Fail-Safe Group Shutdown of the ET 200SP F-Motor Starter with F-PM-E

SIMATIC Safety Integrated

https://support.industry.siemens.com/cs/ww/en/view/109748128

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Table of Contents

1 Task

A machine is operated with different actuators. To protect the operating staff, these actuators are monitored in a fail-safe controller and shut down through technical protective measures (e.g., emergency stop command device) in the event of danger.

This application example shows you how to safely shut down one or more actuators with the ET 200SP F-motor starter in combination with the ET 200SP F-PM-E fail-safe power module. The application example described in this document meets the requirements of IEC 62061 (SIL3) and ISO 13849-1 (PLe).

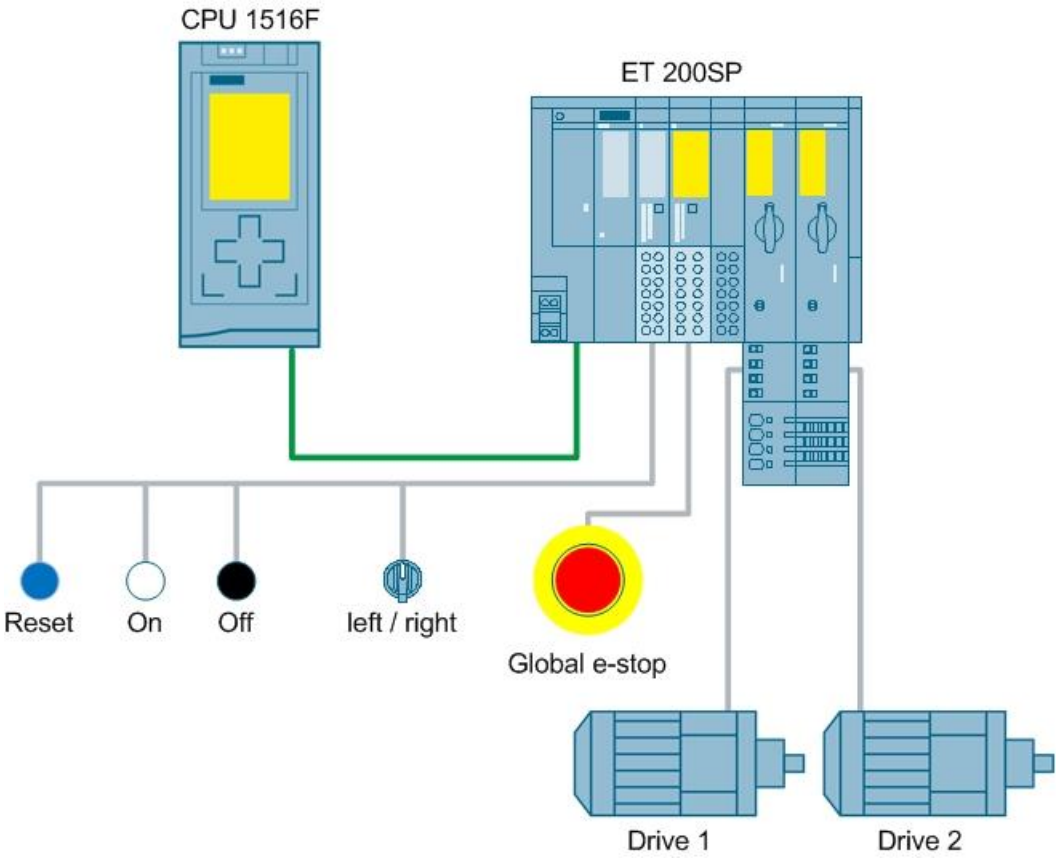
2 Solution

2.1 Overview

Group shutdown is the simultaneous shutdown of multiple actuators with one shutdown signal. Fail-safe group shutdown means that the shutdown signal is triggered by a safety function (e.g., emergency stop). All the actuators integrated in a group shut down simultaneously.

