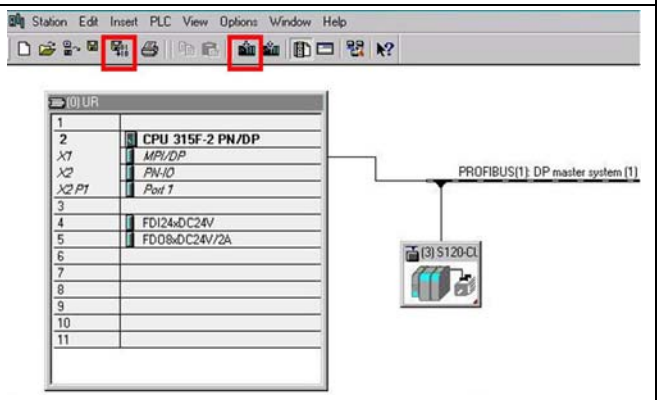
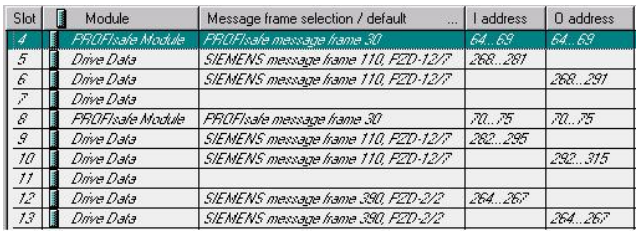
Table 5-3: Configuring the basic functions

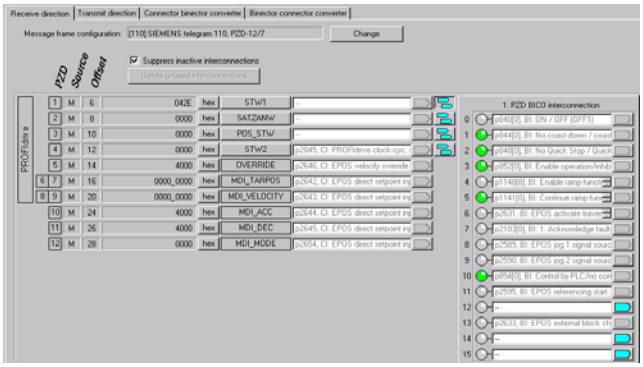
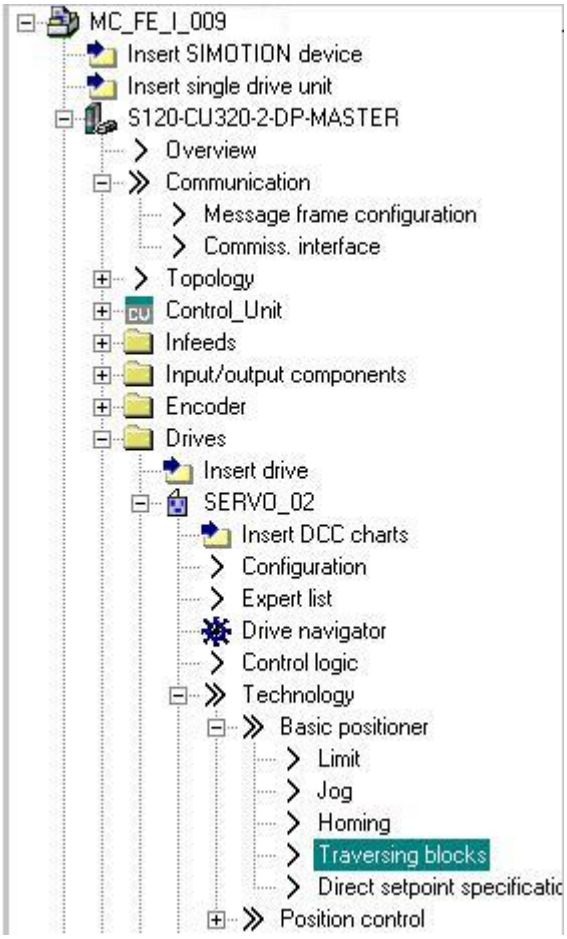
No.	Action	Remark
1.	Open SCOUT from the SIMATIC project. To do this right-click on SINAMICS in HW Config. Click on "Open Object with SIMOTION SCOUT".	
2.	Go online.	
3.	Restore factory settings.	
4.	Start the automatic configuration of the drives.	
5.	Select "Servo" as the drive object and create with "Create".	
6.	Go offline.	
7.	Save.	

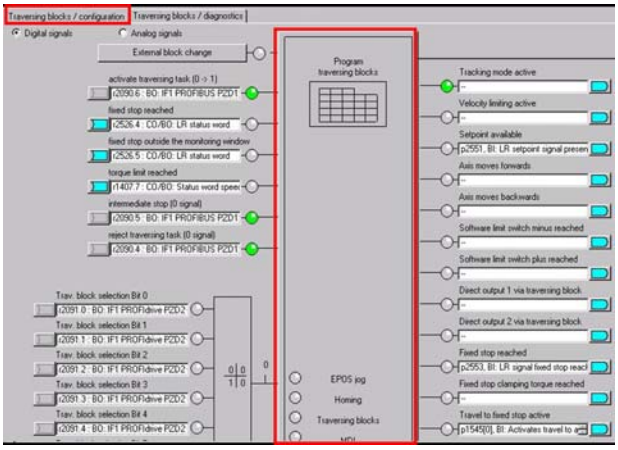
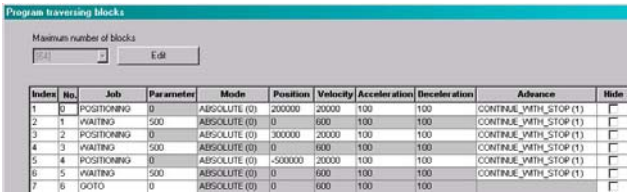
No.	Action	Remark
8.	**Post configuration, both drives** In the project navigator for drive 1 or drive 2 (SERVO_02 or SERVO_03), open the "Configuration" window . "Configure DDS" starts the prompted post configuration. **Note** In the following, only those screen forms are described in which a change is required.	
9.	**Post configuration, both drives** Under "Function modules" →, activate "Basic positioner".	
10.	**Post configuration, both drives** A signal to "Infeed in operation" (p0864) is required for operation. Here, fixed binector 1 is used in the example. **Note** In a real application, fixed binector 1 should not be used as a signal for "Infeed in operation" (p0864).	

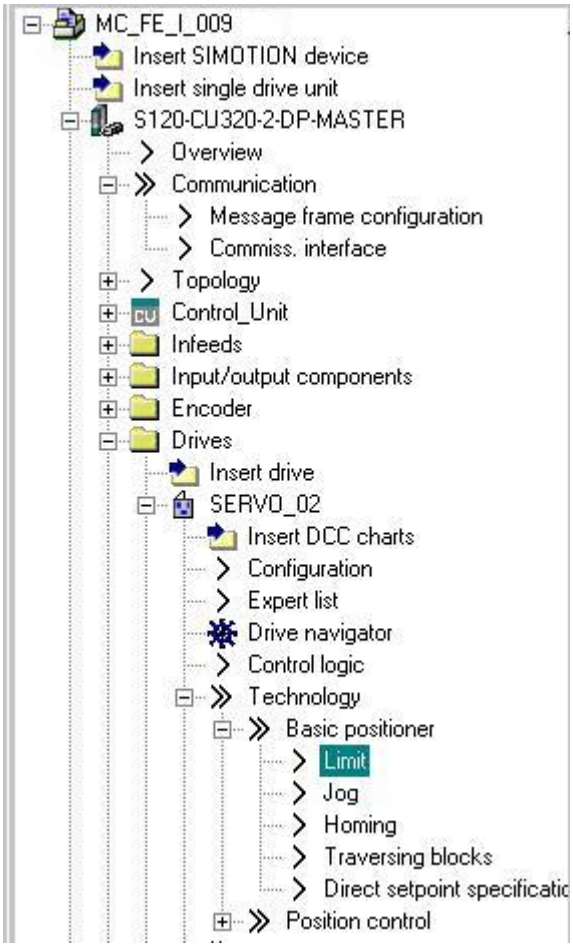
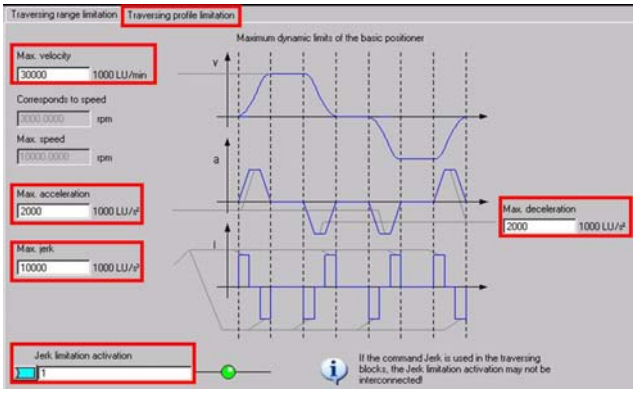
No.	Action	Remark
11.	**Post configuration, drive 2** The second drive does not have a Drive-CLiQ encoder; the motor must be manually selected. A 1FK7022 - 5AK71 - 1AG0 motor is used in the example.	
12.	**Post configuration, drive 2** Just like the motor, the encoder must also be manually selected. 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** 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.	

No.	Action	Remark
19.	**Telegram configuration** The telegram configuration can be found under "Communication" and then "Message frame configuration".	
20.	**Telegram configuration** Select SIEMENS telegram 110 for both drives. SIEMENS telegram 390 is selected for the CU.	
21.	**Telegram configuration** For both drives, using the "Adapt message frame configuration" button, create a PROFIsafe slot.	

No.	Action	Remark
22.	**Telegram configuration** Then, transfer the configuration to HW Config. To do this, click on "Set up addresses". The telegram configuration should now look like this, as shown in the diagram. The addresses can possibly deviate.	
23.	**Telegram configuration** HW Config must now be saved, compiled and downloaded again in the Simatic Manager.	
24.	**Note** The telegram selection was automatically entered in HW Config in the Simatic Manager. The specified address can be changed here.	
25.	**Configuring both drives** If a Single Line Module is used for 230V 1AC (included in the training cases), then the DC link parameters should be adapted. **Note** Since the 5 kW SLM has no DRIVE-CLiQ interfaces, it is not necessary to parameterize the infeed.	p0210: 345V p1248[0]: 240V p1244[0]: 401V p1135[0]: 0.5s See also FAQ ID: 27038754

No.	Action	Remark
26.	By selecting standard telegrams, all the interconnections required for the example were created automatically.	
27.	**Configuring both drives** The traversing blocks are now programmed on both drives. To do this, first click on „Technology“ → „Basic positioner“ and then „Traversing blocks“.	

