Two-Hand Control Panel with Integrated Emergency Stop in SIL 3 / PL e

STEP 7 Professional (TIA Portal),
STEP 7 Safety (TIA Portal)

https://support.industry.siemens.com/cs/ww/en/view/21331100

Siemens Industry Online Support

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Table of Contents

1 Task

1.1 Overview

Introduction

Two-hand control panels are used for machines and equipment with hazardous features; it is intended to keep both hands of the operator in place.

Figure 1-1: Two-Hand Control Panel with Emergency Stop

Two-hand controls are widely used in the industrial field, e.g.:

- Pressing
- Spot welding
- Punching
- Print finishing or wood working

SIRIUS 3SB3 two-hand control panels meet the requirements of EN 574.

The control panels have the following standard configuration:

- 2 black mushroom buttons (1 NO + 1 NC)
- 1 red emergency stop mushroom button (2 NC)

Note

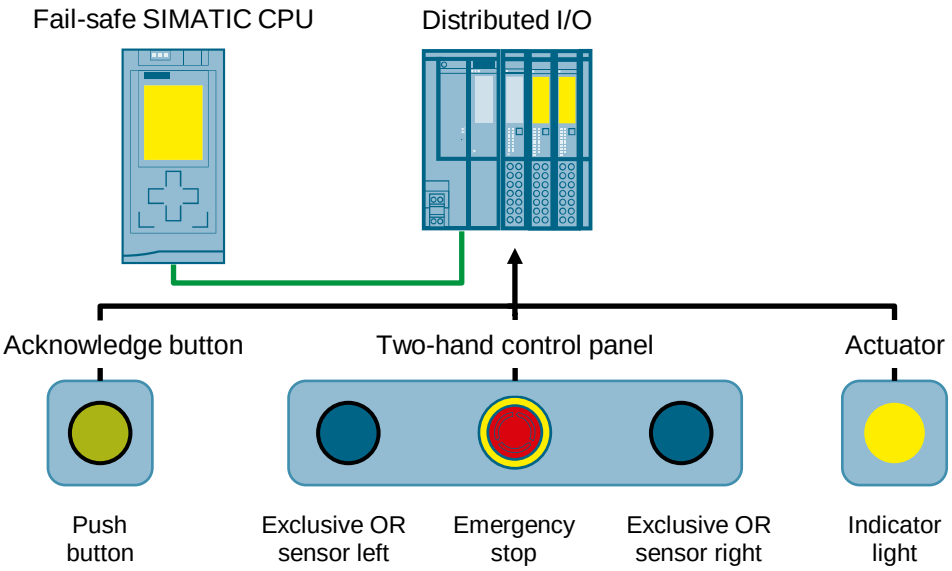
General information on safety in the TIA Portal can be found here:

Programming Guideline for S7-1200/S7-1500
https://support.industry.siemens.com/cs/ww/en/view/81318674

Overview of the automation task

The automation task comprises the two-hand control panel (two exclusive OR sensors and an emergency stop push button), an acknowledge button and an actuator (simulated with a light indicator). All signals are acquired with the distributed IO and processed by a fail-safe SIMATIC CPU.

Figure 1-2: Overview of the automation task

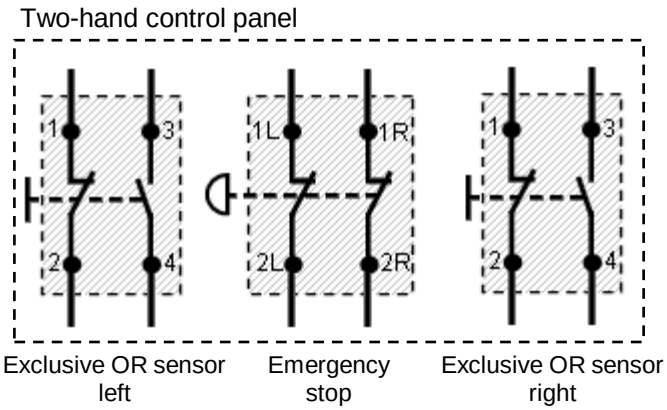


1.2 Requirements

1.2.1 Two-hand control panel

A characteristic feature of the two-hand control is the fact that both hands are kept in one place. The desired actions can only be started if both exclusive OR sensors (one break contact, one make contact) of the two-hand control are pressed.

Figure 1-3: Two-hand control panel connections



Make contact and break contact of the exclusive OR sensor have to switch within a discrepancy time when operated. This discrepancy time must not exceed 500 ms according to EN 574.

Besides the discrepancy time monitoring between make contact and break contact of an exclusive OR sensor, the switching times between exclusive OR sensor left and right are monitored.

When actuating both exclusive OR sensors, an application starts which is active for 4 seconds. After that time, or if at least one of the exclusive OR sensors is released, the machine shuts down automatically. Restarting the application is only possible if both exclusive OR sensors are released and actuated again.

In the application example, the actuator is simulated by a light indicator that is connected to a fail-safe digital output module of the distributed IO.

An application can be a hazardous machine, for instance. The term "machine" will be used to designate the indicator light (actuator) in the following.

1.2.2 Emergency stop

Pressing the emergency stop push button at the two-hand control panel resets the light indicator (simulated stop of the "machine"). Prior to a restart of the "machine" start it is required to unlock and acknowledge the emergency stop push button.

1.2.3 Reading back the process signals

For achieving SIL 3 / PL e, the complete safety chain (sensors, evaluation devices, actuators) must be considered. One partial aspect of this is (for certain actuators) the mandatory reading back of the process signal from the actuator.

The part of a circuit in which read back is realized is referred to as feedback circuit. There, the states of the contactor auxiliary contacts are evaluated; it is necessary to use positively opening contacts.

Starting a safety application is only possible in a closed feedback circuit. If, for instance, a main contact or a release contact welds at a contactor, reactivating the safety circuit is not possible.

Reading back is used for monitoring an actuator to prevent a restart in the case of an error.

1.2.4 Acknowledgement

An acknowledgement is necessary in the following cases:

- before starting the "machine" for the first time
- after unlocking the emergency stop button
- after exceeding the discrepancy time of an exclusive OR sensor
- after reintegration (end of passivation) of the F-DI
- after a readback error

1.2.5 Reaction time

Use the Excel file, which is available for SIMATIC STEP7 Safety Advanced, for the calculation of the max. reaction time of your F system. This file is available on the internet:

https://support.industry.siemens.com/cs/ww/en/view/93839056

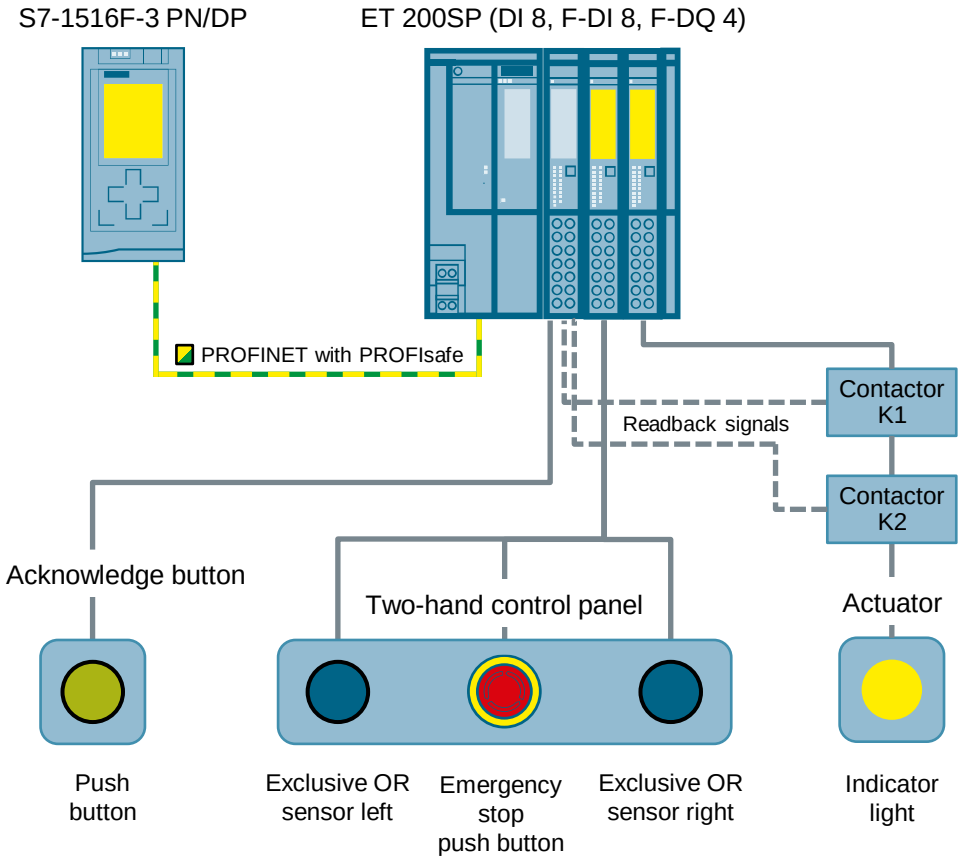
2 Solution

2.1 Overview

Schematic layout

The figure below shows a schematic overview of the most important components of the solution:

Figure 2-1: Overview of the automation task



Delimitation

This application does not contain a description of general Safety programming.

Basic knowledge of this topic is required.

Assumed knowledge

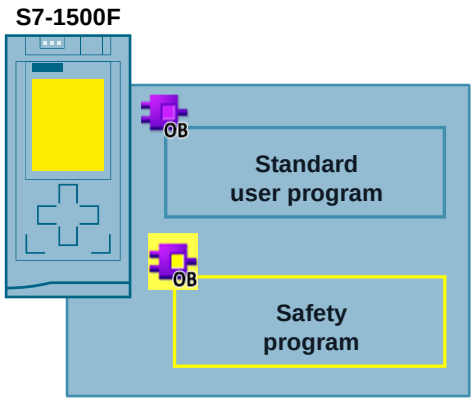
Basic knowledge of STEP 7 programming is assumed.

2.2 Advantages / customer benefits

SIMATIC Safety Integrated

- Wiring reduced to a minimum due to use of fail-safe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the fail-safe program with STEP7 engineering tools.
- Only one S7-CPU is required, since fail-safe standard program parts run on a coexistent basis in the S7-CPU.
- Use of prefabricated and certified fail-safe blocks from the STEP 7 Safety Advanced library (F-application blocks).

