Safety door monitoring with RFID safety switch 3SE64 with guard locking and ET 200SP

SIMATIC Safety Integrated / SIRIUS Safety Integrated

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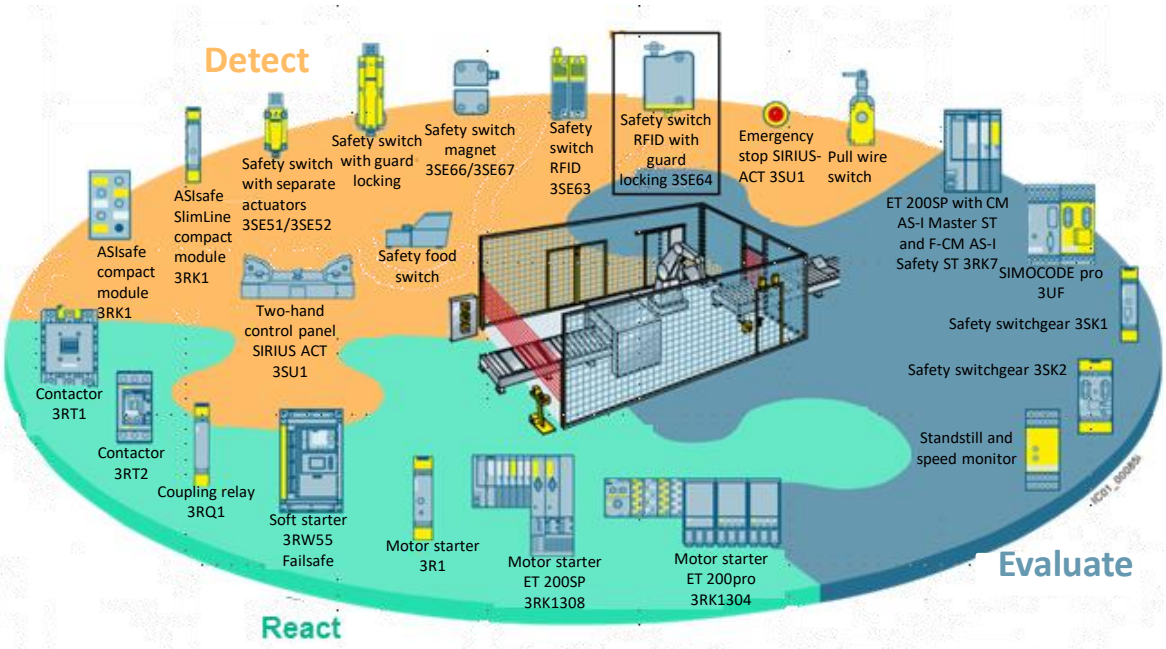
1 About this document

This documentation is available for download free-of-charge on the internet (http://support.automation.siemens.com/WW/view/en/).

1.1 Purpose of this documentation

This documentation uses a circuit example to show how safety functions can be implemented with the ET 200SP. In particular, the application area with a 3SE64 RFID safety switch with tumbler and the corresponding parameter assignments are shown here.

Figure 1-1 Detect – React - Evaluate



You can find additional information on the topic of ET 200SP as well as the corresponding 3SE safety switch here:

Safety switch 3SE64:
https://new.siemens.com/global/en/products/automation/industrial-controls/sirius/sirius-command/position-safety-switches.html

https://support.industry.siemens.com/cs/attachments/109747945/SIRIUS_IC10_complete_English_2022_202201211307422162.pdf?download=true

(Catalog IC10, Section 12)

ET 200SP:

https://support.industry.siemens.com/cs/ww/en/view/84133942

1.2 Target group

This documentation contains information for the following target groups:

- Decision makers
- Technologists
- Configuration engineers
- Commissioning engineers

1.3 Required knowledge

General knowledge of the following areas is needed in order to understand this documentation:

- Low-voltage switchgear
- Digital circuitry
- Automation engineering
- Safety engineering
- SIMATIC STEP 7 or TIA Portal

2 Introduction

2.1 Overview

Introduction

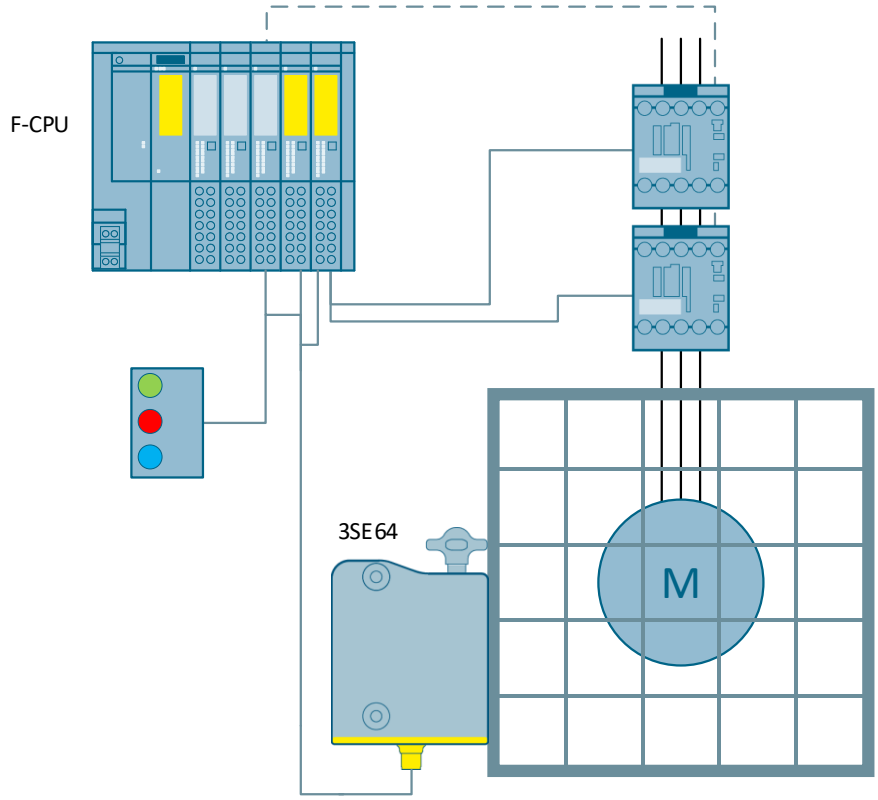
Protective doors are frequently used to fence off danger zones. These are monitored for position and, if necessary, the area from which the hazard emanates is switched off. If the machine continues to present a hazard even after switching off, access can be prevented for this period by a tumbler.
If the application is to be implemented directly at the machine with a small, distributed control cabinet, the ET 200SP is a suitable choice.

This application example shows the connection options that are available for protective door monitoring with tumbler on the ET 200SP and how these can be wired and configured and programmed in the TIA Portal. The architecture of the safety function and the achievable safety level are also discussed.

Structure

Figure 2-1 shows a schematic diagram of the most important components of the solution. This includes RFID safety switch with tumbler, distributed fail-safe control system ET 200SP with standard input module and fail-safe input and output module, start, stop and acknowledge buttons as well as contactor / motor.

Figure 2-1 Overview of the components



Achievable SIL/PL

The application example includes two safety functions (SF1; SF2):

Table 2-1 Safety functions

Safety function	Description	Requirement
SF1 "Protective door monitoring"	If the protective door is opened, the machine is safely shut down.	SIL 3 or PL e Cat 4
SF2 "Protective door tumbler"	The protective door is held shut until the machine comes to a standstill.	SIL 2 or PL d Cat. 2

For safety function 1 "Protective door monitoring", SIL 3/ PL e is possible according to the design in this application example. For safety function 2 "Protective door tumbler", SIL 2/ PL d is possible according to the design in this application example. There are currently two variants for connecting the protective door and tumbler, for which there are differences in regard to the safety level achieved. See section 2.2.1.

Required knowledge

The following knowledge is required:

- Basics of functional safety
- Basics in STEP 7 programming

2.2 Principle of operation

The position of a protective door is monitored via one safety switch. In addition, the door is locked via a tumbler integrated in the safety switch. If the door is opened, the motor is switched off in a fail-safe manner via two contactors. If the command to release the door is sent via a toggle switch, the fail-safe control system switches off the power contactors in a safety-related manner. Once a configured time has elapsed, the tumbler is unlocked and access to the machine is enabled.

Once the door has been closed and locked again and the feedback loop has been closed, the machine can be switched on again by the start button.

2.2.1 Monitoring the position of the protective door and tumbler function

The position of the protective door is monitored by a 3SE64 RFID safety switch with tumbler. With the safety switch used, the position of the protective door is detected by an actuator that closes an RFID contact when the protective door is closed.