No.	Action	Remark
28.	**Configuring both drives** Under the "Traversing blocks/configuration" tab, select the button in the red frame.	
29.	**Configuring both drives** The traversing blocks are programmed here. Deviating from this example, the other EPOS functions, such as JOG and MDI can also be used.	

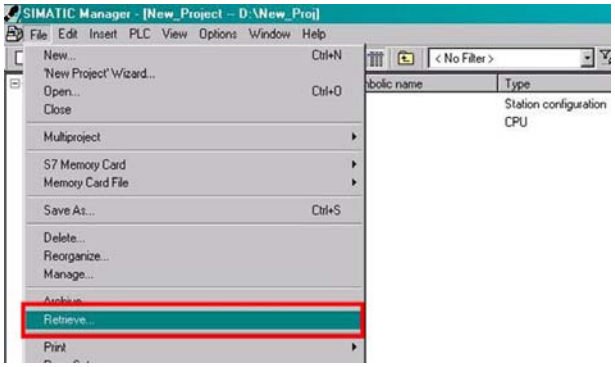
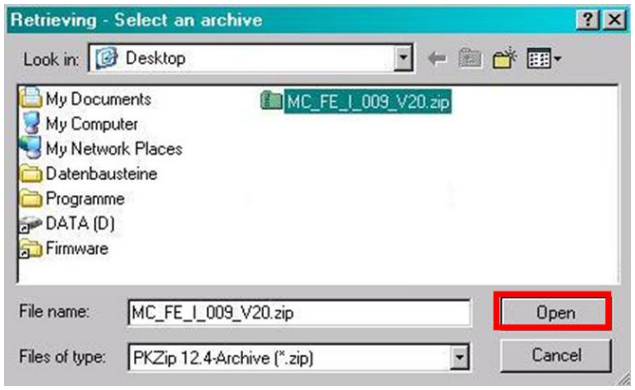
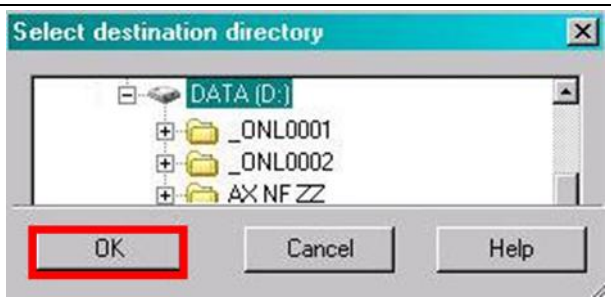
No.	Action	Remark
30.	**Configuring both drives** The traversing profile limits are now adapted. For this purpose, under the tab "Technology" → " "Basic positioner", open the screen form "Limit".	
31.	**Configuring both drives** Under the "Traversing profile limitation" tab, set the following: - Max.velocity: 30000 1000LU/min - Max. acceleration: 2000 1000LU/s² - Max. jerk: 10000 1000LU/s² - Max. deceleration: 2000 1000LU/s² - Jerk limitation activation: 1	
32.	Save the project.	
33.	Go online.	
34.	Load the project into the target device.	
35.	Copy from RAM to ROM.	

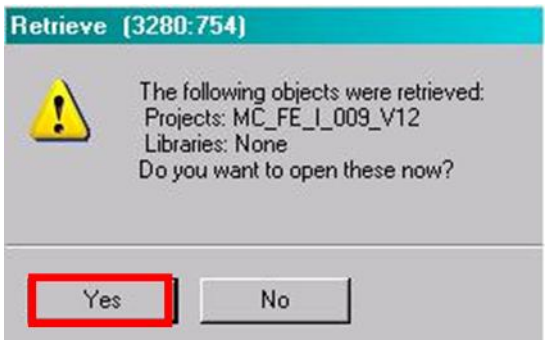
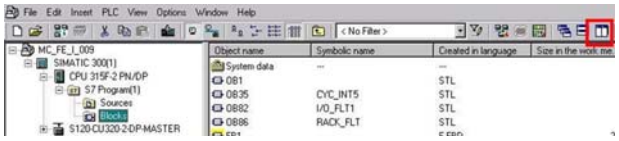
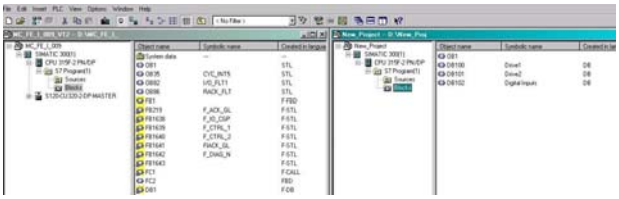
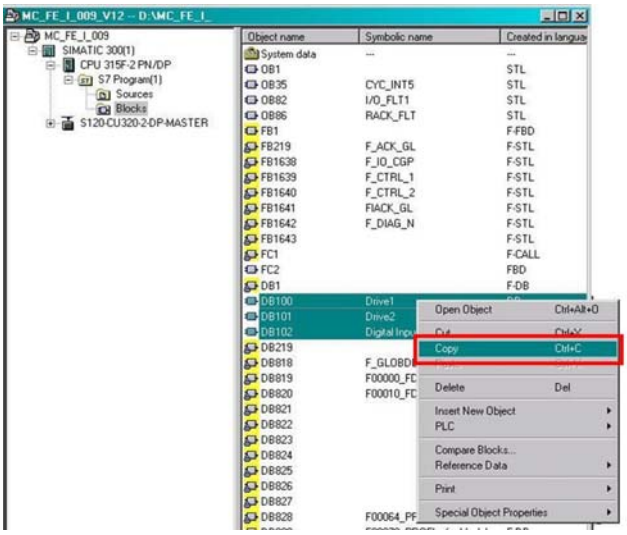
5.5 Generating the standard program

The following symbol has been used for programming the standard program.

Note Data blocks DB100 – DB102 can be newly created (assignment, see Table 5-5); however, here it is recommended that the blocks are imported from the project example. This is shown in the following table.

Table 5-4: Inserting data blocks from the project example

No.	Action	Remark
1.	The project example is first dearchived. To do this, click on the „File“ → „Retrieve“.	
2.	The zip "MC_FE_I_009_V20.zip" file contained in the project example is now opened.	
3.	A search is then made for the memory location where the file should be saved.	

No.	Action	Remark
4.	Here, you are prompted as to whether the project should be opened. Click on "Yes".	
5.	The project that you created and the project example can now be shown next to one another if you click on the button in the red frame.	
6.	The view in the SIMATIC Manager is the same as shown in the diagram.	
7.	Data blocks DB100 - DB102 are now selected in the project example and copied.	

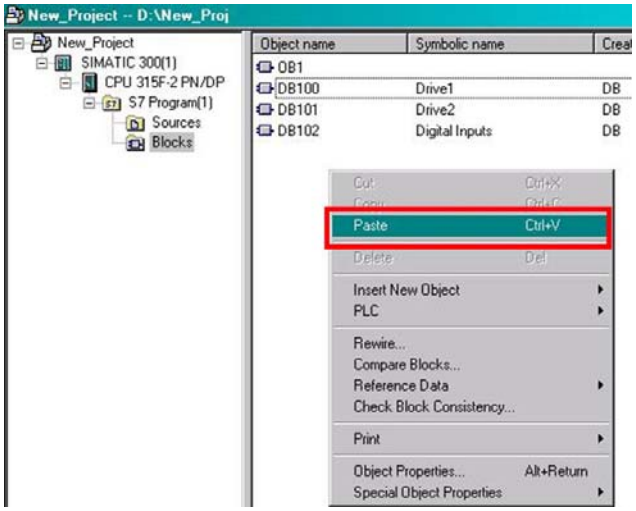
No.	Action	Remark
8.	Finally, the blocks are linked into your project with a „right click“ → „Paste“.	

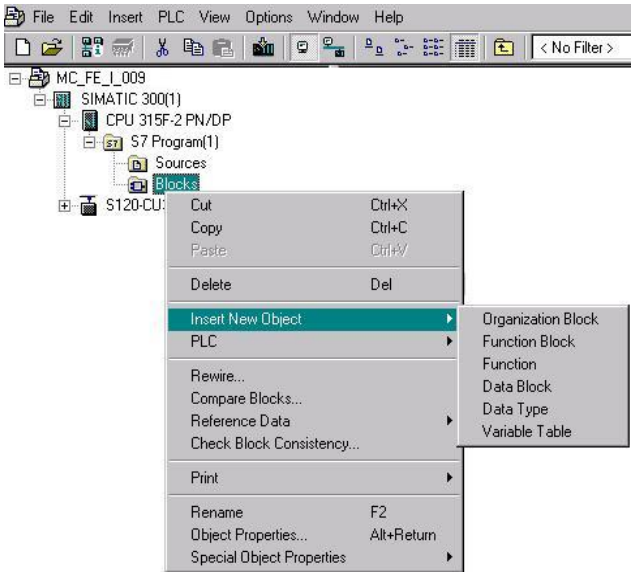
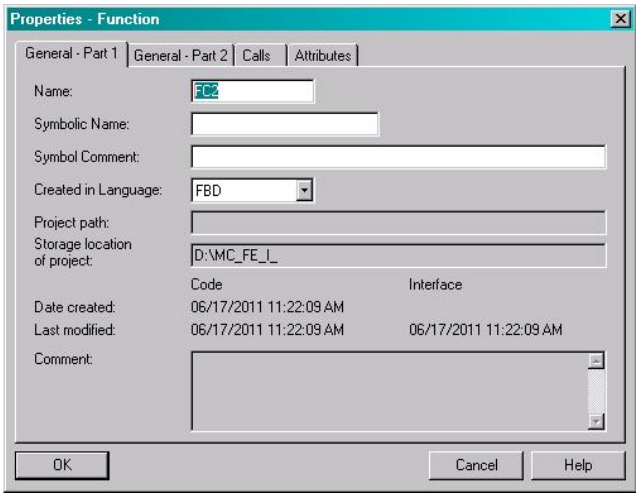
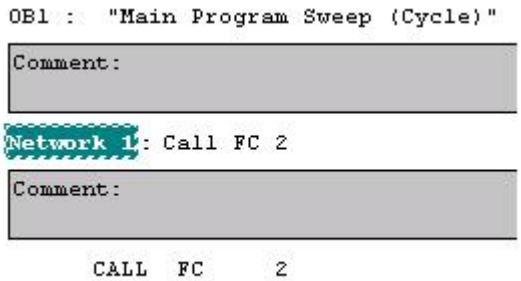
Table 5--5 table of the symbols used