Figure 2-2: S7-1500 F-CPU with integrated standard and safety program



SIRIUS two-hand control panel

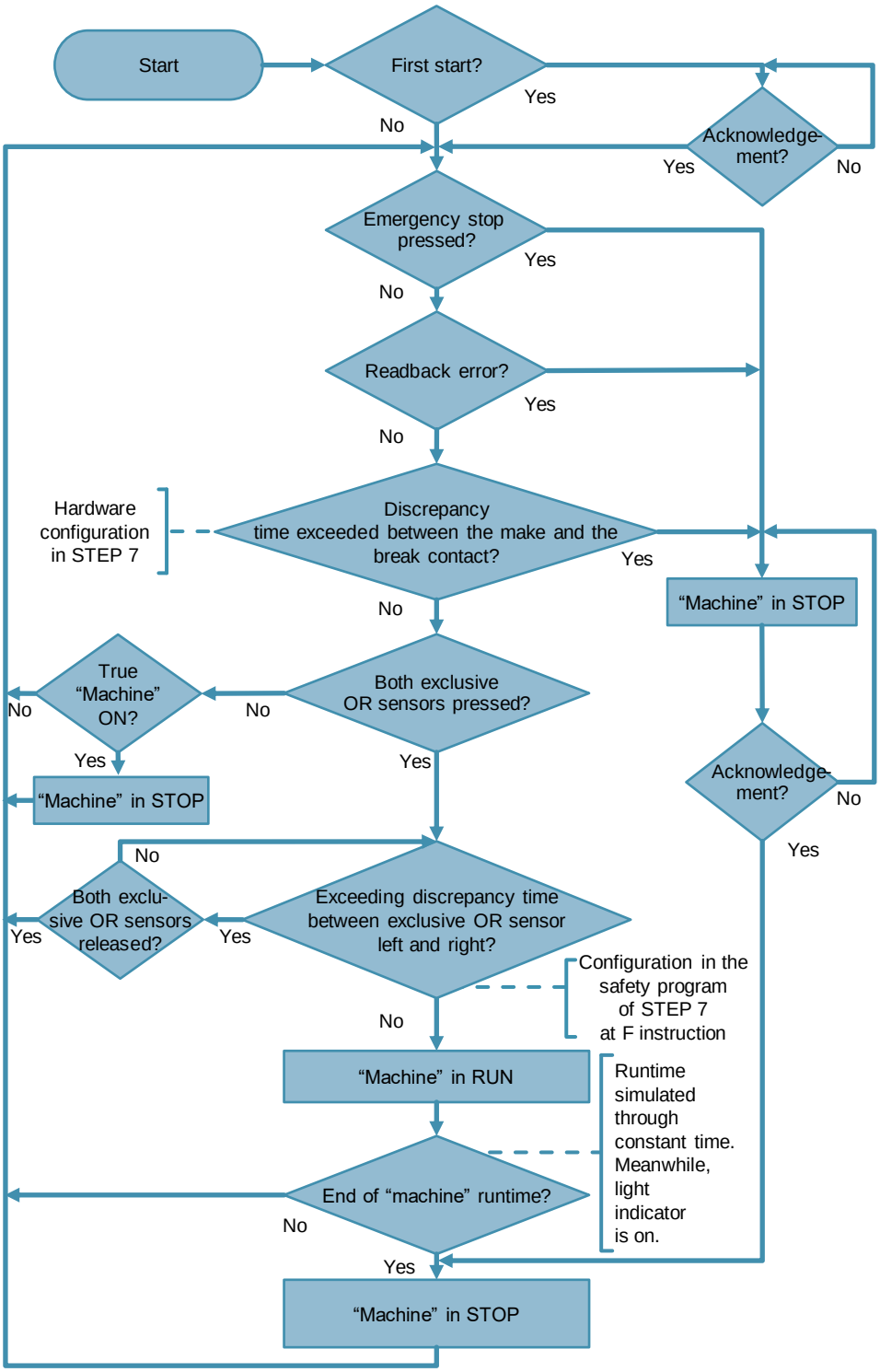
- Design of the two-hand control with integrated control devices including emergency stop
- Additional control devices can be mounted
- Two-hand control panel in metal design for harsh industrial environment
- Compliance with all relevant standards

2.3 Description of the core functionality

The figure below illustrates the complete device configuration of the application.

Flowchart

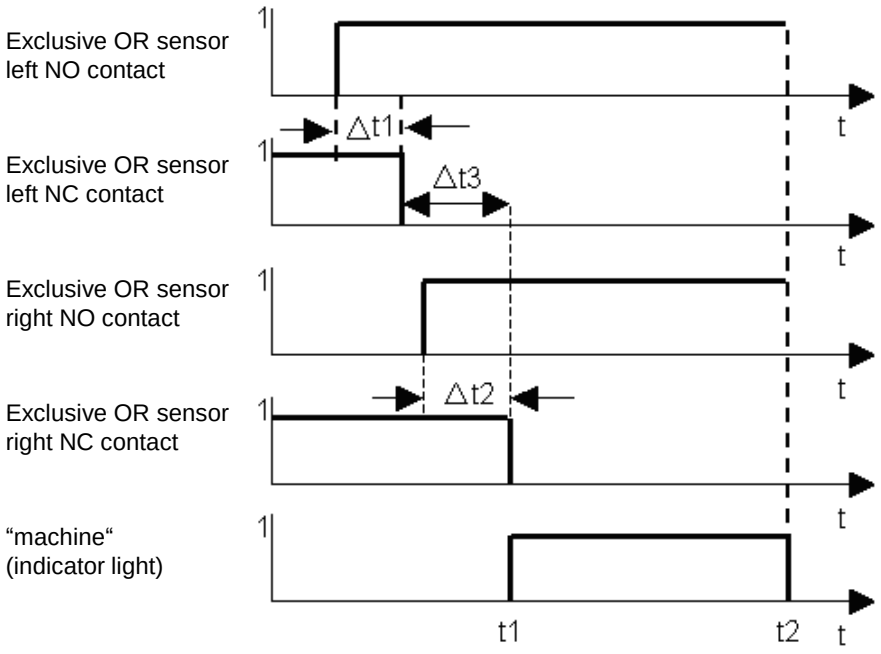
Figure 2-3: Flowchart of the safety program



2.3 Description of the core functionality

Time sequence

Figure 2-4: Time relationships



The above times are explained in the following table.

Table 2-1: Legend

Time	Explanation	Note
Δt1	Discrepancy time between make contact and break contact at exclusive OR sensor left	Parameterized in the hardware configuration of STEP 7.
Δt2	Discrepancy time between make contact and break contact at exclusive OR sensor right	
Δt3	Discrepancy time between exclusive OR sensor left and right	Programmed in the safety program of STEP 7.
t1	Start of the "machine"	Simulated by switching on the indicator light.
t2	Stop of the "machine"	Simulated by switching off the indicator light. Possible reasons for the stop: • End of "machine run time" • At least one exclusive OR sensor was released • Emergency stop was actuated • Passivation of the fail-safe input module of ET 200SP (F-DI)

2.4 Hardware and software components

The application was generated and tested with the following components:

It is recommended to use the TIA Selection Tool for configuring the hardware:

http://www.siemens.com/tia-selection-tool

Note

A list of the hardware and software products used can be found in the archive "21331100_TwoHandControlPanel_PRODUCTS_vXX.zip". Use the TIA Selection Tool for this.

Since at the time of issue not all products are available in the TIA Selection Tool, all products which are not in the TIA Selection Tool are marked "gray" in the following list.

Hardware components

Table 2-2: Hardware components used

Component	Qty	Article number	Note
Load current supply PM 70W, 120/230 V AC, 24 V DC, 3 A	1	6EP1332-4BA00	Other 24 volt power supplies may be used alternatively.
CPU 1516F-3 PN/DP	1	6ES7516-3FN00-0AB0	Firmware V1.7
Memory card, 4 MB	1	6ES7954-8LC02-0AA0	-
IM 155-6 PN ST with server module, with bus adapter 2xRJ45	1	6ES7155-6AA00-0BN0	-
DI 8x24VDC ST	1	6ES7131-6BF00-0BA0	-
F-DI 8x24VDC HF	1	6ES7136-6BA00-0CA0	-
F-DQ 4x24VDC/2A PM HF	1	6ES7136-6DB00-0CA0	-
BU type A0, 16 push-in, 2 infeed term. jumpered (digital/analog, 24VDC/10A)	2	6ES7193-6BP00-0BA0	-
BU type A0, 16 push-in, 2 infeed term. separate (digital/analog, max. 24VDC/10A)	1	6ES7193-6BP00-0DA0	-
Contactor AC3:3KW/400V 1OE DC24V	2	3RT1015-1BB42	-
Light indicator including yellow incandescent lamp	1	3SB3217-6AA30	-
Push button, green, 1 make contact	1	3SB3801-0DA3	-
SIRIUS two-hand control panel, plastic version	1	3SB3863-1BB	-

Software components

Table 2-3: Software components used

Component	Qty	Article number	Note
STEP 7 Professional V13 SP1	1	6ES7822-1..03-..	-
STEP 7 Safety Advanced V13 SP1	1	6ES7833-1F.13-0Y..	-

Example files and projects

The following list includes all files and projects that are used in this example.

Table 2-4: Example files and documentation

Component	Note
21331100_TwoHandControlPanel_CODE_v40.zip	TIA Portal project
21331100_TwoHandControlPanel_PRODUCTS_v40.zip	The zip file contains: TIA Selection Tool file with hardware and software products.
21331100_TwoHandControlPanel_DOKU_v40_en.zip	This document

3 Function Principle

3.1 General overview

Preliminary Remarks

The STEP 7 project delivered with this safety application example contains the hardware configuration and the sample code. The sample code is described in the following.

The sample code is always assigned to the components used in the safety function example and implements the required functionality. Problems not dealt with in this document are to be realized by the user; the sample code may serve as a basis.

The sample code provides measures for fault detection (diagnostics). The user has to evaluate this information and the fault must be responded to (second shut-down method, ...).

Password

In all cases, the password used for the safety-relevant part of the sample code is: siemens

Using the STEP7 project

The STEP 7 project shows:

- Connection of a SIRIUS two-hand control panel with integrated emergency stop at failsafe ET 200SP modules (F-DI 8, F-DQ 4).
- Evaluation with a fail-safe S7-1500 F-CPU
- Reading back the actuator signal (necessary for achieving SIL 3 / PL e)

Functionality of the STEP 7 project

The following functions are implemented with the STEP 7 project:

- With the two-hand control panel a "machine" is started, which is simulated by a light indicator in this example.
- As soon as one exclusive OR sensor is released or if the simulated "machine run time" has elapsed, the "machine" stops (light indicator turns off).
- Furthermore, the "machine" stops if the failsafe input/output modules of the ET 200SP are passivated and if the emergency stop push button integrated in the two-hand control panel is actuated.
- The readback signals of the contactors are evaluated, and during a readback error the "machine" is stopped (indicator light off).

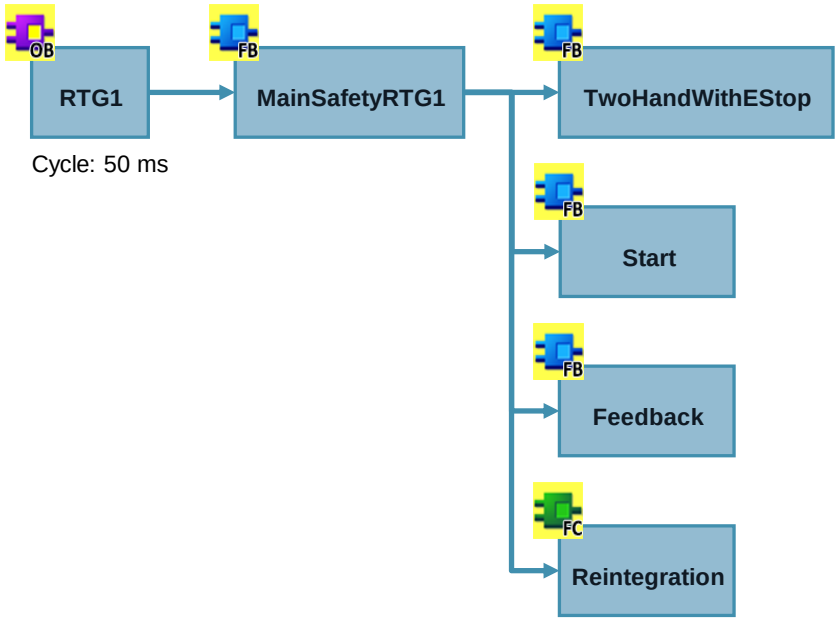
3.2 Program execution of the standard user program

The standard program only consists of an empty Main (OB1).

3.3 Program execution of the safety program

The safety program has the following structure:

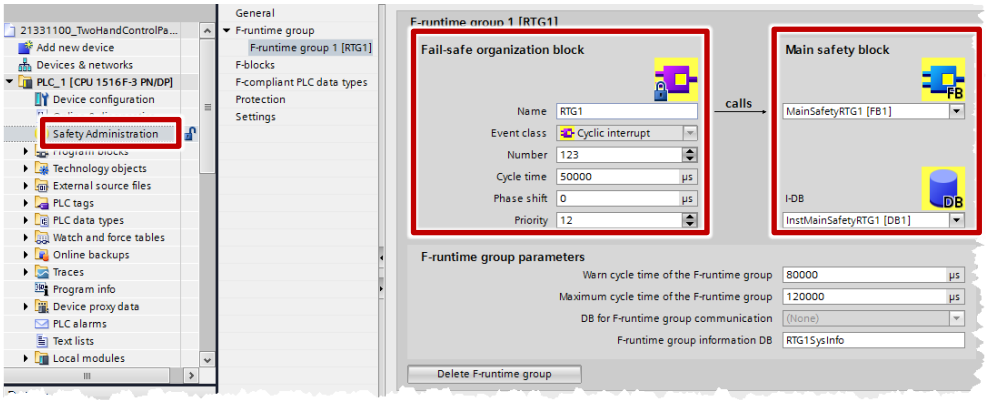
Figure 3-1: Structure of the safety program



OB "RTG1"

The blocks " RTG1" and " MainSafetyRTG1" are configured at "Safety administration". The blocks are automatically created by the TIA Portal. In the functional example, the names of the blocks were adjusted and do not correspond to the automatic standard names.