Configuration of the application example

Figure 2-1 Configuration



Required knowledge

The following knowledge is required:

- Basics of functional safety
- Basics of STEP 7 programming

2.2 Hardware and software components

2.2.1 Validity

This application example is valid for:

- All fail-safe SIMATIC controllers
- STEP 7 Professional V14 or higher with STEP 7 Safety Advanced

2.2.2 Components used

The application example was created with the following components:

Table 2-1 Hardware components

Component	No.	Article no.	Note
Power supply	1	6EP1332-4BA00	PM 70W
Fail-safe S7 CPU	1	6ES7516-3FN00-0AB0	CPU 1516F-3 PN/DP
SIMATIC Memory Card	1	6ES7954-8LC02-0AA0	SMC 4MB
Interface module for ET 200SP	1	6ES7155-6AU00-0BN0	IM155-6PN ST
Digital input module	1	6ES7131-6BF00-0CA0	DI 8X24VDC HF
Base unit	1	6ES7193-6BP00-0DA0	Infeed terminal separated
Fail-safe power module	1	6ES7136-6PA00-0BC0	F-PM-E PPM, 24V DC
Base unit	1	6ES7193-6BP20-0DC0	Infeed terminal separated, type C0, BU20-P6+A2+4D
Empty module cover	1	6ES7133-6CV15-1AM0	15mm base unit cover
Base unit empty module	1	6ES7193-6BP00-0BA0	Infeed terminal bridged
ET 200SP fail-safe motor starter	1	3RK1308-0CC00-0CP0	F-direct-on-line starter 0.9-3A
Base unit	1	3RK1908-0AP00-0CP0	BU for ET 200SP motor starter with 500V infeed, MS2
ET 200SP fail-safe motor starter	1	3RK1308-0DC00-0CP0	F-reversing starter 0.9-3A
Base unit	1	3RK1908-0AP00-0DP0	BU for ET 200SP motor starter without infeed, MS4
Server module	1	6ES7193-6PA00-0AA0	ET 200SP, server module
Emergency stop command device, complete unit	1	3SU1150-1HB20-1CH0	Mushroom pushbutton with one normally closed contact
Contact module, 1 NC	1	3SU1400-2AA10-1CA0	Additional contact for emergency stop
Reset pushbutton, complete unit	1	3SU1150-0AB50-1BA0	Pushbutton, blue, one normally open contact
On pushbutton, complete unit	1	3SU1150-0AB50-1BA0	Pushbutton, white, one normally open contact
Off pushbutton, complete unit	1	3SU1150-0AB10-1BA0	Pushbutton, black, one normally open contact
Selector switch, left/right, complete unit	1	3SU1150-2BL60-1NA0	Selector switch, white, three switch positions I-O-II, latching, two normally open contacts

Table 2-2 Software components

Component	No.	Article no.	Note
STEP 7 Professional	1	6ES7822-1AE04-0YA5	V15.1
STEP 7 Safety Advanced	1	6ES7833-1FA14-0YH5	V15.1
Hardware Support Package	1	HSP0195 – SIMATIC ET 200SP motor starter (not required for V15 and higher)	https://support.industry.siemens.com/cs/ww/en/view/72341852

2.2.3 Sample files and projects

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

Table 2-3 2.2.3 Sample files and projects

Component	Note
109748128_ET200SP_F-PM-E_DOC_v10_en.docx	This document
109748128_ET_200SP_with_F-PM-E_PROG.zip	TIA Portal project

3 Hardware Configuration

3.1 Shutdown options

ET 200SP motor starters are offered in two versions, standard and fail-safe, each available as a direct-on-line starter and as a reversing starter.

Depending on the application example, the ET 200SP F-motor starter can be safely shut down in different ways, for example

- with a 3SK safety relay,
- an ET 200SP F-DQ fail-safe digital output module or
- an ET 200SP F-PM E fail-safe power module.

The below selection matrix illustrates the different shutdown options.