Table 2-2 Properties of the selected RFID safety switch 3SE64 with tumbler

Property	Description	Property
Integrated tumbler	The tumbler of the door prevents entry into the hazardous area during operation.	Integrated tumbler
Spring-actuated lock / closed-circuit principle	The door is held closed in the de-energized state and unlocked by applying a voltage.	Spring-actuated lock / closed-circuit principle

Figure 2-2 RFID safety switch 3SE64 with tumbler

Table 2-3: Contact assignment of the 3SE64, M12 with 8-pin connector

Function of safety switching device		Pin assignment of the integrated socket	Color code
	With conventional diagnostics output		according to EN 60947-5-2
A1	U_e	1	WH
X1	Safety input 1	2	BN
A2	GND	3	GN
OSSD1	Safety output 1	4	YE
OUT	Diagnostics output	5	GY
X2	Safety input 2	6	PK
OSSD2	Safety output 2	7	BU
IN	Solenoid control	8	RD

Figure 2-3 Contact assignment of the M12 socket 8-pin

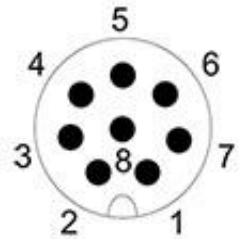
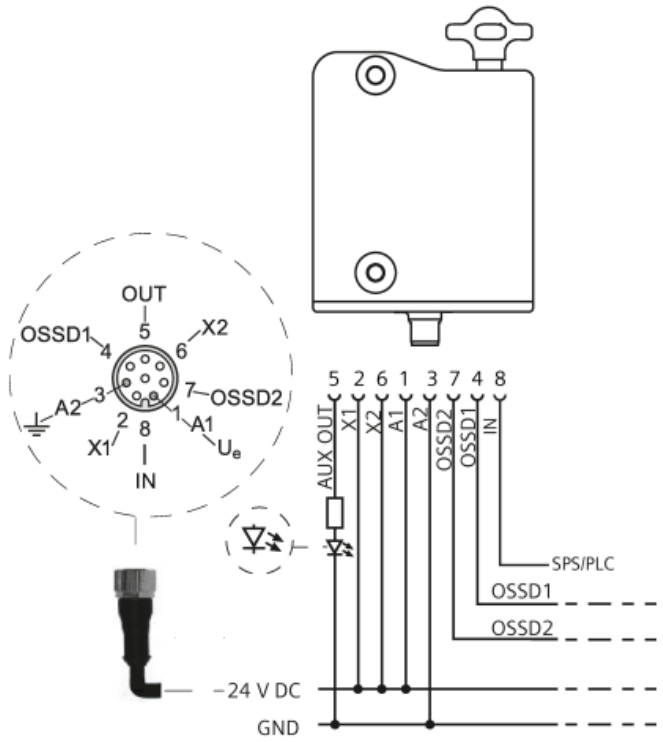


Figure 2-4 Device circuit diagram 3SE6415-1.B0.



The signals of the RFID safety switch are transmitted to the fail-safe I/O ET 200SP via a M12 plug and 8-pin connection cable.

In order to achieve the required safety level (SIL 3 or PL e), the switching state is electronically queried via RFID. The magnetic field ensures contactless tumbler and thus virtually wear-free switching. This results in low maintenance expenditure.

The 3SE64 RFID safety switch with tumbler complies with IP69 degree of protection, is permitted up to SIL 3 / PL e and is resilient against environmental influences such as dirt or vibrations.

Variants of the 3SE64

The switch itself (3SE6415) has two variants. The variants differ in the control principle of the tumbler function. A distinction is made here between the open-circuit principle and the closed-circuit principle. In the case of mechanical position switches with tumbler (e.g. 3SE5322-0SD21 or 3SE5322-0SB21), this is referred to as spring or magnetic field locking.

Table 2-4 Properties of the selected RFID safety switch

Variant 1	Variant 2
Closed-circuit principle 3SE6415-1BB01 3SE6415-1BB02 3SE6415-1CB01	Open-circuit principle 3SE6415-1AB01 3SE6415-1AB02
The variants operate according to the closed-circuit principle / spring-force interlocked. PL e applies for the interlock function, which corresponds to SIL 3. PL d applies for tumbler function, which corresponds to SIL 2. With this variant, the tumbler is monitored, thus the required DC for achieving SIL 2 / PL d is achieved. The application is personal protection.	The variants operate according to the open-circuit principle / magnetic field locking. PL e applies for the interlock function, which corresponds to SIL 3. The tumbler function here does not have SIL or PL. The tumbler is not monitored in this variant. Use is the process protection.

In addition to the switch, an actuator 3SE6410-1AC01 is always required.

Variant 1

With variant 1, both OSSD outputs of the safety switch only become active once the tumbler has been properly operated. In this case, the tumbler is also monitored and can be evaluated in the user program to determine whether or not the door is actually locked. Thus, the maximum achievable safety level of the safety function SF2 "Protective door locking" is limited to SIL 2 or PL d (diagnostics possible).

Variant 2

With variant 2, both OSSD outputs of the safety switch are already active when the protective door is closed. Therefore, it cannot be evaluated in the user program whether or not the door is actually locked. With the open-circuit principle, no diagnostics of the tumbler is necessary, since the type of interlocking prevents any SIL/PL. In this variant, the tumbler is used exclusively for process protection.

Overview of both variants

Table 2-5 Variants 1 and 2

Variant	RFID safety switch with tumbler	Property of safety function
1	3SE6415-1.B0. Closed-circuit principle/ Spring-locked	SF1: max. SIL 3 / PL e SF2: max. SIL 2 / PL d
2	3SE6415-1AB. Open-circuit principle/ Magnetic field locked	SF1: max. SIL 3 / PL e SF2: no SIL / PL, process protection only

SF 1: "Protective door monitoring"

SF 2: "Protective door tumbler"

Note If a SIL or PL is required for the tumbler function (SIL 1 / PL c or SIL 2 / PL d), variant 1 must be selected. If the tumbler is not a safety function (with SIL / PL), variant 2 should be selected, since this provides for simpler parameterization and wiring in the user program.

Variant 1 is discussed in more detail in the remainder of this document.

2.2.2 Actuator control and monitoring

In order to achieve PL e according to ISO 13849-1 or SIL 3 according to IEC 62061 (for monitoring the protective door), shutdown is performed redundantly. Two SIRIUS 3RT2 contactors are used and their correct function is monitored via their auxiliary contacts (mirror contacts) by the fail-safe control system (feedback loop monitoring). The mirror contacts can also be read in by a standard input module.

If one of the two contactors seals, safe shutdown is still ensured by the second contactor. Sealing of a contactor is detected by the feedback loop monitoring at the next signal change and new switch-on is prevented until the fault has been cleared.

2.3 Components Used

The application example was created with the following components.

Table 2-6 Hardware components

Component	Qty.	Article number	Note
Fail-safe S7 CPU	1	6ES7512-1SK01-0AB0	CPU 1512SP F-1PN
Bus adapter	1	6ES7193-6AR00-0AA0	BA 2xRJ45
SIMATIC Memory Card	1	6ES7954-8LF02-0AA0	SMC 24MB
Standard input card	1	6ES7131-6BH00-0BA0	DI 16x24VDC ST
Fail-safe input card	1	6ES7136-6BA00-0CA0	F-DI 8x24VDC HF
Fail-safe output card	1	6ES7136-6DC00-0CA0	F-DQ 8x24VDC/0.5A PP HF
Server module	1	6ES7193-6PA00-0AA0	-
Base unit light	1	6ES7193-6BP00-0DA0	-
Base unit dark	2	6ES7193-6BP00-0BA0	-
RFID safety switch with tumbler	1	3SE6415-1BB01	
RFID actuator		3SE6410-1AC01	
Pushbutton	3	3SU1	
Power contactor	2	3RT2015-1BB42	
Cable 8-pin, 5m cable	1	3SX5601-2GA05	

Table 2-7 Software components

Component	Qty.	Article number	Note
STEP 7 Professional	1	6ES7822-1AA07-0YA7	V17
STEP 7 Safety Advanced	1	6ES7822-1AA07-0YA7	V17
LSafe_FDoorGuardLocking	1	-	

3 Engineering

Scope of validity

This application example is valid for:

- All SIMATIC F-controllers
- STEP 7 Professional as of V17
- STEP 7 Safety Advanced as of V17

Example files and projects

The following table contains all files and projects that must be used in this example.