Symbol	Address
"Drive1".WR_PZD_POSBETR	DB100.DBX0.0
"Drive1".WR_PZD_POSBETR.STW1.Aus1	DB100.DBX1.0
"Drive1".WR_PZD_POSBETR.STW1.Fahrverwerf	DB100.DBX1.4
"Drive1".WR_PZD_POSBETR.STW1.Fahr_akt	DB100.DBX1.6
"Drive1".WR_PZD_POSBETR.STW1.Stoer_ruecks	DB100.DBX1.7
"Drive1".WR_PZD_POSBETR.PosStw.Referenzpunkt_setzen	DB100.DBX5.1
"Drive1".RD_PZD_POSBETR	DB100.DBX24.0
"Drive1".RD_PZD_POSBETR.ZSW1.Referenzpunkt_gesetzt	DB100.DBX24.3
"Drive1".RD_PZD_POSBETR.ZSW1.Einschaltbereit	DB100.DBX25.0
"Drive1".RetVal1	DB100.DBW38
"Drive1".RetVal2	DB100.DBW40
"Drive2".WR_PZD_POSBETR	DB101.DBX0.0
"Drive2".WR_PZD_POSBETR.STW1.Aus1	DB101.DBX1.0
"Drive2".WR_PZD_POSBETR.STW1.Fahrverwerf	DB101.DBX1.4
"Drive2".WR_PZD_POSBETR.STW1.Zwihalt	DB101.DBX1.5
"Drive2".WR_PZD_POSBETR.STW1.Fahr_akt	DB101.DBX1.6
"Drive2".WR_PZD_POSBETR.STW1.Stoer_ruecks	DB101.DBX1.7

Symbol	Address
"Drive2".WR_PZD_POSBETR.PosStw.Referenzpunkt_setzen	DB101.DBX5.1
"Drive1".RD_PZD_POSBETR	DB101.DBX24.0
"Drive2".RD_PZD_POSBETR.ZSW1.Referenzpunkt_gesetzt	DB101.DBX24.3
"Drive2".RD_PZD_POSBETR.ZSW1.Einschaltbereit	DB101.DBX25.0
"Drive2".RetVal1	DB101.DBW38
"Drive2".RetVal2	DB101.DBW40
"Digital inputs".WR_PZD_DIDO	DB102.DBX0.0
"Digital inputs".RD_PZD_DIDO.Digital_input.DI_0	DB102.DBX6.0
"Digital inputs".RD_PZD_DIDO.Digital_input.DI_1	DB102.DBX6.1
"Digital inputs".RD_PZD_DIDO.Digital_input.DI_2	DB102.DBX6.2
"Digital inputs".RD_PZD_DIDO.Digital_input.DI_3	DB102.DBX6.3
"Digital inputs".RD_PZD_DIDO.Digital_input.DI_6	DB102.DBX6.6
"Digital inputs".RD_PZD_DIDO	DB102.DBX4.0
"Digital inputs".RetVal1	DB102.DBW8
"Digital inputs".RetVal2	DB102.DBW10

The following programming must be carried out in the standard program of the F-CPU.

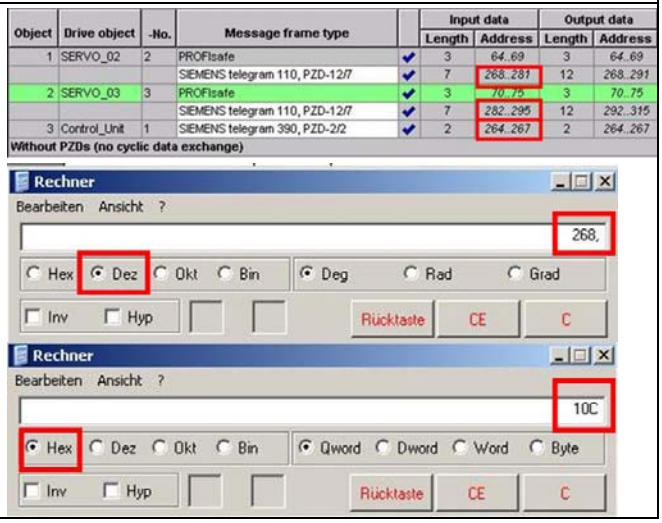
Table 5-6: Generating the standard program

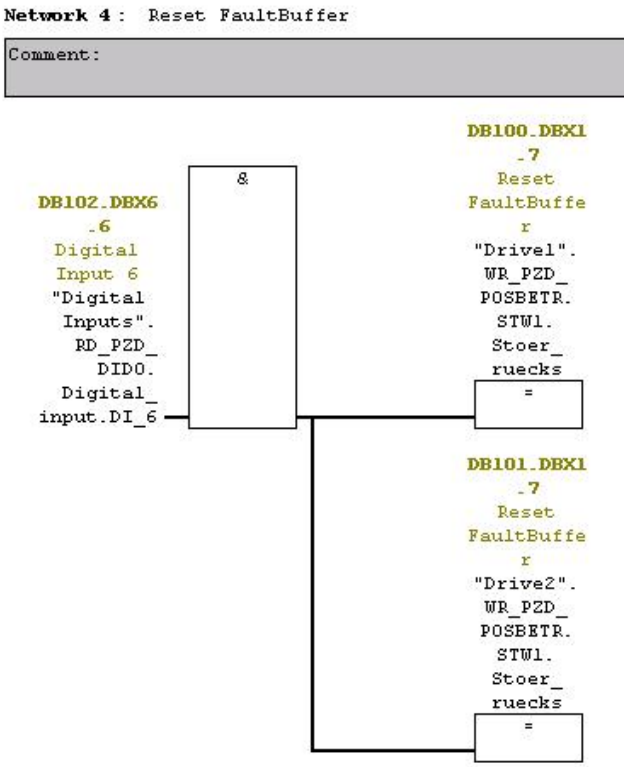
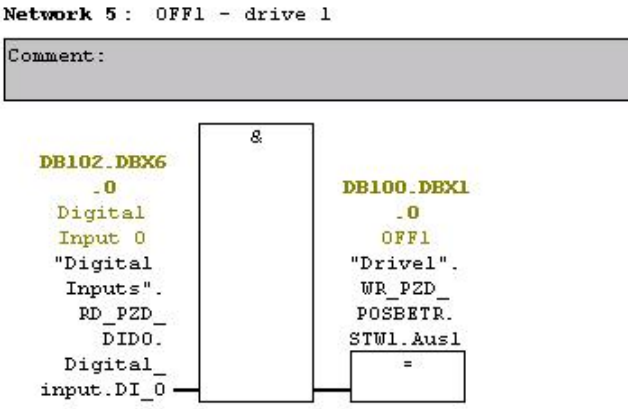
No.	Action	Remark
1.	To insert blocks, right click on "Blocks" → "Insert New Object".	
2.	Create the function FC2 using the programming language FBD (corresponds to FUP (DE)).	
3.	**OB1** Calling FC 2.	

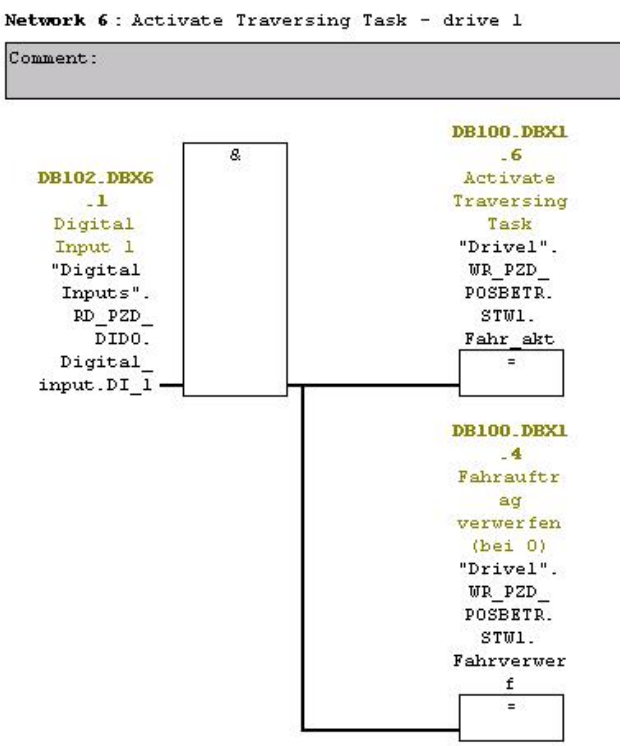
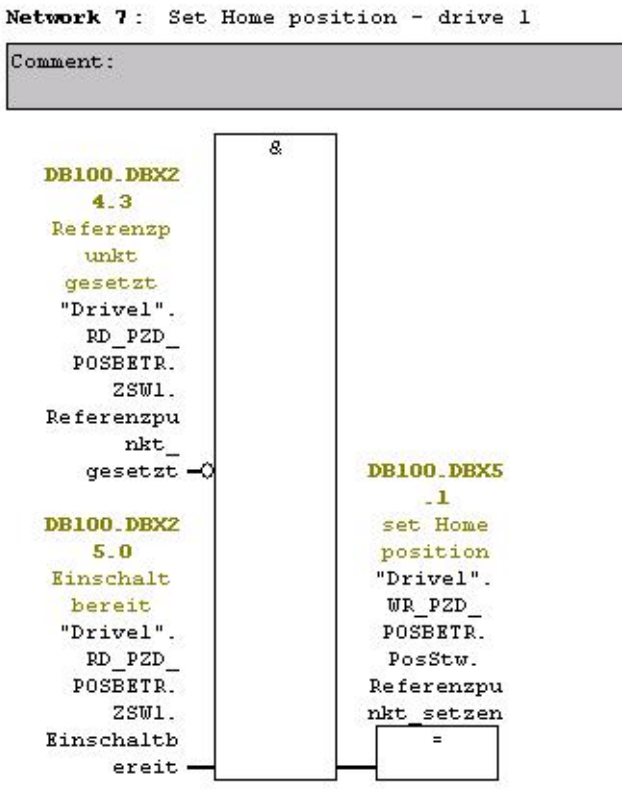
<table>
<tr><th>No.</th><th>Action</th><th>Remark</th></tr>
<tr><td>4.</td><td>FC2
Networks 1, 2 and 3:
Write the input data of the standard telegrams to the associated data blocks.
SFC14 is used for this purpose.