Table 3-1 Shutdown options

ET 200SP F-motor starter shutdown principle		**Application example with 3SK safety relay**	**Application example with F-DQ fail-safe digital output**	**Application example with F-PM-E fail-safe power module**
Hardware diversity	Suitable for group shutdown	Yes	Yes	Yes
	Suitable for single shutdown	Yes	Yes	No
Use for cyclically requested safety functions (e.g., safety door, light curtain)		Yes	Yes	No
Use for acyclically requested safety functions (e.g., emergency stop)		Yes	Yes	Yes
Motor starter can still be accessed by the CPU after fail-safe shutdown		Yes	Yes	No
Suitable for immediate ready for operation again		Yes	Yes	No (recovery time: >= 2.2s)
External wiring overhead		Yes	Yes	No
Standard and safety technology		Separate	Integrated in one device	Integrated in one device

3.2 Mode of operation

The following example explains safe group shutdown with an S7-1500F-CPU and a distributed ET 200SP station. Fail-safe group shutdown is implemented combining the ET 200SP F-PM E (fail-safe power module) and ET 200SP F-motor starters. Safe shutdown is triggered by the emergency stop command device.

A new potential group is set up with the F-PM-E fail-safe power module (24VDC/8A PPM ST). The DC 24 V supply voltage of the potential group is supplied by the internal voltage buses, P1 and P2. Safety-related shutdown via the F-PM-E module turns off the DC 24 V supply voltage of all modules of the potential group. In the following example, fail-safe shutdown of the ET 200SP F-motor starter is ensured by removing the supply voltage by the ET 200SP F-PM-E.

For group shutdown using the F-PM-E, please note the following: After voltage recovery, the modules in the potential group require a recovery time (>= 2.2 s) to be ready for operation again. To ensure that this delay time does not affect the operational process, it is advisable to use this group shutdown for shutdown functions with low switching frequencies, for example for the emergency stop safety function. The emergency stop safety function is regarded as a complementary protective measure and does not affect the operational process. Actuating an emergency stop command device stops all actuators. Once the hazardous situation has been eliminated and the safety function has been acknowledged, the process can start again.

In this example, the group is set up with two fail-safe motor starters, one direct-on-line starter and one reversing starter. The use of more motor starters or the maximum configuration depends on the load voltage conditions. Follow the instructions provided in the “Manual – SIMATIC ET 200SP Motor Starter”:

https://support.industry.siemens.com/cs/ww/en/view/109479973

Slot rules

Trouble-free use of the ET 200SP motor starter requires that you use an empty module in front of the first motor starter.

For more information about setting up a plant with the ET 200SP motor starter, please refer to the “SIMATIC ET 200SP Distributed I/O System” system manual:

https://support.industry.siemens.com/cs/ww/en/view/58649293

Note Protecting the lines from the feeding point to the motor starter requires additional measures such as a 3RV circuit breaker. As this is not part of functional safety, this is not included in the following overviews and connection diagrams.

It is also possible to implement an application with the ET 200SP F-motor starter according to the requirements of SIL 1 to SIL 2 (according to IEC 62061) or PL a to PL d (according to ISO 13849-1). In your design of the safety function, make sure to comply with the architecture of the required safety integrity level.

