Function Example No. MC-FE-I-010-V10-EN

SINAMICS S120
Safety Integrated Extended Functions

Fail-Safe Drives, Controlling the CU320
with EPOS using TM54F and F-CPU

safety INTEGRATED

SIEMENS

Preliminary remarks

Function examples for the topic "Safety Integrated" are fully-functioning and tested automation configurations based on standard I DT & IA products for simple, fast and low-cost implementation of automation tasks in safety engineering. Each of the function examples available deals with a typical problem that occurs in safety engineering.

Besides listing all the necessary software and hardware components, and describing their interconnection, the function examples also include tested and commented code. This means the functionalities described here can be set up within a short time and can thus be used as the basis for individual expansions.

Important note

The Safety function examples are non-binding and do not claim to be complete in respect of configuration, equipment or practical contingencies. The Safety function examples are not customer-specific solutions but are only intended to provide support in implementing typical tasks. You yourself are responsible for proper operation of the described products.

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Contents

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2 Automation function

2.1 Description of the function example

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

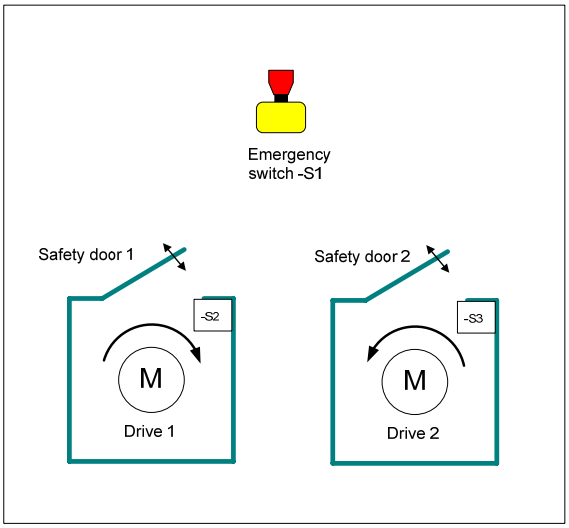
Name	Function	Description
STO	Safe Torque Off	• Safe disconnection of the torque-generating power supply to the motor. • The "Switching On Inhibited" condition prevents the drive from restarting. (Stop function, Category 0 according to EN 60204-1)
SBC	Safe Brake Control	• SBC is only used when there 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)
SOS	Safe Operating Stop	• This function serves to safely monitor the standstill position of a drive; the drive remains in closed-loop control.
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).

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, the fail-safe Terminal Module TM54F is used to control the safety functions.

Task description

The extended safety functions integrated in the SINAMICS S120 drives are to be controlled by a TM54F using hardware signals. The drives belong to different drive groups. An F-CPU handles the safety-related logical pre-processing of the input signals.

A typical overview of the assumed machine configuration is shown in the following diagram.

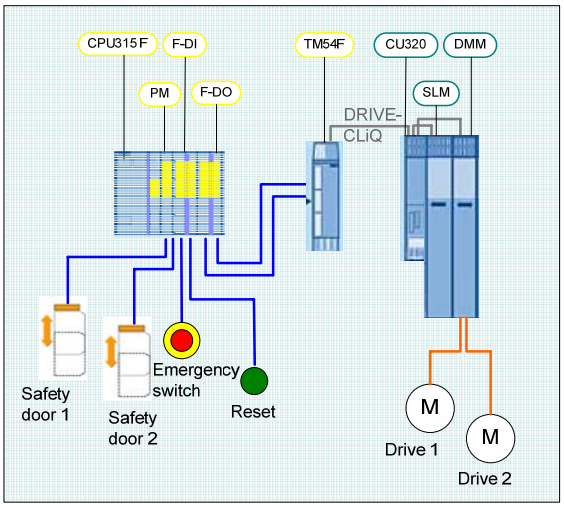


The following safety functions are used as basis for further consideration.

Safety function	Description	Reaction
SF1	Actuation of the emergency stop button	Drive 1 is stopped with immediate pulse suppression (STO) Drive 2 is quickly stopped in a controlled fashion -> subsequent pulse suppression (SS1)
SF2	When protective door 1 is open, drive 1 must not exceed a maximum speed	Speed monitoring at drive 1 (SLS)
SF3	Drive 2 should be stopped quickly when protective door 2 is opened. Drive 2 must then be held at standstill and the standstill position safely monitored.	For drive 2: Interrupt positioning, perform application-specific braking and, at the same time, select SOS.

Solution

Hardware overview



This function example shows how the STO, SS1, SOS and SLS safety functions are controlled via the TM54F terminal expansion module in 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. 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-related signals are sensed using fail-safe inputs of the ET200M and evaluated in the F-CPU. The preprocessed signals are transferred to the TM54F terminal expansion module via fail-safe ET200M outputs. These control the safety functions integrated in the SINAMICS S120 drive. The control signals are processed in a standard program in the F-CPU and output to the SINAMICS S120 system via PROFIBUS.

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

Two switches in the SAFETY training case simulate a protective door for drives 1 and 2 respectively. When protective door 1 is opened, the speed setpoint for drive 1 is reduced via the EPOS speed override, and the SLS function is selected simultaneously. 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.

2.2 Advantages / customer benefits

- 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.

3 Required components

The hardware components and software versions required to implement the function example are listed in this chapter.

3.1 Hardware components

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	6SL3050-0AA00-3BA0	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
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

SINAMICS training case

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

Note The function 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.

3.2 Software components

3.2.1 Engineering software

Table 3-1

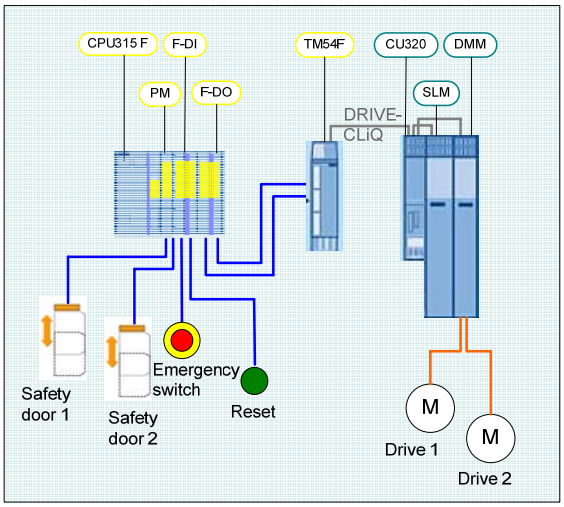
Component	Type	Order no./Ordering data	Qty	Manufacturer
STEP 7	V5.4 SP4	6ES7810-4CC08-0YA5	1	Siemens
S7 Distributed Safety programming	V5.4 SP4	6ES7833-1FC02-0YA5	1	Siemens
S7 F ConfigurationPack	V5.5 SP5		1	Siemens
STARTER	V4.1 SP2	6SL3072-0AA00-0AG0	1	Siemens
Drive ES Basic	V5.4 SP3	6SW1700-5JA00-4AA0	1	Siemens
or as an alternative to STARTER & DRIVE ES Basic software:				
SIMOTION SCOUT	V4.1 SP2	6AU1810-1BA41-1XA0	1	Siemens

3.2.2 Firmware

All SINAMICS components must have firmware release V2.5 SP1 or higher.

4 Configuration and wiring

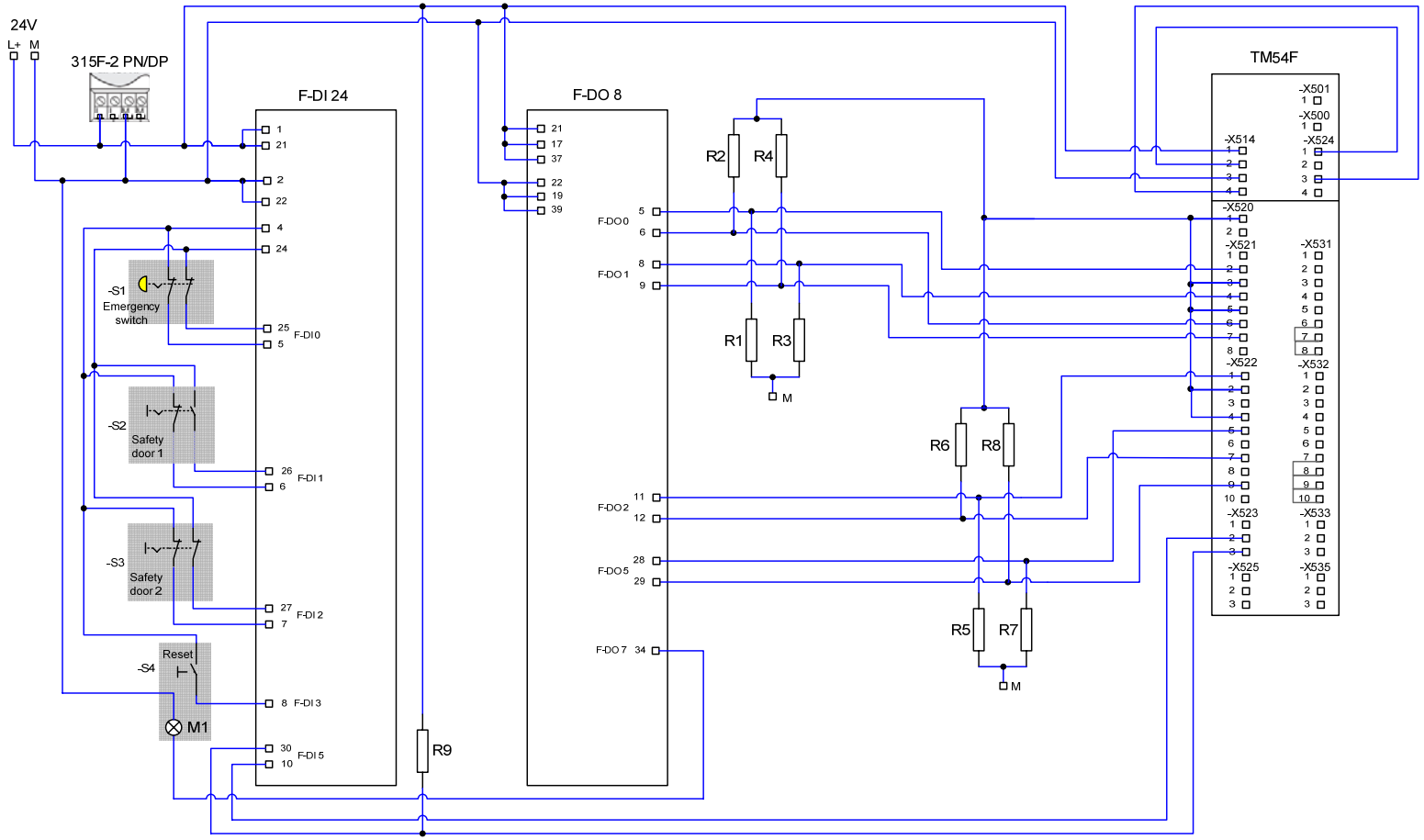
4.1 Overview of the hardware configuration



Basic configuration

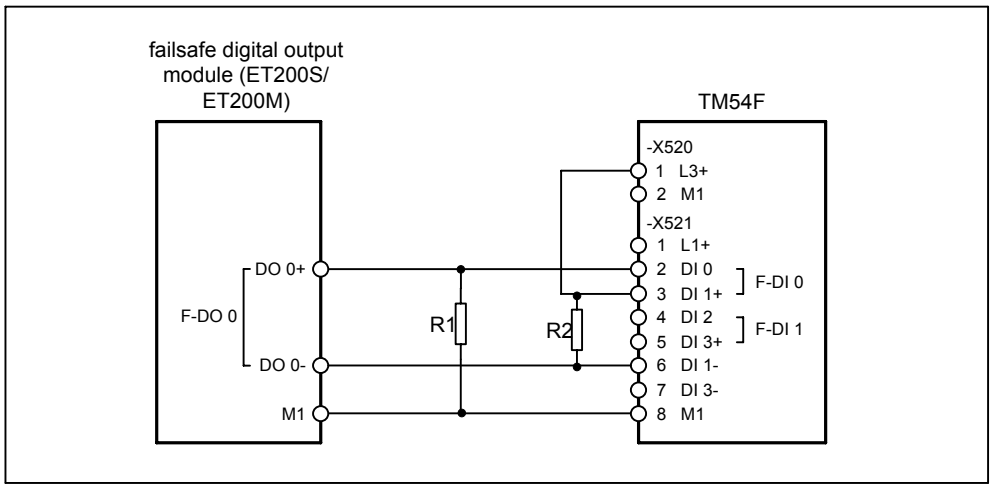
4.2 Wiring of the hardware components

4.2.1 Wiring the control voltage



Wiring safety training case

4.2.2 Principle of connection of the F-CPU to the TM54F



Connection, F-DO sourcing/sinking (F-CPU) → F-DI (TM54F)

Dimensioning the load resistors

Any conditions specified for the digital output in the manufacturer's documentation, (e.g. a minimum load or a maximum load resistance) should be taken into account.

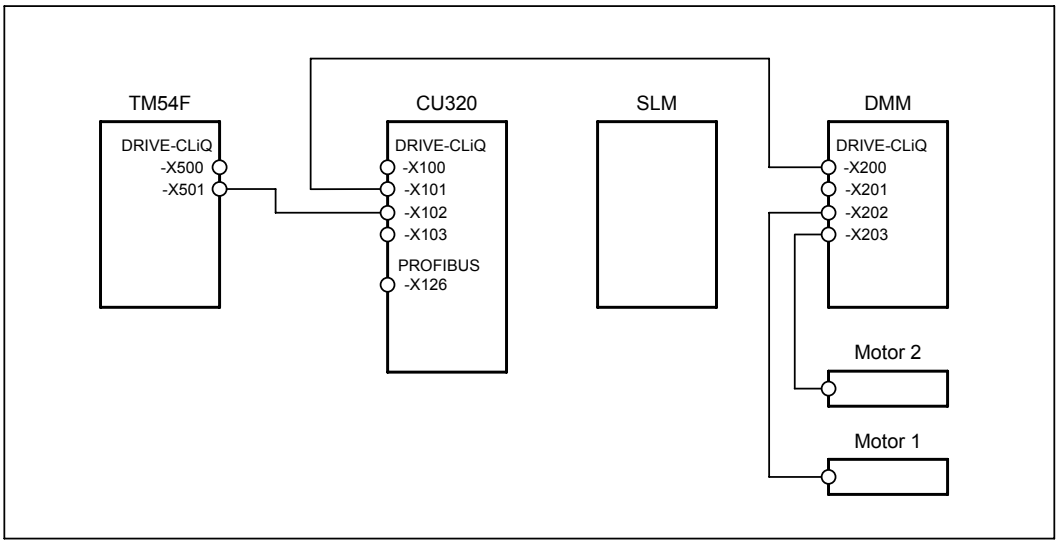
For example, a minimum load of 1 kΩ is specified for the SIMATIC ET200S 4 F-DO I/O module.

This means that two additional load resistors of 1 kΩ and a continuous load capacity of at least $P = V^2/R = (28.8\ V)^2/1\ k\Omega = 830$ mW are required to connect such an F-DO with an F-DI of the TM54F.

Note: When using regulated SITOP power supplies, the voltage tolerance on the 24 V side is significantly less than the maximum permissible tolerance of +20% of the power supply voltage at the ET200S modules. The power dissipated in the resistor is, in this case, less than the maximum power calculated above.

4.2.3 DRIVE-CLiQ interconnection

The SINAMICS units should be connected-up using the DRIVE-CLiQ cable as shown in the following diagram.