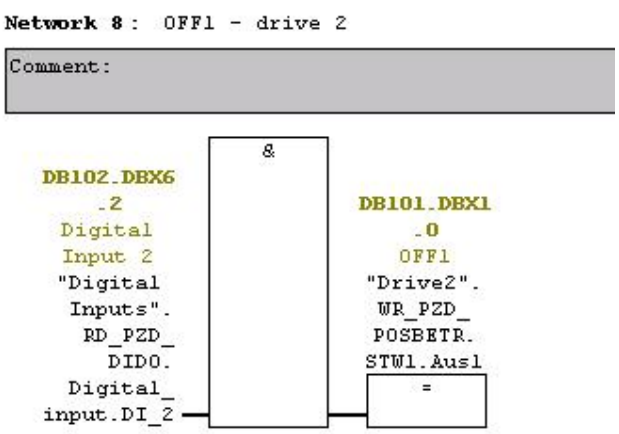
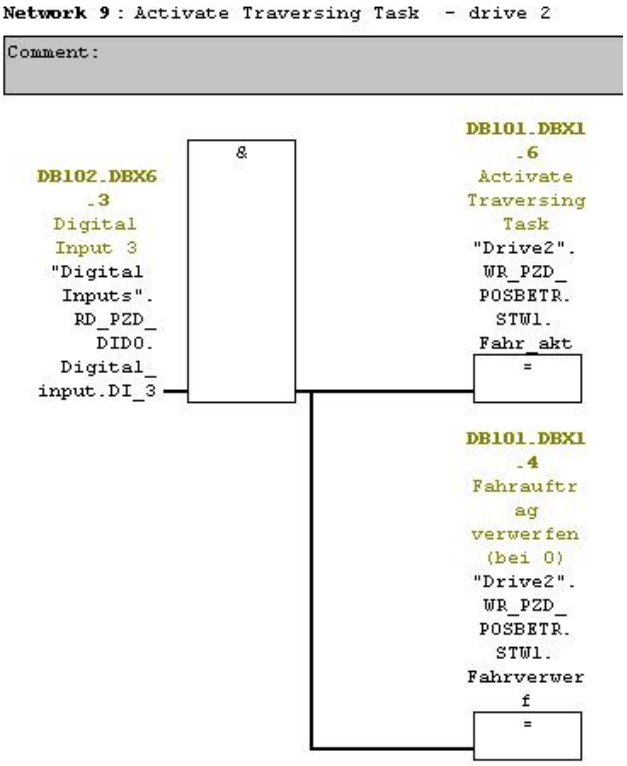
Note
The LADDR address can be read out of the telegram configuration for the input data in Chapter 5.4. However, the addresses are specified there in the decimal notation. As the hexadecimal address is required here, it must still be converted. A brief explanation is provided in the next line</td><td>FC2 : Control of the drives
Comment:
Network 1: Read drive 1
Comment:
CALL "DPRD_DAT" SFC14
LADDR :=W#16#10C
RET_VAL:="Drive1".RetVal1 DB100.DBW38
RECORD :="Drive1".RD_PZD_POSBETR P#DB100.DBX24.0

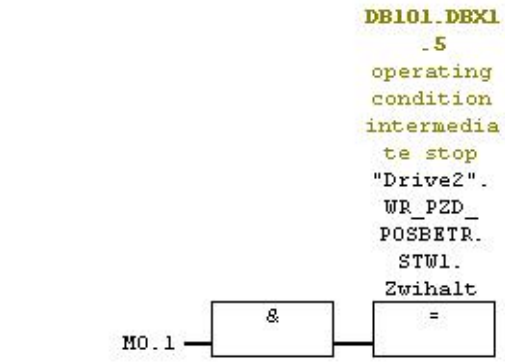
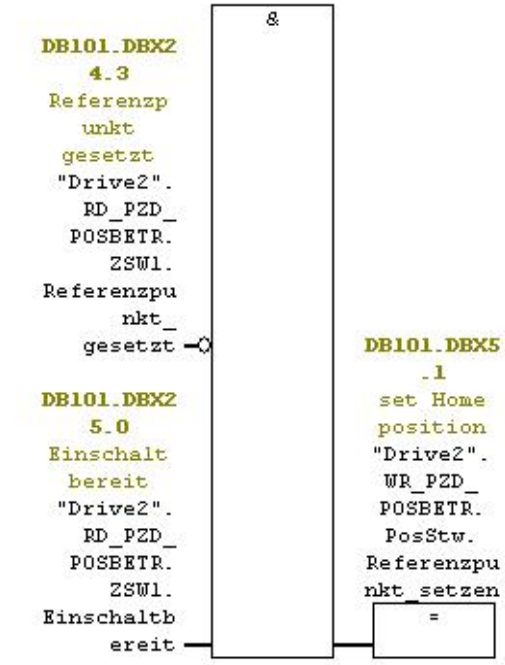
Network 2: Read drive 2
Comment:
CALL "DPRD_DAT" SFC14
LADDR :=W#16#11A
RET_VAL:="Drive2".RetVal1 DB101.DBW38
RECORD :="Drive2".RD_PZD_POSBETR P#DB101.DBX24.0

Network 3: Read digital I/O
Comment:
CALL "DPRD_DAT" SFC14
LADDR :=W#16#108
RET_VAL:="Digital Inputs".RetVal1 DB102.DBW8
RECORD :="Digital Inputs".RD_PZD_DID0 P#DB102.DBX4.0</td></tr>
<tr><td>5.</td><td>Remark
The conversion of the decimal addresses to hexadecimal is described here.
Initially, the input address (dec.) of the drive is evaluated in the telegram configuration
Using a calculator (in this case, a Windows-based computer) the number is converted into a hexadecimal number by selecting the "Hex" option button.</td><td> 
</td></tr>
</table>

No.	Action	Remark
6.	**FC2** Network 4: Acknowledge drive fault.	
7.	**FC2** Network 5: Drive enable for drive 1.	

No.	Action	Remark
8.	**FC2** Network 6: Start traversing blocks for drive 1	
9.	**FC2** Network 7: Automatic setting of the home position of drive 1. Here, the home position is always set when drive 1 is ready to start and the home position has not yet been set.	

No.	Action	Remark
10.	**FC2** Network 8: Drive enable, drive 2	
11.	**FC2** Network 9: Start traversing blocks for drive 2	

No.	Action	Remark
12.	**FC2** Network 10: Interrupt traversing blocks for drive 2 with intermediate stop, if protective door 2 is opened. M0.1 is the deselection from the safety program. Network 11: Automatic setting of the home position of drive 2. Here, the home position is always set when drive 2 is ready to start and the home position has not yet been set.	**Network 10** : operating condition intermediate Comment:  **Network 11** : Set Home position - drive 2 Comment: 

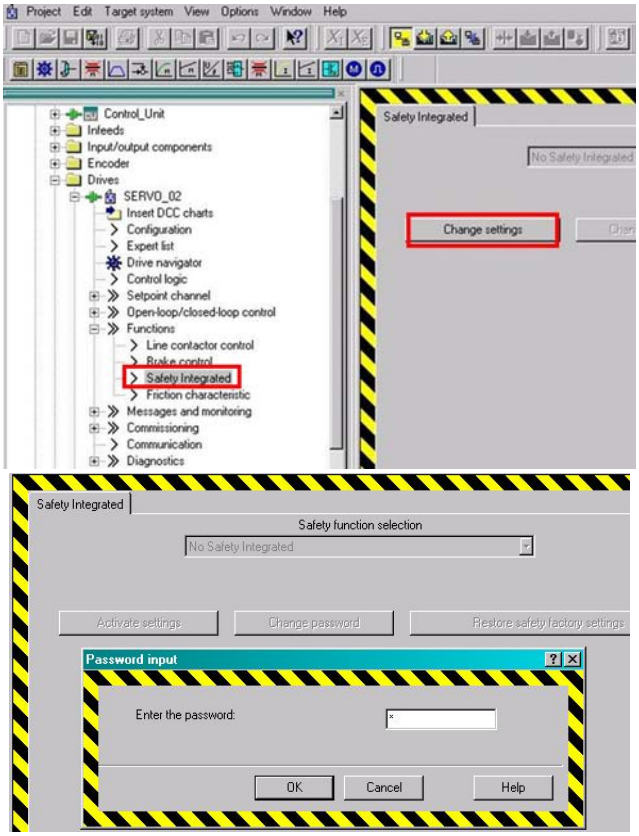
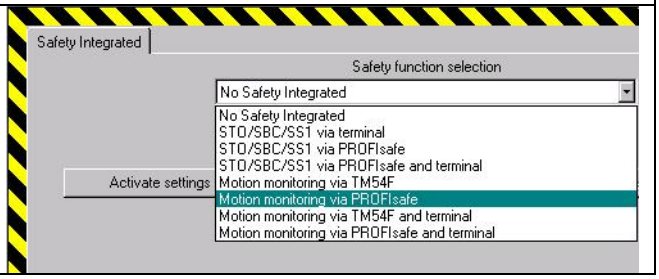
No.	Action	Remark
13.	**FC2** Networks 12,13 and 14: Writing all output data of the standard telegrams from the associated data blocks. SFC15 is used here. **Note** The LADDR address can be read out of the telegram configuration for the output data in Chapter 5.4. However, the addresses are specified there in the decimal notation. As the hexadecimal address is required here, it must still be converted. The conversion is performed as explained in Chapter 5.5.	**Network 12** : Write drive 1 Comment: CALL "DPWR_DAT" SFC15 LADDR :=W#16#10C RECORD :="Drive1".WR_PZD_POSBETR P#DB100.DBX0.0 RET_VAL:="Drive1".RetVal2 DB100.DBW40 **Network 13** : Write drive 2 Comment: CALL "DPWR_DAT" SFC15 LADDR :=W#16#124 RECORD :="Drive2".WR_PZD_POSBETR P#DB101.DBX0.0 RET_VAL:="Drive2".RetVal2 DB101.DBW40 **Network 14** : Write digital I/O Comment: CALL "DPWR_DAT" SFC15 LADDR :=W#16#108 RECORD :="Digital Inputs".WR_PZD_DID0 P#DB102.DBX0.0 RET_VAL:="Digital Inputs".RetVal2 DB102.DBW10

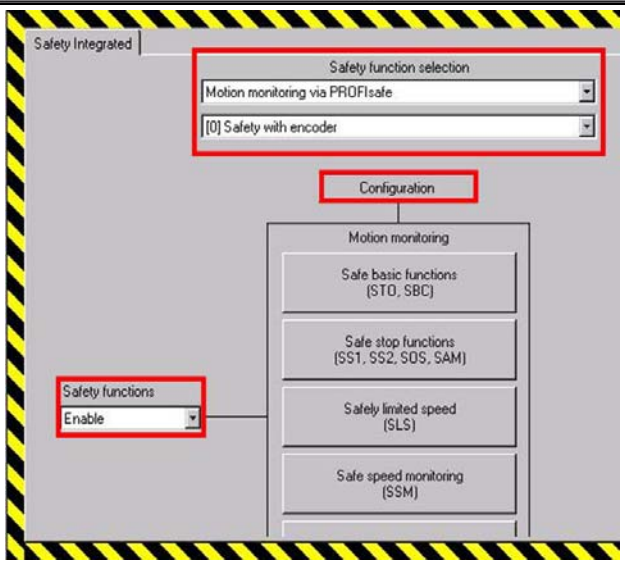
5.6 Parameterizing the safety functions integrated in the drive