Table 3-1 Files and projects of the application example

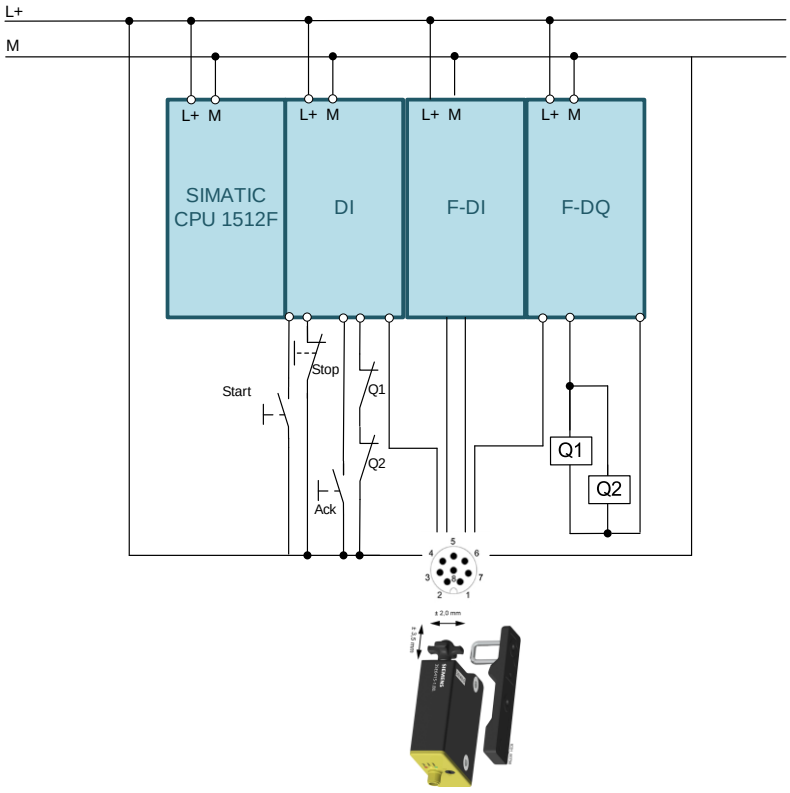
Component	Note
Protective_door_3SE64_RFID_SIL3_V17.zap17	TIA Portal project
Protective_door_3SE64_RFID_SIL3_V17.tia	TST file

3.1 Hardware setup

Wiring example

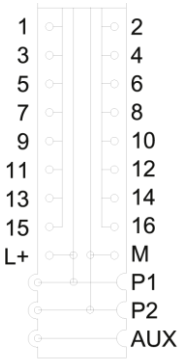
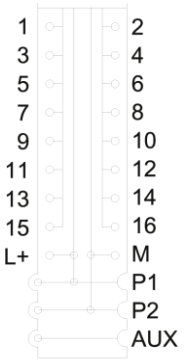
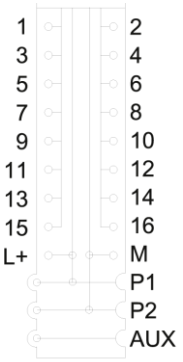
Figure 3-1 shows the schematic structure of the example and the components involved.

Figure 3-1 Wiring example



Pin assignment ET 200SP

Table 3-2 Pin assignment ET 200SP

DI	F-DI	F-DQ
		

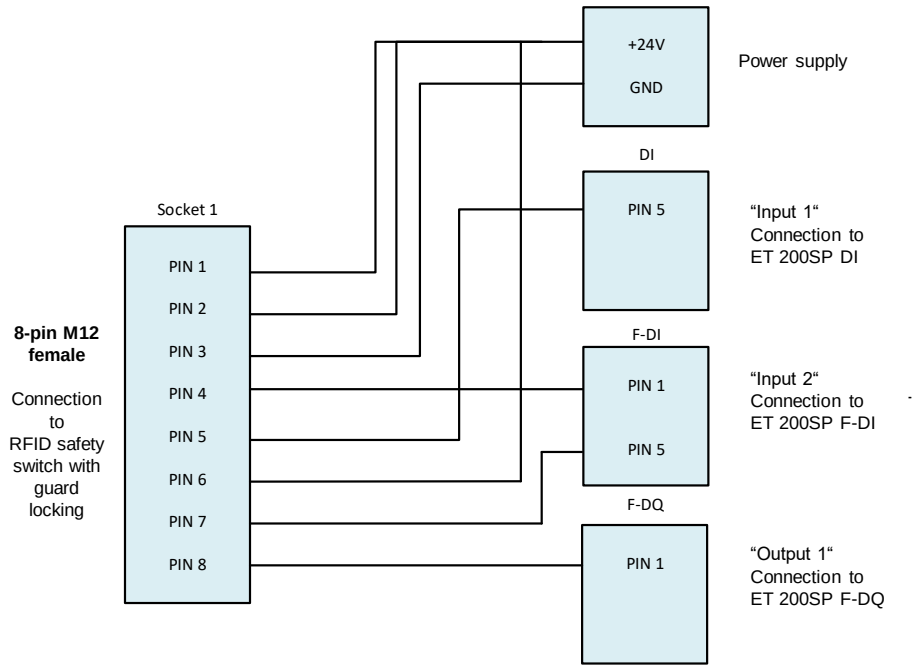
DI	
Pin	Assignment
1	Start
2	Stop
3	Acknowledge
4	Readback
5	Diagnostics

F-DI	
Pin	Assignment
1	Door contact 1 (OSSD 1)
5	Door contact 2 (OSSD 2)

F-DQ	
Pin	Assignment
1	Locking solenoid
2	Contactor control

The 8 pins of the position switch are split to an M12 connector so that the open ends can be connected to the modules of the ET 200SP as shown in Table 3-2.

Figure 3-2 Connection M12 plug 8-pin to modules



Note

In this application example, the two inputs of the RFID safety switch are supplied via a static 24V supply

Operation via the internal sensor supply of the ET 200SP F-DI 8x24VDC is also possible and does not affect the safety level or the functionality of the two safety functions of variant 1.

Regardless of whether the supply voltage of the 3SE64 comes from the internal encoder supply of the F-DI or directly from L+, the short-circuit and cross-circuit monitoring of the F-DI must be disabled.

3.2 Configuration

The supplied TIA Portal project does not require any further configuration. If you should reproduce the application example with other components, the most important settings are shown in this chapter.

CAUTION	**Loss of the safety function** The settings shown below help to fulfill the required safety. Changes to the settings can lead to a loss of the safety function.

3.2.1 Hardware Configuration

In the following, the hardware configuration of a CPU 1512SP F-1 PN is implemented with corresponding I/O cards.

Once a new CPU 1512SP F-1 PN has been created in the project, the required input and output cards are configured. You can find the exact order numbers in Table 2-6 "Hardware components".

Configuration of the CPU 1512SP F-1 PN in the TIA Portal

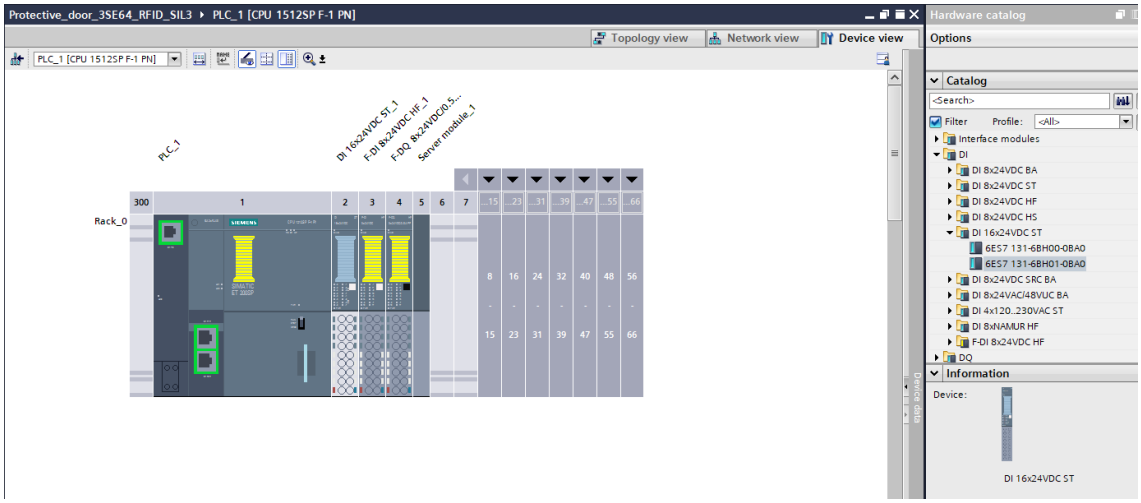
Configure the fail-safe controller (in this example CPU 1512SP F-1 PN) with its input and output modules under "Devices & networks".