DRIVE-CLiQ interconnection

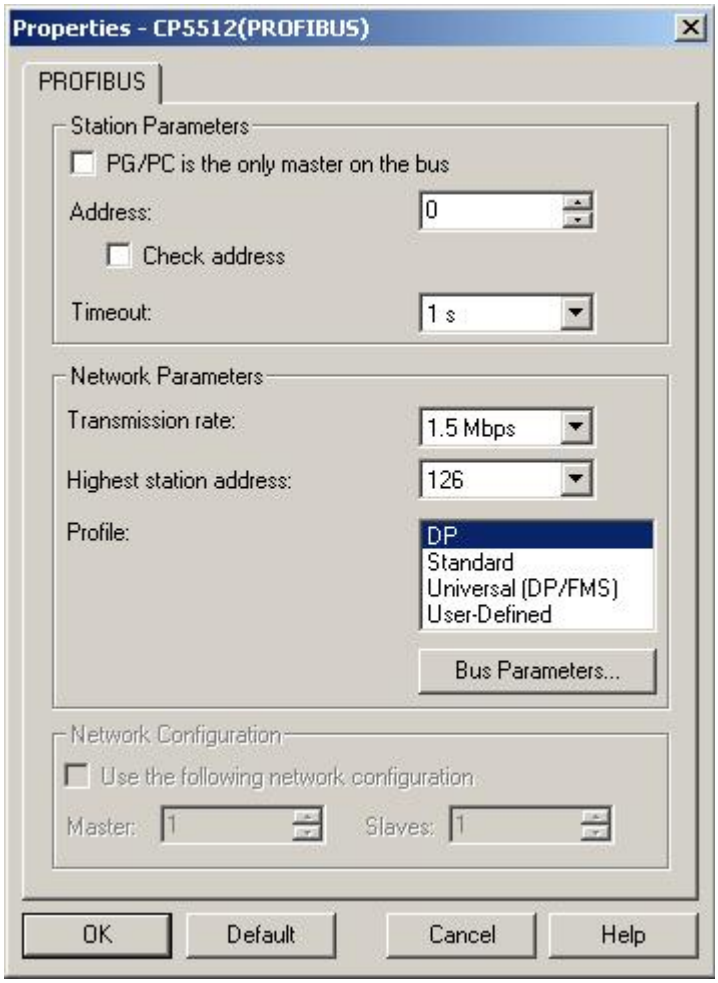
4.3 Important settings on the hardware components

In this function example, the PROFIBUS interfaces of the F-CPU and SINAMICS S120 are used for programming and for the exchange of PROFIdrive data and fail-safe signals. Hardwired 24 V signals are used exclusively for the safety-related signal exchange between the F-CPU and the TM54F.

4.3.1 Bus interfaces

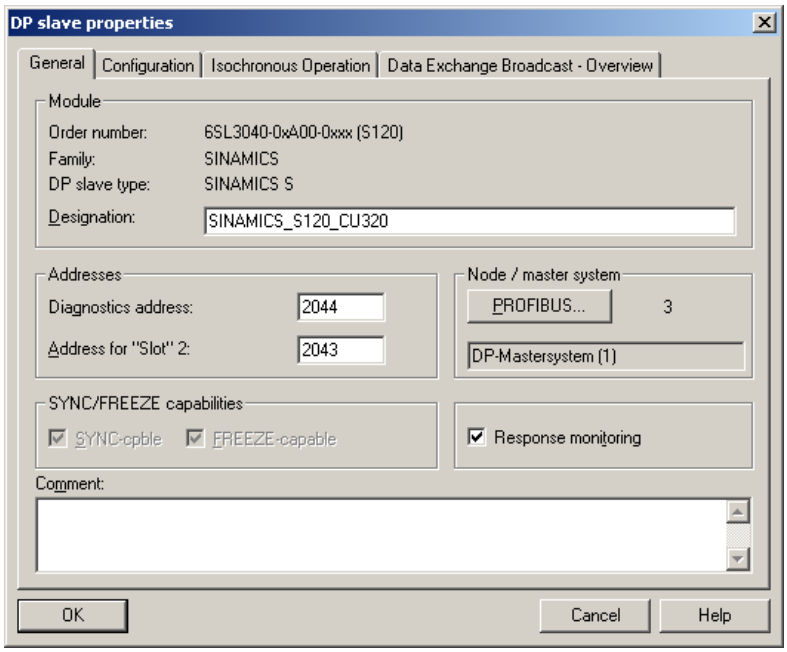
Programming device / PC

- PROFIBUS address = 0
- As the F-CPU used is the bus master, the PROFIBUS interface of the programming device must not be configured as the only master on the bus (do not enter a checkmark in the field "PG/PC is the only master on the bus").



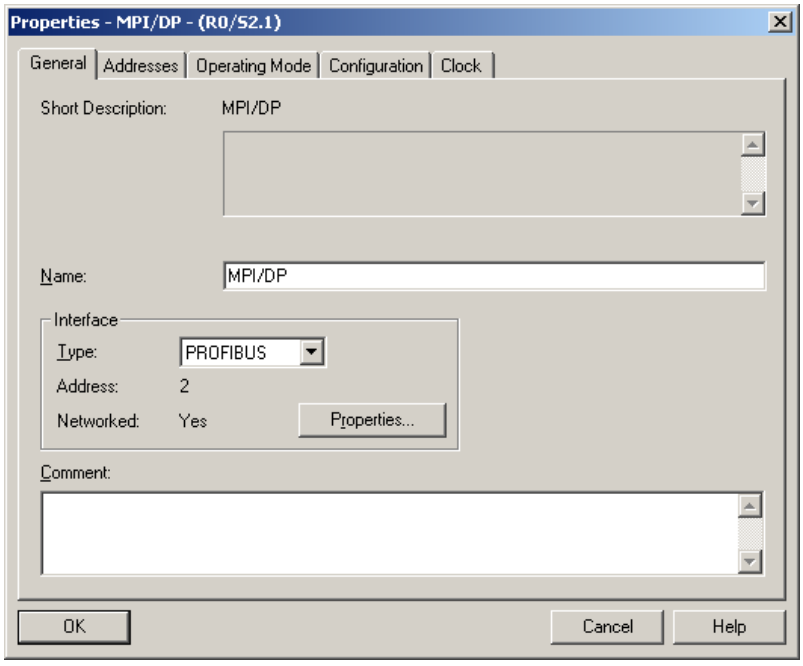
SINAMICS S120 CU320

- PROFIBUS address = 3
- The PROFIBUS address is set via HW Config and must match the DIP switch setting at the CU320.



SIMATIC 315F-2 PN/DP CPU

- PROFIBUS address = 2

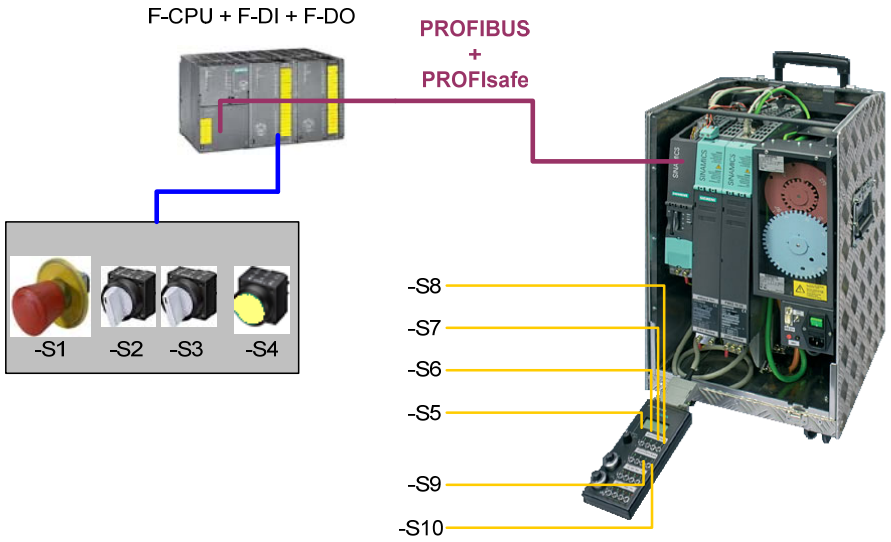


4.3.2 Requirements for operation

- The SIMATIC components have been mounted and connected with one another. The PROFIsafe addresses of the fail-safe input and output modules must have been set by means of the DIL switch; see Chapter 6.2Hardware configuration of the fail-safe controller
- All components have been connected as specified in Chapter 4.2 Wiring of the hardware components.
- The DRIVE-CLiQ topology of the SINAMICS components has been maintained.
- The motors have been connected to the Motor Module using the power and encoder 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.

5 Overview and operation

5.1 Description of operation



Hardware overview

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 -S10 are located on a switchbox that belongs to the SINAMICS training case. These switches are used to switch axis enable signals, start traversing programs, start the test function for the safety functions and acknowledge faults.

The emergency stop button S1 must be released in order to be able to operate the drives

The axis enable signals for drive 1 (upper motor) are switched using switch -S5. Traversing blocks can be started using -S6. The enable signal for axis 2 (lower motor) is issued using -S7 and the traversing blocks activated using -S8. Alarms present on the SINAMICS system can be acknowledged using -S9. 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 -S10.

If the emergency stop button -S1 is pressed, then STO is activated directly for drive 1 (upper motor), i.e. the drive coasts down to standstill. When an Emergency Stop is initiated, drive 2 comes to a standstill before drive 1. The safety function SS1 is triggered for drive 2 (lower motor); i.e. the drive is braked on the OFF3 ramp and STO then activated.

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

Drive 2 can be operated when protective door 2 is closed (toggle switch -S3). If -S3 is opened, the SOS safety function is activated, i.e. the drive is braked by the application program using the EPOS function "Intermediate stop" and held at the standstill position. After expiry of a defined period, 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 to its original speed. In this case, an ON command is not necessary.

5.2 Summary of input signals

SINAMICS digital inputs

DI0	**-S5**	Drive 1	Set / cancel axis enable signals
DI1	**-S6**	Drive 1	Start / stop the traversing program
DI2	**-S7**	Drive 2	Set / cancel axis enable signals
DI3	**-S8**	Drive 2	Start / stop the traversing program
DI6	**-S9**	Drive 1 / Drive 2	Acknowledge alarms
DI7	**-S10**	Drive 1 / Drive 2	Initiate a test stop

Fail-safe inputs on the F-DI module

F-DI0	**-S1**	Emergency stop button	Drive 1: STO Drive 2: SS1
F-DI1	**-S2**	Protective door 1 (for drive 1)	SLS
F-DI2	**-S3**	Protective door 2 (for drive 2)	SOS
F-DI3	**-S4**	Acknowledgement button	Fail-safe acknowledgement (drives 1 & 2) and depassivation (all F-slaves)

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

6 Example project

In this chapter, you get to know how the individual components must be parameterized. STARTER, DRIVE ES Basic and SIMOTION SCOUT may be used as engineering software for SINAMICS S120.

SIMOTION SCOUT was used to produce this example. STEP 7 and Distributed Safety is a prerequisite for programming the F-CPU.

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

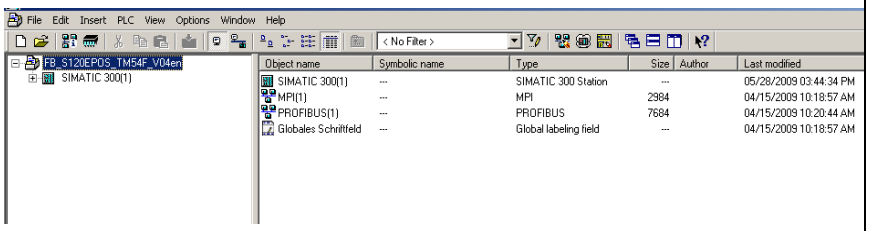
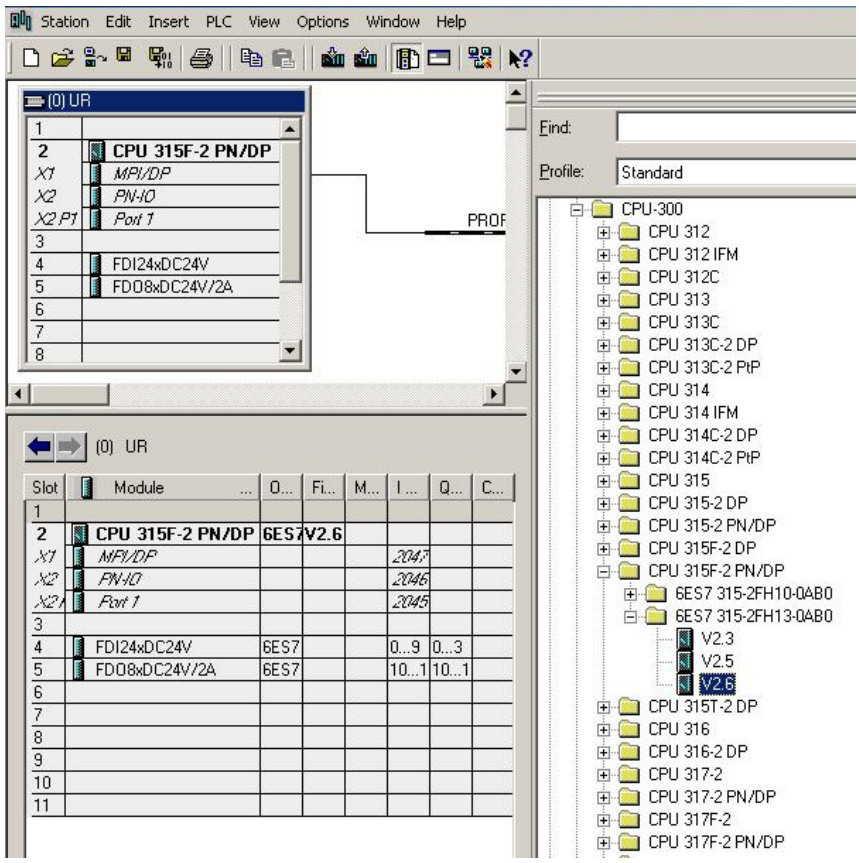
6.1 Passwords