Monitoring the feedback circuit

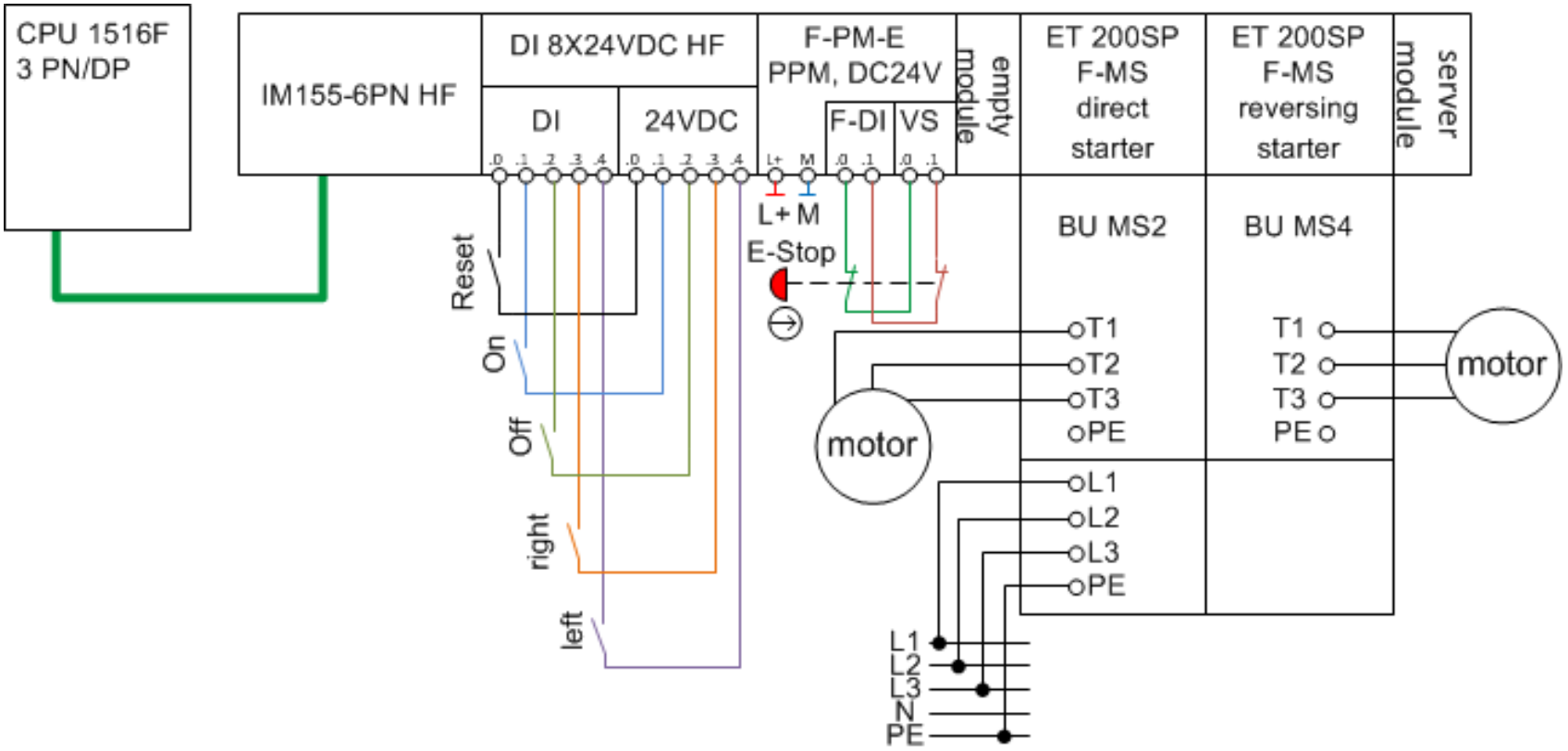
For the ET 200SP fail-safe motor starter 3RK1308-0**00-0CP0, the OFF state is defined as a safe state. The motor starters are self-monitoring in compliance with SILCL 3 / PL e; therefore, it is not necessary to monitor them in the feedback circuit of the upstream evaluation unit.

If an error occurs, the motor starter itself prevents a restart.

Different base unit types (BU30 MS1 to MS10) are available for the ET 200SP motor starter. In this example, group shutdown is implemented with the MS2 (3RK1908-0AP00-0CP0) and MS4 (3RK1908-0AP00-0DP0) types. The motor starters are supplied by the 24 V DC infeed of the F-PM-E. The 400 V infeed of the actuators is connected to the MS2 base unit of the motor starter that has just been inserted. Due to the use of the MS4 base unit, the 400 V infeed is bridged by MS5 and does not need to be reconnected.

3.3 Wiring example

Figure 3-1 Application example wiring



4 Configuration and Project Engineering

4.1 Hardware configuration

The supplied project does not require any further configuration. If you reproduce the application example with other components, this chapter shows the most important settings.

NOTICE	The settings shown below help meet PL e / SIL 3. Changes to the settings can lead to a reduction or loss of the safety function.

NOTICE	The defaults used in this sample project may differ from your specific requirements.