Procedure:

1. Open your STEP 7 project in the TIA Portal.
2. Add your corresponding F-CPU including the input and output modules from the hardware catalog in the "Device configuration" tab.
3. Select ET 200SP CPU 1512SP F-1 PN in the "Hardware catalog" window. "Controllers > SIMATIC ET200 CPU > ET 200SP CPU > CPU 1512SP F-1 PN > 6ES7 512-1SK01-0AB0" and add it with a double-click. (Ensure that the version matches that of your device or perform a FW update)
4. Add the required modules to your configuration. To do this, double-click the controller you have just added. "DI > DI16 x 24VDC ST > 6ES7 131-6BH01-0BA0"
5. Similarly, you configure one F-DI module, one F-DQ module and one server module.

Result:

Figure 3-3 Adding the controller and DI/DQ modules



Assign fail-safe address

Fail-safe modules ET 200eco PN as well as ET 200SP, MP and AL do not have a DIP switch with which you can set the unique F-destination address (= PROFIsafe address) of the module. Instead, you assign the PROFIsafe address directly from STEP 7. You assign the F-destination address parameter in the hardware configuration for the F-module. Assignment is required for initial commissioning, among other things. The F-destination address can only be assigned if the PROFINET device name is assigned. Since an online connection to the corresponding modules is required, you can find the detailed steps in chapter 3.3.3 "Assigning PROFIsafe addresses".

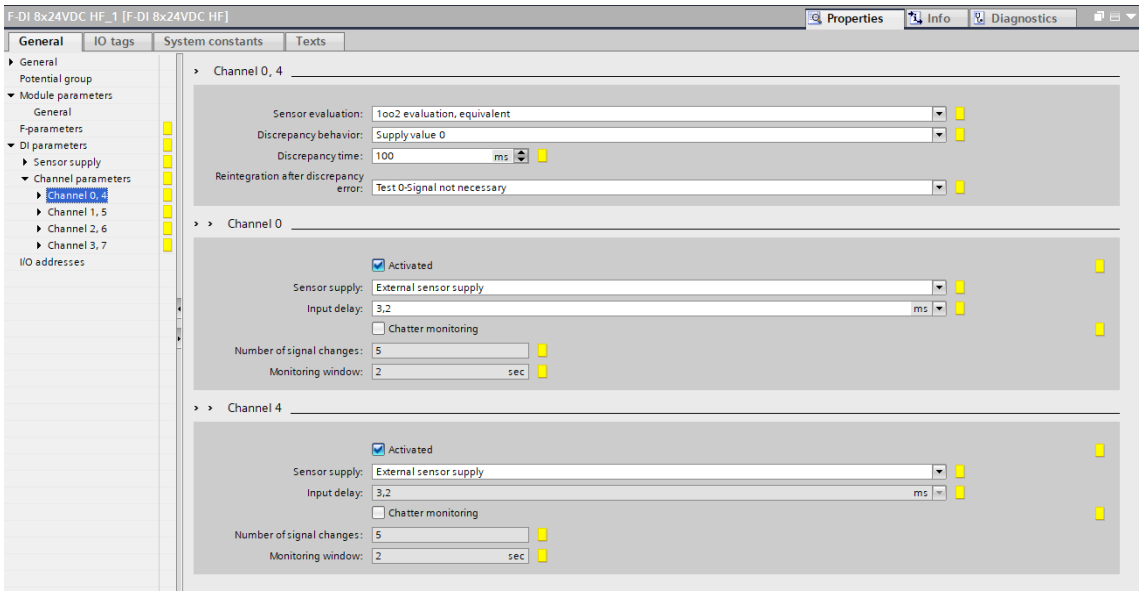
Configuration of the F-DI

The OSSD outputs of the RFID switch are evaluated for safe monitoring of the door. The control of the solenoid is also evaluated here (see chapter 2.2.1 _Variant 1). Since the OSSD diagnostic mechanisms of the 3SE64 safety switch are used, the channels must be configured for external sensor supply.

For this monitoring, a 1oo2 evaluation is selected in the corresponding F-DI channels of the ET 200SP (channel 0 and channel 4). Here, the discrepancy monitoring is performed by the module. The discrepancy time can be set to 100 ms due to the electronic inputs. The discrepancy time must be selected depending on the reaction time of the safety function. In addition, the value status of the channel pair is evaluated. The exact parameter settings can be taken from the following figures.

All other evaluations are performed by the "LSafe_FDoorGuardLocking" block.

Figure 3-4 Configuration of the position switch, evaluation of the encoders



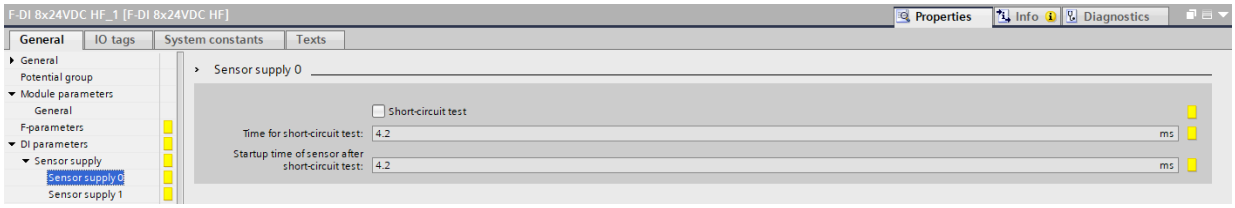
Note on the settings for the discrepancy evaluation:

Table 3-3 Discrepancy evaluation

Discrepancy evaluation	Possible	Advantage / Disadvantage
Discrepancy monitoring via "LSafe_FDoorGuardLocking" (1oo1 evaluation)	✓	+ No passivation of the F-module in case of discrepancy error - Immediate reaction to discrepancy error, delay time would have to be additionally inserted
Discrepancy monitoring by hardware (1oo2 evaluation)	✓	+ Discrepancy error is detected and evaluated by the module - Discrepancy error leads to passivation of the channel pair of the F-DI module

By the setting "external sensor supply", the short-circuit test at the corresponding sensor supply is already deactivated. The same setting is made when using the internal sensor supply of the F-DI for the power supply of 3SE64.

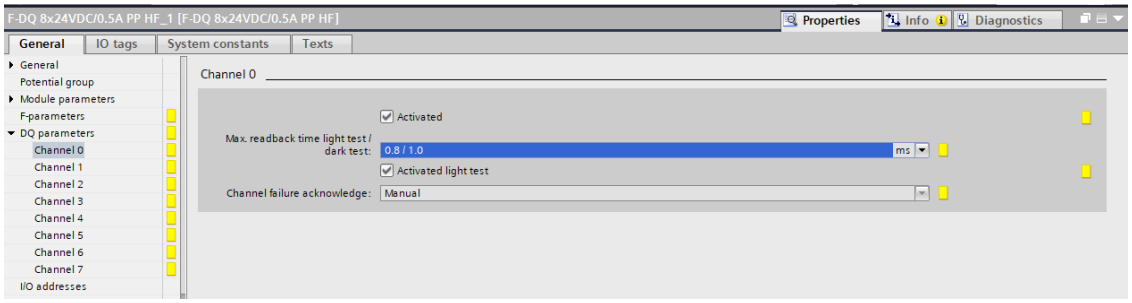
Figure 3-5 Configuration of the position switch, encoder supply setting



Configuration of the F-DQ (control of solenoid for tumbler)

The solenoid for releasing the door tumbler is controlled via a fail-safe output of the ET 200SP F-DQ 8x24VDC/0.5A.

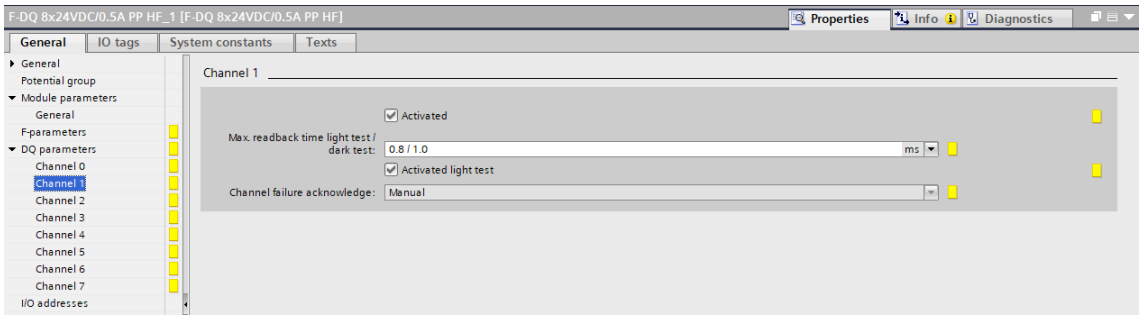
Figure 3-6 Configuration of the tumbler control



Configuration of the F-DQ (control of the contactors)

The two contactors are also controlled via the central F-DQ module of the F-CPU. We connect the contactors to channel 1. Readback times are to be set according to the contactors used.