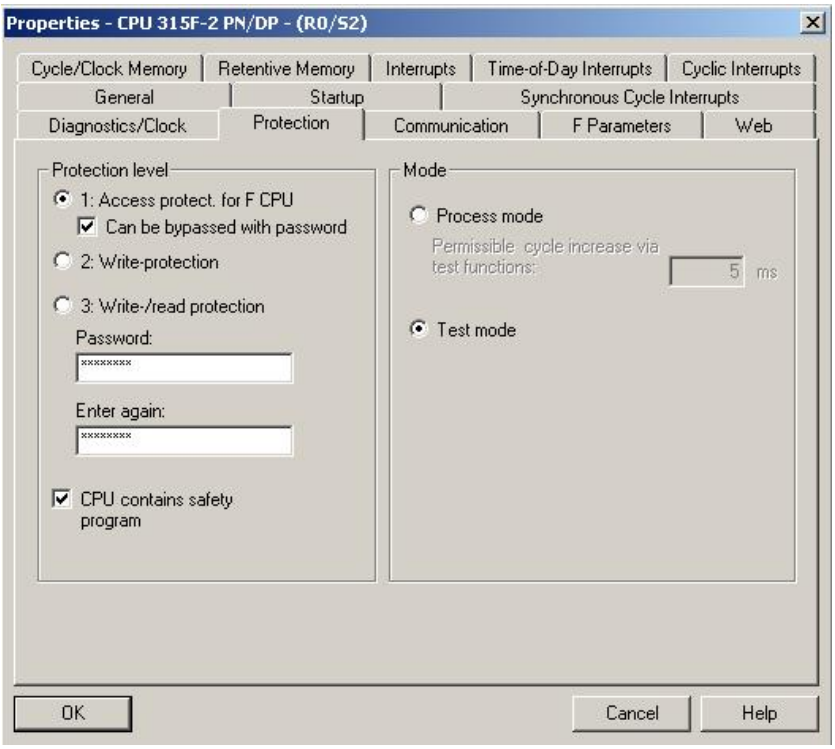
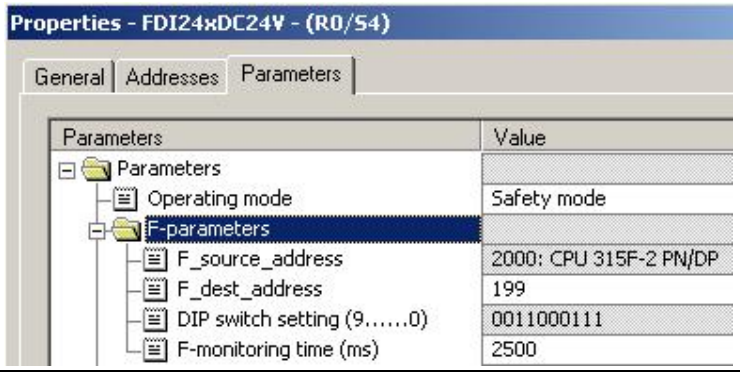
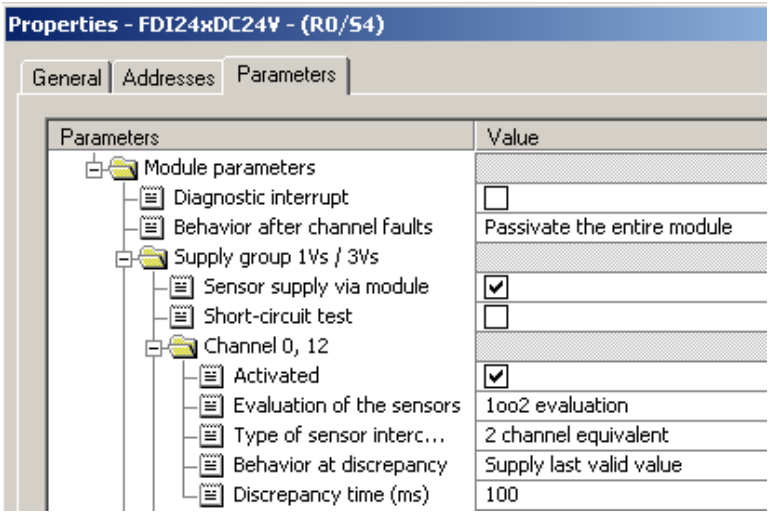
For reasons of simplicity, a common safety password is used for the program and hardware on the SIMATIC components in the project. Also when configuring the Safety functionality of the SINAMICS components, one common password is used for the drives.

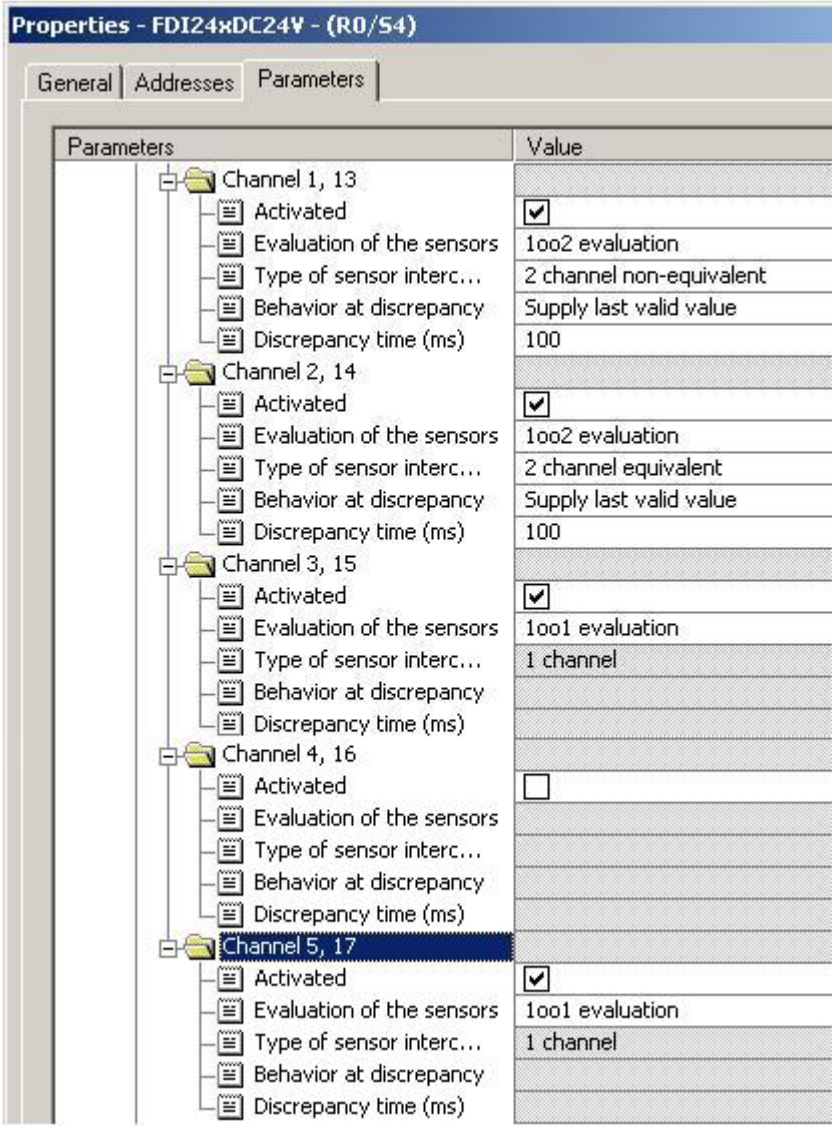
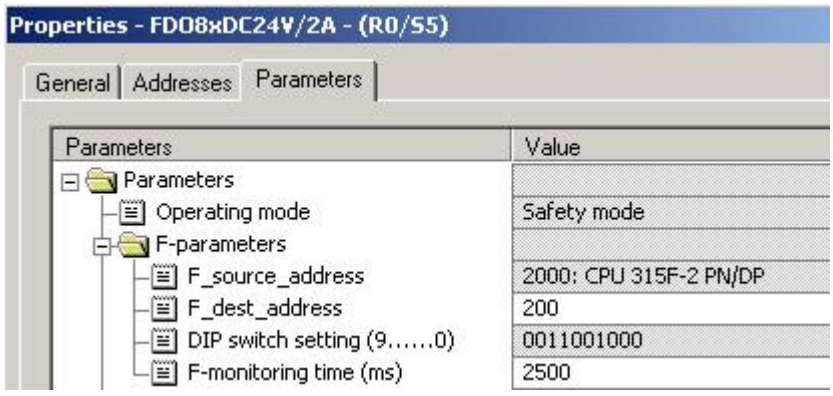
- **Safety password on the F-CPU: "0"**
- **Safety password on SINAMICS: "1"**

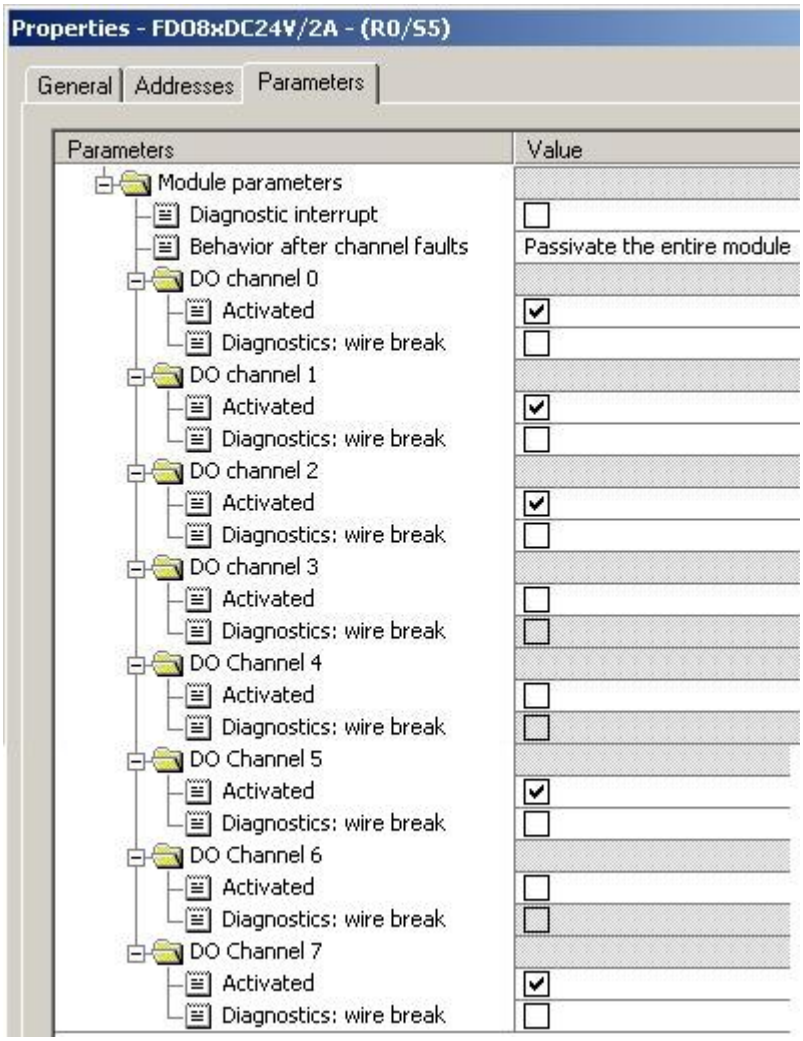
These passwords should be changed for real applications!

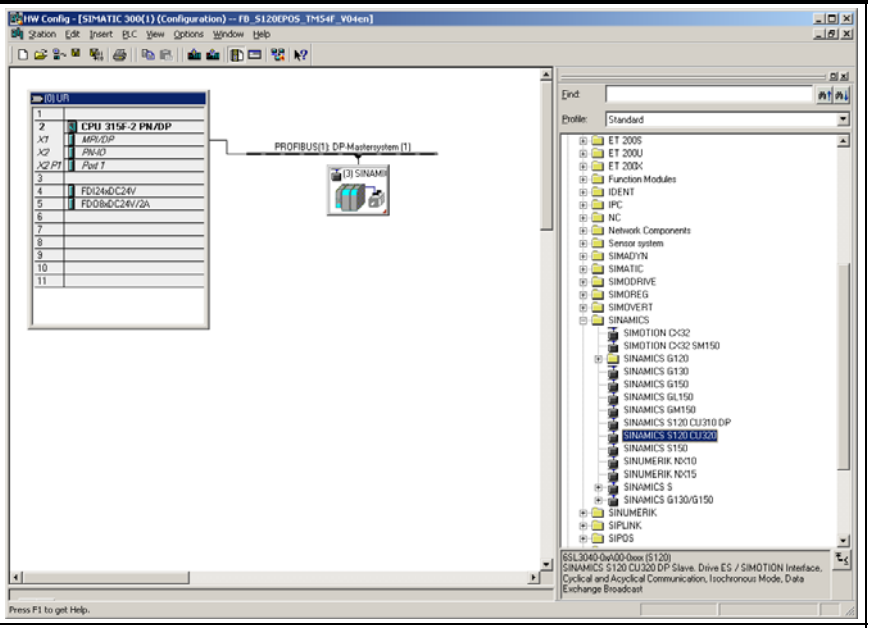
6.2 Hardware configuration of the fail-safe controller

Description	Note
In the SIMATIC Manager, insert a SIMATIC 300 station into the project.	
Completely create and parameterize the station in HW Config. Therefore, drag the modules contained in the parts list of Chapter 3.1 Hardware components from the catalog window and drop them into the configuration window. Set the address of the DP interface as described in Chapter 4.3.	

Description	Note
Configuring the F-CPU In the Properties window of the F-CPU, under the Protection tab, activate access protection for the F-CPU and protect using a password. Activate the safety program ("CPU contains safety program").	
Configuring the F-DI module. Configure the PROFIsafe address using DIL switches.	
Configuring the F-DI module. Configuring F-DI 0 (Channel 0, 12)	

Description	Note
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)	
Configuring the F-DO module. Configure the PROFIsafe address using DIL switches.	

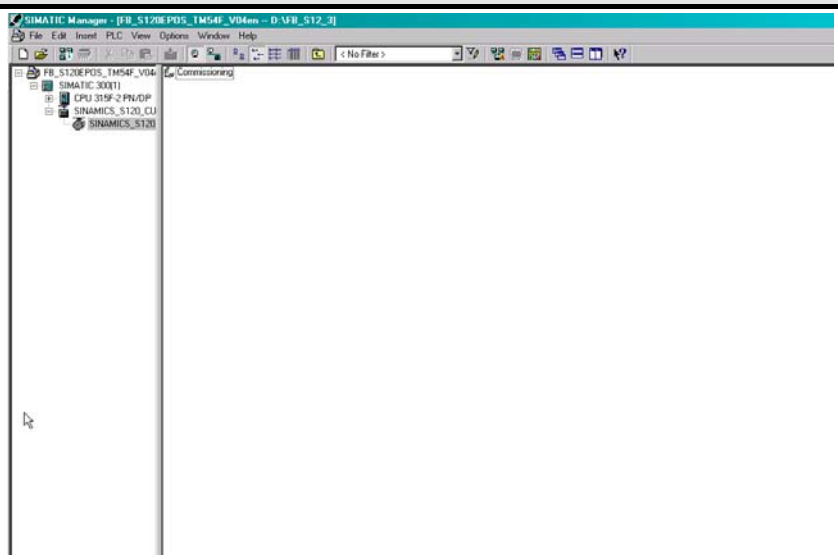
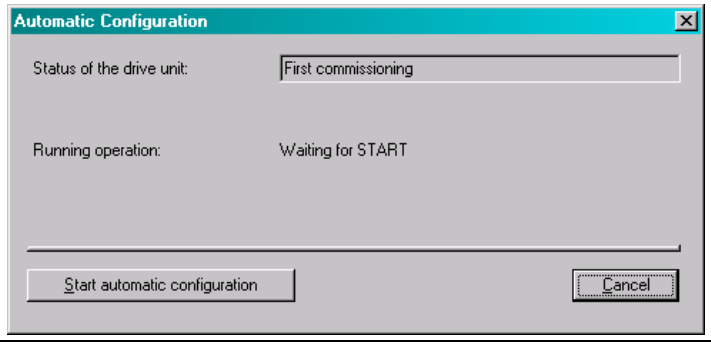
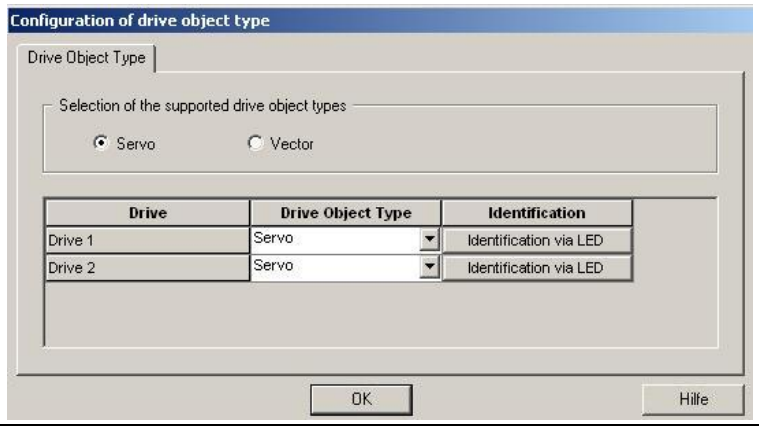
Description	Note
Configuring the F-DO module. Configuring F-DO 0 Configuring F-DO 1 Configuring F-DO 2 Configuring F-DO 5 Configuring F-DO 7	