Figure 4-1 Hardware configuration

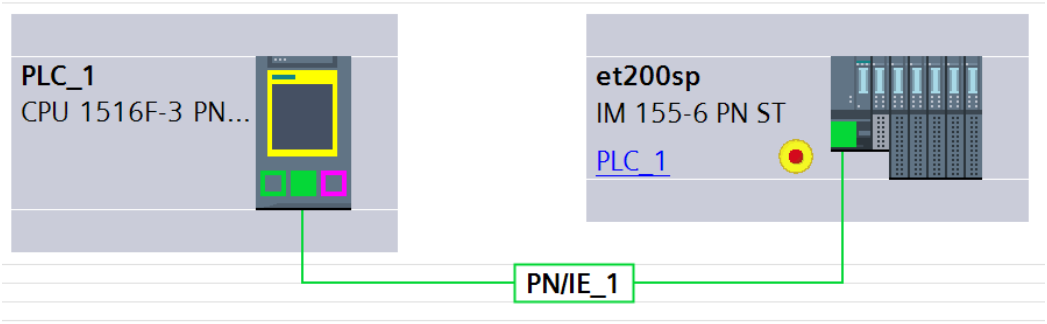
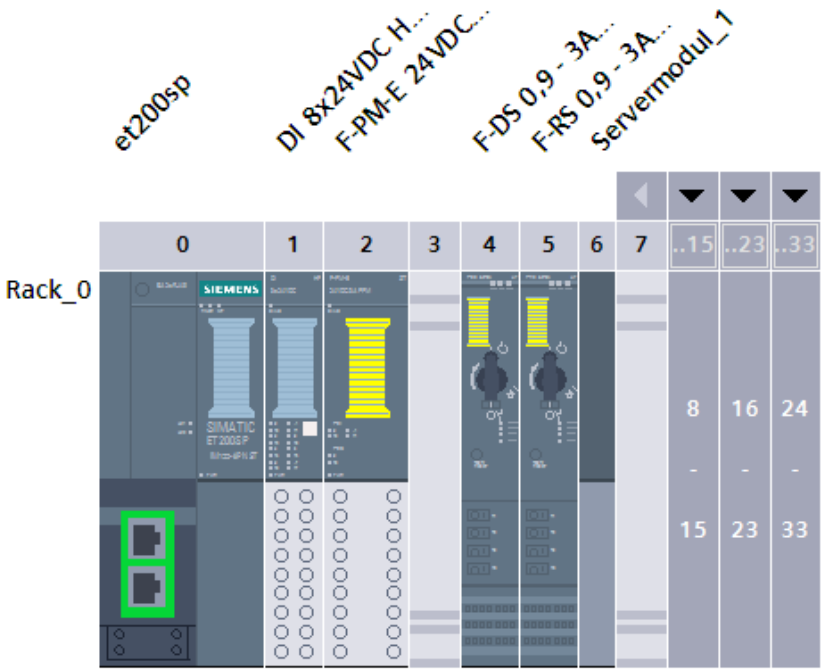