Figure 3-2: Safety Administration



The cyclic OB " RTG1" has the task to call up FB " MainSafetyRTG1". The safety program is created in the " MainSafetyRTG1" block. Both blocks together form the F run-time group.

FB "MainSafetyRTG1"

This block has the following task:

Calling...

- FB "TwoHandWithEstop" (network 1)
- FB "Start" (network 2)
- FB "Feedback" (network 3)
- FC "Reintegration" (network 4)

FB "TwoHandWithEStop"

This block represents the functionality of the two-hand control panel and has the following tasks:

- Evaluation of the status of the two exclusive OR sensors
- Evaluation of the emergency stop push button

Figure 3-3: Calling FB "TwoHandWithEStop"

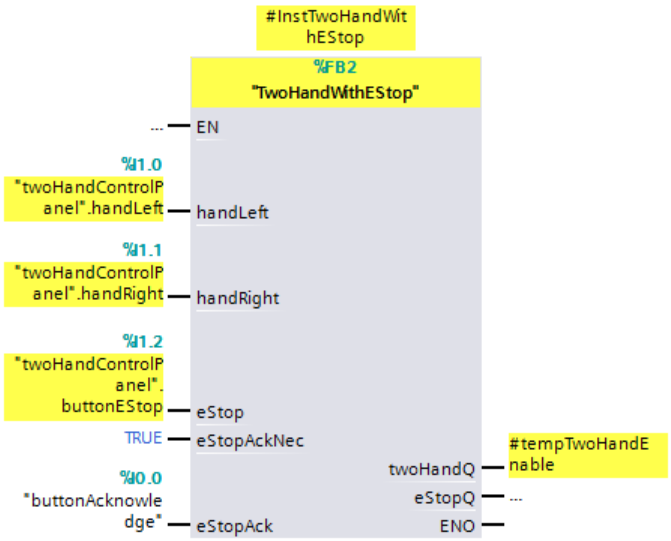
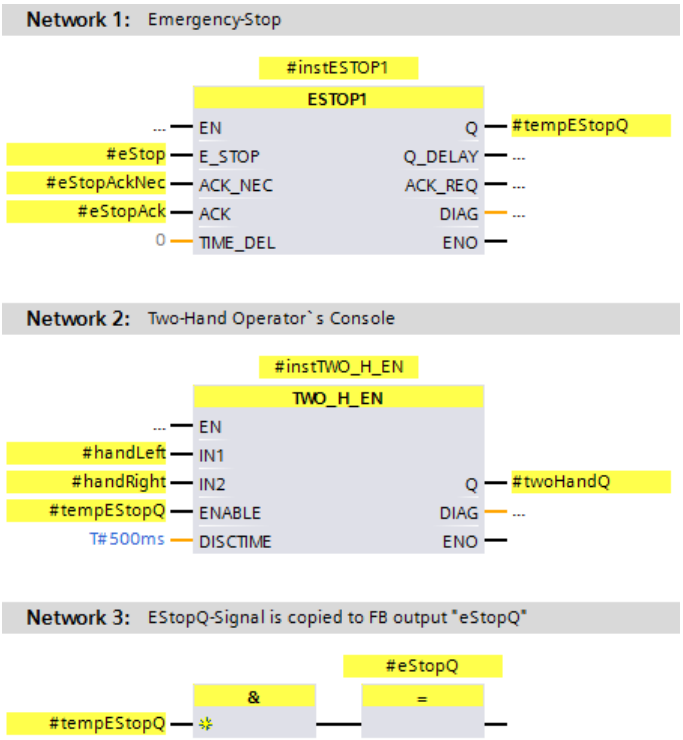


Table 3-1: Formal parameter FB "TwoHandWithEStop"

Formal parameter	Data type	Note
Input		
handLeft	Bool	Exclusive OR sensor on the left side of the two-hand control panel
handRight	Bool	Exclusive OR sensor on the right side of the two-hand control panel
eStop	Bool	Emergency stop push button of the two-hand control panel
eStopAckNec	Bool	Emergency stop acknowledgement required
eStopAck	Bool	Acknowledge emergency stop
Output		
twoHandQ	Bool	'TRUE', if exclusive OR sensors are pressed simultaneously and no emergency stop is active or modules are passivated.
eStopQ	Bool	Output of the EStop signals for further optical processing at further usage locations.

Figure 3-4: Program FB "TwoHandWithEStop"



Note

You have the option to evaluate the DIAG interfaces of instructions to detect occurring errors.

For more information refer to the Online Help of the TIA Portal.

FB "Start"

This block has the following tasks:

- Starting the "machine" (light indicator) with a defined maximum time, when FB "TwoHandWithEStop" enables it.

Figure 3-5: Calling FB "Start"

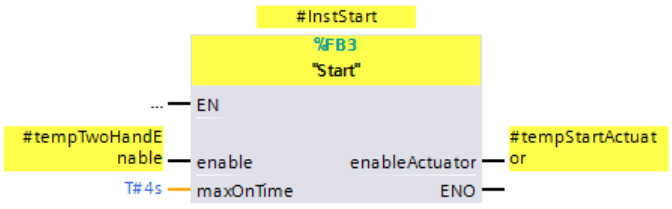
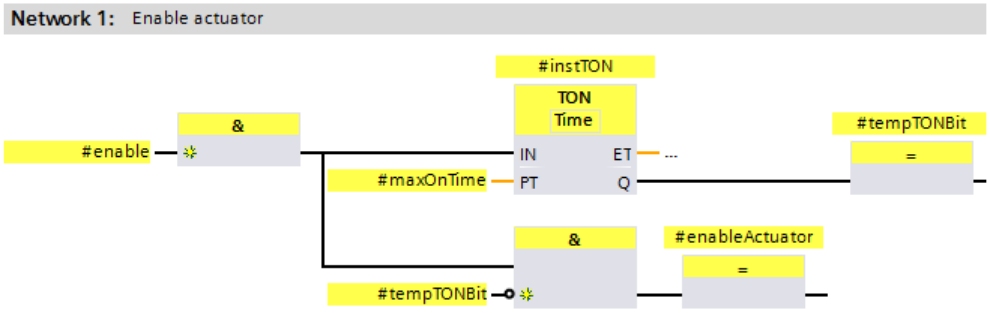


Table 3-2: Formal parameter FB "Start"

Formal parameter	Data type	Note
Input		
enable	Bool	Start the "machine" (light indicator)
maxOnTime	Time	Maximum time the "machine" (light indicator) may be active.

Formal parameter	Data type	Note
Output		
enableActuator	Bool	Start the "machine" (light indicator) with a maximum duration of 4 seconds.

Figure 3-6: Program FB "Start"



FB "Feedback"

This block has the following tasks:

- Evaluating the readback signals of contactors K1 and K2
- Deactivating the actuator during readback error

Figure 3-7: Calling FB "Feedback"

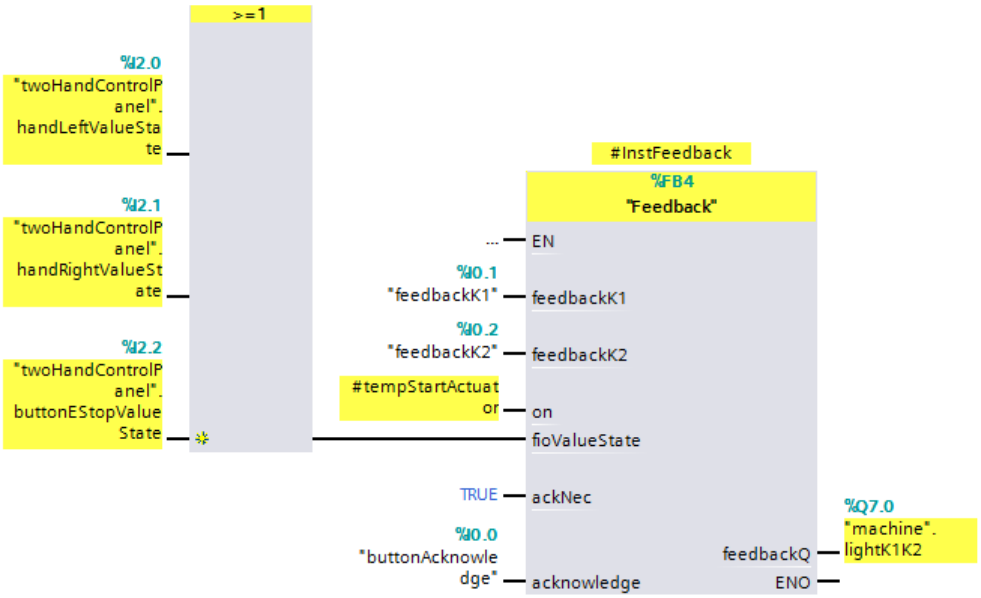
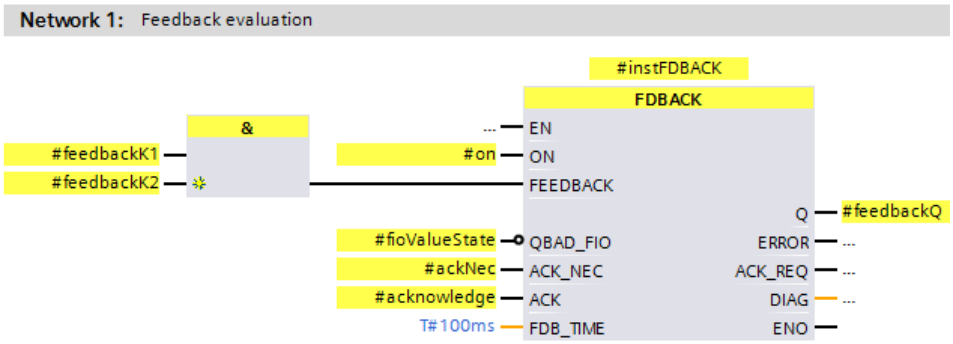


Table 3-3: Formal parameter FB "Feedback"

Formal parameter	Data type	Note
Input		
feedbackK1	Bool	Feedback from contactor K1
feedbackK2	Bool	Feedback from contactor K2
On	Bool	When on = 1, output "feedbackQ" = 1, if no readback error is detected.
fioValueState	Bool	Value status of exclusive OR sensor left, exclusive OR sensor right, emergency stop push button
acknowledge	Bool	Readback error acknowledged.
Output		
feedbackQ	Bool	See input "on"

Figure 3-8: FB "Feedback" program



Note

In this functional example, output "ERROR" of the "FDBACK" block is not evaluated by the user program.
For more information on evaluating the "ERROR" output, please refer to the online help of the TIA Portal.

FC "Reintegration"

This block has the following task:

- Reintegration after passivation of the F-DI or F-DO module.

Figure 3-9: Calling FB "Reintegration"

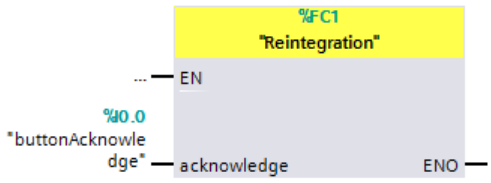
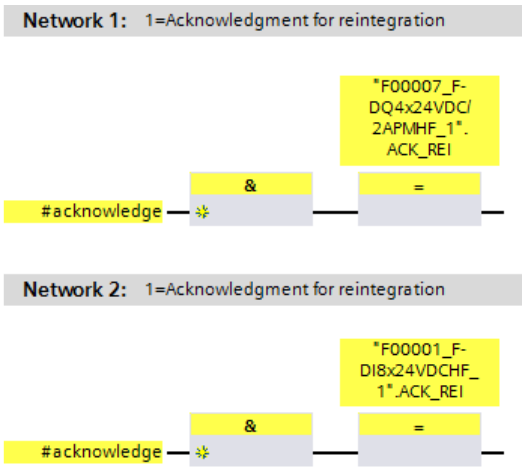


Table 3-4: Formal parameter FC "Reintegration"

Formal parameter	Data type	Note
Input		
acknowledge	Bool	Acknowledges the passivated modules.