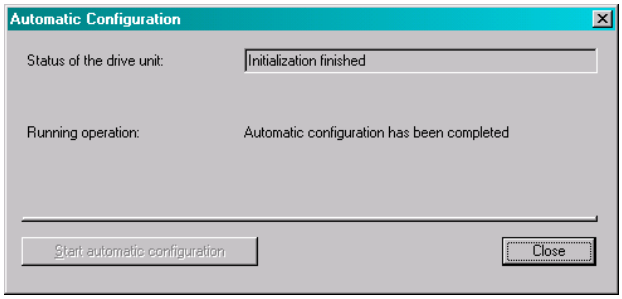
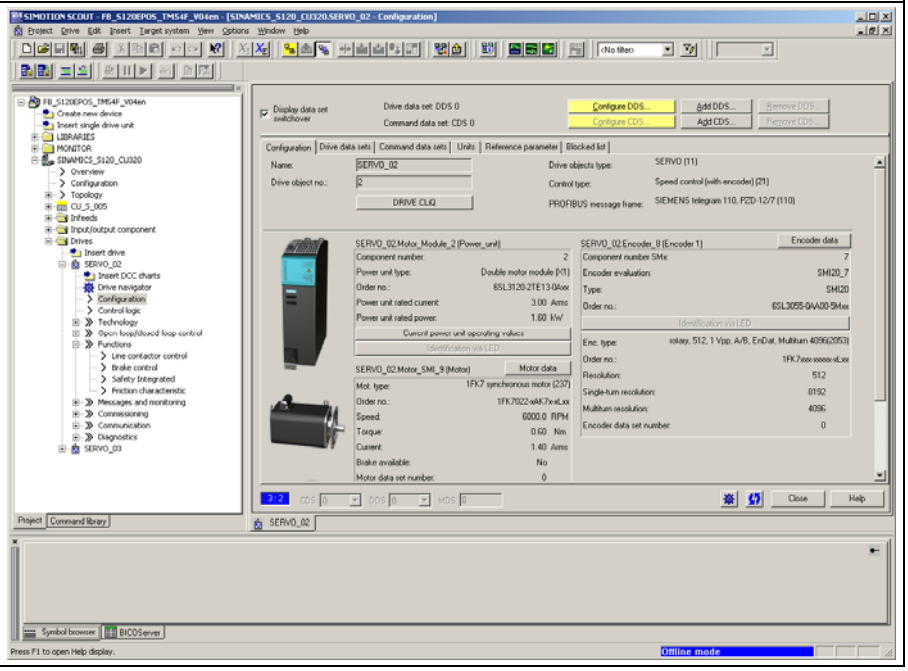
Description	Note
Insert SINAMICS S120 CU320 on PROFIBUS DP Set PROFIBUS address 3 Select device version 2.5	
Save and compile HW Config Download HW Config to the F-CPU	

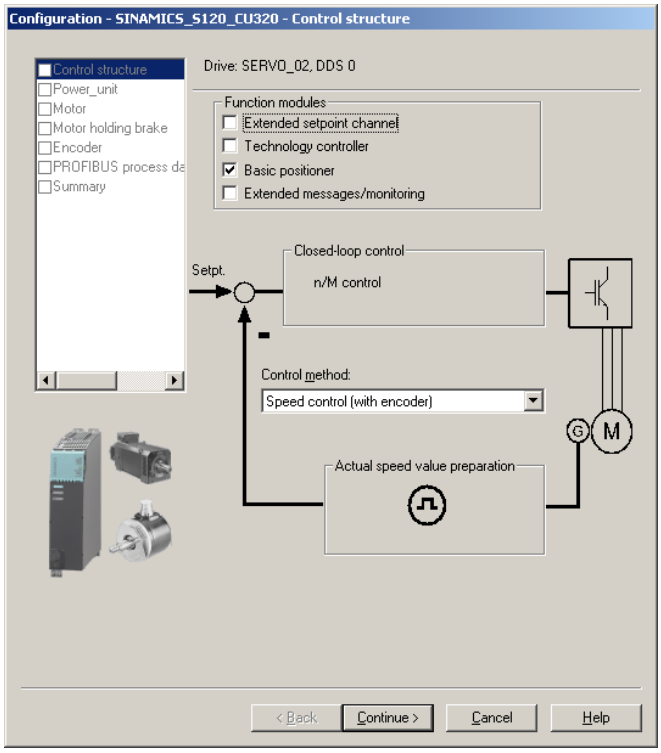
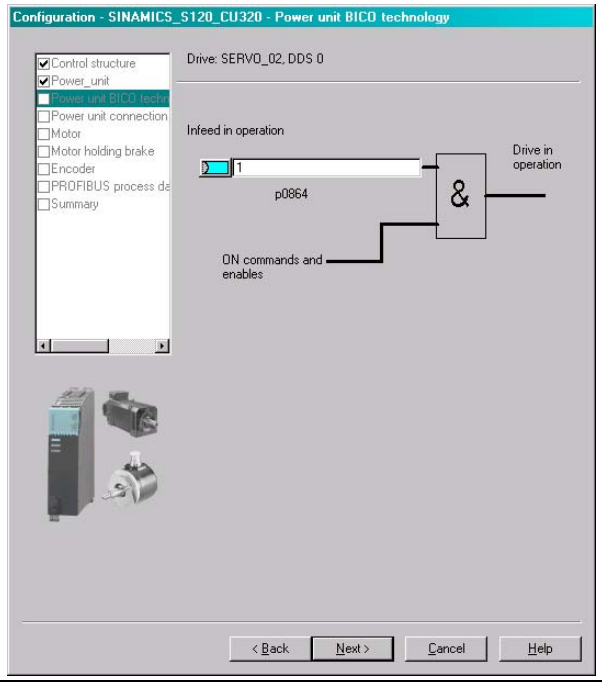
6.3 SINAMICS parameter assignment

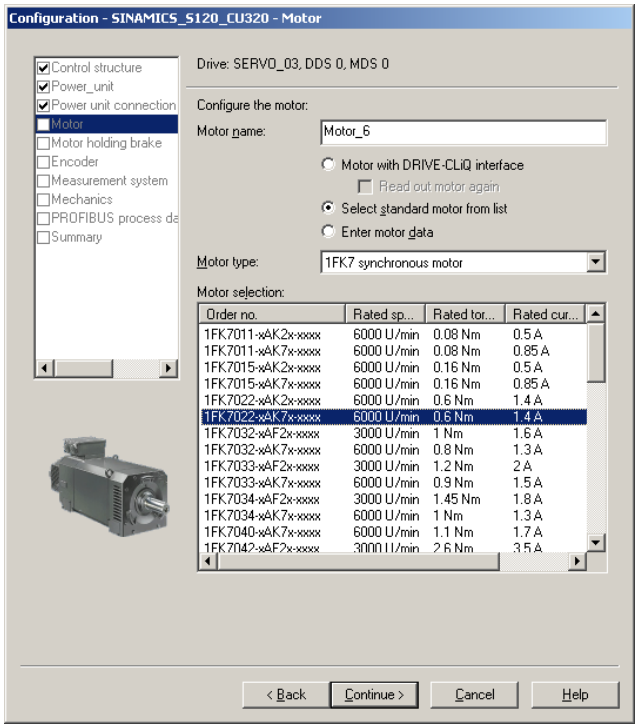
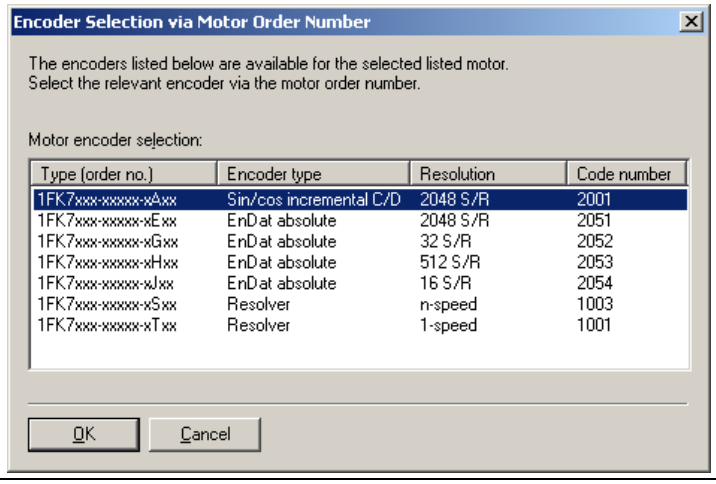
First of all, the existing hardware in the drive system must be commissioned and the desired motion functions set up.

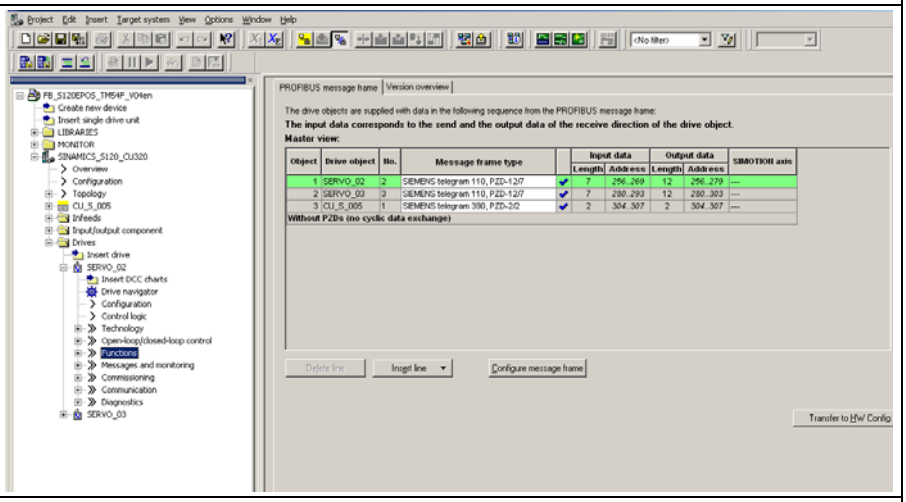
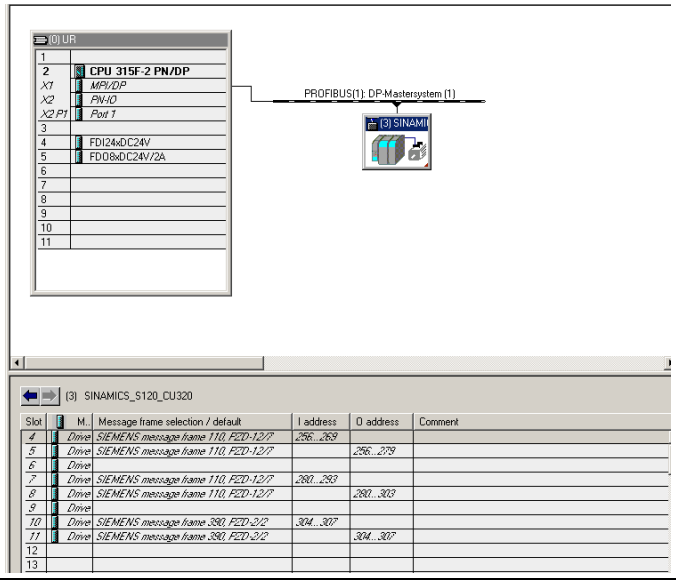
Commissioning the hardware

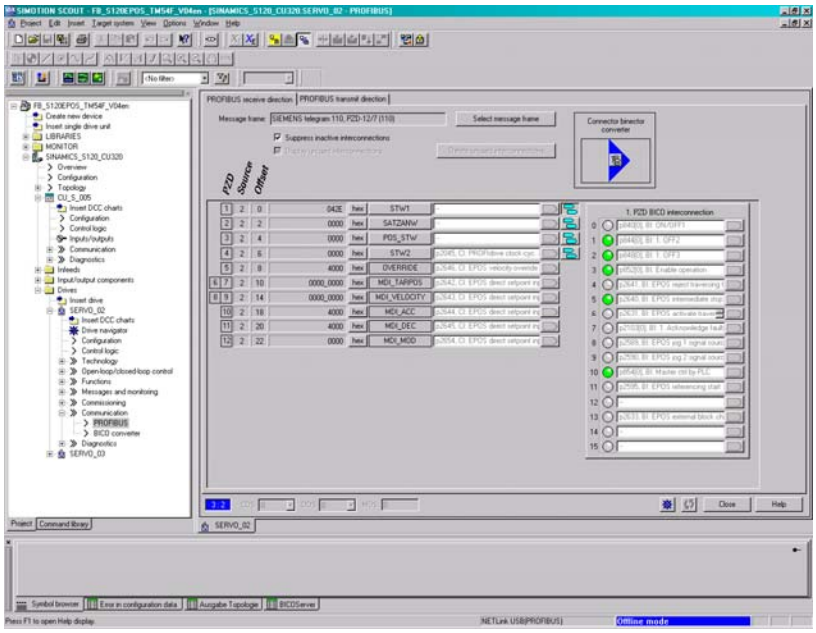
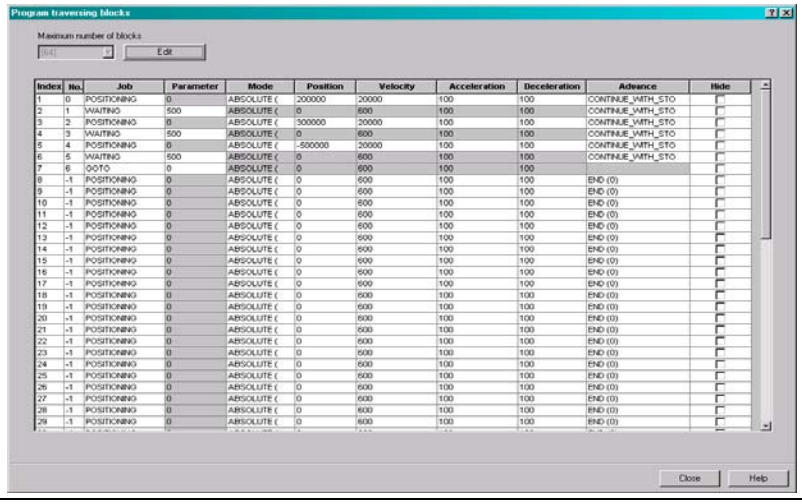
Description	Note
Double-click on Commissioning to open the STARTER program.	
Go online.	
Carry out automatic first commissioning for the drive line-up.	
Select "Servo" as drive object type.	