Figure 4-2 ET 200SP station configuration

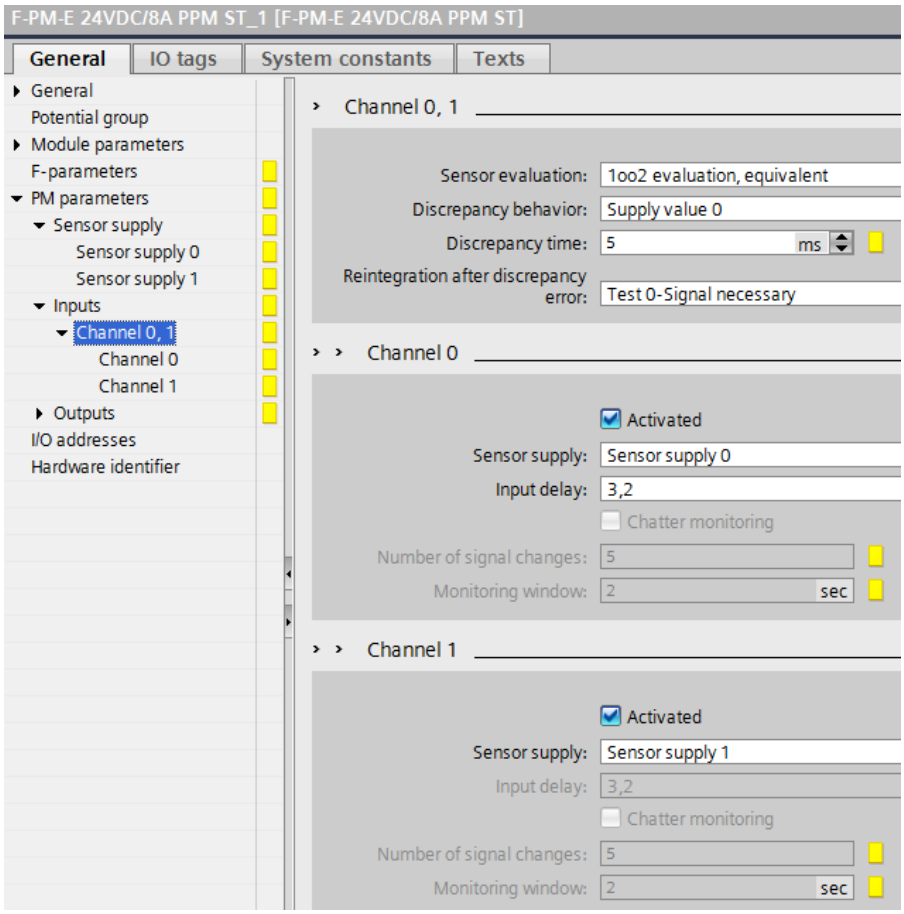


4.2 Module parameters

F-PM-E settings

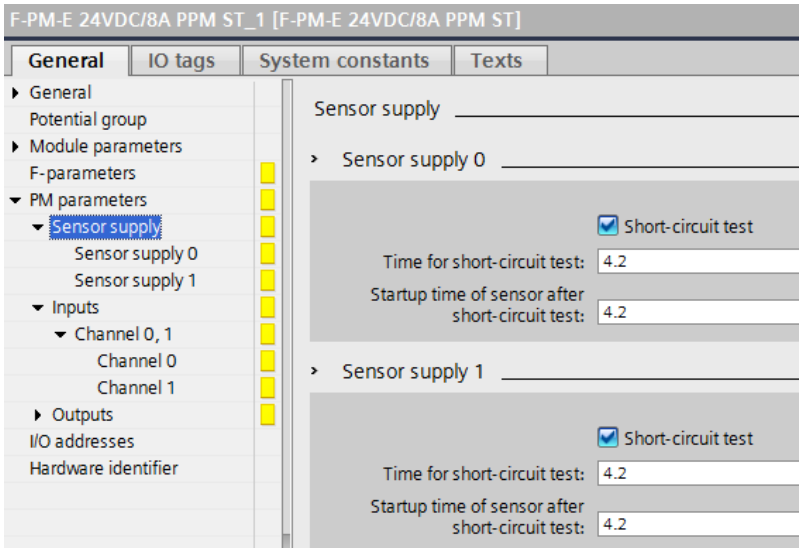
Activate channel 0 and channel 1 on the F-PM-E for reading the emergency stop safety function. Both channels are supplied by the sensor supply on the F-PM-E.