Figure 3-10: Program FC "Reintegration"



4 Configuration and Settings

4.1 Overview

The STEP 7 project delivered with this application example contains the hardware configuration and the sample code.

For a better overview, the following chapter goes into some important STEP 7 hardware settings. It is possible to change these settings (e.g. to adapt the system to individual requirements), but please consider the following note:

NOTICE	The settings shown below contribute to meet the requirements of PL e / SIL 3. Changes at the settings may cause loss of the safety function.

If you make changes to the hardware configuration of STEP 7 (e.g. add an additional module), the sample code of the delivered STEP 7 project must be adapted accordingly.

Overview picture

Figure 4-1: Hardware configuration with PROFINET addresses

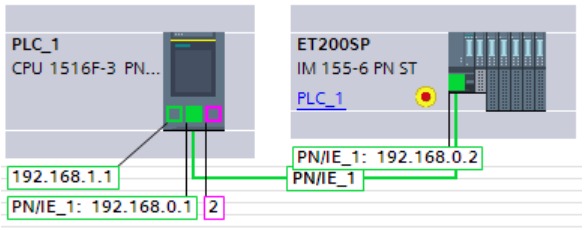
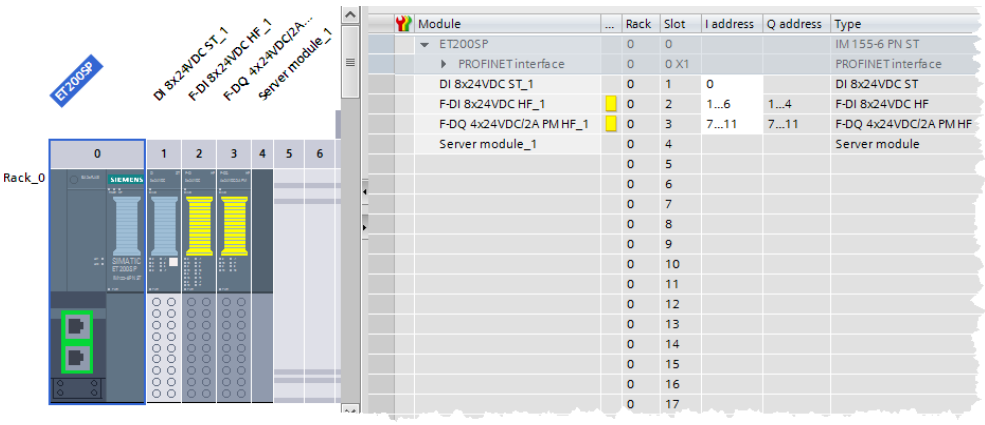


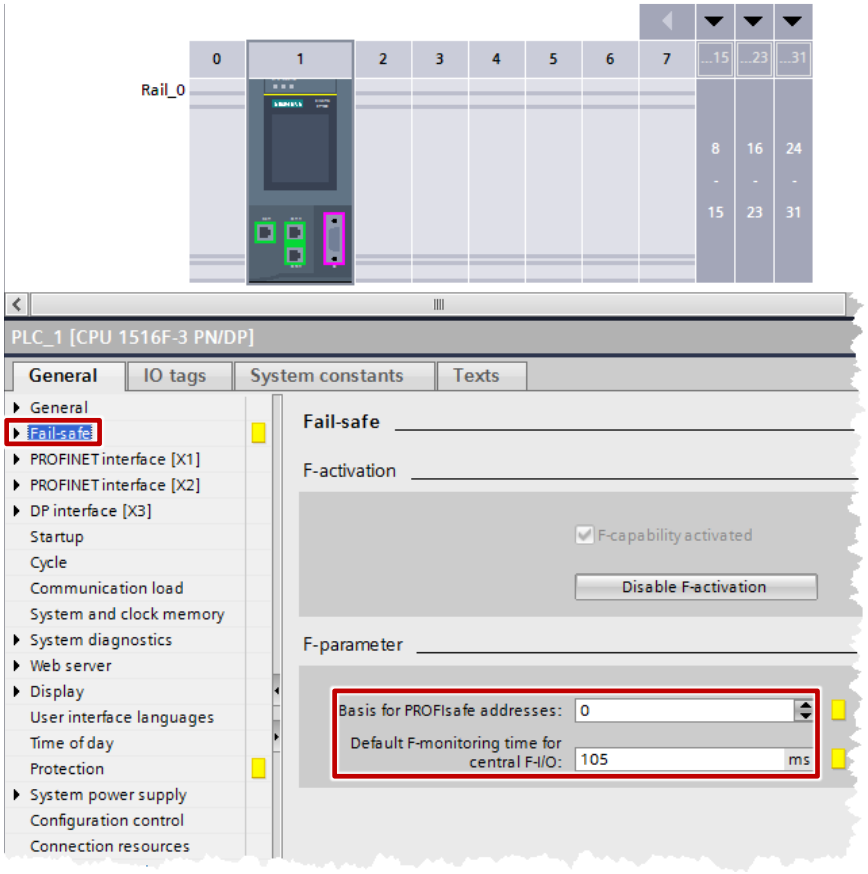
Figure 4-2: Hardware configuration of the ET 200SP station with I/O addresses



4.2 Safety settings in the CPU S7-1500 F-CPU

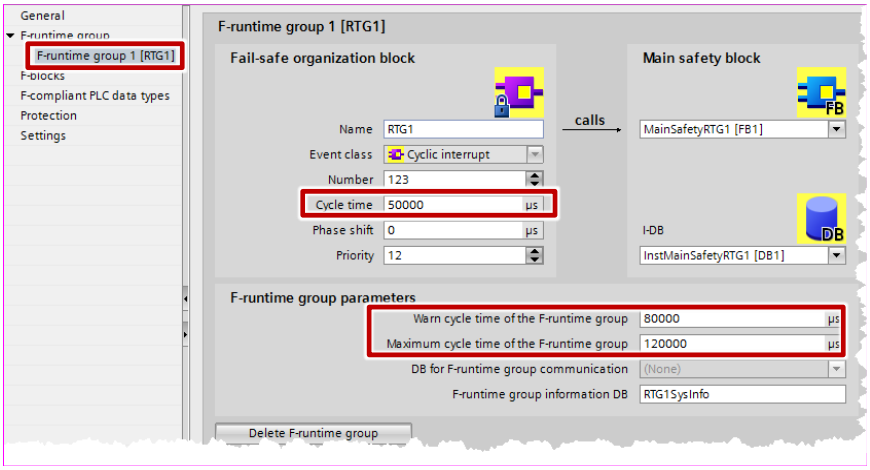
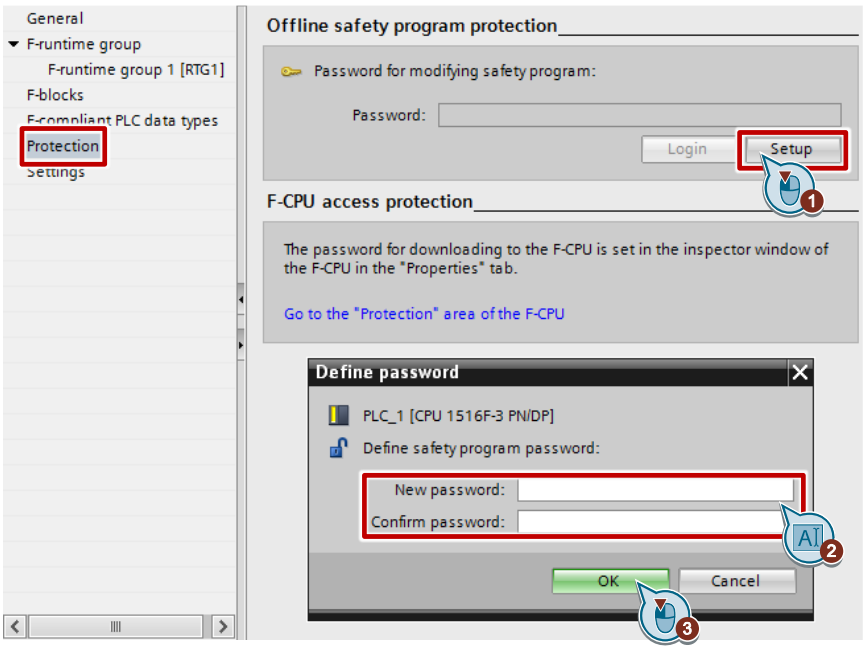
Safety settings in the device configuration of S7-1500 F-CPU

Table 4-1: Safety settings in the device configuration of S7-1500 F-CPU

	Note
1.	Perform the following safety settings in the device configuration of S7-1500 F-CPU under "Fail-safe": • "Basis for PROFIsafe addresses": 0 • "Default F-monitoring time for central F-I/O": 105 ms 

Settings in the "Safety Administration" of S7-1500 F-CPU

Table 4-2: Settings in the "Safety Administration" of S7-1500 F-CPU

	Note
2.	The following values are configured in the "Safety Administration" under "F-runtime group 1": • "Cycle time" of the "F-runtime group": 50ms • "Warn cycle time of the F-runtime group": 80ms • "Maximum cycle time of the F-runtime group": 120ms 
3.	A password must be configured under "Protection" in the "Safety administration": Password used here: siemens 

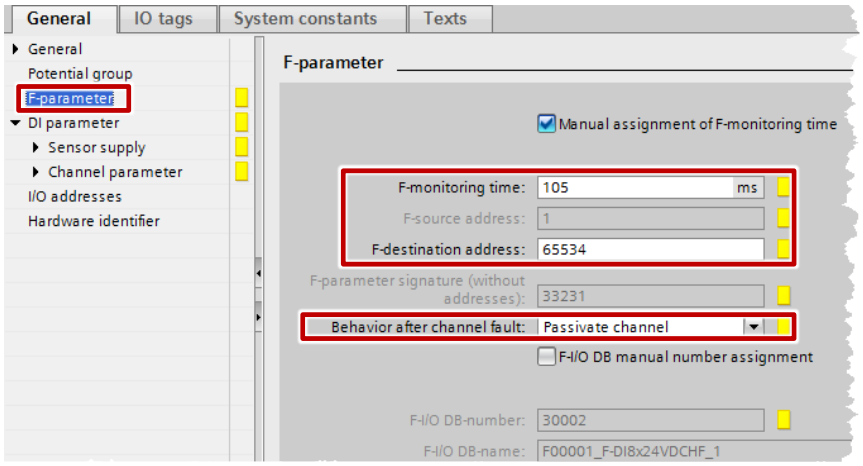
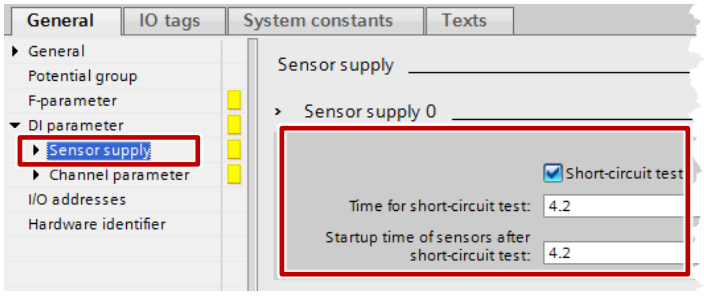
4.3 Safety settings in the ET 200SP station