Figure 3-7 Configuration of the redundant contactors control

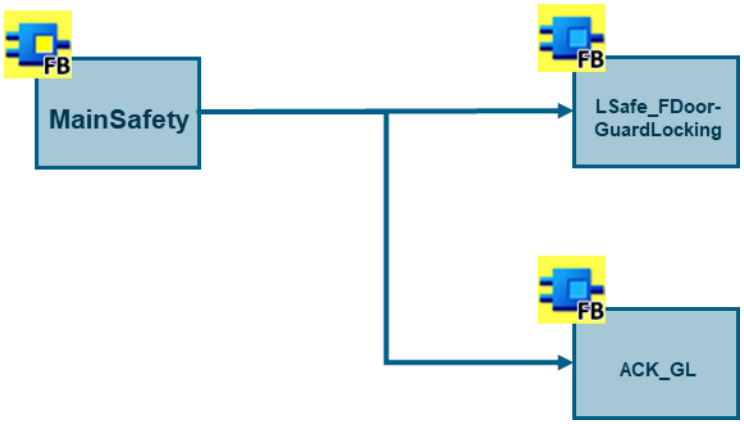


3.2.2 Programming

In this circuit example, the focus is on the safety-related switching of the machine. Therefore, operational switching is not considered and no standard user program is programmed. Only a direct link of the required input signals is stored. The standard program must be written by the user of this example – adapted to the requirements of the user's machine.

Overview of the safety program

Figure 3-3-2 Safety program



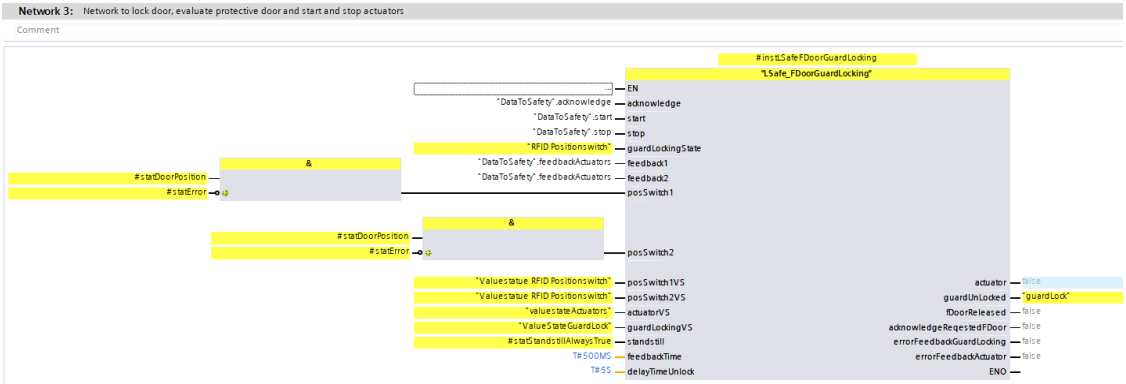
The MainSafety function block is called cyclically by an F-runtime group. This contains all other safety-related program parts.

Monitoring the position of the protective door and the interlock

To be able to switch on the machine, the protective door must be closed and locked. The protective door can only be unlocked after a configured time has elapsed and after the machine has been switched off, in order to protect the operator from dangerous machine movements that follow.

The "LSafe_FDoorGuardLocking" block from the LSafe library was used to implement these requirements.

Figure 3-8 LSafe_FDoorGuardLocking



Inputs/outputs of FB "LSafe_FDoorGuardLocking"

Table 3-4 Inputs

Identifier	Data type	Default value	Description
acknowledge	Bool	FALSE	Acknowledgment, positive edge required, NO
start	Bool	FALSE	Start request
stop	Bool	FALSE	Stop request
guardLockingState	Bool	FALSE	Monitoring solenoid in position switch
feedback1	Bool	FALSE	Feedback signal of the auxiliary contact of contactor 1, NC False: Contactor has closed
feedback2	Bool	FALSE	Feedback signal of the auxiliary contact of contactor 2, NC False: Contactor has closed
posSwitch1	Bool	FALSE	Door position switch 1
posSwitch2	Bool	FALSE	Door position switch 2
posSwitch1VS	Bool	FALSE	Value status door position switch 1
posSwitch2VS	Bool	FALSE	Value status of door position switch 2
actuatorVS	Bool	FALSE	Value status of "actuator", False: Error
guardLockingVS	Bool	FALSE	Value status of "door magnet", False: Error
standstill	Bool	FALSE	Standstill detection (set to True if not used)
feedbackTime	Time	T#0s	Time between control command and reaction of contactors
delayTimeUnlock	Time	T#0s	Time delay after switching off the actuators to release the protective door.

Table 3-5 Outputs

Identifier	Data type	Description
actuator	Bool	Actuator output to F-DQ
guardUnLocked	Bool	Door magnet
fDoorReleased	Bool	Release door, True: Door is closed and acknowledged
acknowledgeReqestedFDoor	Bool	Acknowledgment door required, True: Acknowledgment required
errorFeedbackGuardLocking	Bool	Message for missing feedback of the door tumbler
errorFeedbackActuator	Bool	Message for missing feedback of actuator control

DANGER

If the time at the "delayTimeUnlock" input is set too low, the machine can be accessed while it still poses a danger.

The time at the "delayTimeUnlock" input must therefore be adapted to the requirements of the machine.

Note

The feedback time "feedbackTime" for the lock as well as the actuator must be adapted to the respective components.

Note

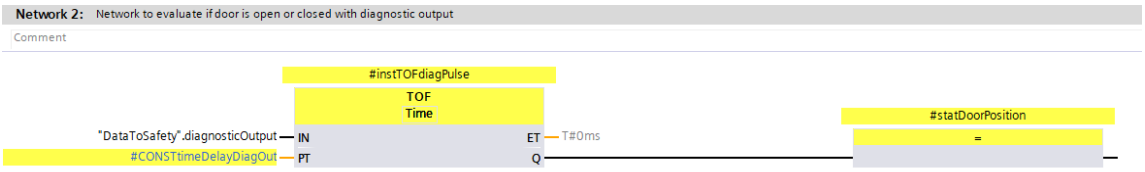
Variant two can be connected similarly to the example shown here. For this, the use of the diagnostic channel can be omitted and the bit for tumbler must be negated.

For the exact function of the "LSafe_FDoorGuardLocking" block, refer to the "LSafe" library for basic safety functions.

Monitoring the protective door

The "LSafe_FDoorGuardLocking" instruction is used to additionally query the position of the protective door. The non-safety-related diagnostics output of the safety switch is used for this purpose. This output must be provided with pulse stretching, since the diagnostics output emits a short switch-off pulse when interlocking is activated.

Figure 3-9 Monitoring the position of the protective door



Tumbler function of the protective door

The door is unlocked under the following conditions:

- The actuator is switched off
- The configured time after switching off the actuator has elapsed.
- To open and close the protective door for the first time (startup test)

The door is locked under the following conditions:

- The protective door is closed
- The start command is present

Since in variant 1 (closed-circuit principle) the OSSD outputs of the safety switch only become "true" when the door is also properly locked, the diagnostics output is also connected to the door contact inputs here in addition to the OSSD outputs. In combination with the "error" outputs of the function block, this maps whether the protective door is closed.

Note

The RFID safety switch with tumbler can also be integrated without the finished "LSafe_FDoorGuardLocking" function block. The advantage of the function block is that it has already been tested for function.

The safety functions described here with the 3SE64 RFID safety switch with tumbler can also be implemented with a 3SK2 safety relay.