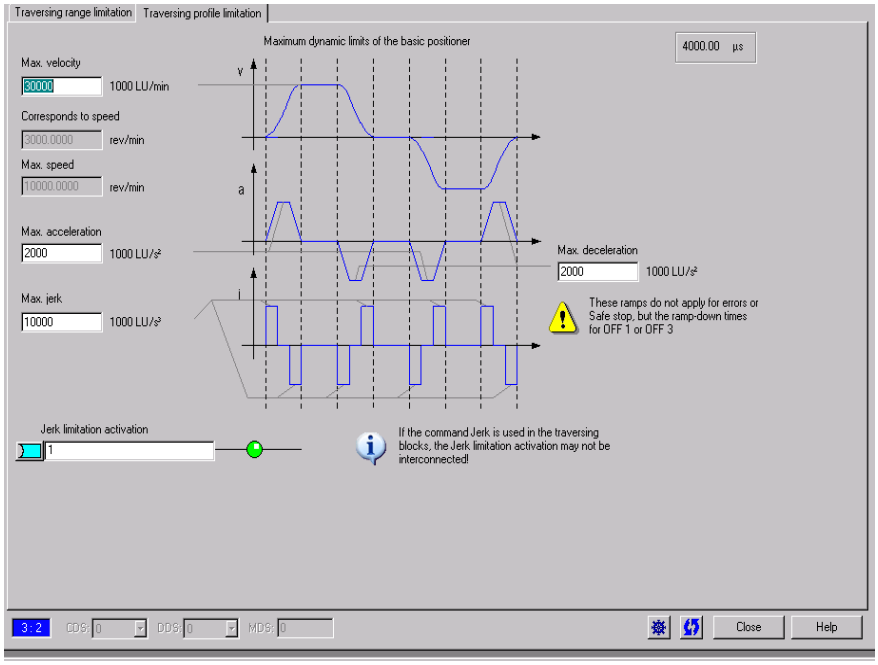
Description	Note
Complete automatic configuration.	
Go offline and "Save and Compile"	
Post configuration, both drives In the Project Navigator for drive 1 (SERVO_02), open the Configuration window. "Configure DDS" starts the navigated post configuration. Note: In the following, only those screen forms are described in which a change is required.	

Description	Note
Post configuration, both drives Activate "Basic positioner" as the control structure.	
Post configuration, both drives A signal for "Infeed in operation" (p0864) must be configured. Here, fixed binector 1 is used in the example.	

Description	Note
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.	
Post configuration, drive 2 Just like the motor, the encoder must also be manually selected. This is also implemented using the type number (order no.).	

Description	Note
Since the 5 kW SLM has no DRIVE-CLiQ interfaces, it is not necessary to configure the infeed.	**Notice**! If a Single Line Module is used for 230V 1AC (included in the training cases), the DC link parameters must be adapted as follows: p0210: 345V p1248[0]: 240V p1244[0]: 401V See also FAQ ID: 27038754 Upgrading/replacing a Motor Module in the SINAMICS S120 training case http://support.automation.siemens.com/WW/view/de/27038754
Set the OFF3 ramp-down time.	p1135: 0.4s
Select SIEMENS telegram 110 for both drives. Select SIEMENS telegram 390 on the CU. Then, transfer the configuration to HW Config.	
The telegram selected and address specification were entered automatically in HW Config. The specified address can be changed here.	

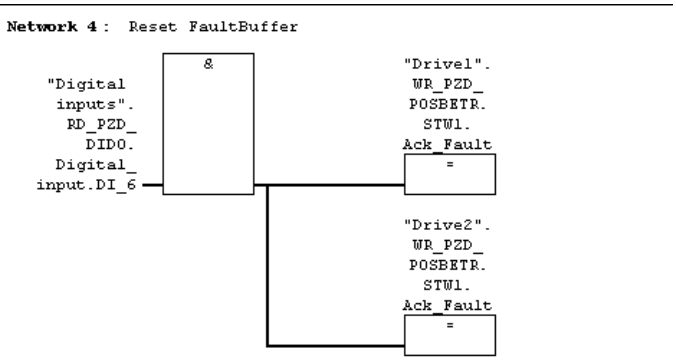
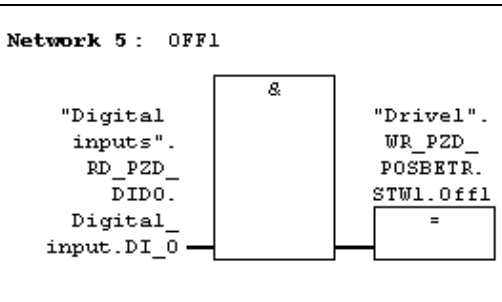
Description	Note
Save and compile the HW configuration.	
Then, download the HW configuration to the target system.	
By selecting standard telegrams, all the inter-connections required for the example were created automatically.	
Program the traversing blocks for both axes. You can also deviate from this example and use other EPOS functions, such as JOG and MDI.	

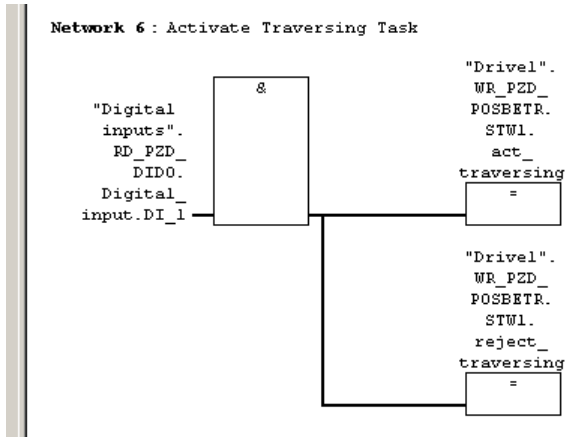
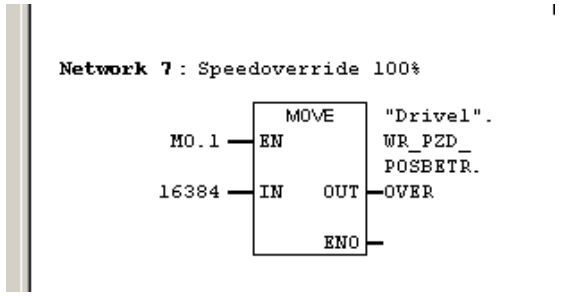
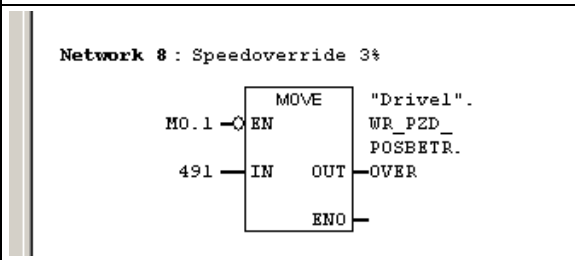
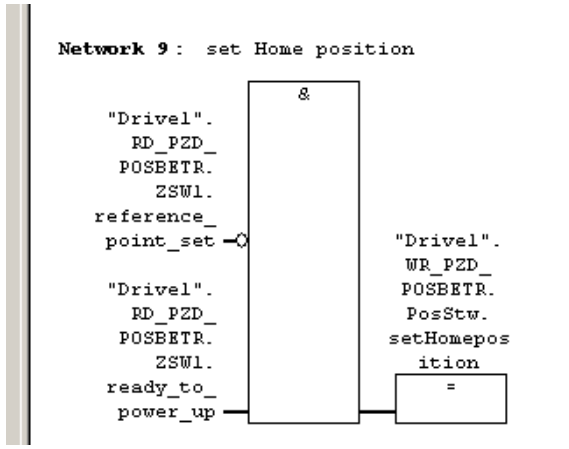
Description	Note
Adapt the traversing profile limits for both drives. Set the maximum acceleration and deceleration to 2000 and the maximum jerk to 10000. Activate the jerk limitation.	
Save the project.	
Go online.	
Download the project to the target device and copy RAM to ROM.	

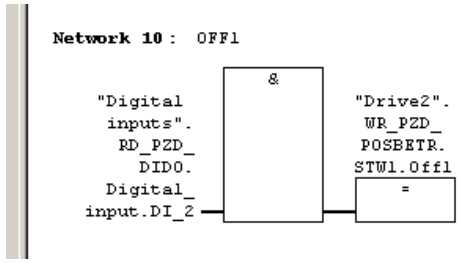
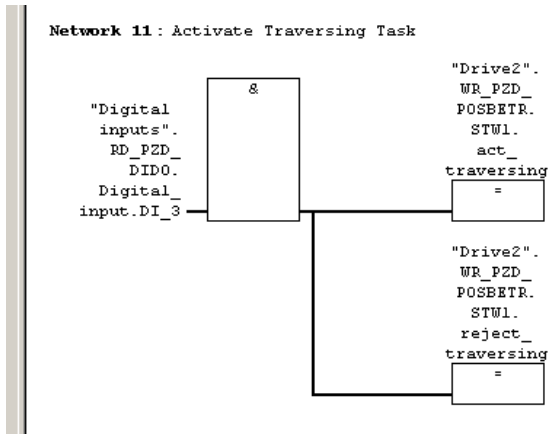
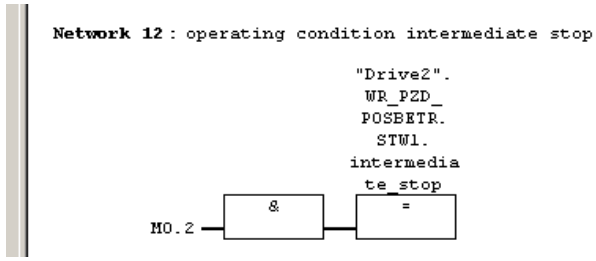
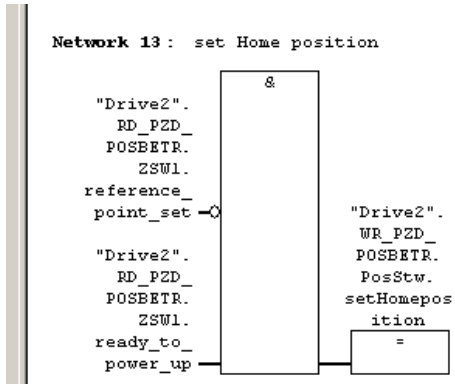
6.4 SIMATIC – Setting the standard program

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

Description	Note
OB1:NW1 Call up function FC2. FC2 is the user program in this case.	OB1 : "Main Program Sweep (Cycle)" Netzwerk 1: Call FC 2 CALL FC 2
Then save the block OB1 and load it to the target system.	

Description	Note
FC2:NW1, NW2 and NW3 Write the input data of the standard telegrams to the associated data blocks. SFC14 is used for this purpose.	FC2 : Drivecontrolling Network 1: Read Drive 1 CALL "DPRD_DAT" LADDR :=W#16#100 RET_VAL:="Drive1".RetVall RECORD :="Drive1".RD_PZD_POSBETR Network 2 : Read Drive 2 CALL "DPRD_DAT" LADDR :=W#16#118 RET_VAL:="Drive2".RetVall RECORD :="Drive2".RD_PZD_POSBETR Network 3 : Read digital I/O CALL "DPRD_DAT" LADDR :=W#16#130 RET_VAL:="Digital inputs".RetVall RECORD :="Digital inputs".RD_PZD_DID0
FC2:NW4 Acknowledge drive fault.	
FC2:NW5 Drive enable, drive 1	

Description	Note
FC2:NW6 Start traversing blocks for drive 1	
FC2:NW7 Set the speed override for protective door closed to 16384 = 100%. M0.1 stands for deselection from within the safety program.	
FC2:NW8 Set the velocity override for safety door closed to 491 = 3%. M0.1 stands for deselection from within the safety program.	
FC2:NW9 Automatic setting of home position for drive 1. In the example, the home position is always set when the drive is ready to power up and the home position has not yet been set.	

Description	Note
FC2:NW10 Drive enable, drive 2	
FC2:NW11 Start traversing blocks for drive 2	
FC2:NW12 Interrupt traversing blocks for drive 2 with intermediate stop when the protective door is opened. M0.2 stands for deselection from within the safety program.	
FC2:NW13 Automatic setting of home position for drive 2. In the example, the home position is always set when the drive is ready to power up and the home position has not yet been set.	

Description	Note
FC2:NW14, NW15 and NW16 Write the output data of the standard telegrams from the associated data blocks. SFC15 is used for this purpose.	**Network 14** : Write Drive 1 CALL "DPWR_DAT" LADDR :=W#16#100 RECORD :="Drive1".WR_PZD_POSBETR RET_VAL:="Drive1".RetVal2 **Network 15** : Write Drive 2 CALL "DPWR_DAT" LADDR :=W#16#118 RECORD :="Drive2".WR_PZD_POSBETR RET_VAL:="Drive2".RetVal2 **Network 16** : Write digital I/O CALL "DPWR_DAT" LADDR :=W#16#130 RECORD :="Digital inputs".WR_PZD_DIDO RET_VAL:="Digital inputs".RetVal2
Then save the block FC and load it to the target system.	 + 
Then download data blocks DB100, DB101 and DB102 These data blocks correspond to standard telegrams 110 and 390.	 + 

Table of symbols used:

Symbol	Address
"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

Symbol	Address
"Digital inputs".RetVal2	DB102.DBW10
"Drive1".WR_PZD_POSBETR	DB100.DBX0.0
"Drive1".WR_PZD_POSBETR.STW1.Off1	DB100.DBX1.0
"Drive1".WR_PZD_POSBETR.STW1.reject_traversing	DB100.DBX1.4
"Drive1".WR_PZD_POSBETR.STW1.act_traversing	DB100.DBX1.6
"Drive1".WR_PZD_POSBETR.STW1.Ack_Fault	DB100.DBX1.7
"Drive1".WR_PZD_POSBETR.PosStw.setHomeposition	DB100.DBX5.1
"Drive1".WR_PZD_POSBETR.OVER	DB100.DBW8
"Drive1".RD_PZD_POSBETR	DB100.DBX24.0
"Drive1".RD_PZD_POSBETR.ZSW1.reference_point_set	DB100.DBX24.3
"Drive1".RD_PZD_POSBETR.ZSW1.ready_to_power_up	DB100.DBX25.0
"Drive1".RetVal1	DB100.DBW38
"Drive1".RetVal2	DB100.DBW40
"Drive2".WR_PZD_POSBETR	DB101.DBX0.0
"Drive2".WR_PZD_POSBETR.STW1.Off1	DB101.DBX1.0
"Drive2".WR_PZD_POSBETR.STW1.reject_traversing	DB101.DBX1.4
"Drive2".WR_PZD_POSBETR.STW1.intermediate_stop	DB101.DBX1.5
"Drive2".WR_PZD_POSBETR.STW1.act_traversing	DB101.DBX1.6
"Drive2".WR_PZD_POSBETR.STW1.Ack_Fault	DB101.DBX1.7
"Drive2".WR_PZD_POSBETR.PosStw.setHomeposition	DB101.DBX5.1
"Drive1".RD_PZD_POSBETR	DB101.DBX24.0
"Drive2".RD_PZD_POSBETR.ZSW1.reference_point_set	DB101.DBX24.3
"Drive2".RD_PZD_POSBETR.ZSW1.ready_to_power_up	DB101.DBX25.0
"Drive2".RetVal1	DB101.DBW38
"Drive2".RetVal2	DB101.DBW40