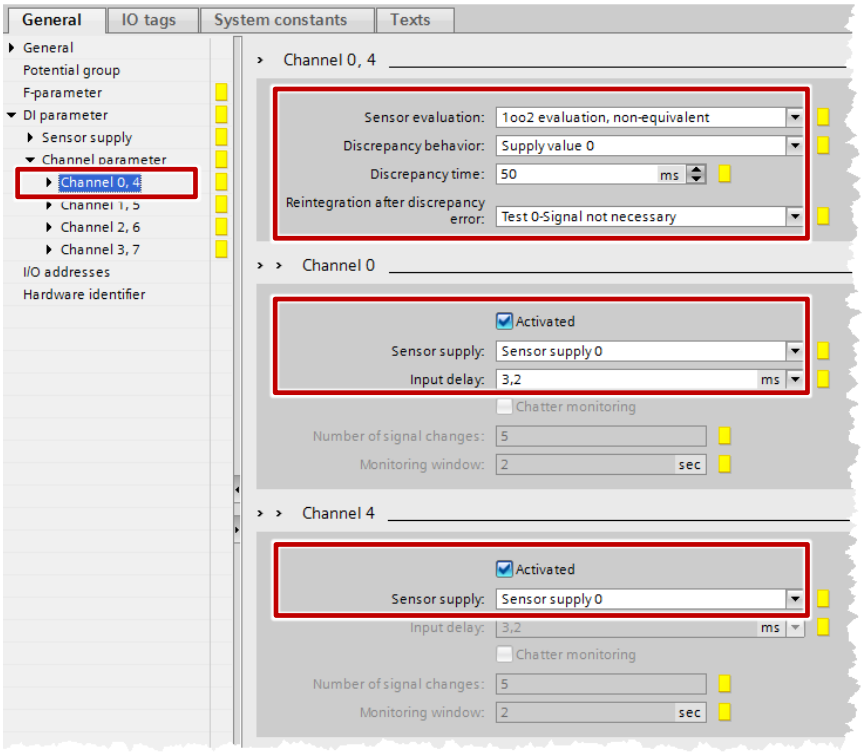
4.3.1 Device configuration of the F-DI 8x24VDC HF module

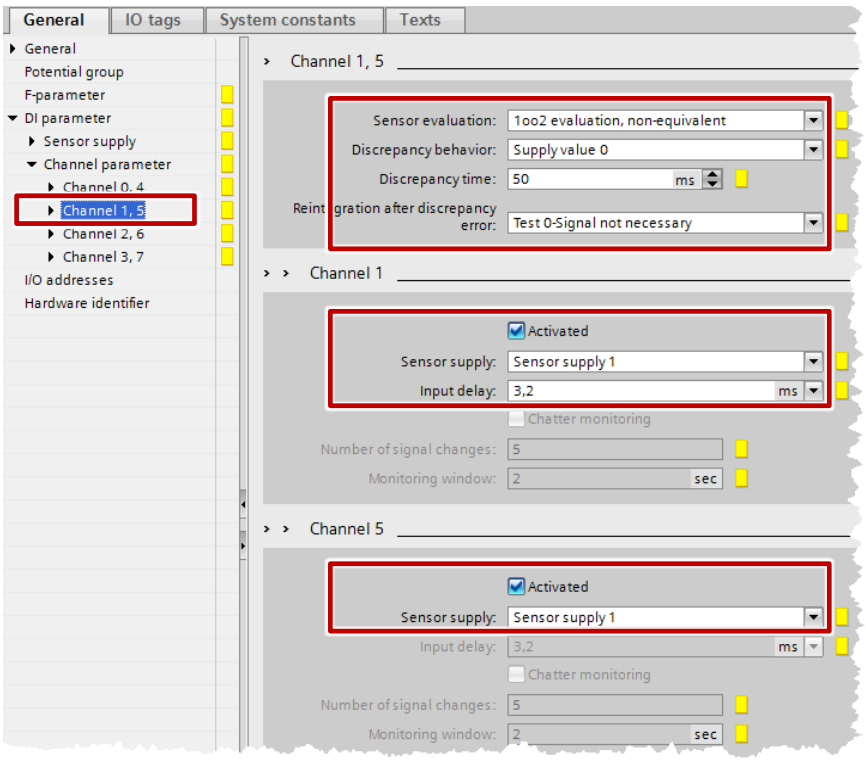
The following values are configured in the "Device configuration":

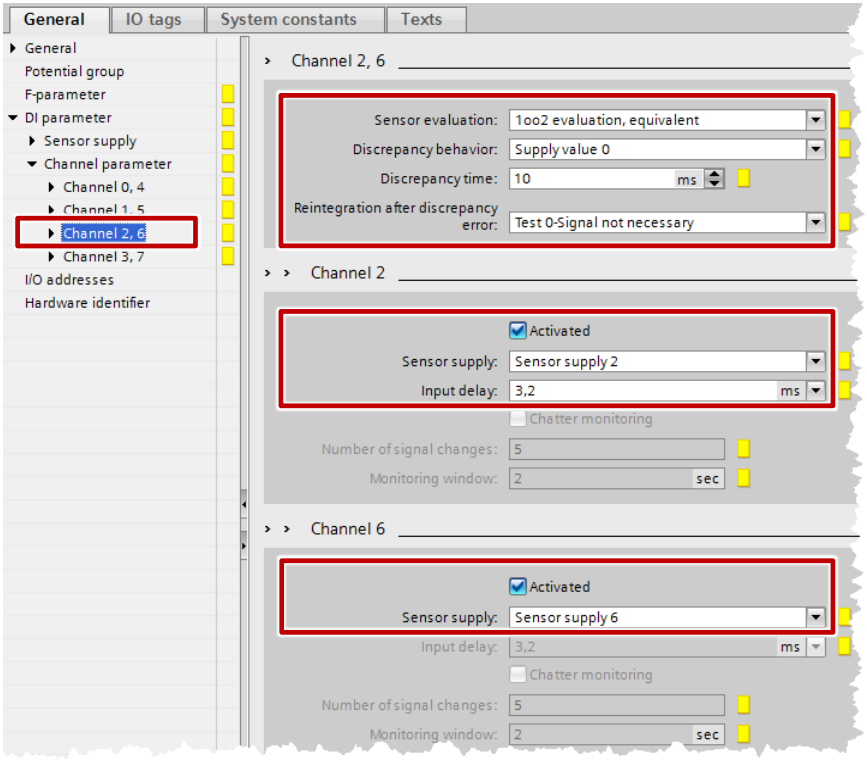
All values are set as shown in the following figures:

Table 4-3: Device configuration of the F-DI 8x24VDC HF module

	Note
4.	F parameters  Note: • The "F-destination address" must be larger than the "Cycle time" of the "F-runtime group". Use the value 105ms. • The "F-destination address" is loaded to the module with the TIA Portal (see Chapter 5.3.3 Downloading F address in ET 200SP modules). The address is automatically assigned by the TIA Portal. • "Behavior after channel fault": In case of a channel fault the respective channel is passivated.
5.	Sensor supply  Note: • The settings in "Sensor supply 0" also apply to channels 1, 2, and 6. • PL e / SIL 3 is reached by carrying out a cross-circuit detection. For this purpose, the cyclic short-circuit test must be activated via the F module.

	Note
6.	Channel 0,4: Left exclusive OR sensor  Note: • PL e / SIL 3 is reached by carrying out a cross-circuit detection. The sensor supply must be activated via the F module. • Channel 0,4: "Discrepancy behavior" between the make and the break contact of an exclusive OR sensor. • "Reintegration after discrepancy error": After the discrepancy fault has been eliminated, no further test with a "0" signal is required.

	Note
7.	Channel 1,5: Right exclusive OR sensor  Note: • PL e / SIL 3 is reached by carrying out a cross-circuit detection. The sensor supply must be activated via the F module. • Channel 1, 5: "Discrepancy behavior" between the make and the break contact of an exclusive OR sensor. • "Reintegration after discrepancy error": After the discrepancy fault has been eliminated, no further test with a "0" signal is required.

	Note
8.	Channel 2,6: Emergency stop push button  Note: "Reintegration after discrepancy error": After the discrepancy fault has been eliminated, no further test with a "0" signal is required.

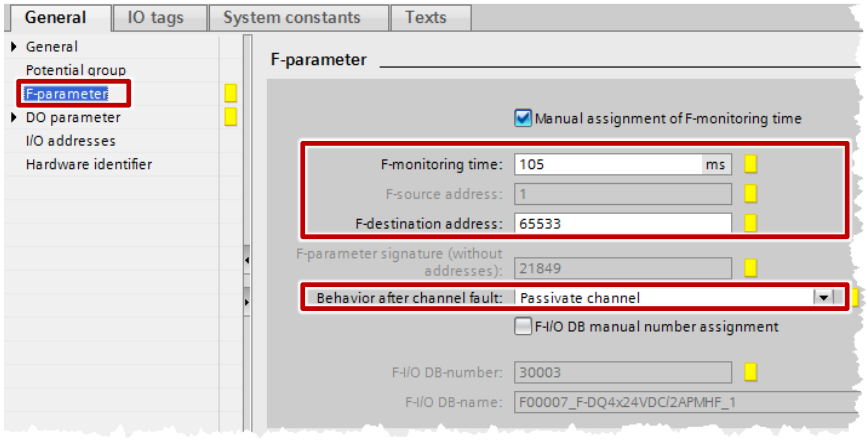
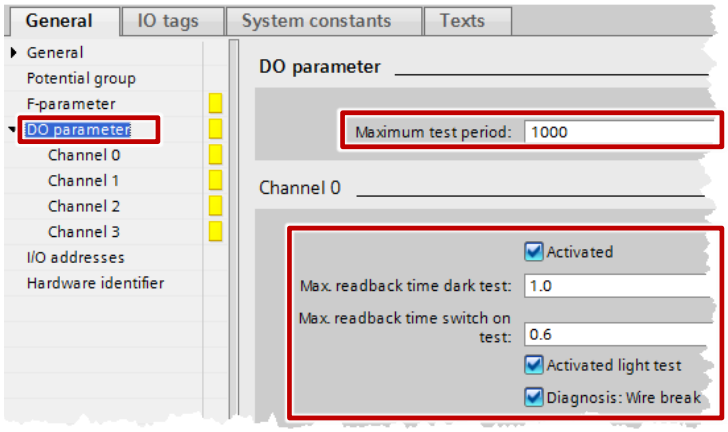
Note Channels which are not used are to be deactivated (already implemented in the S7 example project).

4.3.2 Device configuration of the F-DQ 4x24VDC/2A PM HF module

The following values are configured in the "Device configuration":

All values are set as shown in the following figures:

Table 4-4: Device configuration of the F-DI 8x24VDC HF module

	Note
1.	 Note: • The "F-destination address" must be larger than the "Cycle time" of the "F-runtime group". Use the value 105ms. • The "F-destination address" is loaded to the module with the TIA Portal (see Chapter 5.3.3 Downloading F address in ET 200SP modules). The address is automatically assigned by the TIA Portal. • "Behavior after channel fault": In case of a channel fault the respective channel is passivated.
2.	Channel 0: "Machine" (indicator light)  Note: The "Max. readback time dark test" and "Max. readback time switch on test" is configured using the capacity loads of the actuator. Detailed information on the correct configuration can be found in the Online Help of the TIA Portal.

5 Installation and Commissioning

This chapter describes the steps necessary to install and start up the example using the hardware list and the code from the download.

In order to set up and wire the safety function example, it is absolutely necessary to consider the following note:

NOTICE	In order to meet the requirements of PL e / SIL 3, it is obligatory for certain actuators (e.g. contactor) to read back the process signal to the actuator.

5.1 Installing the hardware

Overall arrangement

The figure below shows the hardware setup of the application.