Additional information:
https://support.industry.siemens.com/cs/ww/en/view/109811081

The following table shows the switching states of the outputs of the 3SE64 safety switch

Table 3-6 Diagnostics information

System state	Solenoid control IN		LED			Safety outputs OSSD1, OSSD2		Diagnostics output OUT
	Closed-circuit current	Open-circuit current	Green	Red	Yellow	3SE6415-1BB01 -1CB01	3SE6415-1AB01	
Door open	**24 V (0 V)**	**0 V (24 V)**	**On**	**Off**	**Off**	**0 V**	**0 V**	**0 V**
Door closed, not locked	24 V	0 V	On	Off	Flashing	0 V	24 V	24 V
Door closed, locking not possible	0 V	24 V	On	Off	Flashing	0 V	24 V	0 V
Door closed and locked	0 V	24 V	On	Off	On	24 V	24 V	24 V
Error warning[1)]	0 V	24 V	On	Flashes[2)]	On	24 V[1)]	24 V[1)]	0 V
Error	0 V (24 V)	24 V (0 V)	On	Flashes[2)]	Off	0 V	0 V	0 V
Additionally for version 3SE6415-1.B-02								
Actuator teach-in started			Off	On	Flashing	0 V	0 V	0 V

Table 3-3: Diagnostics information

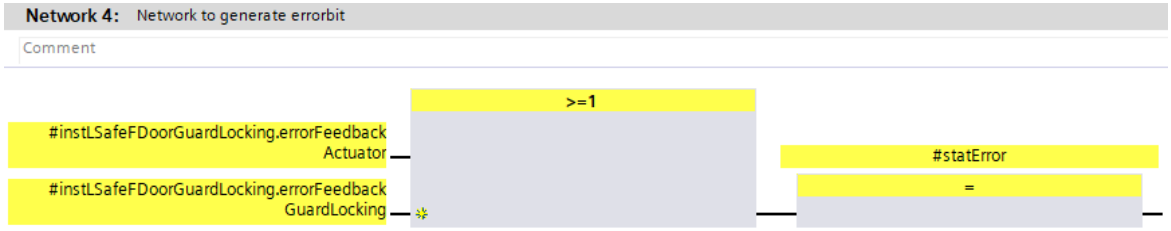
The red frame in Table 3-3: Diagnostics information shows the behavior of the OSSD outputs of the selected RFID safety switch. The diagnostics output always behaves the same regardless of the variant used.

Actuator control

The motor is switched on if:

- The protective door is closed
- The protective door is locked
- No interlock error is present
- The start signal from the standard process is present

Figure 3-10 Generate a general error bit



For the switch-on process of the actuators, it is evaluated whether the block has detected an error and whether the protective door is closed and locked.

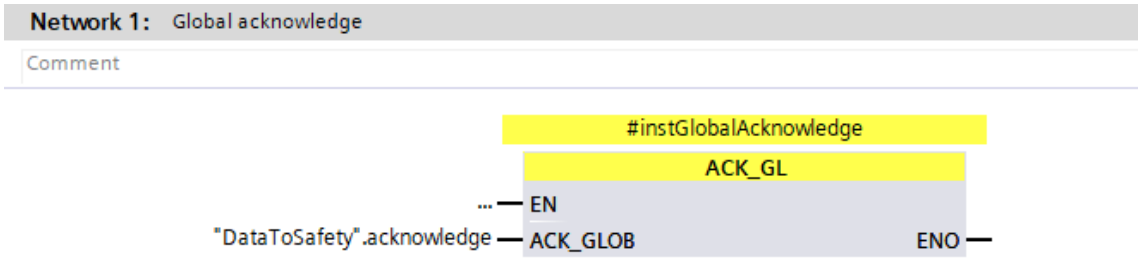
Figure 3-11 Checking the switch-on conditions for the actuator

In the event of a stop request, the motor switches off immediately and tumbler is canceled after the configured time has elapsed.

Reintegration of passivated channels

The ACK_GL instruction contained in STEP 7 Safety is used for this purpose. It generates an acknowledgment for simultaneous re-integration of all F-I/O/channels of the F-I/O of an F-runtime group after communication errors or F-I/O/channel errors.

Figure 3-12 ACK_GL call



Examples of events leading to passivation:

- Cross-circuit at the F-DQ
- No voltage supply at the F-DI

Note If an error occurs in the hardware (e.g. detected wire break), it may take a few seconds, depending on the error, until the module recognizes that the error has been cleared. Only then does the acknowledgment have an effect.

Data exchange between standard user program and safety program

During communication between the standard user program and the safety program, inadequate programming can lead to data corruption with a resulting CPU/system stop (see https://support.industry.siemens.com/cs/en/en/view/19183712).

To exchange data between the standard user program and the safety program, two global data blocks should therefore be used:

- DataToSafety
- DataFromSafety

The DataToSafety data block is written by the standard user program and read by the safety program. The DataFromSafety data block is written by the safety program and read by the standard user program.

Note

You can find more information about the data exchange between the standard user program and the safety program in the "Safety Programming Guide" and in the "SIMATIC Safety - Configuration and Programming" manual:

https://support.industry.siemens.com/cs/document/81318674/

https://support.industry.siemens.com/cs/ww/en/view/54110126

3.3 Commissioning

3.3.1 Preparation

1. Download the project file "Protective_door_3SE64_RFID_SIL3_V17.zap17.zip".
2. Save the zip file in any directory on your computer and unzip it.
3. Set the IP address of the PG/PC so that the PG/PC is in the same subnet as the CPU.
4. Connect the PG/PC with the Ethernet interface of the CPU 1512F-1 PN using an Ethernet cable.

The following IP address was used for this application example:

CPU 1512F-1 PN
IP address: 192.168.0.1
Subnet mask: 255.255.255.0

3.3.2 Downloading the S7 project to the CPU

1. Open "TIA Portal V17".
2. Switch to the project view.
3. Click on "Project > Open" in the menu bar of the TIA Portal.
4. Click "Browse" and open the unzipped project.
5. Set the CPU 1512F-1 PN to STOP.
6. In the project tree, right-click on "PLC_1 [CPU 1512F-1 PN]" and then click "Download to device > Hardware and software (only changes)".
7. Select the respective interface in the window that opens and click on "Start search".
8. Select the CPU based on the MAC address and then click "Load".

Note The IP address and the device name are automatically assigned when the project is loaded into the CPU.

9. Confirm the dialog by clicking "Load".
10. Click "Done" when the download is completed.

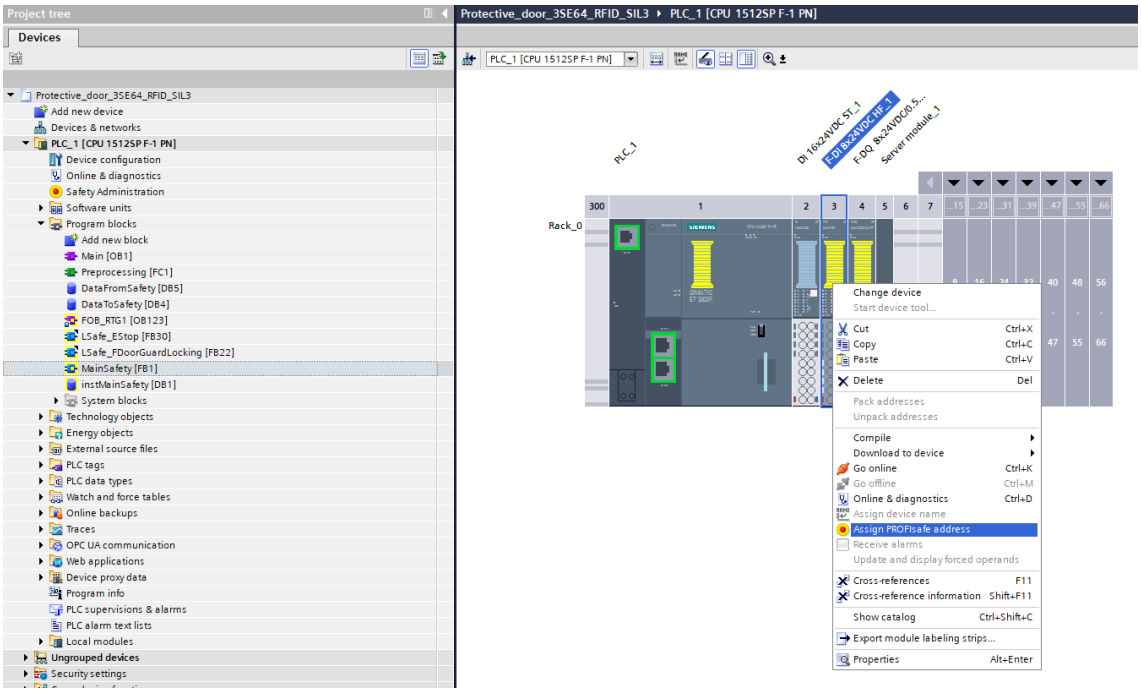
3.3.3 Assigning PROFIsafe addresses

PROFIsafe addresses still have to be assigned to the modules to realize safe communication between the F-CPU and the fail-safe modules (ET 200SP F-DI and F-DQ).