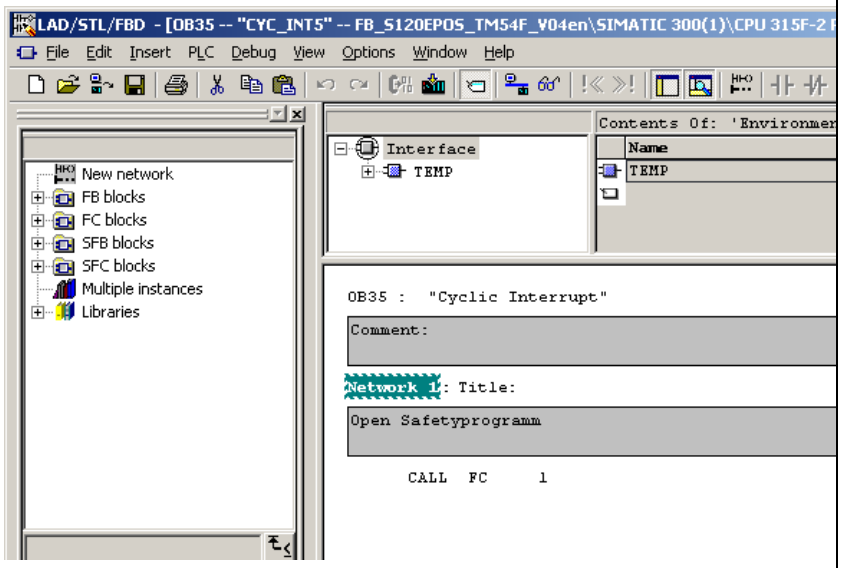
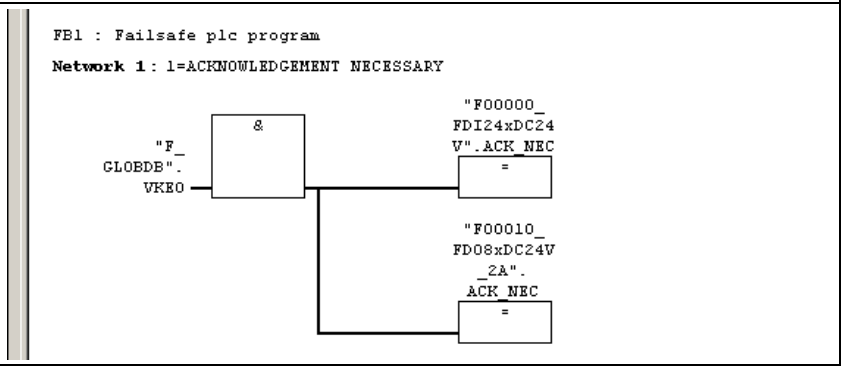
6.5 Programming the fail-safe controller

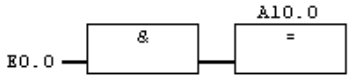
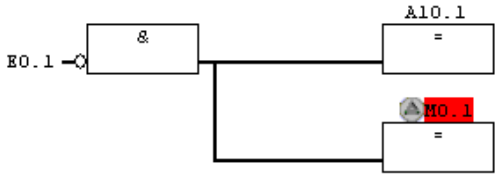
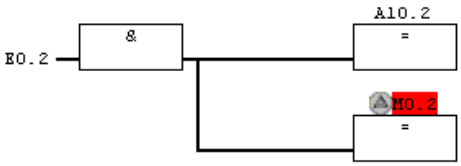
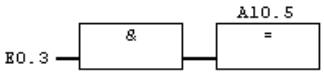
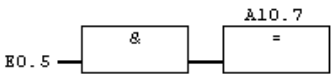
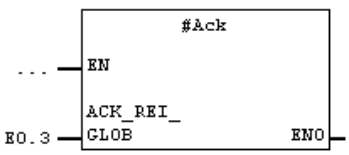
In this example, the safety program in the F-CPU is processed in fail-safe function block FB1. A simplified program sequence has been selected to illustrate how the functions work. Complex safety logic and boundary conditions for creating the safety program are covered in the relevant function examples and in the Distributed Safety manuals.

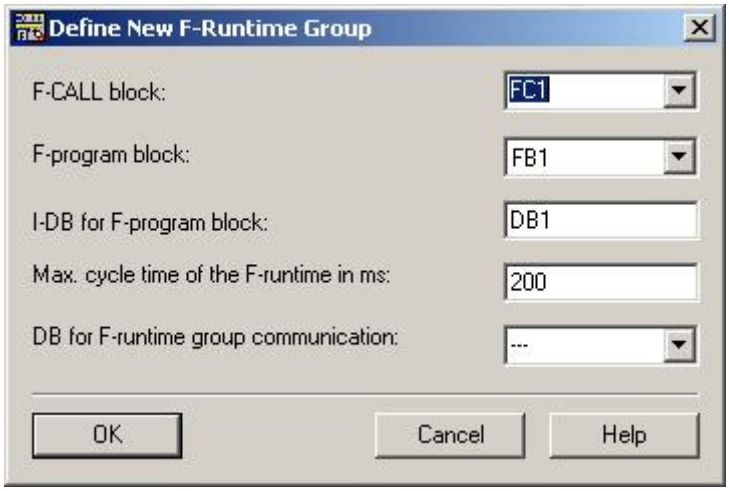
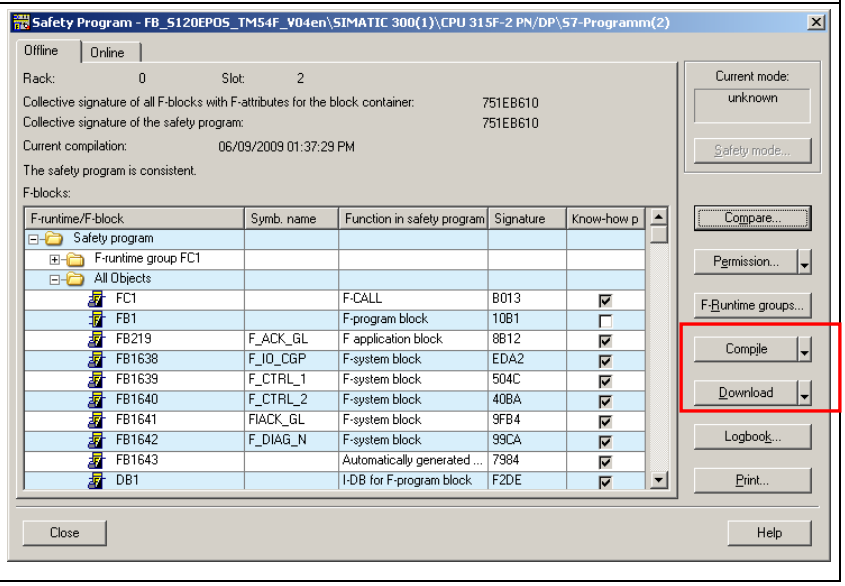
Caution:
In this form, it is not permissible that the program is used for a real application.

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 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 using the F-LAD or F-FBD programming language.

Description	Note
Programming OB35 Calling the safety program	
Programming FB1 Network 1: Activate automatic acknowledgement	

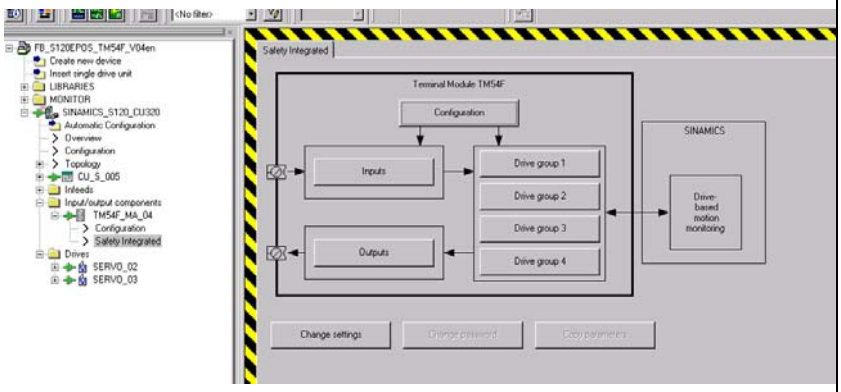
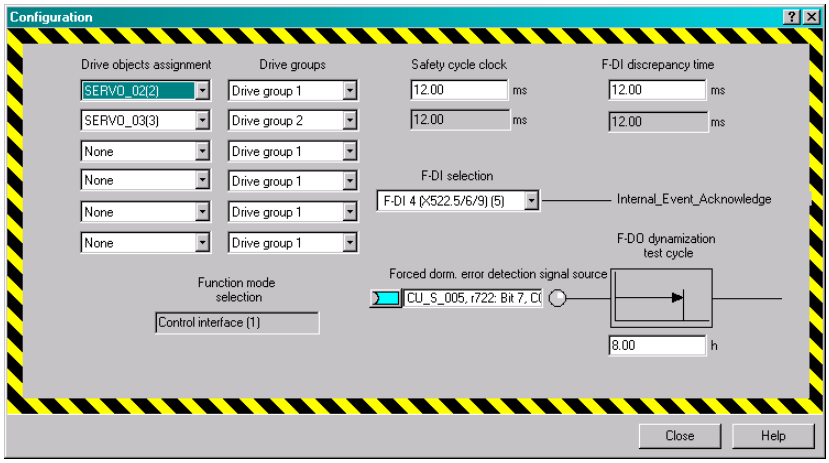
Description	Note
Programming FB1 Network 2: -S1 (emergency stop) is interconnected to F-DO 0. F-DO 0 (F-DO module) is connected to F-DI 0 (TM54F)- Network 3: -S2 (protective door 1) is interconnected in inverted form to F-DO 1 and bit memory M0.1. F-DO 1 (F-DO module) is connected to F-DI 1 (TM54F). Bit memory M0.1 is used to evaluate the request in the standard program.	**Network 2** : Emergency STOP S1 (Mushroom pushbutton)  **Network 3** : Switch S2 (simulated safety door 1) 
Programming FB1 Network 4: -S3 (protective door 2) is interconnected to F-DO2. F-DO 2 (F-DO module) is connected to F-DI 2 (TM54F) Network 5: -S4 (acknowledgement) is connected to F-DO 5. F-DO 5 (F-DO module) is connected to F-DI 4 (TM54F)	**Network 4** : Switch S3 (simulated safety door 2)  **Network 5** : Pushbutton S4 (acknowledgment) 
Programming FB1 Network 6: Switching the signal lamp in S4 for safe standstill detection. Network 7: -S4 is used for acknowledgement.	**Network 6** : Switching the lamp in switch S4  **Network 7** : Reintegration of all f-slaves 

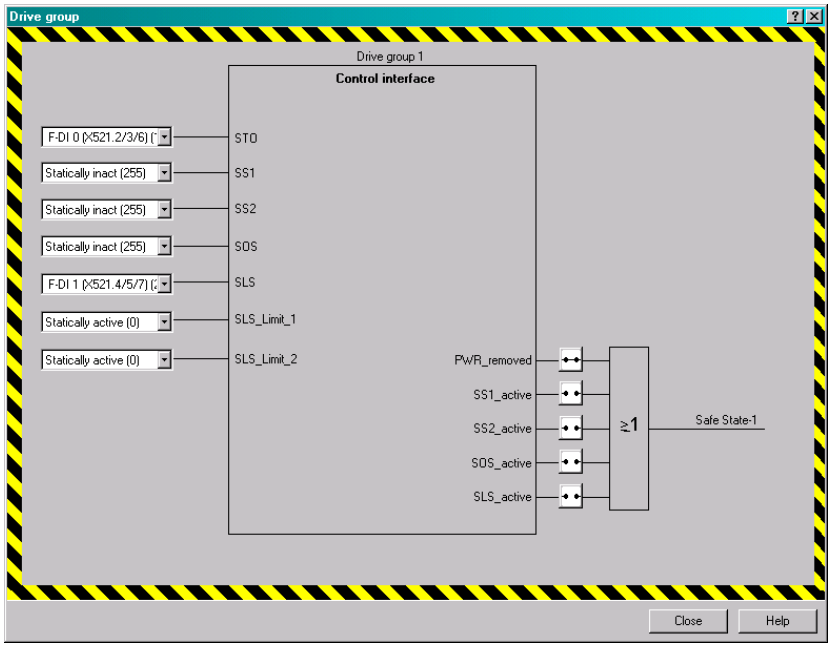
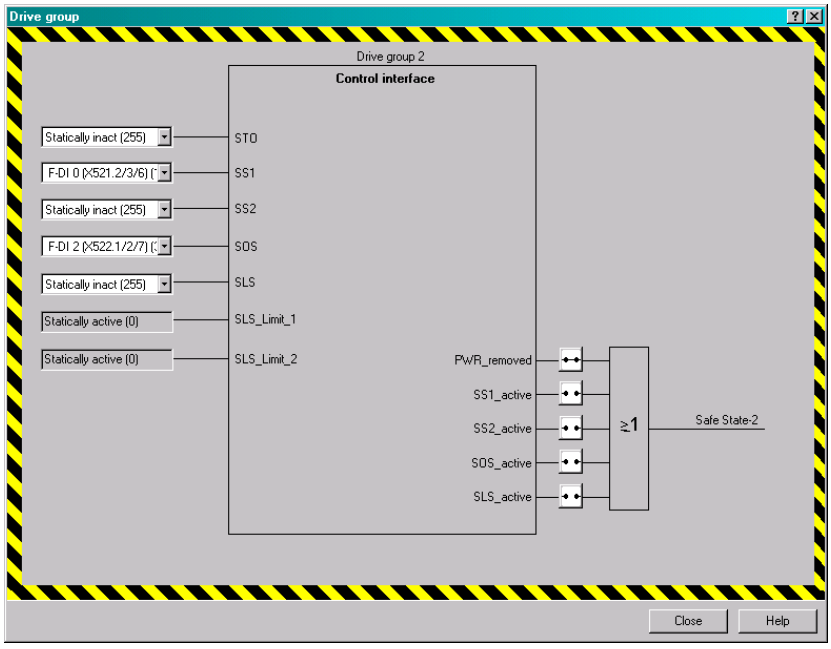
Description	Note
Creating a new F-runtime group Here, the safety program (FB1) is assigned to FC1 and the associated I-DB is defined.	
Then, generate the safety program and download to the CPU. In addition, download the standard blocks to the F-CPU.	

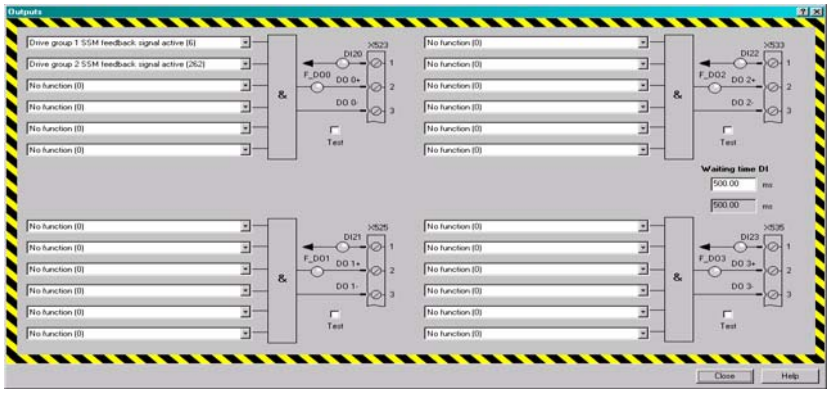
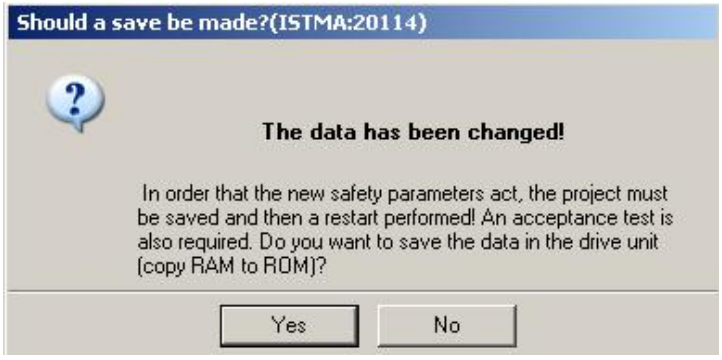
6.5.1 Configuring the fail-safe TM54F terminal module

Note:
The fail-safe terminal module must be configured online.