Figure 5-1: Hardware setup

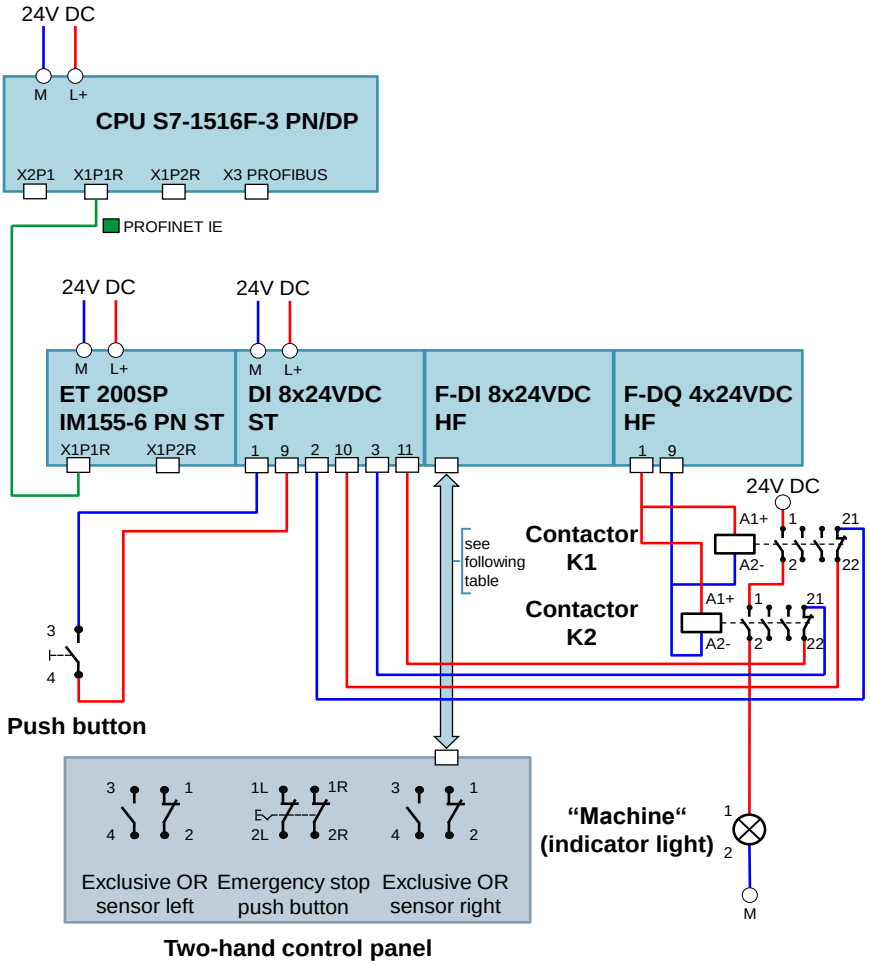


Table 5-1: Wiring the terminals between two-hand control panel and F-DI 8x24VDC

Two-hand control panel		F-DI 8x24VDC
Left exclusive OR sensor	3	1
	1	5
	2	9
	4	
Emergency stop push button	1L	3
	2L	11
	1R	7
	2R	15
Right exclusive OR sensor	3	2
	1	6
	2	10
	4	

The wiring diagram shown above takes the following aspect into account:

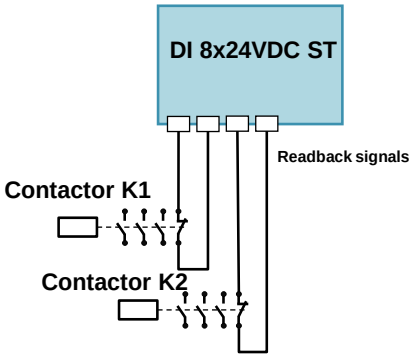
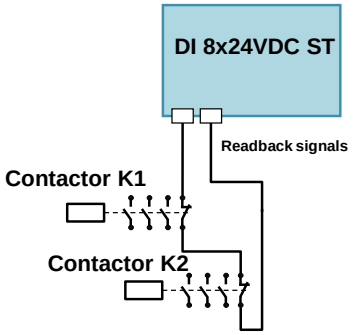
Each of the two exclusive OR sensors of the two-hand control panel has to be connected in such a way that the first contact is a make contact and the second contact is a break contact. If the short circuit test of the failsafe input module (F-DI 8x24VDC) is activated, both contacts of the exclusive OR sensor have to be supplied with voltage via the internal sensor supply VS0 (terminal 9) and VS1 (terminal 10).

As soon as a discrepancy between the signals of the two affected input channels is detected, the respective channel passivates. In the F program outputs instead the substitute value "0" (Parameterized in the hardware configuration of STEP 7).

Readback signal

The readback signals are connected to the hardware via the auxiliary contacts (NC) of the contactors. The auxiliary contacts of the contactors are connected to the standard digital input module (ET 200SP DI 8X24VDC ST). There are two options:

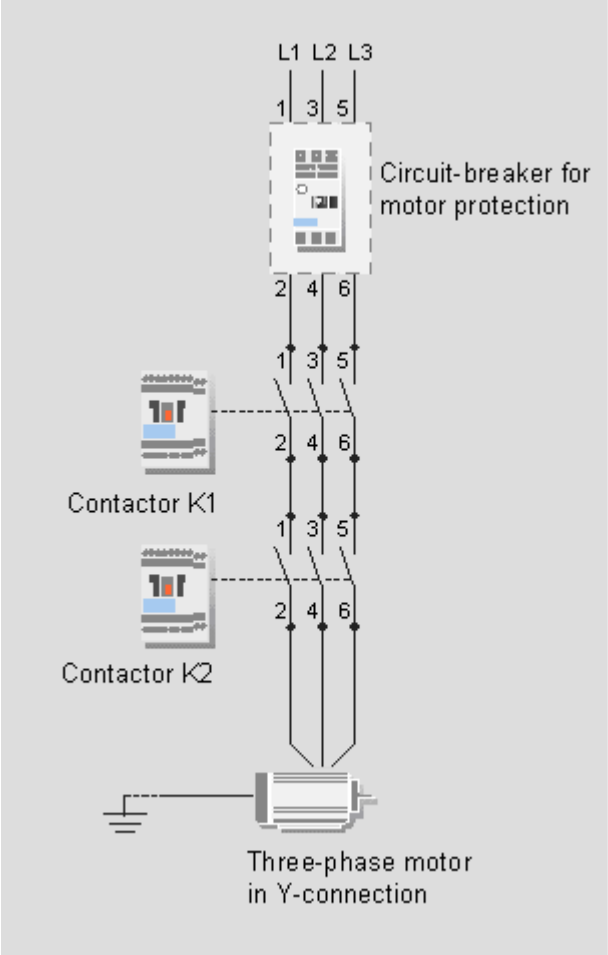
Table 5-2: Connecting options of the readback signal

Option 1 (parallel)	Option 2 (in series)
As described in this application example:	Could also be done as shown below:
	
The signals are read back individually via one input each. This ensures better diagnostic functions.	The signals are read back via a total of one input.

Example wiring for a motor as actuator

In this example, a lamp was used as an actuator. The figure below shows the wiring of a load current circuit for a three-phase motor.

Figure 5-2: Load current circuit for a three-phase motor



5.2 Installing the software

This chapter describes the steps for the installation of the example code.

Install the following software:

Table 5-3: Installing the software

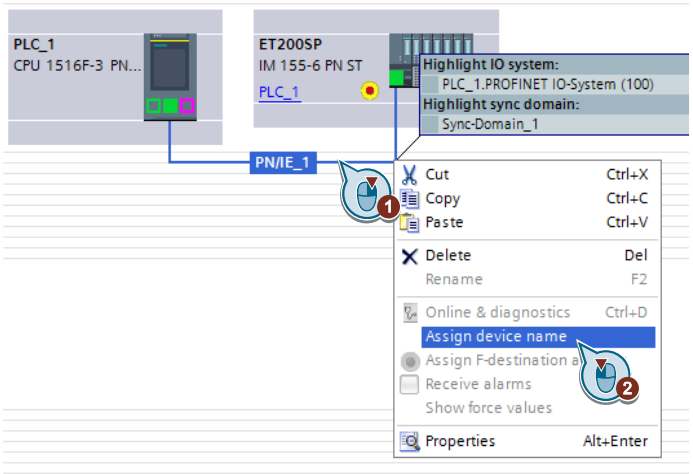
	Action	Remarks
1.	STEP 7 Professional V13 SP1	-
2.	STEP 7 Safety Advanced V13 SP1	Option package for STEP 7 (TIA Portal)

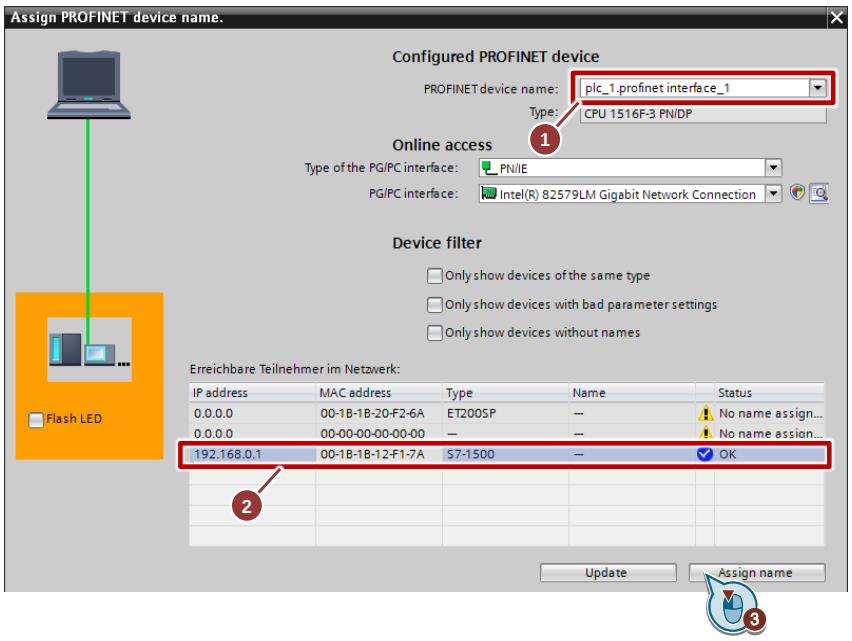
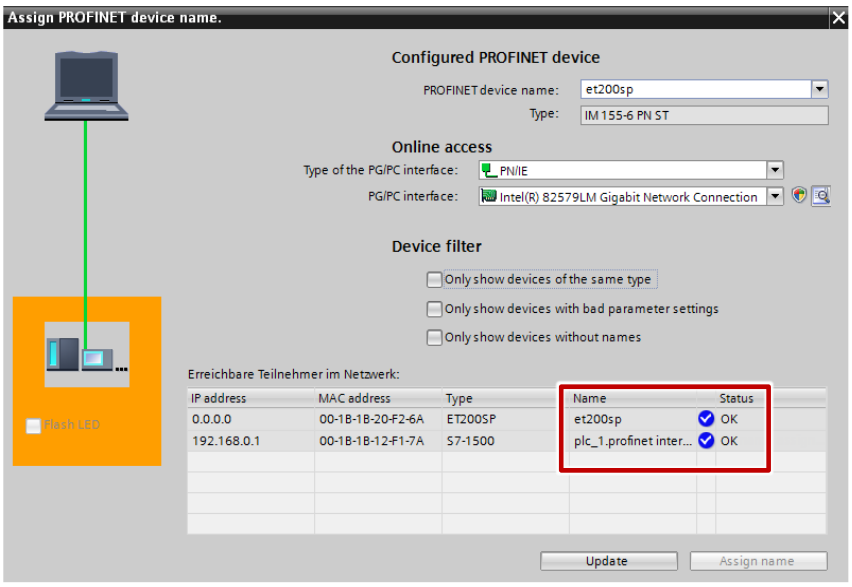
5.3 Commissioning

Perform the following steps in order to commission the application on the S7-1500 F-CPU.