Note

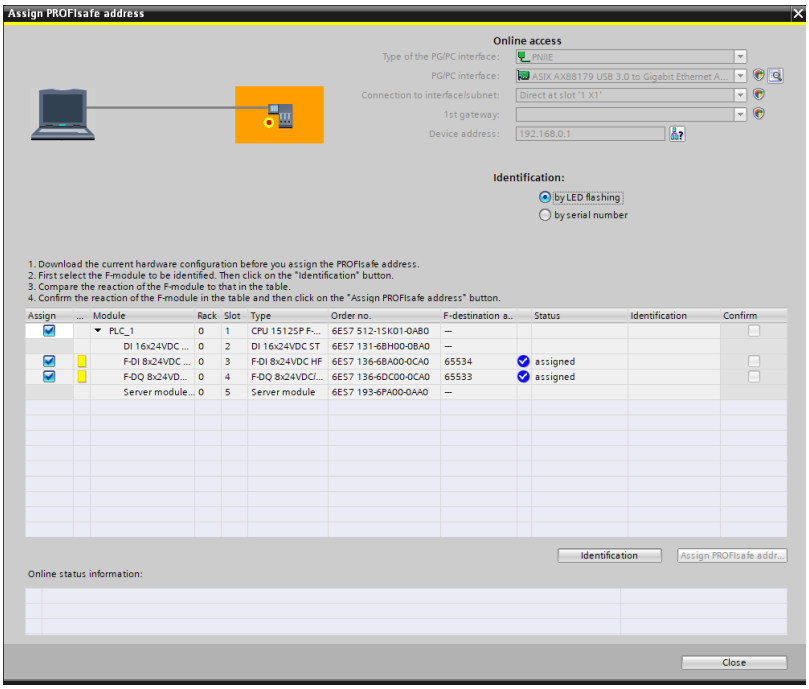
Since the PROFIsafe address is stored in the electronic coding element, this step is only required if no PROFIsafe address or a different one has been assigned to the coding element beforehand.

1. Open "Devices & networks" from the project tree
2. Right-click the F-modules of the ET 200SP and select the action "Assign PROFIsafe address".



3. Select the checkbox of the first fail-safe module and click the "Identification" button
4. When the LEDs of the F-modules of the ET200SP flash simultaneously every second, select the "Confirm" checkbox

5. Then click the "Assign PROFIsafe address" button and confirm the dialog with "Yes"



6. Close the window

Note

All red LEDs of the fail-safe modules should go out after the PROFIsafe addresses have been assigned. If this does not happen, there may be an error in the wiring.

7. Now set the CPU 1512F-1 PN to RUN.

3.4 Operation of the application example

Starting the machine for the first time

Table 3-7 Starting machine

No.	Action	Comment
1	Set the CPU to RUN	The machine is stopped and the protective door is unlocked, no direct machine start is possible.
2	Open and close the protective door when starting the application example for the first time.	
3	Acknowledge the initial opening and closing of the protective door.	
4	Press the start button.	The interlock is activated and the machine starts.

Unlocking and opening the protective door

Table 3-8 Unlocking and opening the protective door

No.	Action	Comment
1	Press the stop button	The machine switches off and ramps down.
2	Wait for the configured delay time for unlocking the protective door.	In the example: 5 seconds The solenoid is then supplied with voltage and unlocks the ratchet wheel.
3	Open the protective door.	

Closing the protective door and switching it on again

Table 3-9 Closing the safety door and switching it on again

No.	Action	Comment
1	Close the protective door	The block issues an acknowledgment request.
2	Acknowledge the closing of the protective door.	
3	Press the start button	The interlock is activated and the machine starts.

Acknowledging a safety function error

If an error occurs in the safety function, the machine is immediately switched off and a restart is prevented. Proceed as follows to acknowledge the error.

Table 3-10 Acknowledging errors of the safety function

No.	Action	Comment
1	Check the LEDs on the fail-safe modules. If a red LED lights up, an error has been detected in the hardware. Search for the error using the online diagnostics in TIA Portal.	
2	If all LEDs light up green, an error has been detected by the safety program. Consult the tag table to find the error.	The "errorFeedbackGuardLocking" and "errorFeedbackActuator" tags of the "LSafe_FDoorGuardLocking" block instructions can help in the search.
3	Correct the error.	
4	Close the protective door.	
5	Press the reset button.	Passivated channels of the fail-safe modules are re-integrated. Detected errors of the safety program are acknowledged.
6	Press the start button.	The interlock is activated and the machine starts.

Possible errors that are acknowledged in this way include:

- External voltage on the fail-safe outputs
- Pulling of a fail-safe module
- Sealing of a contactor

4 Assessment of the safety function

In this application example, the following safety functions are implemented.

Table 4-1 Description of the safety function

Safety function	Description	Requirement
SF1 "Protective door monitoring"	If the protective door is opened, the machine is safely shut down.	SIL 3 or PL e
SF2 "Protective door tumbler"	The protective door is held shut until the machine comes to a standstill.	SIL 2 or PL d (variant 1)

An assessment of the two safety functions SF 1 and SF2 according to ISO 13849-1 as well as IEC 62061 for variant 1 and variant 2 was performed with Safety Evaluation in the TIA Selection Tool (SE@TST):

Safety Evaluation in the TIA Selection Tool

The file is attached to this application example.

4.1 Assessment according to ISO 13849-1

An assessment according to ISO 13849-1 was performed with the Safety Evaluation in the TIA Selection Tool (SE@TST):

Safety Evaluation in the TIA Selection Tool

4.1.1 Safety function SF1 protective door monitoring

The individual subsystems of the safety function are explained below.

"Detect" assessment SF1

For SF1, the SIRIUS 3SE64 RFID position switch with tumbler represents the "Detect" subsystem. The correct function of the protective door is monitored in variant 1 with two OSSD contacts.

Breakage of the door lock is diagnosed. The architecture thus corresponds to a category 4 according to ISO 13849-1.

The safety-related parameters of the component are provided by the manufacturer.

Table 4-2 Result of "Detect" SF1

Component	PFH_D	PL	Stipulated by
RFID safety switch with tumbler	5.20×10^{-9}	PL e	Siemens AG
Total	5.20×10^{-9}	PL e	

"Evaluate" assessment SF1

The ET 200SP fail-safe controller and its modules for evaluating the RFID position switch with tumbler are involved in the "Evaluate" subsystem. The position of the protective door is read in via two fail-safe inputs of the ET 200SP F-DI. Furthermore, the fail-safe output of the ET200SP is involved in the "Evaluate" subsystem for controlling the motor.

Table 4-3 Result of "Evaluate" SF1

Component	PFH_D	PL	Stipulated by
CPU 1512SP F-1 PN incl. PROFIsafe	2.00×10^{-9}	PL e	Siemens AG
ET 200SP, El. Mod., F-DI 8x24VDC HF	2.00×10^{-10}	PL e	
ET 200SP, F-DQ 8x 24VDC/0.5A PP	2.00×10^{-9}	PL e	
Total	6.00×10^{-9}	PL e	

"React" assessment SF1

For SF1, the two 3RT20 power contactors represent the "React" subsystem. An error in controlling the contactors is immediately detected by the dynamic feedback loop monitoring and results in a machine shutdown. The probability of the operator attempting to enter the hazardous area at the same moment as this error is negligible (see also Section 8.4 ISO 14119).

The architecture thus corresponds to a category 4 according to ISO 13849-1.

The safety-related parameters of the component are provided by the manufacturer. The resulting probability of a dangerous failure depends on the actual actuation cycles and the type of installation of the component, which must be completed by the user.

Table 4-4 Parameters of "React" SF1

Monitoring	Value	Reason	Stipulated by
B10 Operating cycles	1.000.000	Manufacturer specifications	SIEMENS AG
Percentage of hazardous failures	73%	Manufacturer specifications	
T1 Service life	20 years	Manufacturer specifications	
Architecture	Category 4	Dual-channel system	Users
Actuations / Test interval	3/day	Assumption	
CFF measures	≥ 65	Sufficient measures must be taken against CCF according to ISO 13849-1 Table F.1	
DC diagnostic coverage	≥ 99%	Dynamic monitoring of the feedback loop	

Table 4-5 Result of "React" SF1

PFH_D	Achieved PL
9.06×10^{-10}	PL e

Result of the assessment according to ISO 13849-1 SF1

Table 4-6 Result of the assessment according to ISO 13849-1 SF1

Subsystem	PFH_D	Achieved PL
Detection	5.20×10^{-9}	PL e
Evaluation	6.00×10^{-9}	PL e
React	9.06×10^{-10}	PL e
Total	1.21×10^{-8}	PL e

4.1.2 Safety function SF 2 protective door tumbler

The individual subsystems of the safety function are explained below.

"Detect" assessment SF2

In this application example, the safe condition to release the protective door is not determined by sensors. Instead, it can be estimated in time if the resulting dangerous motion is always the same. The protective door is therefore released via a time delay after the actuator is switched off, which is evaluated in the safety program. Once the protective door has been released, it can be opened by the operator.