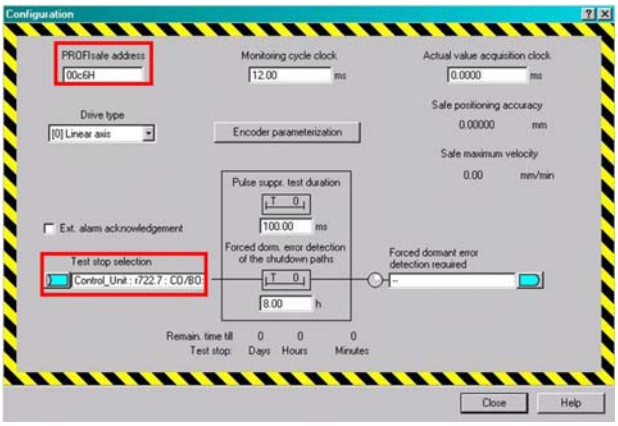
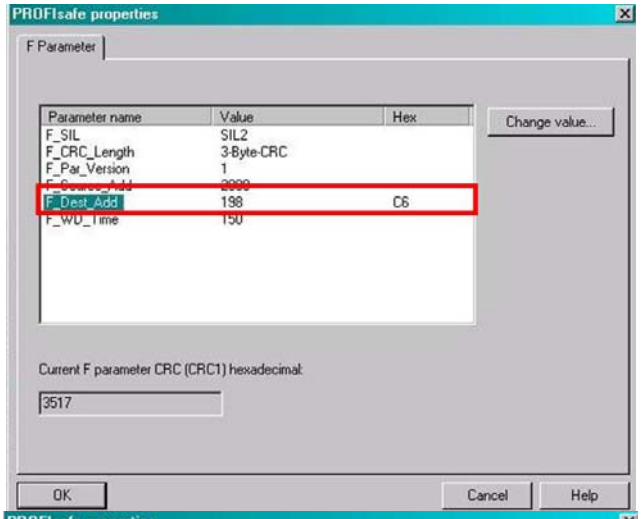
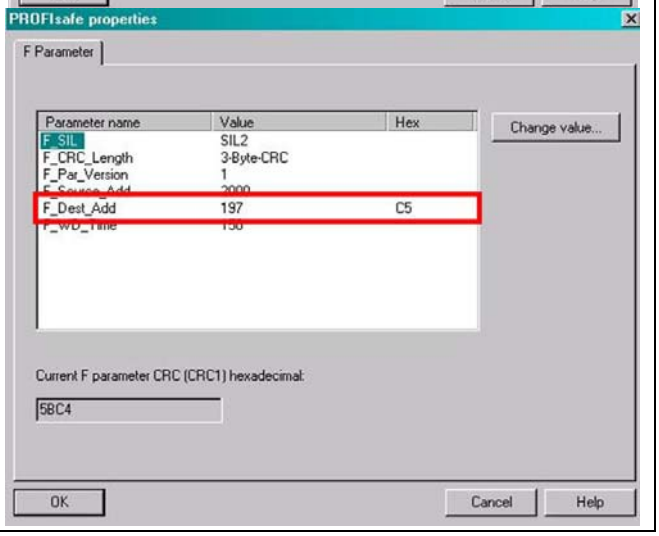
Notes

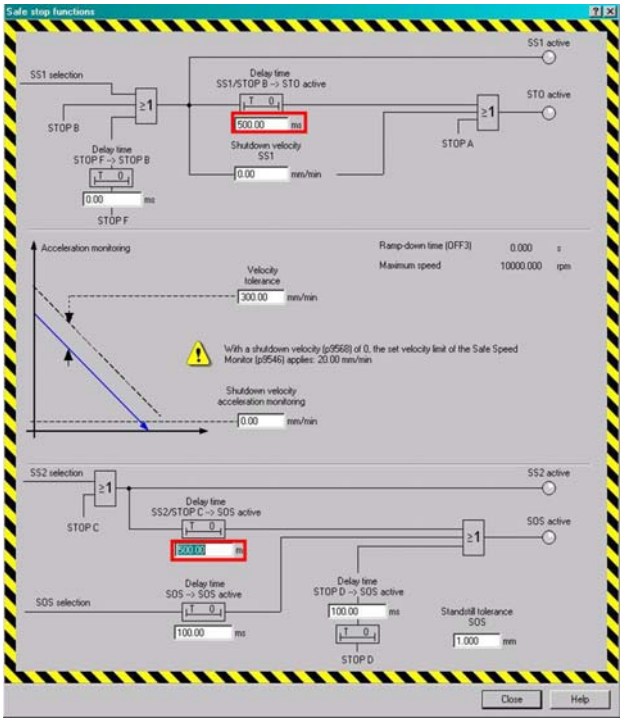
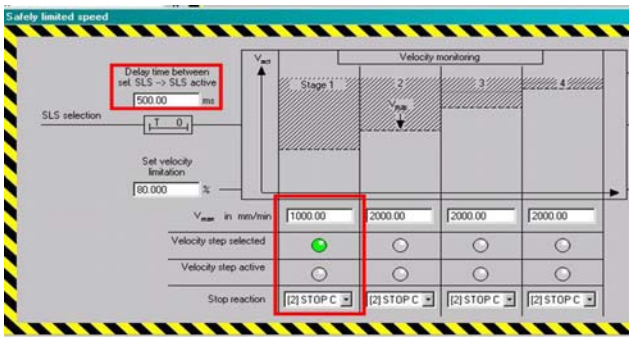
- The safety functions in the drives were configured online.
- Only the windows are described in which parameter changes are required.
- In this example, the following safety functions are used: STO, SS1, SLS and SOS.

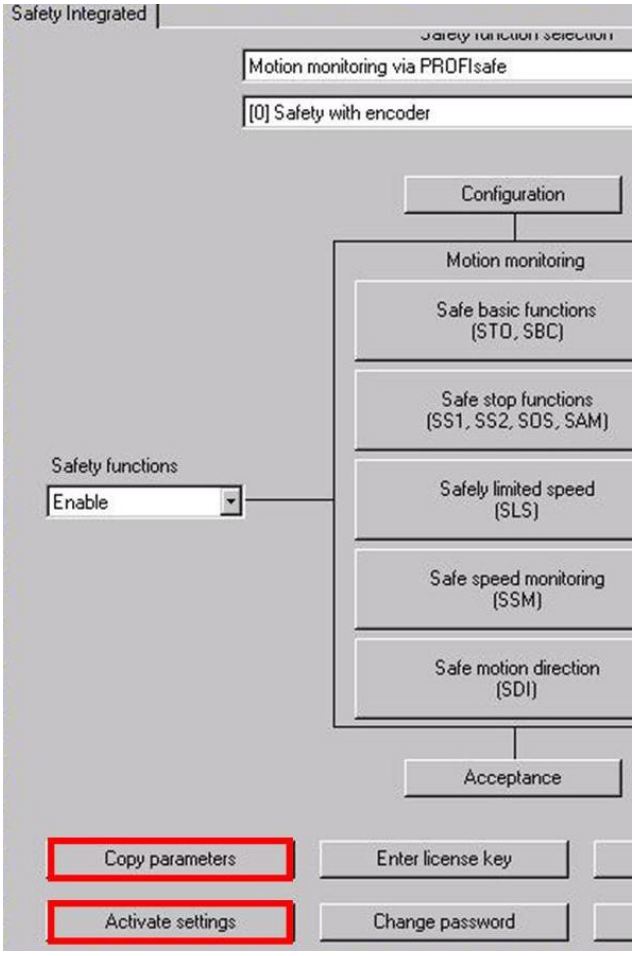
Table 5-7: Parameterizing the safety functions integrated in the drive

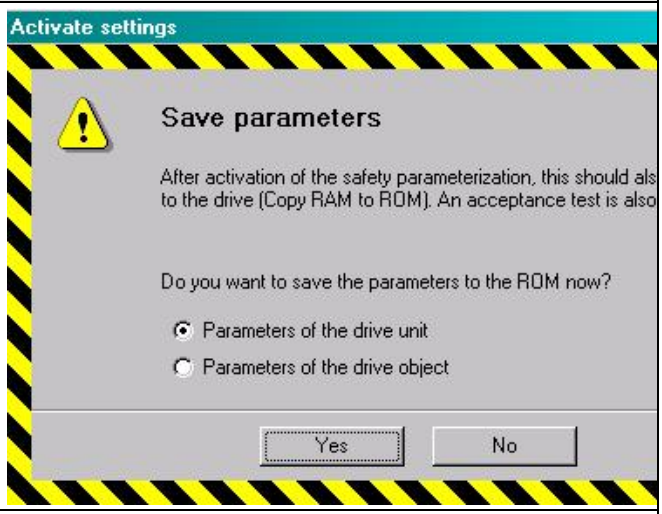
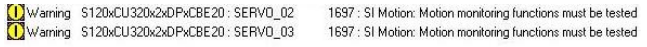
No.	Action	Remark
1.	Go online with SCOUT.	
2.	**Configuring both drives** Open the "Safety Integrated" window under "Functions" for the drives. In order to change the settings in the Safety screen form, click on "Change settings". You are now prompted to enter a password. The default password for the first commissioning is "0".	
3.	**Configuring both drives** Switchover the control selection to "Motion monitoring via PROFIsafe".	

No.	Action	Remark
4.	**Configuring both drives** Close the message using "Close".	
5.	**Configuring both drives** "Safety Integrated" window The following is 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.	**Configuring 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 be read out from HW Config under the PROFIsafe properties. Interconnect the signal source, test stop with DI7 of SINAMICS.	  

No.	Action	Remark
7.	**Configuring both drives** "Safe stop functions" window The following values were entered for the example: Delay time SS1 → pulse suppression = 500 ms Delay time stop C/SS2 →SOS active = 500 ms	
8.	**Configuring drive 1** "Safely Limited Speed (SLS)" window The velocity limit for level 1 is 1000 mm/min. When the limit is exceeded, the STOP C response configured here is initiated. Within the delay time "Select SLS → SLS active" (p9551), the drive speed must be below the limit value n_max. Entered in the example: Delay time SLS → SLS active: 500ms N_max for level 1: 1000 mm/min for drive 1	

No.	Action	Remark
9.	**Configuring both drives** The parameters must now be copied. To do this, click on the "Copy parameters" button. Then click on "Activate settings".	
10.	**Configuring both drives** You will now be prompted to assign a new password. To do this, for example set the password to "1"	

No.	Action	Remark
11.	**Configuring both drives** The parameters of the drive unit will now be copied to ROM. Confirm with "Yes".	
12.	**Post configuration, drive 1** Connect parameter p2594 with parameter r9733. Via this connection, when SLS is selected the maximum velocity of EPOS is reduced.	
13.	Go offline.	
14.	Then perform a power-on reset on the Control Unit.	POWER OFF/ON
15.	Go online.	
16.	Download 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. They are alarms, i.e. the drives can be switched-on and operated. In this example, the test stop can be initiated using switch -S9.	