5.3.1 Assigning the PROFINET name

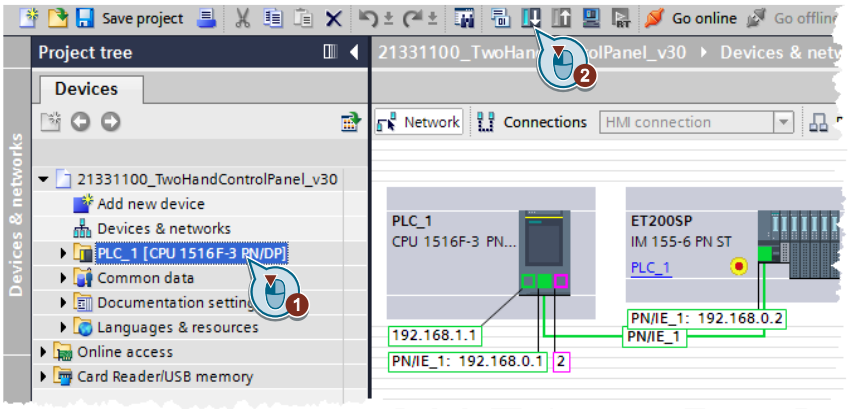
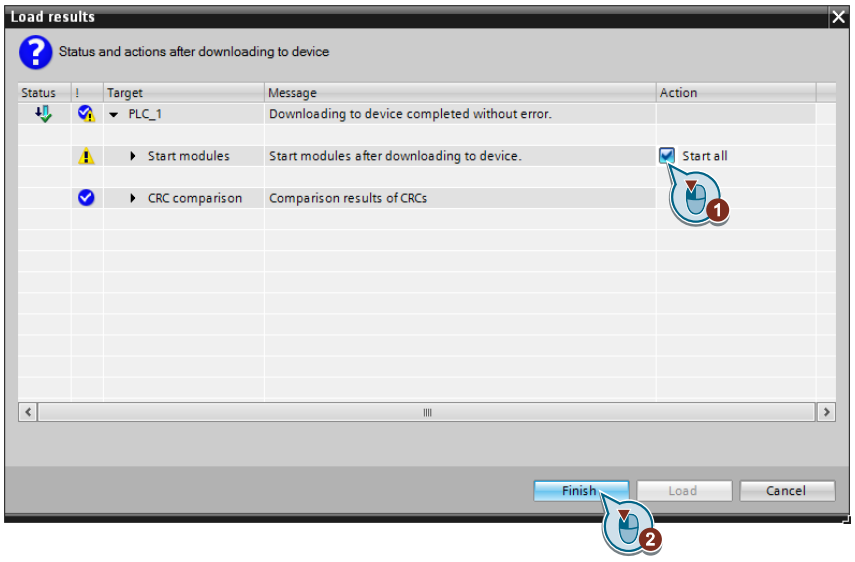
Table 5-4: Assigning the PROFINET name

Step	Action
1.	Start the TIA Portal and open the 21331100_TwoHandControlPanell_CODE_v30 project.
2.	Open "Devices & Networks". 1. Right click on the PROFINET connection 2. Select "Assign device name". 

Step	Action
3.	Assign the PROFINET name configured in the project to the S7-1500 F-CPU and the ET 200SP station. 1. Select the PROFINET name of the device 2. Select the device to name 3. Click "Assign Name". 
4.	When all devices have received the PROFINET name, this is shown in the dialog. Now you can close the dialog. 

5.3.2 Downloading the project

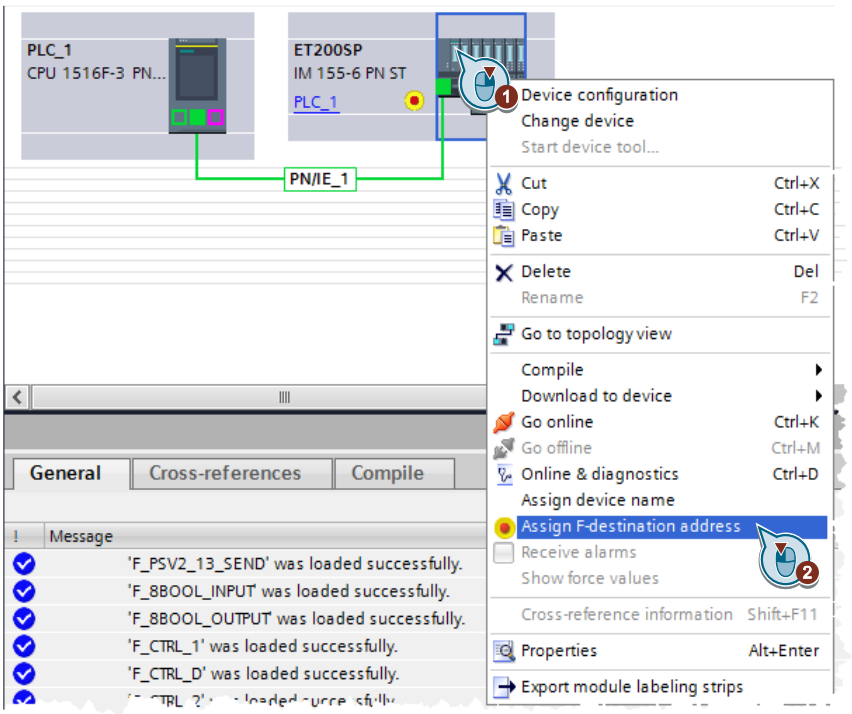
Table 5-5: Downloading the project

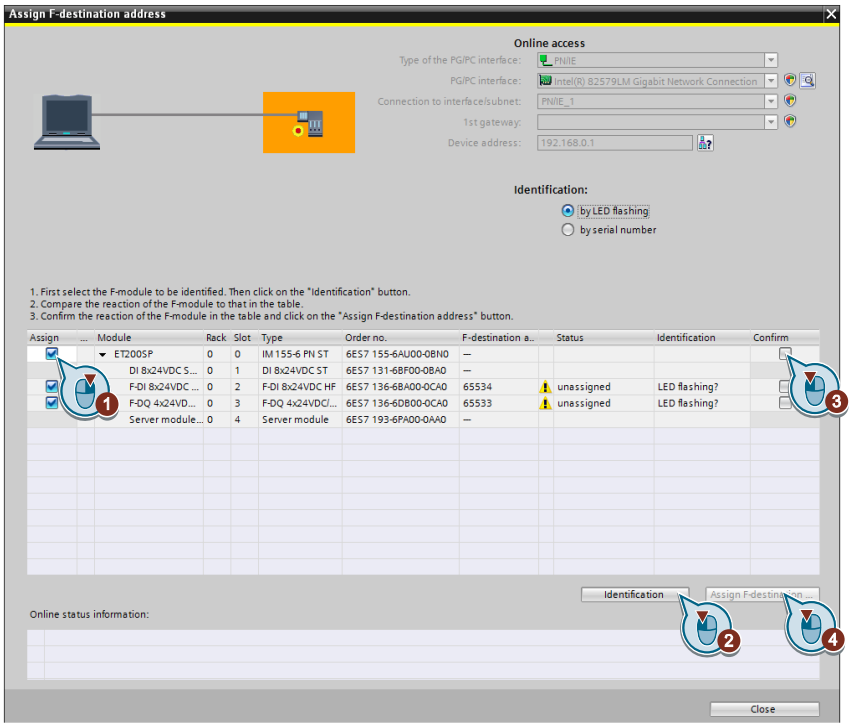
Step	Action
1.	1. In the project navigation, select "PLC_1". 2. Download the hardware configuration and the program with the "Download" button.  Confirm the dialog box with the "Download" button.
2.	1. Activate the "Start all" check box. 2. Click on the "Finish" button: 

5.3.3 Downloading F address in ET 200SP modules

For ET 200SP F modules, the F-destination address does not have to be configured with DIP switches at the module anymore. The F-destination address is downloaded with the TIA Portal.

Table 5-6: Downloading F address in ET 200SP modules

Step	Action
1.	1. Right click the ET 200SP station 2. Select "Assign F-destination address" 

Step	Action
2.	1. Activate the "Assign" checkbox. 2. Click "Identification". 3. Activate the "Confirm" checkbox. 4. Click "Assign F-destination address" 
3.	Confirm the dialog.

5.4 Function test

The inputs and outputs used can be checked with regard to their functionality if the following conditions are met:

- The hardware components are wired.
- The STEP 7 project was loaded into the S7-1500 F-CPU.

Note For testing the signals, open the example project and activate "Go online" in the TIA Portal. Open the " SignalsInputOutput" watch table.

NOTICE This is a reduced function test and does not claim to be complete.

Please note, that for productive operation, a complete function test must be performed, including error simulation.

Inputs/outputs used

The figure below illustrates the watch table " SignalsInputOutput ". All values displayed in the "Monitor value" column correspond to the default values.

Figure 5-3: Watch table " SignalsInputOutput"

	Name	Address	Display format	Monitor value
1	// Acknowledge button and conductors (DI)			
2	"buttonAcknowledge"	%I0.0	Bool	FALSE
3	"feedbackK1"	%I0.1	Bool	TRUE
4	"feedbackK2"	%I0.2	Bool	TRUE
5	// Two Hand Control Panel (F-DI)			
6	"twoHandControlPanel".handLeft	%I1.0	Bool	FALSE
7	"twoHandControlPanel".handRight	%I1.1	Bool	FALSE
8	"twoHandControlPanel".buttonEStop	%I1.2	Bool	TRUE
9	// Output (F-DQ)			
10	"machine".lightK1K2	%Q7.0	Bool	FALSE
11		<Add new>		

Testing inputs and outputs

Requirement: The inputs and outputs have the default values specified under "Inputs/outputs used".

Table 5-7: Testing inputs and outputs

Step	Action	Response "Machine".Light	Note
1.	Press "buttonAcknowledge" and release it.	"FALSE"	Acknowledgement (the negative edge is evaluated)
2.	Press and simultaneously hold the right and left exclusive OR sensors of the two-hand control panel	"TRUE"	Starting (switching on) the "machine".
3.	Wait 4 seconds	"TRUE" → "FALSE"	Simulated machine run time
4.	Release the exclusive OR sensors 1 and 2 of the two-hand control panel.	"FALSE"	New start of the "machine" possible
5.	Press and simultaneously hold the left ("handLeft") and fight ("handRight") exclusive OR sensor of the two-hand control panel and release one exclusive OR sensor after approx. 1 sec.	"TRUE" → "FALSE"	"Machine" starts and stops

Note An acknowledgement is required after certain events. See section "Acknowledgement" in the Chapter 1.2.4 Acknowledgement

Simulating a welded contactor

Table 5-8: Simulating a welded contactor

No.	Action	Result / Note
1.	Press the "buttonAcknowledge" button and release it.	Acknowledgement (the negative edge is evaluated)
2.	Press and simultaneously hold the right and left exclusive OR sensors of the two-hand control panel	Starting (switching on) the "machine"
3.	Release the exclusive OR sensors 1 and 2 of the two-hand control panel. Keep the coil of contactor K1 or K2 activated.	Simulated welding of a contactor
4.	Press and simultaneously hold the right and left exclusive OR sensors of the two-hand control panel	The channel of the F-DQ for the two contactors K1 and K2 is **not** switched on.

Reintegrating passivated safety module

Table 5-9: Reintegrating passivated safety module

No.	Action	Result / Note
1.	Disconnect the F-DI module in the ET 200SP station.	• F-DI module is passivated • Emergency stop (ESTOP1 block) requires acknowledgement.
2.	Plug the F-DI module back in at the ET 200SP station.	• F-DI module requires reintegration (acknowledgement).
3.	Wait until the F-DI module is ready for reintegration (LED blinking).	-
4.	Press the acknowledgement button	• F-DI module is reintegrated
5.	Press the acknowledgement button again	• Emergency stop ("ESTOP1" block) is acknowledged.

Note

If the F-DI module is passivated and reintegrated, the acknowledgement button is pressed twice. The reason is that the emergency stop (ESTOP1 block) can only be acknowledged when the F-DI module has been integrated. Since the reintegration in the S7 example project comes after the call of the ESTOP block, two program cycles are required for acknowledgement in this case.

6 Further Notes

Two-hand control panel standards:

The relevant standards for the two-hand control panel are listed in the following table:

Standard	Content
EN 574: 2008	Safety of machinery – Two-hand control devices
EN ISO 13850: 2006	Safety of machinery – Emergency stop equipment
DIN EN ISO 13855	Approach speeds
EN ISO 12100-1: 2011	Safety of machinery – General principles of design
EN 60204-1: 2010	Safety of machinery – Electrical equipment of machines
EN 60947-5-1: 2010	Low-voltage switching devices – Positive opening operation
ISO13849-1: 2023	Safety of machinery – Safety-related parts of control systems – Part 1: General design rules
IEC62061:2021	Safety of machinery - Functional safety of safety-relevant electrical, electronic and programmable electronic control systems.