The "Detect" subsystem is therefore not relevant for this application example for either variant and the corresponding area in the TIA file is empty.

"Evaluate" assessment SF2

The ET 200SP fail-safe controller and its modules for controlling the tumbler are involved in the "Evaluate" subsystem. The tumbler is diagnosed here by the RFID position switch with tumbler. The position of the protective door is determined via the diagnostics output of the RFID position switch with tumbler and a standard DI. This is not involved in the consideration.

Table 4-7 Result of "Evaluate" SF2

Component	PFH_D	PL	Stipulated by
CPU 1512SP F-1 PN incl. PROFIsafe	2.00×10^{-9}	PL e	Siemens AG
ET 200SP, F-DQ 8x 24VDC/0.5A PP	2.00×10^{-9}	PL e	
Total	4.00×10^{-9}	PL e	

"React" assessment SF2 variant 1

For SF2, the SIRIUS 3SE64 RFID position switch with tumbler represents the "React" subsystem. The correct function of the tumbler is monitored in variant 1 by the internal diagnostic mechanism of the switch. An error in controlling the tumbler is immediately detected by the dynamic tests of the ET 200SP F-DQ module and results in a machine shutdown. The probability of the operator attempting to enter the hazardous area at the same moment as this error is negligible (see also Section 8.4 ISO 14119).

The safety-related parameters of the component are provided by the manufacturer. Due to the structural limitation, the component of the "React" subsystem achieves PL d.

Table 4-8 Parameters of "React" SF2 variant 1

Component	PFH_D	PL	Stipulated by
RFID safety switch with tumbler	2.00×10^{-9}	PL d	Siemens AG
Total	2.00×10^{-9}	PL d	

Result of the assessment according to ISO 13849-1 for SF2 variant 1

Table 4-9 Result of the assessment according to ISO 13849-1 for SF2 variant 1

Subsystem	PFH_D	Achieved PL
Evaluation	4.00×10^{-9}	PL e
React	2.00×10^{-9}	PL d
Total	6.00×10^{-9}	PL d

"React" assessment SF2 variant 2

Since the SF2 safety function of variant 2 is used purely for process protection, no consideration is made here with regard to functional safety.

4.2 Assessment according to IEC 62061

An assessment according to IEC 62061 was performed with the Safety Evaluation Tool (SET):

4.2.1 Safety function SF1 protective door monitoring

The individual subsystems of the safety function are explained below.

"Detect" assessment SF1

For SF1, the SIRIUS 3SE64 RFID position switch with tumbler represents the "Detect" subsystem. The correct function of the protective door is monitored in variant 1 with two OSSD contacts.

Breakage of the door lock is diagnosed. The architecture thus corresponds to an architecture D basic subsystem in accordance with IEC 62061: Single fault tolerance with diagnostics function.

The safety-related parameters of the component are provided by the manufacturer.

Table 4-10 Result of "Detect" SF1

Component	PFH_D	PL	Stipulated by
RFID safety switch with tumbler	5.20×10^{-9}	SIL 3	Siemens AG
Total	5.20×10^{-9}	SIL 3	

"Evaluate" assessment SF1

The ET 200SP fail-safe controller and its modules for controlling the tumbler are involved in the "Evaluate" subsystem. The tumbler is diagnosed here by the RFID position switch with tumbler. The position of the protective door is determined via the diagnostics output of the RFID position switch with tumbler and a standard DI. This is not involved in the consideration.

Table 4-11 Result of "Evaluate" SF1

Component	PFH_D	PL	Stipulated by
CPU 1512SP F-1 PN incl. PROFIsafe	2.00×10^{-9}	SIL 3	Siemens AG
ET 200SP, El. Mod., F-DI 8x24VDC HF	2.00×10^{-10}	SIL 3	
ET 200SP, F-DQ 8x 24VDC/0.5A PP	2.00×10^{-9}	SIL 3	
Total	6.00×10^{-9}	SIL 3	

"React" assessment SF1

For SF1, the two 3RT20 power contactors represent the "React" subsystem. An error in controlling the contactors is immediately detected by the dynamic feedback loop monitoring and results in a machine shutdown. The probability of the operator attempting to enter the hazardous area at the same moment as this error is negligible (see also Section 8.4 ISO 14119).

This is a basic subsystem architecture D according to IEC62061:
Single fault tolerance with diagnostics function.

The safety-related parameters of the component are provided by the manufacturer. The resulting probability of a dangerous failure depends on the actual actuation cycles and the type of installation of the component, which must be completed by the user.

Table 4-12 Parameters of "React" SF1

Monitoring	Value	Reason	Stipulated by
B10 Operating cycles	1.000.000	Manufacturer specifications	SIEMENS AG
Percentage of hazardous failures	73%	Manufacturer specifications	
T1 Service life	20 years	Manufacturer specifications	
Subsystem architecture	D	Single fault tolerance with diagnostics function	Users
Actuations / Test interval	3/day	Assumption	
DC diagnostic coverage	≥99%	Dynamic monitoring of the feedback loop	

Table 4-13 Result of "React" SF1

PFH_D	Achieved SIL
9.12×10^{-10}	SIL 3

Result of the assessment according to IEC 62061 for SF1

Table 4-14 Result of the assessment according to IEC 62061 for SF1

Subsystem	PFH_D	Achieved SIL
Detection	5.20×10^{-9}	SIL 3
Evaluation	6.00×10^{-9}	SIL 3
React	9.12×10^{-10}	SIL 3
Total	1.21×10^{-8}	SIL 3

4.2.2 Safety function SF 2 protective door tumbler

The individual subsystems of the safety function are explained below.

"Detect" assessment SF2

In this application example, the safe condition to release the protective door is not determined by sensors. Instead, it can be estimated in time if the resulting dangerous motion is always the same. The protective door is therefore released via a time delay after the actuator is switched off, which is evaluated in the safety program. Once the protective door has been released, it can be opened by the operator.

The "Detect" subsystem is therefore not relevant for this application example for either variant and the corresponding area in the TIA file is empty.

"Evaluate" assessment SF2

The ET 200SP fail-safe controller and its modules for controlling the tumbler are involved in the "Evaluate" subsystem. The tumbler is diagnosed here by the RFID position switch with tumbler. The position of the protective door would be determined here via the diagnostics output of the RFID position switch with tumbler and a standard DI. This is not involved in the consideration.

Table 4-15 Result of "Evaluate" SF2

Component	PFH_D	PL	Stipulated by
CPU 1512SP F-1 PN incl. PROFIsafe	2.00×10^{-9}	SIL 3	Siemens AG
ET 200SP, F-DQ 8x 24VDC/0.5A PP	2.00×10^{-9}	SIL 3	
Total	4.00×10^{-9}	SIL 3	

"React" assessment SF2 variant 1

For SF2, the SIRIUS 3SE64 RFID position switch with tumbler represents the "React" subsystem. The correct function of the tumbler is monitored in variant 1 by the internal diagnostic mechanism of the switch. An error in controlling the tumbler is immediately detected by the dynamic tests of the ET 200SP F-DQ module and results in a machine shutdown. The probability of the operator attempting to enter the hazardous area at the same moment as this error is negligible (see also Section 8.4 ISO 14119).

The safety-related parameters of the component are provided by the manufacturer. Due to the structural limitation, the component of the "React" subsystem achieves PL d.

Table 4-16 Parameters of "React" SF2 variant 1

Component	PFH_D	PL	Stipulated by
RFID safety switch with tumbler	2.00×10^{-9}	SIL 2	Siemens AG
Total	2.00×10^{-9}	SIL 2	

Result of the assessment according to IEC 62061 for SF2 variant 1

Table 4-17 Result of the assessment according to IEC 62061 for SF2 variant 1

Subsystem	PFH_D	Achieved SIL
Evaluation	4.00×10^{-9}	SIL 3
React	2.00×10^{-9}	SIL 2
Total	6.00×10^{-9}	SIL 2

"React" assessment SF2 variant 2

Since the SF2 safety function of variant 2 is used purely for process protection, no consideration is made here with regard to functional safety.

5 Appendix

5.1 Service and support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

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You can find detailed information on our range of services in the service catalog web page:

support.industry.siemens.com/cs/sc

Industry Online Support app

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

support.industry.siemens.com/cs/ww/en/sc/2067

5.2 Industry Mall

The Siemens Industry Mall is the platform on which the entire siemens Industry product portfolio is accessible. From the selection of products to the order and the delivery tracking, the Industry Mall enables the complete purchasing processing – directly and independently of time and location:
mall.industry.siemens.com

5.3 Links and literature

Table 5-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109811981
\3\	

5.4 Change documentation

Table 5-2

Version	Date	Modifications
V1.0	07/2022	First version