5.7 Configuring the F-CPU

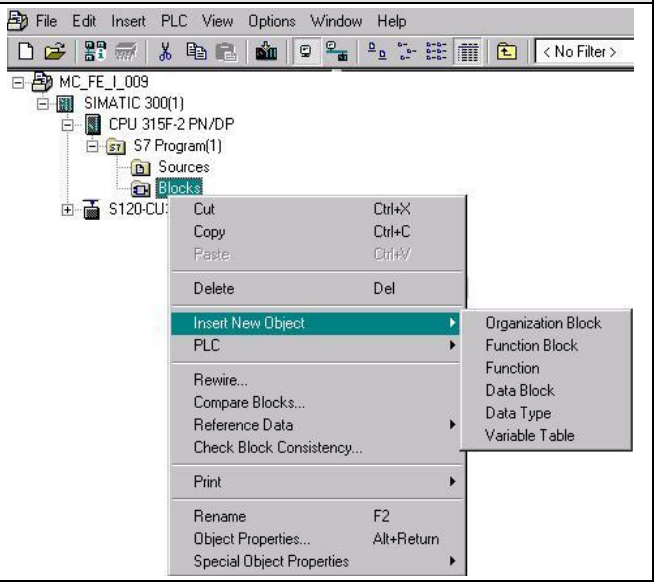
The safety program was consciously selected to be as simple as possible. In this particular case, the main task of the safety program is to generate the PROFIsafe control words for the drives from the signals at the F-DIs. These are transferred to the drives using the PROFIsafe telegrams where they control the safety functions. The blocks required for the safety program must first be created.

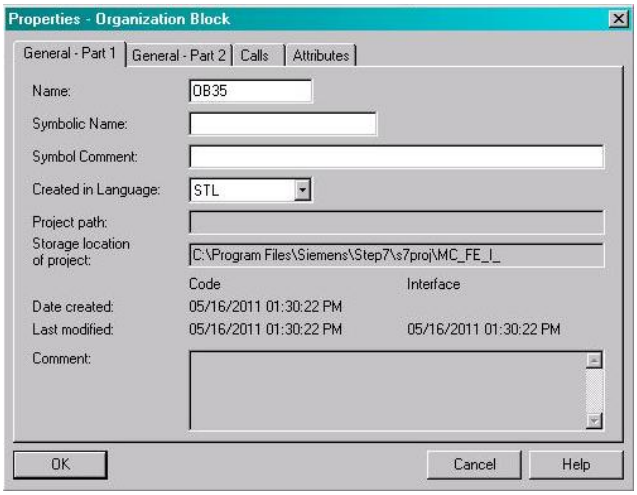
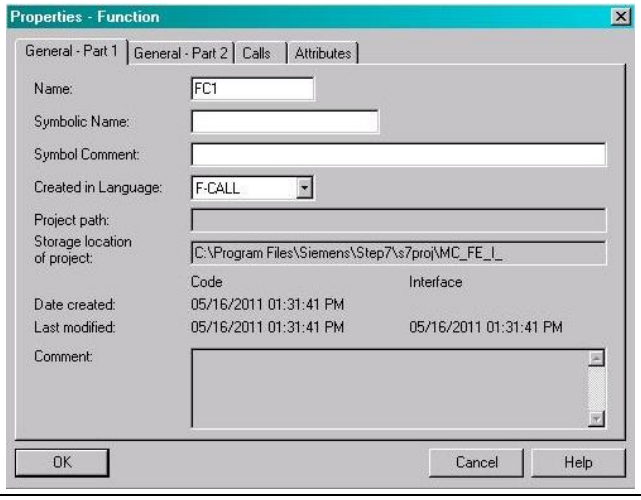
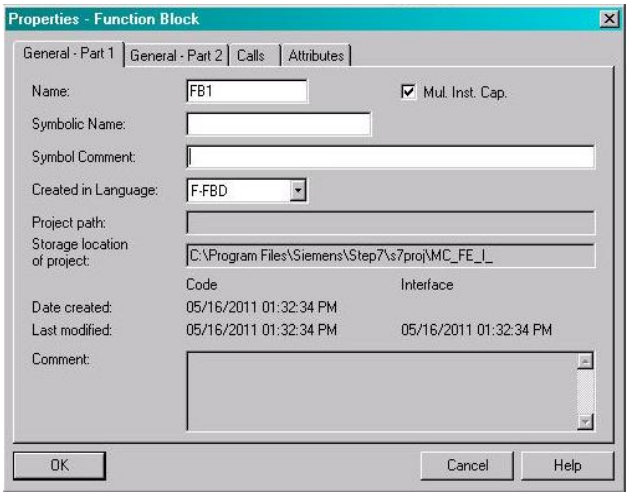
Notice **In this form, it is not permissible that the program is used for a real application.**

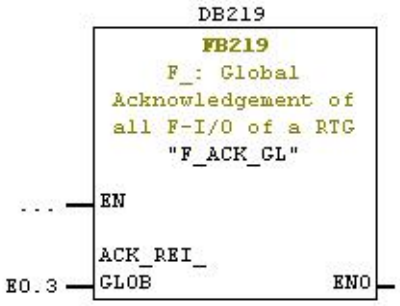
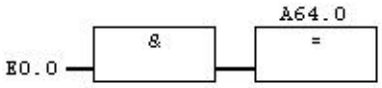
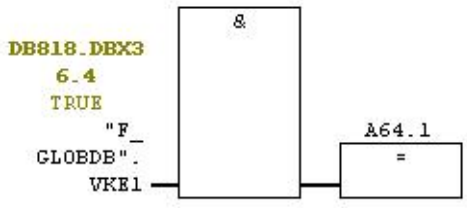
You start with the F-call block. This is required to call the safety program. To do this, a function (in this case, FC1) must be inserted into the block folder using the F-call programming language. Cyclic interrupt OB35 is required to cyclically call the safety program.

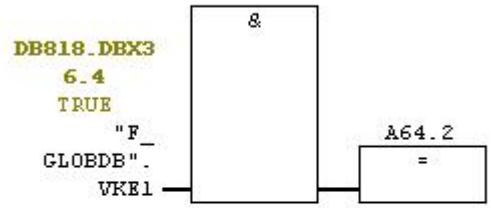
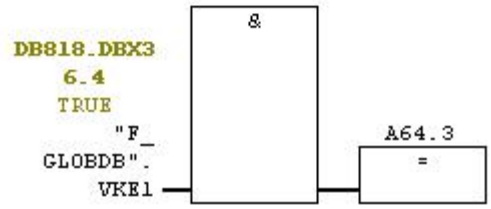
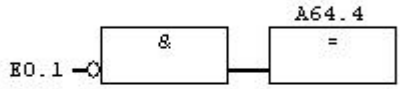
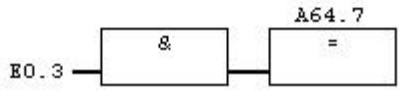
In this example, the actual safety program is executed in a function block (here, FB1); this means that FB 1 must now be inserted with the programming language F-LAD (corresponds to F-LAD (DE)) or F-FBD (corresponds to F-FUP (DE)).

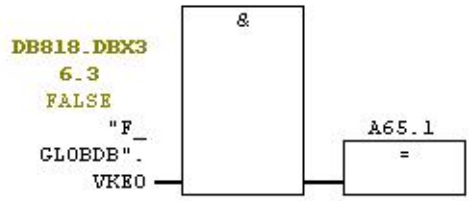
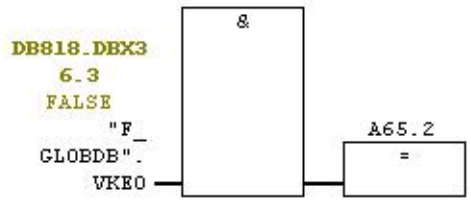
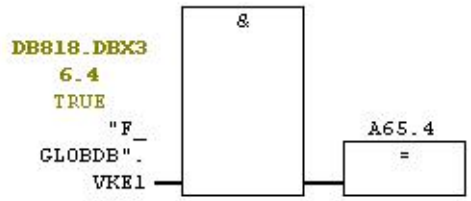
Table 5-8: Configuring the F-CPU

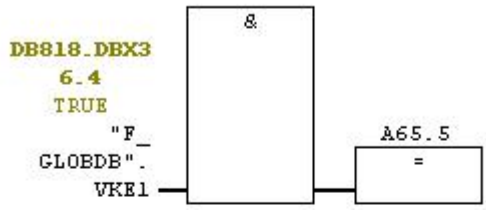
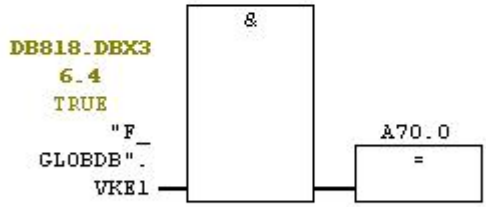
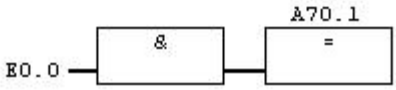
No.	Action	Remark
1.	To insert blocks, right click on "Blocks" → "Insert New Object".	

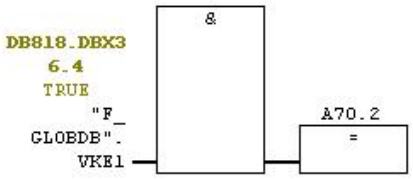
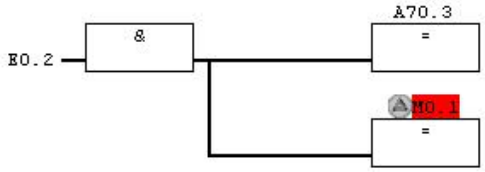
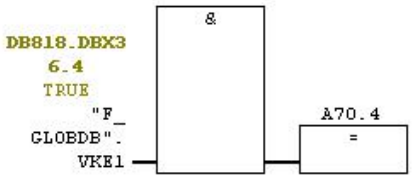
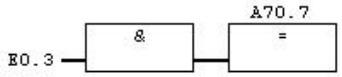
No.	Action	Remark
2.	Create OB35 using the programming language STL (corresponds to AWL (DE)).	
3.	Create FC1 using the the F-CALL programming language. FC1 is the gateway to the safety program.	
4.	Create FB1 using the programming language F-FBD (corresponds to F-FUP (DE)). The safety program is written to FB1.	