Description	Note
Go online in STARTER.	

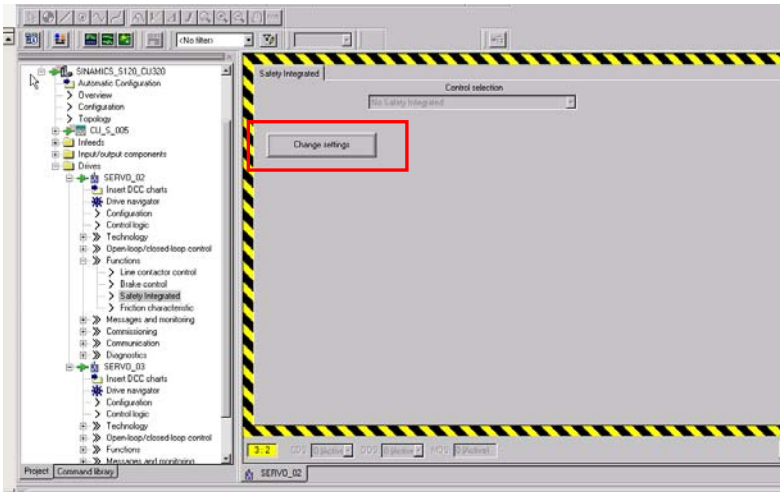
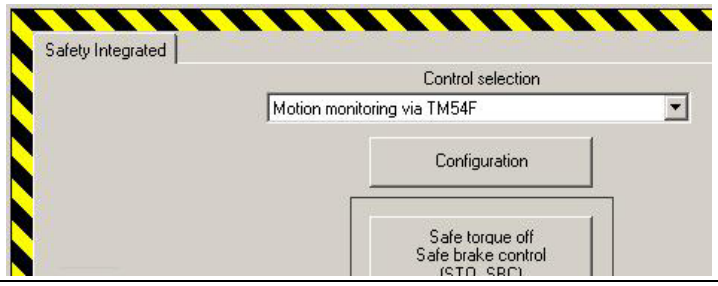
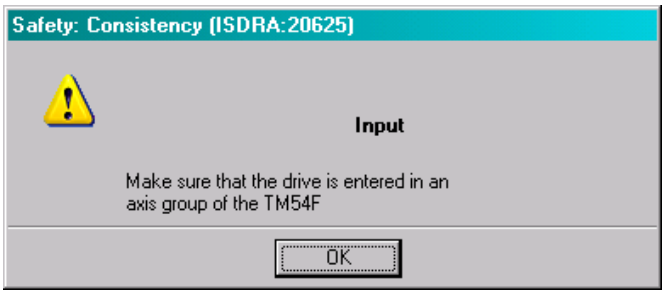
Description	Note
Open the "Safety Integrated" window of the TM54F and activate the commissioning mode with "Change settings". The password for the first commissioning is "0".	
"Configuration" window The following have to be configured in the example: Assignment, drives / drive groups F-DI discrepancy time F-DI for fail-safe acknowledgement Signal source for forced dormant error detection	

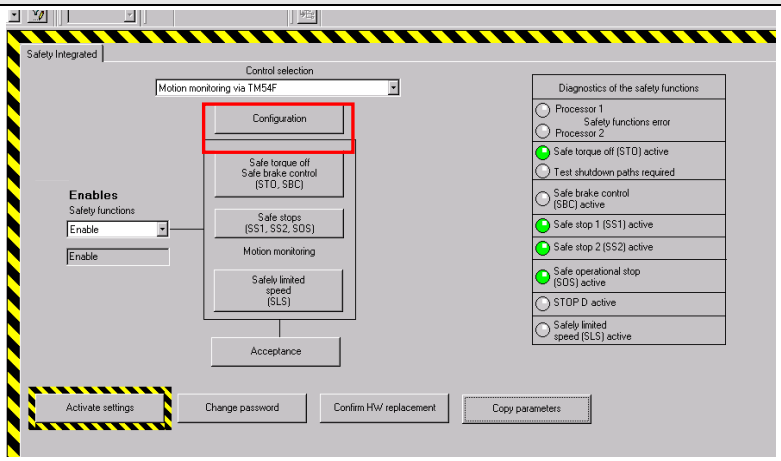
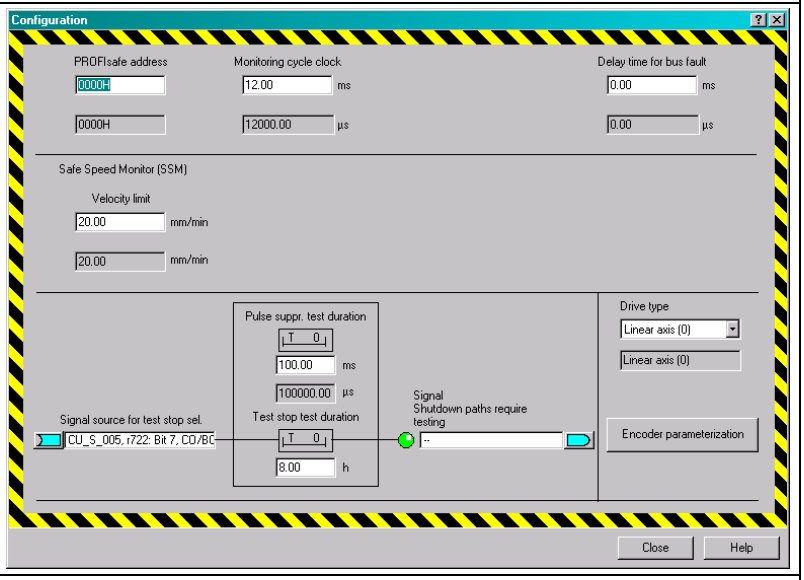
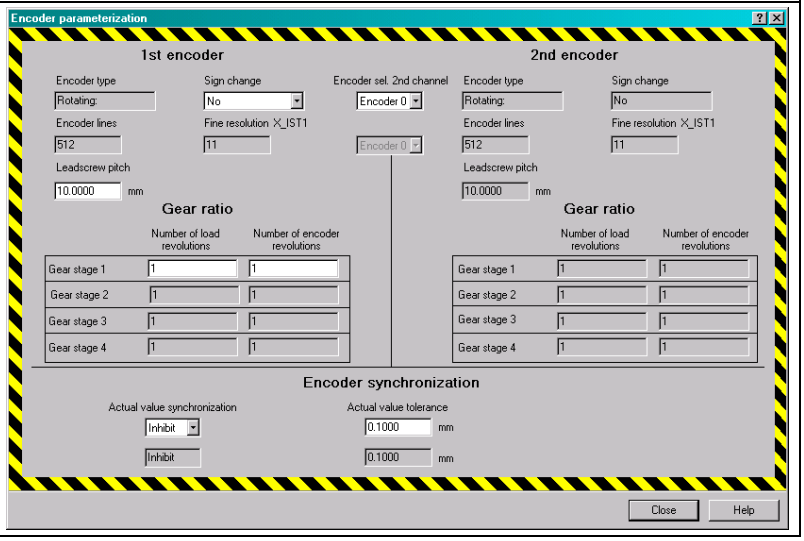
Description	Note
"Drive group 1" window The following have to be configured in the example: STO statically inactive SS1 via F-DI 0 SOS via F-DI 1 SS2 and SLS statically inactive	
"Drive group 2" window The following have to be configured in the example: STO via F-DI 0 SS1, SS2 and SOS statically inactive SLS via F-DI 2	

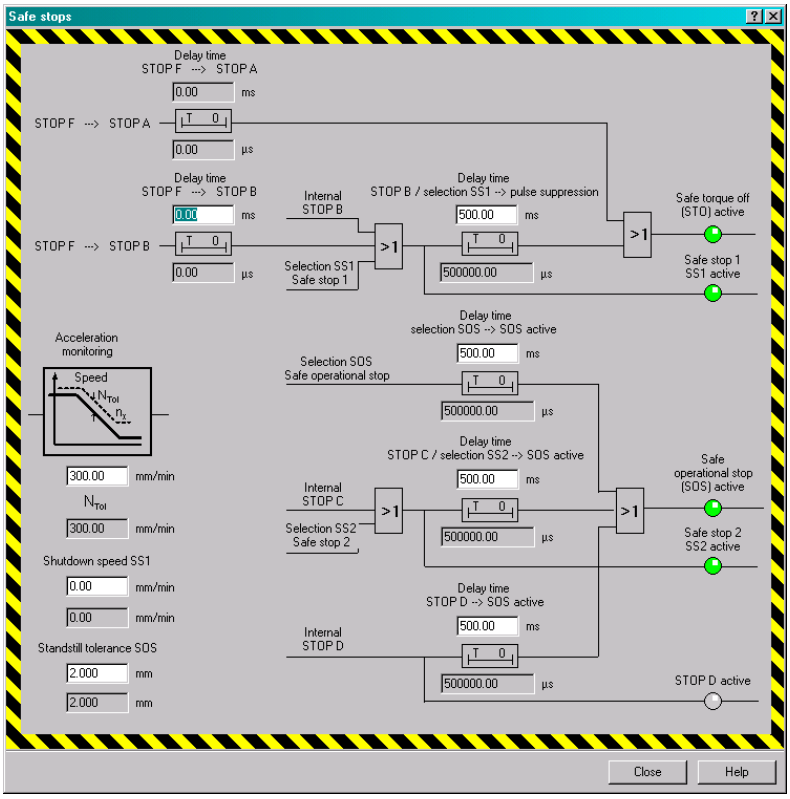
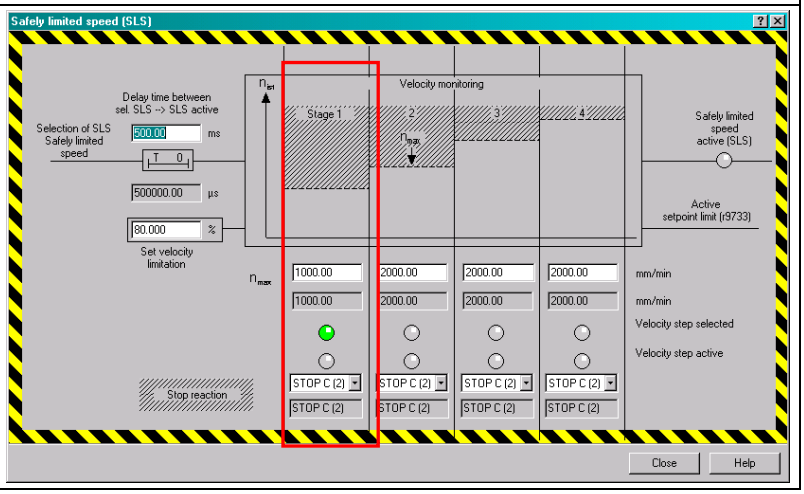
Description	Note
"Outputs" window The following have to be configured in the example: 1st signal for F-DO 0 with checkback signal SSM for drive group 1. 2nd signal for F-DO 0 with checkback signal SSM for drive group 2.	
Copy parameters and then open the dialog box to change the password.	
Enter a new password. The value "1" is used in the example.	
Activate settings	
Execute RAM to ROM backup (start with "OK").	

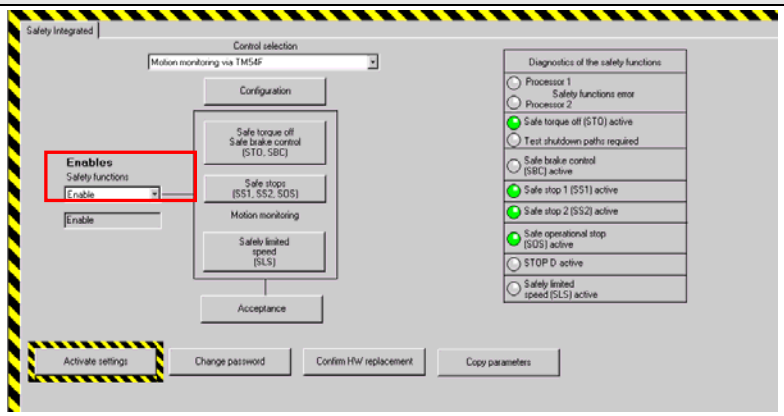
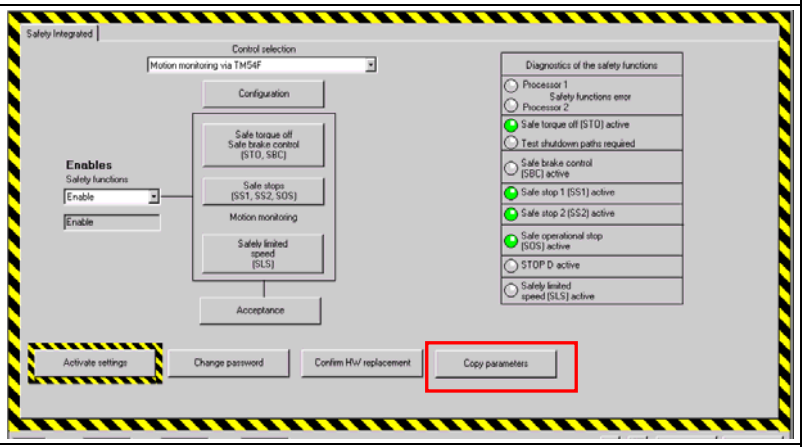
Note:
The system can be immediately restarted. However, it is recommended to configure the safety functions of the axes beforehand.

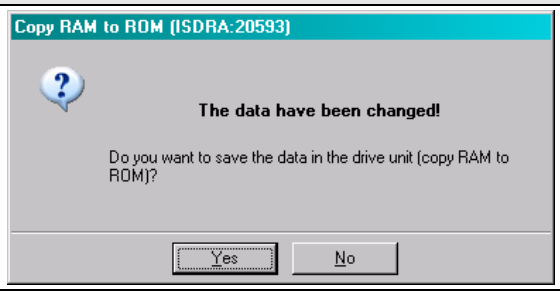
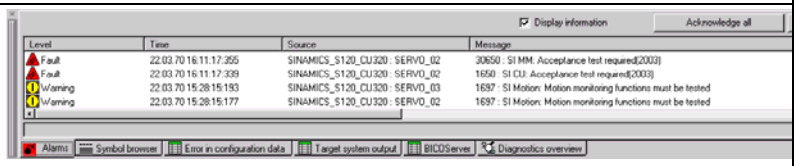
6.6 SINAMICS - Parameterizing the safety functions integrated in the drive

Description	Note
Go online in STARTER.	
Open the "Safety Integrated" window of drive 1/2 (SERVO_02 / SERVO_03) and activate the commissioning mode using "Change settings". The password for the first commissioning is "0".	
Change control selection to "Motion Monitoring via TM54F".	
Confirm message with "OK".	

Description	Note
Click on "Configuration".	
The following have to be configured in the example: Velocity limit (SSM) with 20 mm/min Signal source, test stop with DI7 of SINAMICS.	
In the "Encoder parameterization" window, the encoder data of the drive are entered.	

Description	Note
Enter the following values for the example in the "Safe stops" screen form: Delay time SS1 -> Pulse suppression = 500msec Delay time selection SOS -> SOS active = 500msec Delay time SS2-> SOS active = 100msec Acceleration monitoring = 500mm/min Shutdown speed SS1 = 0mm/min Standstill tolerance SOS = 2.0mm	
Use the "Safely limited speed (SLS)" screen form to enter the maximum speed (limit speed: speed still permissible when protective door is open). Only Stage 1 is used for velocity monitoring. The stop reaction to be initiated if the limit is exceeded must also be selected. (STOP C - internal SS2) Within the "Delay time between sel. SLS -> SLS active" (p9551'), the drive speed must be lower than the limit n_max.	