7 Evaluation according to IEC62061:2021 and ISO13849-1:2023

7.1 Information on the standards

- The following safety application example gives an overview of IEC62061:2021: https://support.industry.siemens.com/cs/ww/en/view/23996473
- For an overview of the ISO13849-1:2023, see the following book: \6\

7.2 Safety functions

Preliminary Remarks

- Emergency stop is not a means of risk reduction.
- Emergency stop is a "supplementary safety function".

Safety functions

The following safety functions are important for the following considerations:

Table 7-1

Safety functions	
SF1	To start the machine, the left and right exclusive OR sensors must be pressed within 500ms.
SF2	Emergency stop: not included in this assessment.

This safety application example does not deal with all parts of the safety function; it focuses on certain tasks only:

Table 7-2

Supplementary safety function	Tasks		
	Detection	Evaluation	Reaction
SF1	x	x	Not evaluated, for more information see \3\

The tasks mentioned above will be assessed on the basis of the two standards IEC62061:2021 and EN ISO13849-1:2023.

7.3 Evaluation according to IEC62061:2021

The following section consists of an assessment according to IEC62061:2021 with the Safety Evaluation in TIA Selection Tool. For the link to the Safety Evaluation, refer to the Internet under \4\.

7.3.1 Evaluating "Detection"

The parameters relevant for the assessment (of Two-Hand Operation) are provided by the manufacturer and specified by the user.

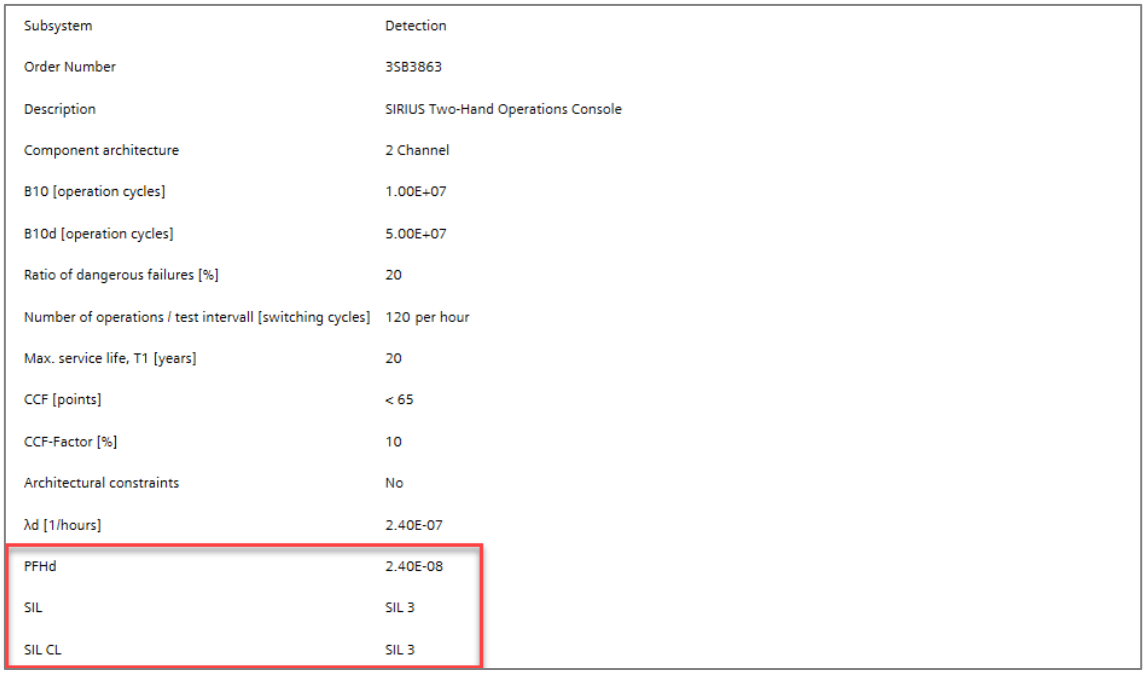
Table 7-3: Evaluating "Detection"

Parameter	Value	Explanation	Definition
B10 B10 value Two-Hand Operation	1 * 10^7	Manufacturer information	SIEMENS AG
Dangerous failure fraction Two-Hand Operation	0.2 (20%)	Manufacturer information	
T1 Lifetime	175,200 h (20 years)	Life expectancy	
β (CCF factor) Susceptibility to common cause failures	0.1 (10%)	In installations acc. to EN 62061:2005/A1:2013, a CCF factor of 0.1 (10%) is achieved. This is a safe value ("conservative value").	User
DC Diagnostic coverage	≥ 0.99 (99%)	Cross-comparison in F-DI	

The Safety Evaluation calculation for the subsystem executing function block "Detection" resulted in

- a $\boldsymbol{PFH_D = 2.40 \cdot 10^{-8}}$, which
- corresponds to **max. SIL 3** (see Figure 7-1).

Figure 7-1 Evaluating "Detection" (IEC62061:2021)



Subsystem	Detection
Order Number	3SB3863
Description	SIRIUS Two-Hand Operations Console
Component architecture	2 Channel
B10 [operation cycles]	1.00E+07
B10d [operation cycles]	5.00E+07
Ratio of dangerous failures [%]	20
Number of operations / test intervall [switching cycles]	120 per hour
Max. service life, T1 [years]	20
CCF [points]	< 65
CCF-Factor [%]	10
Architectural constraints	No
λd [1/hours]	2.40E-07
PFHd	2.40E-08
SIL	SIL 3
SIL CL	SIL 3

7.3.2 Evaluating "Evaluation"

The parameters relevant for the assessment (of the emergency stop) are provided by the manufacturer and available in the Safety Evaluation in TIA Selection Tool:

Table 7-4: Evaluating "Evaluation"

Parameter	Component	Value	Definition
PFH_D (F-CPU) incl. P_{TE} (F communication)	CPU 1516F-3PN/DP F Communication: F-CPU and ET 200SP	$2 \cdot 10^{-9}$	SIEMENS AG
PFH_D (F-I/O)	F-DI of the ET 200SP	$1 \cdot 10^{-9}$	
	F-DQ of the ET 200SP	$1 \cdot 10^{-9}$	

The SET calculation for the subsystem executing function block "Detection" resulted in

- a $\boldsymbol{PFH_D = 4 \cdot 10^{-9}}$ (total of the values listed above), which
- corresponds to **max. SIL 3**.

7.3.3 Evaluation according to IEC62061:2021

The total of both subsystems results in a $\boldsymbol{PFH_D = 2.8 \cdot 10^{-8}}$**.** This value is within the range of **SIL 3** ($PFH_D < 1 \cdot 10^{-7}$). This range must be met, even if the $2.8 \cdot 10^{-8}$ is added to the $PFH_D value$ of the subsystem that executes function block "Reaction". The subsystem executing function block "Reaction" is not considered here.

7.4 Evaluation according to ISO13849-1:2023

The following section consists of an evaluation according to ISO13849-1:2023 with the Safety Evaluation in TIA Selection Tool. For the link to the Safety Evaluation, refer to the Internet under \4\.

7.4.1 Evaluating "Detection"

The parameters relevant for the evaluation are provided by the manufacturer and specified by the user.

Table 7-5

Parameter	Value	Explanation	Definition
B10 B10 value Two-Hand Operation	$1 * 10^7$	Manufacturer information	SIEMENS AG
Dangerous failure fraction Two-Hand Operation	0.2 (20%)	Manufacturer information	
T1 Lifetime	175,200 h (20 years)	Life expectancy	
CCF points Susceptibility to common cause failures	≥ 65	ISO13849-1:2023 Table F.1: Scoring process and quantification of measures against CCF	User
DC Diagnostic coverage	≥ 0.99 (99%)	Cross-comparison in F-DI	

The SET calculation for SRP/CS "Detection" results in

- a $\boldsymbol{PFH_D = 4.85 \cdot 10^{-9}}$, which
- corresponds to **max. SIL 3** (see Figure 7-2).

Figure 7-2 Evaluating "Detection" (ISO13849-1:2023)

Subsystem	Detection
Order Number	3SB3863
Description	SIRIUS Two-Hand Operations Console
Component category	4
B10 [operation cycles]	1.00E+07
B10d [operation cycles]	5.00E+07
Ratio of dangerous failures [%]	20
Number of operations / test intervall [switching cycles]	120 per hour
Max. service life, T1 [years]	20
CCF [points]	≥ 65
MTTFd [years]	475
PFHd	4.85E-09
PL	PL e

7.4.2 Evaluating "Evaluation"

The parameters relevant for the evaluation (of the emergency stop) are provided by the manufacturer and available in the Safety Evaluation in TIA Selection Tool:

Table 7-6

Parameter	Component	Value	Definition
PFH_D (F-CPU) inkl. P_{TE} (F communication)	CPU 1516F-3PN/DP F Communication: F-CPU and ET 200SP	$2 \cdot 10^{-9}$	SIEMENS AG
PFH_D (F-I/O)	F-DI of the ET 200SP	$1 \cdot 10^{-9}$	
	F-DQ of the ET 200SP	$1 \cdot 10^{-9}$	

The Safety Evaluation calculation for SRP/CS "Detection" results in

- a $\boldsymbol{PFH_D = 4 \cdot 10^{-9}}$ (total of values listed in above table), which
- corresponds to **max. SIL 3**.

7.4.3 Result of the evaluation according to ISO13849-1:2023

The total of both SRP/CS results in a $\boldsymbol{PFH_D = 8.85 \cdot 10^{-9}}$. This value is within the range of **PL e**. The $PFH_D < 1 \cdot 10^{-7}$ range must be met, even if the $= 8.85 \cdot 10^{-9}$ is added to the $PFH_D value$ of the SRP/CS "Reaction". SRP/CS "Reaction" is not considered here.

8 Appendix

8.1 Service and support

SiePortal

The integrated platform for product selection, purchasing and support - and connection of Industry Mall and Online support. The SiePortal home page replaces the previous home pages of the Industry Mall and the Online Support Portal (SIOS) and combines them.

- Products & Services
  In Products & Services, you can find all our offerings as previously available in Mall Catalog.
- Support
  In Support, you can find all information helpful for resolving technical issues with our products.
- mySiePortal
  mySiePortal collects all your personal data and processes, from your account to current orders, service requests and more. You can only see the full range of functions here after you have logged in.

You can access SiePortal via this address: sieportal.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts.

Please send queries to Technical Support via Web form:
support.industry.siemens.com/cs/my/src

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We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that’s tailored to the customer’s specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:

siemens.com/sitrain

Industry Online Support app

You will receive optimum support wherever you are with the "Industry Online Support" app. The app is available for iOS and Android:

8.2 Links and Literature

Table 8-1

	Topic	Title
\1\	Siemens Industry Online Support	https://support.industry.siemens.com
\2\	Download page of the entry	https://support.industry.siemens.com/cs/ww/en/view/21331100
\3\	Safety application example "Read back"	https://support.industry.siemens.com/cs/ww/en/view/21331098
\4\	Safety Evaluation with TIA Selection Tool	http://siemens.com/safety-evaluation
\5\	SIMATIC Safety - configuring and programming	https://support.industry.siemens.com/cs/ww/en/view/54110126
\6\	Functional safety	Funktionale Sicherheit von Maschinen und Anlagen [Functional safety of machines and systems] Umsetzung der europäischen Maschinenrichtlinie in der Praxis. (ISBN-13: 978-3-89578-281-7, ISBN-10: 3-89578-281-5)

8.3 Change documentation

Table 8-2

Version	Date	Modifications
V1.0	02/2005	First version
V2.0	09/2007	Updating the contents regarding: • Hardware and software • Performance data • Screenshots
		New chapters: • Evaluation of the safety function example according to the new standards EN 62061 and EN ISO 13849-1:2006
V3.1	02/2015	Complete revision with new hardware: • Control: S7-1500 F-CPU • Distributed IO: ET 200SP Engineering with TIA Portal V13 Supplement: Evaluating readback (feedback) signals
V4.0	03/2021	Migration of Safety Evaluation Tool to Safety Evaluation with TIA Selection Tool
V4.1	06/2025	Chapter 7: Evaluation Safety function updated