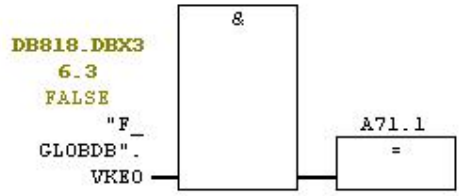
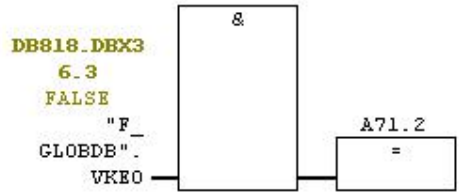
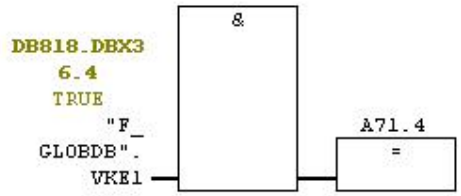
No.	Action	Remark
5.	**OB35** Calling the safety program	OB35 : "Cyclic Interrupt" Comment: Network 1: Open Safety-Program Comment: CALL FC 1
6.	**FB1** **Drive 1** Network 1: acknowledge errors using -S4. **Note** FB219 can be found in FB1, in the folder "Libraries" → "Distributed Safety" → "F-Application Blocks". Network 2: -S1 is interconnected to PROFIsafe STW 1 with STO. Network 3: SS1 is permanently deselected with a fail-safe VKE1.	FB1 : Safety-Program Comment: **Network 1**: Reintegration of all components Comment:  **Network 2**: PROFIsafe Drive 1 STO Comment:  **Network 3**: PROFIsafe Drive 1 SS1 Comment: 

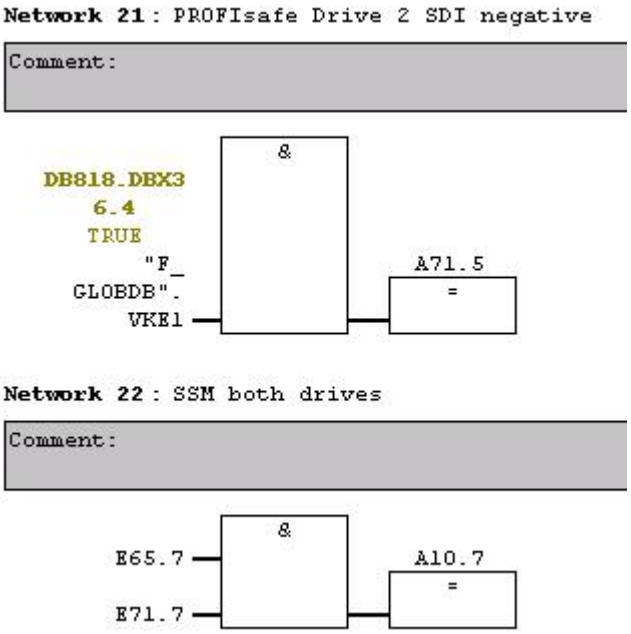
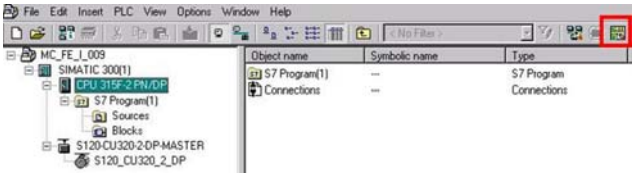
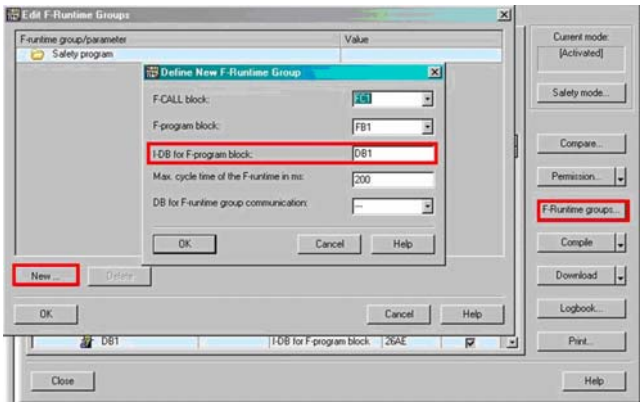
No.	Action	Remark
7.	**FB1** **Drive 1** Network 4: SS2 is permanently deselected with a fail-safe VKE1. Network 5: SOS is permanently deselected with a fail-safe VKE1. Network 6: -S2 is interconnected to PROFIsafe STW 1 with SLS. Inversion is necessary, as -S2 is connected as NO/NC contact. Network 7: -S4 is interconnected to PROFIsafe STW 1 with fail-safe acknowledgment.	**Network 4** : PROFIsafe Drive 1 SS2 Comment:  **Network 5** : PROFIsafe Drive 1 SOS Comment:  **Network 6** : PROFIsafe Drive 1 SLS Comment:  **Network 7** : PROFIsafe Acknowledgement Comment: 

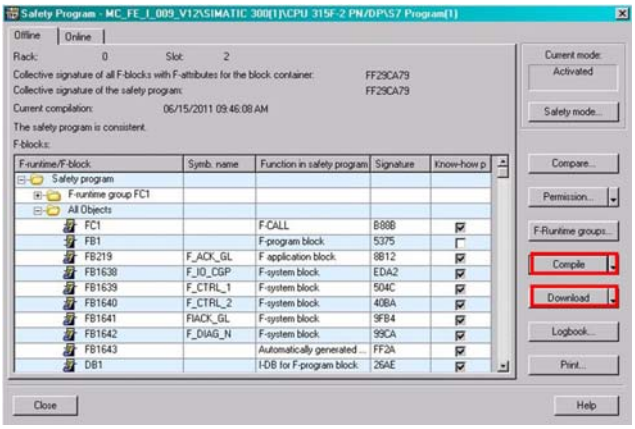
No.	Action	Remark
8.	**FB1** **Drive 1** Networks 8 and 9: The fail-safe VKE0 is interconnected to A65.1 and A65.2, so that SLS level 1 is permanently selected. Network 10: The fail-safe VKE1 is interconnected to A65.4, so that SDI positive direction is therefore permanently deselected.	**Network 8** : PROFIsafe Drive 1 SLS stage Bit 0 Comment:  **Network 9** : PROFIsafe Drive 1 SLS stage Bit 1 Comment:  **Network 10** : PROFIsafe Drive 1 SDI positive Comment: 

No.	Action	Remark
9.	**FB1** **Drive 1** Network 11: The fail-safe VKE1 is interconnected to A65.5, so that SDI negative direction is therefore permanently deselected. **Drive 2** Network 12: STO is permanently deselected with a fail-safe VKE1. Network 13: -S1 is interconnected to PROFIsafe STW 2 with SS1.	**Network 11** : PROFIsafe Drive 1 SDI negative Comment:  **Network 12** : PROFIsafe Drive 2 STO Comment:  **Network 13** : PROFIsafe Drive 2 SS1 Comment: 

No.	Action	Remark
10.	**FB1** **Drive 2** Network 14: SS2 is permanently deselected with a fail-safe VKE1. Network 15: -S3 is interconnected to PROFIsafe STW 2 with SOS. Bit memory M0.1 is used to evaluate the request in the standard program. Network 16: SLS is permanently deselected with a fail-safe VKE1. Network 17: -S4 is interconnected to PROFIsafe STW 2 with fail-safe acknowledgment.	**Network 14** : PROFIsafe Drive 2 SS2 Comment:  **Network 15** : PROFIsafe Drive 2 SOS Comment:  **Network 16** : PROFIsafe Drive 2 SLS Comment:  **Network 17** : PROFIsafe Acknowledgement Comment: 

No.	Action	Remark
11.	**FB1** **Drive 2** Networks 18 and 19: The fail-safe VKE0 is interconnected to A71.1 and A71.2, so that SLS level 1 is permanently selected. Network 20: The fail-safe VKE1 is interconnected to A71.4, so that SDI positive direction is therefore permanently deselected.	**Network 18** : PROFIsafe Drive 2 SLS stage Bit 0 Comment:  **Network 19** : PROFIsafe Drive 2 SLS stage Bit 1 Comment:  **Network 20** : PROFIsafe Drive 2 SDI positive Comment: 

No.	Action	Remark
12.	**FB1** **Drive 2** Network 21: The fail-safe VKE1 is interconnected to A71.5, so that SDI negative direction is therefore permanently deselected. Network 22: Control of the signal lamp in -S4 for 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 download into the F-CPU. In addition, download the standard blocks to 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.

5.8 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 make it easier to handle the acceptance test, a script has been generated that can be ordered at no charge from the Application database of the APC. This script takes the user step-by-step in a user-friendly way 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.

First, all components (S7-F-CPU and SINAMICS S120) should be generally reset or reset to factory settings.

6.1 Preconditions

Preconditions for operation

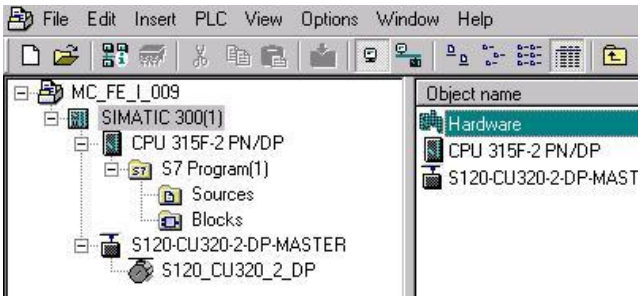
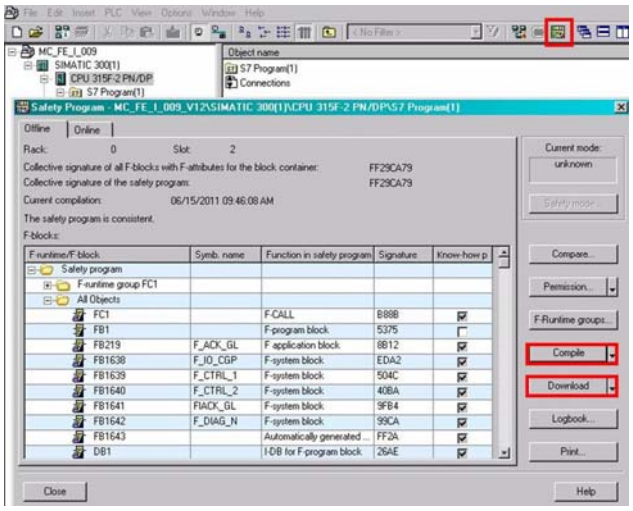
- The SIMATIC components have been installed and connected with one another. The PROFIsafe addresses of the fail-safe input and output modules must be set using the DIL switch; see Chapter 5.4.
- All components have been connected as specified in Chapter 4.
- The DRIVE-CLiQ topology of the SINAMICS components has been maintained.
- The motor is connected to the Motor Module through 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.