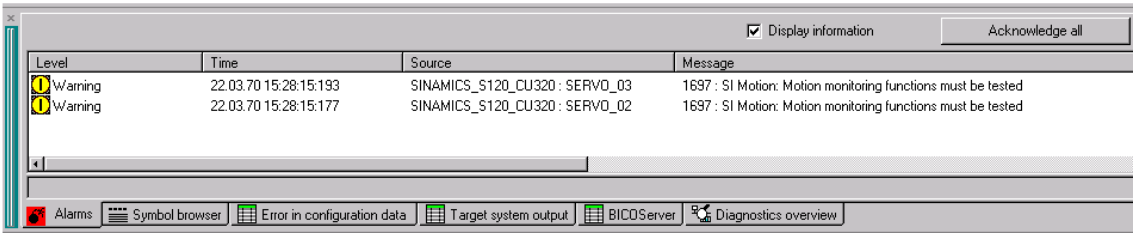
Description	Note
Enable safety functions.	
In order to accept the settings made, click on "Copy parameters".	
Click on "Activate settings".	
When the machine is commissioned for the first time, you are prompted to enter the safety password. In the example, the default password during first commissioning is "0"; the new password is "1".	
Click on "Axis parameters" to save the changes in the drive.	

Description	Note
Confirm message that appears with "Yes". The data is copied from the RAM to the ROM.	
Repeat this procedure for the second drive!	
Acknowledge the messages for acceptance test; Notice: With a real machine, it is necessary to perform acceptance testing (see section 6.9 Acceptance test for details).	
Now, copy from RAM to ROM (on SINAMICS Integrated).	
Then perform a Power-On reset on the Control Unit.	POWER ON
Go online, download the configuration to the PG and save.	

If you have carried out the Safety commissioning for all drives, you can operate the drives with emergency stop deselected.

The use of the safety functions integrated in the drive is selected and these can be activated or deactivated using the operator control elements at the F-CPU.

Only the following messages should be visible.

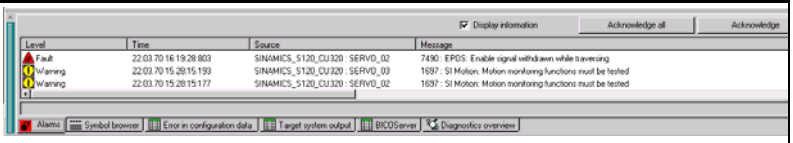
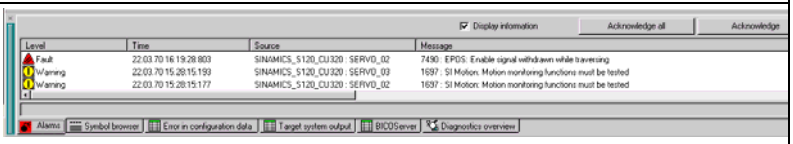


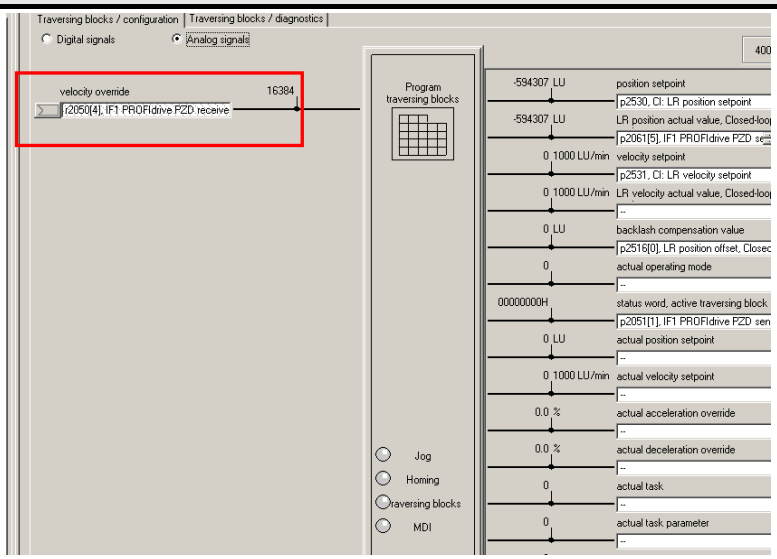
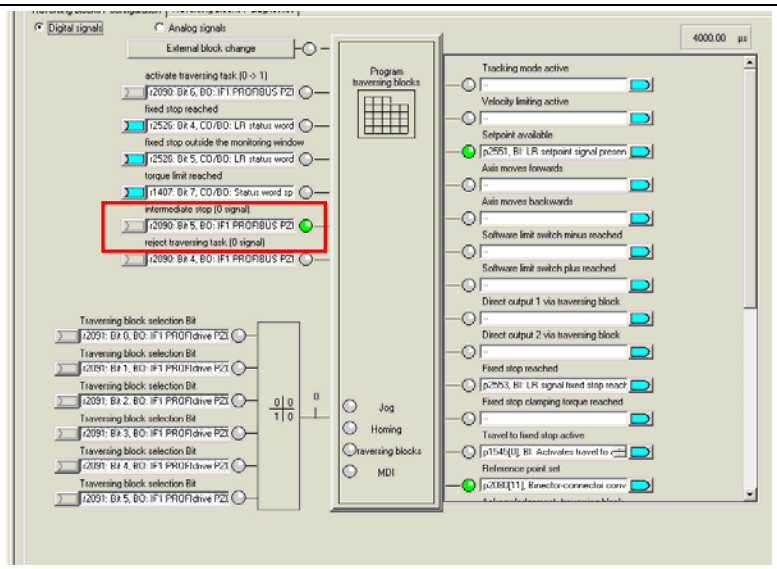
However, these messages do not influence the functionality described above. They only state that a test stop must be performed for the safety functions in the drives (A1697). These messages are warnings, which means that the drives may be energized and put into motion as soon as configuration of the SIMATIC S7 has been completed.

In this example, S10 (DI7) can be used to execute the test stop.

6.7 EPOS reactions

The EPOS reactions on selection of the safety functions are described here.

Description	Note
STO If STO is selected at drive 1, the drive is immediately switched to zero torque. EPOS control over the drive is withdrawn, which produces the error message "7490 EPOS: Enable signal withdrawn while traversing“ This error must be acknowledge by the user, via switch S9 in the example.	
SS1 If SS1 is selected at drive 2, the drive immediately brakes along the OFF3 ramp and is then switched to zero torque. EPOS control over the drive is withdrawn, which produces the error message "7490 EPOS: Enable signal withdrawn while traversing“	

Description	Note
SLS To reduce the speed at drive 1 on selection of the SLS function, the user program reduces the velocity override in FC2. The required interconnection was created automatically when the standard telegram was selected.	
SOS To stop the axis of drive 2 on selection of the SOS function, the user program selects the Intermediate stop function in FC2. The required interconnection was created automatically when the standard telegram was selected.	
SS2 If SS2 is selected at drive 2, the drive immediately brakes along the OFF3 ramp and then SOS is activated: EPOS control over the drive is withdrawn, which produces the error message "7490 EPOS: Enable signal withdrawn while traversing“	Since this produces an error message and switches the drive to zero torque, it makes no sense to use the SS2 function with EPOS at present. Instead of SS2, the SOS function is recommended, using the Intermediate stop function, for example, to bring the drive to a halt.

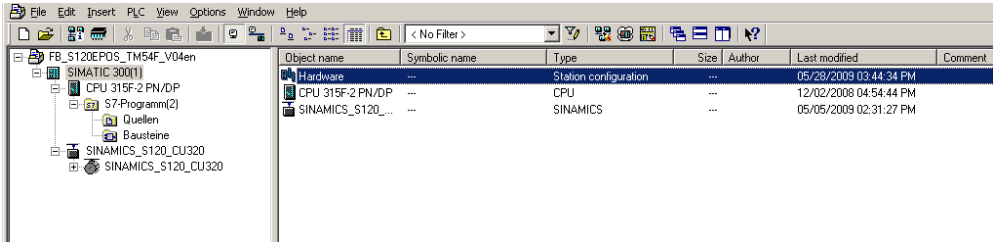
6.8 Downloading the sample project

Up until now, the configuration of the function 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.

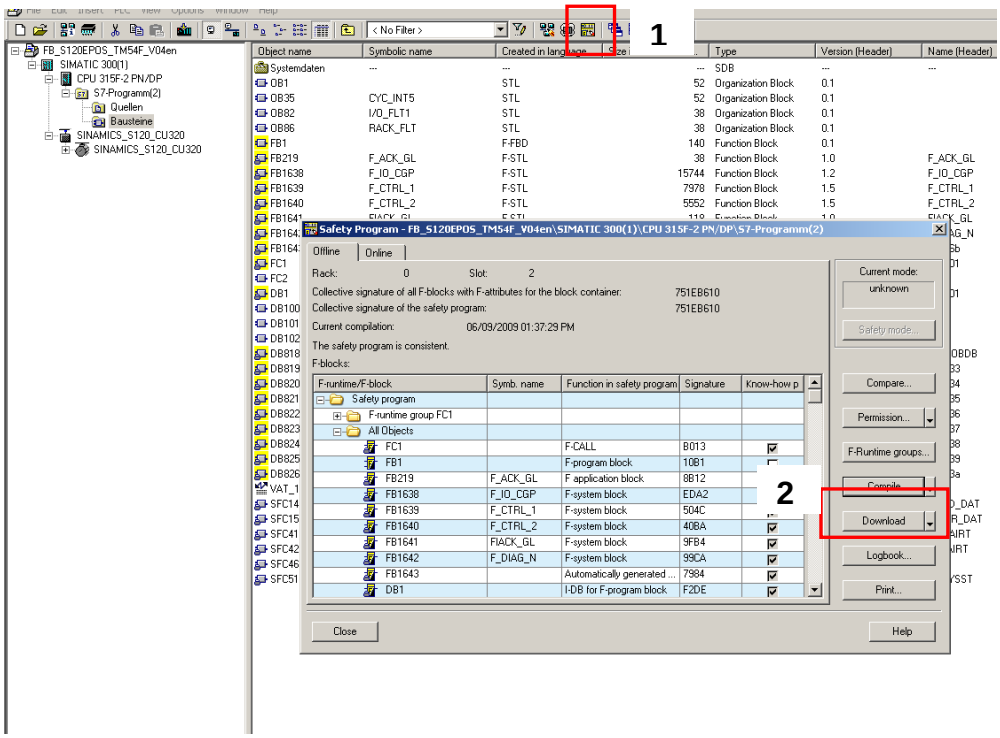
6.8.1 Downloading the S7-F-CPU configuration

First, 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 the previous configuration on the F-CPU side, if required, the baud rate of the PC/PG interface must be adapted to download the hardware configuration of the F-CPU. **Note:** If a Safety program existed on the CPU beforehand, 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. SIEMENS PG). If the card is deleted or formatted using a card reader, the card will be destroyed.

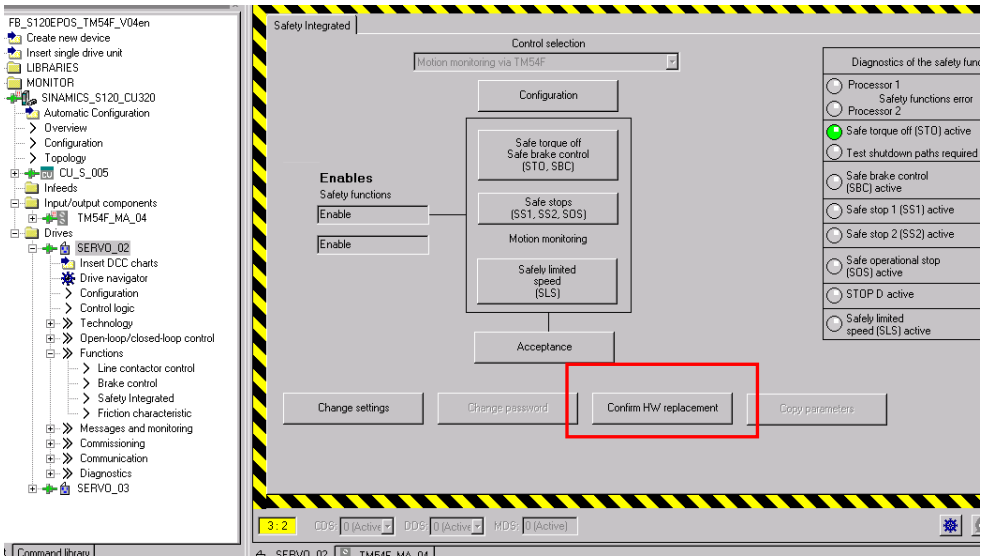
After the HW configuration has been downloaded, the program blocks must be downloaded to the F-CPU.



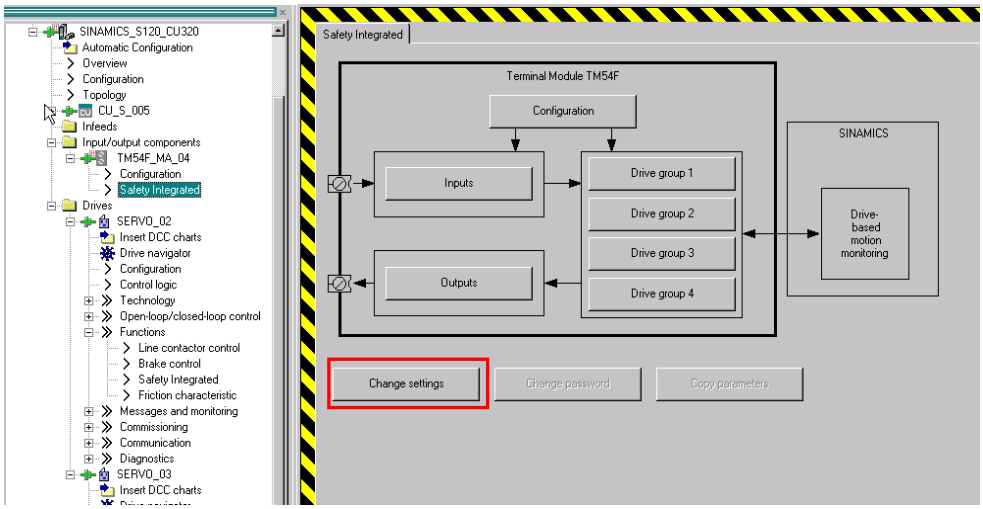
The window to download the safety functions is first opened using the "yellow" button in the function bar. The download is then initiated from this window using the "Download" button. The remaining (non-safety-related) blocks are then downloaded normally.

6.8.2 Downloading the SINAMICS S120 configuration

You can download the configuration directly to the SINAMICS S120. After the download, various safety faults are present as the serial numbers of the encoder modules, motor modules and the TM54F do not match those of the devices that were used to generate the sample project. Now, for each series commissioning, the new serial numbers must be transferred to the Safety configuration. This is done using "Confirm HW replacement" The simplest way is to open the Safety screen form on **both** drives and there to press the "Confirm HW replacement" button.



This function does not exist as a button for the TM54F. Here, the Safety screen should also be opened and the commissioning mode selected using the "Change settings" button and exited again using "Activate settings". To do this, the Safety password ("1") must be entered.



The backup procedure from RAM to ROM must then be initiated for SINAMICS and a restart carried out (Power On reset).

6.9 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 performed.

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".

7 History

Table 7-1 History

Version	Date	Change
V1.0	17.07.2009	First edition