Figure 4-3 F-PM-E settings, channel 0, 1



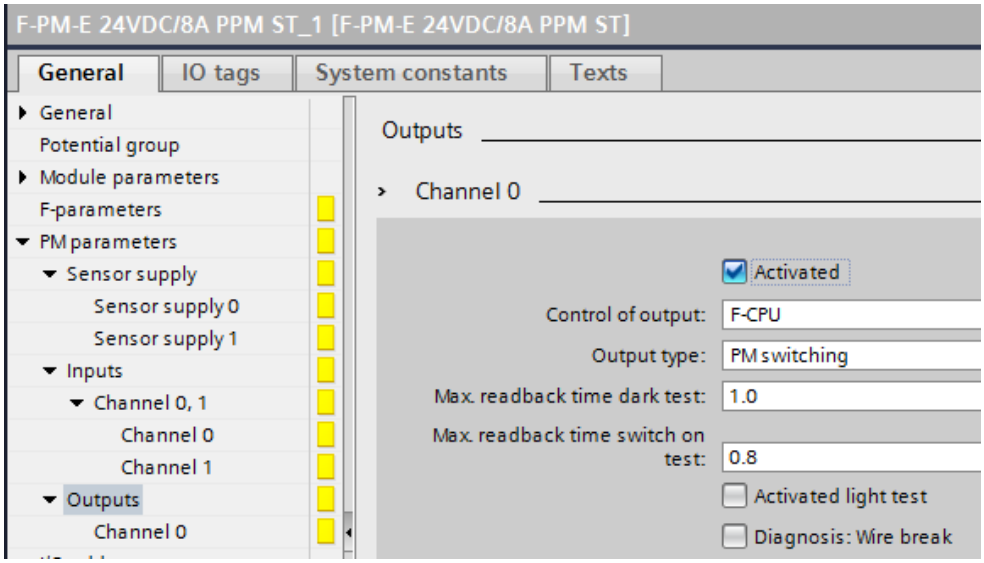
Activate the short-circuit test for the sensor supply of channels 0 and 1.

Figure 4-4 Sensor supply settings



Activate the fail-safe output on channel 0.

Figure 4-5 fail-safe output settings



F-motor starter settings

For fail-safe operation of the motor starter, no other parameters need to be set in the motor starter's properties.

For correct operation of the motor, set the specific requirements of your application in the properties (e.g., rated normal current, current limits and shutdown class).

4.3 First commissioning

For safety mode of the F-PM-E, it is required to assign an F-destination address on the module.

For more information about assigning the F-destination address, please refer to the “SIMATIC Industrial Software SIMATIC Safety – Configuring and Programming” programming and operating manual:
http://support.automation.siemens.com/WW/view/en/54110126

First commissioning of the ET 200SP motor starter requires that safety-related parameters be acknowledged. Confirm the relevant parameters by pressing the reset button twice.

For more information about commissioning the fail-safe motor starter, please refer to the “SIMATIC ET 200SP Motor Starter” equipment manual:
https://support.industry.siemens.com/cs/ww/en/view/109479973

5 Mode of Operation

5.1 Complete overview

The following figure shows the standard user program and the safety program. It additionally shows the data exchange between the standard program and the safety program with a global data block.

Figure 5-1 Program overview

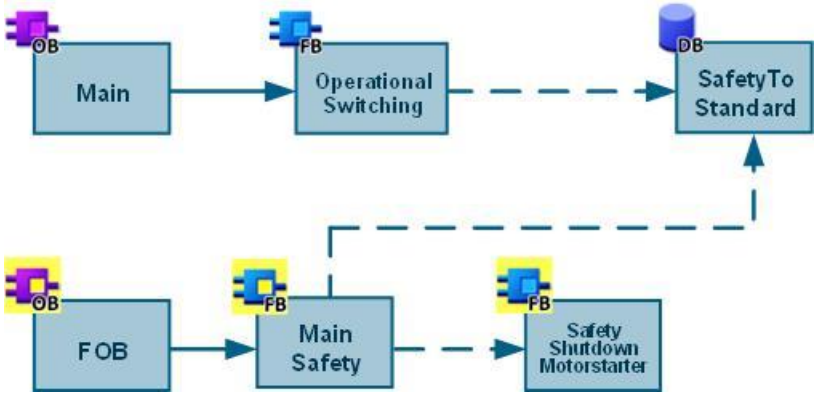


Table 5-1

Block	Function
OperationalSwitching	The standard user program is processed in this block.
MainSafety	This block contains the safety program and calls other safety-related instructions.
SafetyShutdownMotorstarter	Safety-related shutdown of the motor starter by triggering the emergency stop safety function is implemented in this block.
SafetyToStandard	In this global data block, the “OperationalSwitching” block provides the control signals to the safety program.

5.2 Safety program

An emergency stop safety function is evaluated in the application example shown in this document. When the emergency stop command device is actuated, the motor starter is shut down in a safety-related manner. In the safety program, the safety function is monitored using the ESTOP1 program block.