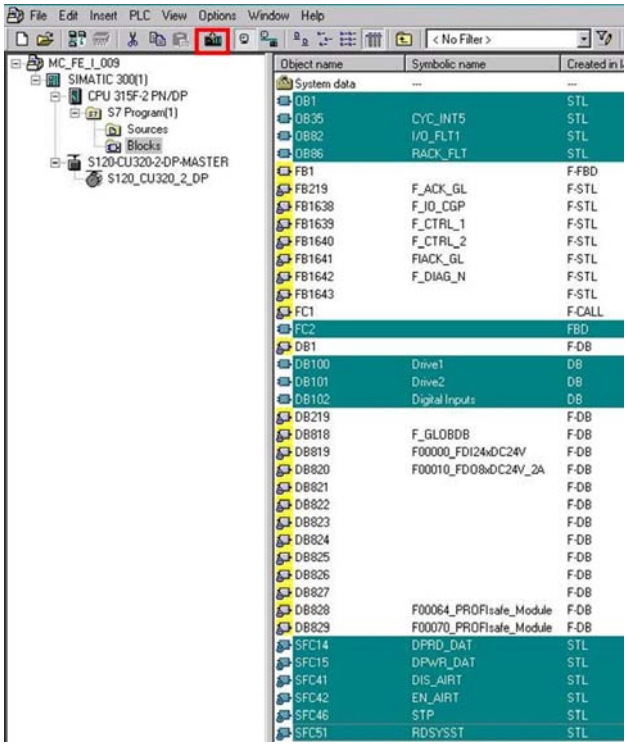
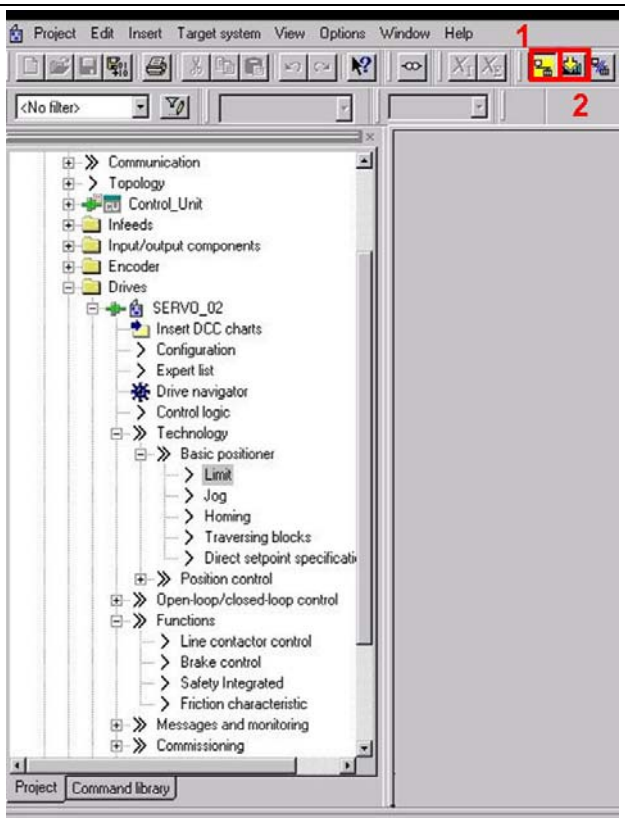
6.2 Preparation

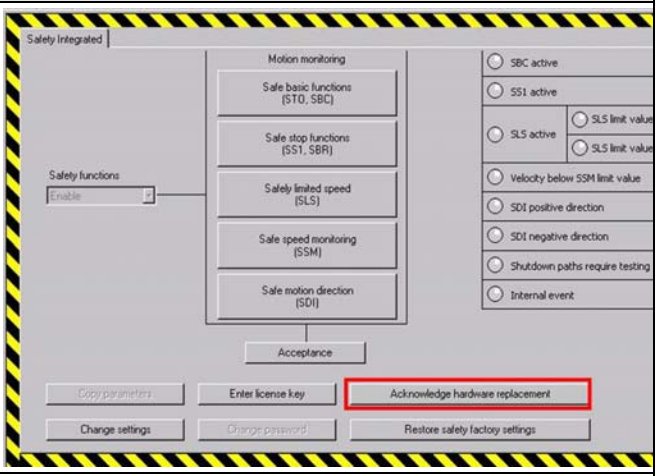
(see chapter 5.2 Preparation)

6.3 Commissioning

Table 6-1: Commissioning the application example

No.	Action	Remark
1.	**Loading the configuration of the F-CPU** To start, the HW configuration of the S7-F-CPU must be downloaded. The HW configuration is opened by double-clicking on "Hardware". Depending on the default values and/or the previous configuration on the F-CPU side, it may be necessary to adapt the PROFIBUS address of the PGs in NetPro for downloading the hardware configuration of the F-CPU.	
2.	**Note** If a safety program was already 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 cleared using a suitable device (e.g. SIEMENS PG). If the card is cleared or formatted using a card reader, the card will be destroyed.	
3.	After the HW configuration has been downloaded, the program blocks must be downloaded to the F-CPU. The window to download 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 first been generated ("compiled").	

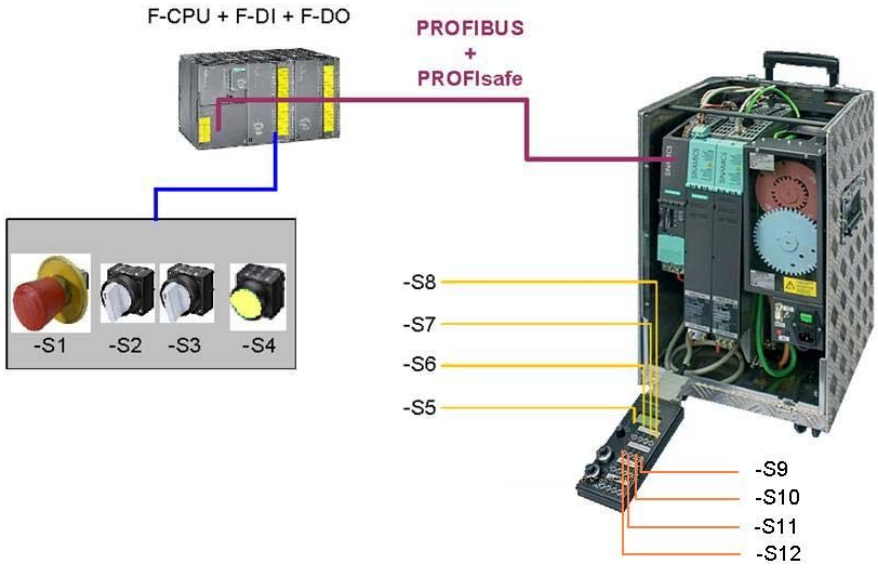
No.	Action	Remark
4.	The remaining (non-safety-related) blocks are then downloaded normally.	
5.	**Loading the SINAMICS S120 configuration** You can download the configuration directly to the SINAMICS S120. To do so, first go online and then download the configuration.	

No.	Action	Remark
6.	For each series commissioning, the new serial numbers must now be transferred to the Safety configuration. This is realized using "Acknowledge hardware replacement" in the Safety screen form of both drives.	
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. This is used to select the various safety functions.

Switches -S5 to -S12 are located on a switchbox that belongs to the SINAMICS training case. These switches are used to switch the drives on and off, enter different speeds, start the test function of the safety functions and acknowledge faults.

7.2 Description

Reintegration

The drives have to be reintegrated after power OFF/ON. All alarm messages are acknowledged and the signal lamp of -S4 is switched on when pressing key -S4.

Switching-on/off

The Emergency Stop button S1 must be released in order to be able to operate the drives. Drive 1 is switched on with switch -S5 and drive 2 is switched on with -S7 (OFF1).

Traversing programs

The traversing program for drive 1 is started using -S6. The traversing program for drive 2 is started by pressing switch -S8. The traversing blocks for both drives are identical. Drive 1 or 2 first operates at 20000 mm/min up to position 200000. After a certain wait time, position 300000 is entered and the corresponding drive rotates with 20000 mm/min. After another wait time, the drive continues operating at 20000 mm/min and moves to position -500000. Finally, after another wait time, the traversing program starts again from the beginning.

Acknowledgement of alarms

Alarms active 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.

Emergency Stop

If Emergency Stop pushbutton -S1 is pressed, then STO is directly initiated for drive 1 and the drive coasts to a standstill. For drive 2, safety function SS1 is initiated; as a consequence, the drive is braked along the OFF3 ramp and then STO is activated.

Protective door 1

Drive 1 can be operated at any speed when protective door 1 is closed (switch -S2). If protective door 1 is opened, then the traversing speed is reduced via the external maximum velocity of the EPOS and SLS is activated. The user is responsible for maintaining an axis speed/velocity that lies below the speed limit for level 1 of the SLS safety function. This limit value is monitored by safety function SLS after a defined time has expired. If protective door 1 is closed again, then SLS is deactivated and the speed/velocity reduction is canceled by the application program. The drive can now be operated again with the configured speed.

Protective door 2

Drive 2 can be operated at any velocity when protective door 2 is closed (switch -S3). If -S3 is opened, then safety function SOS is initiated. The drive is braked by the application program using the EPOS intermediate stop function and held at the standstill position. After a defined time has elapsed, the next state SOS is activated. Drive 1 is now in the controlled standstill state with speed setpoint value = 0 and the standstill position is safely monitored. If the simulated protective door – S3 is closed again, SOS and the EPOS Intermediate stop function is deselected. The drive accelerates again up to its original speed. In this case, an ON command is not necessary.

7.3 Summary of input signals

Table 7-2: Sinamics digital inputs

Digital input	Switch	Component	Description
DI 0	-S5	Drive 1	Set / cancel axis enable signals
DI 1	-S6	Drive 1	Start / stop the traversing program
DI 2	-S7	Drive 2	Set / cancel axis enable signals
DI 3	-S8	Drive 2	Start / stop the traversing program
DI 6	-S10	Drive 1 / Drive 2	Acknowledge alarms
DI 7	-S9	Drive 1 / Drive 2	Initiate a test stop

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

Digital input	Switch	Component	Description
F-DI 0	-S1	Emergency Stop button	Drive 1: STO
			Drive 2: SS1
F-DI 1	-S2	Protective door 1 (for drive 1)	SLS
F-DI 2	-S3	Protective door 2 (for drive 2)	SOS
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 links

	Topic	Title
\1\	Reference to the article	http://support.automation.siemens.com/WW/view/de/36813720
\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 version V4.4 and SCOUT 4.2