Program description

The ESTOP1 instruction is included in STEP 7 Safety Advanced. This program block is called in the “SafetyShutDown” FB.

If the emergency stop is not actuated, the ESTOP block outputs the value 1 at the Q output. This means that the motors can be functionally switched. Once the emergency stop has been actuated, the actuators immediately shut down in a safety-related manner. Then the emergency stop command device must be unlocked and acknowledged via the ACK input. An acknowledgment request is

output via the ACK_REQ output. The Q output is buffered to a static tag to simplify access to it in the next networks.

Figure 5-2 Network1

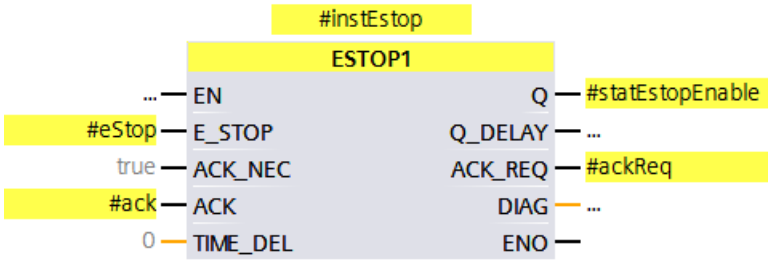
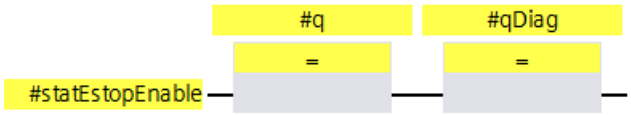
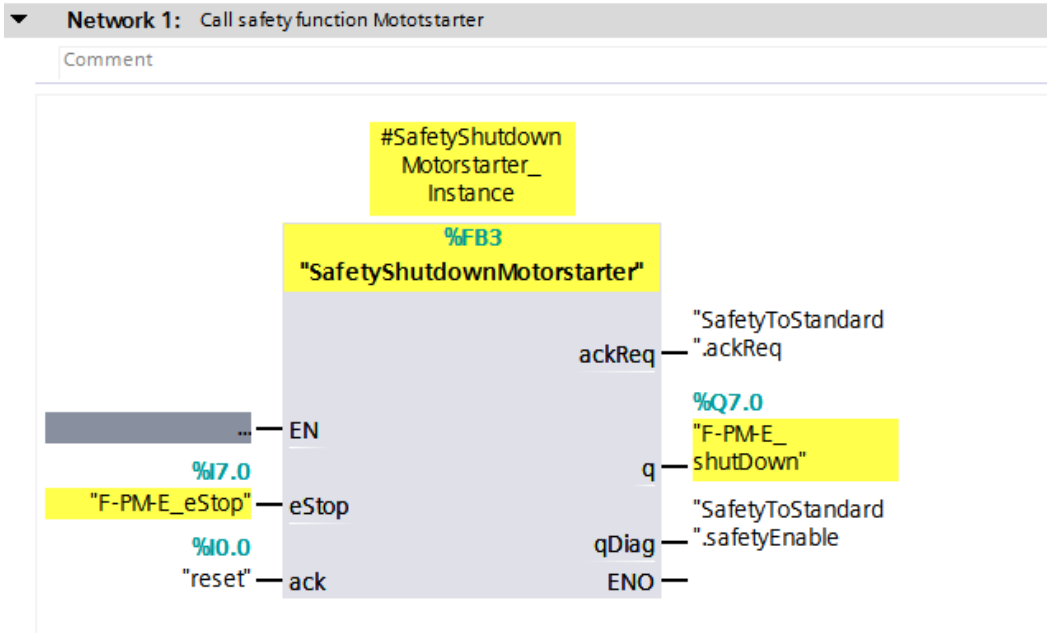


Figure 5-3 Network2



Once the “Main_Safety” FB has been called, the program block is interconnected.

Figure 5-4 Call of the Motorstarter F-FB



Via the “SafetyToStandard” interface, control signals are transferred from the safety program to the user program.

5.3 Operational switching of the motor starter

Operational switching of the motor starter is implemented in the standard user program. If the start conditions are met in the safety program, group shutdown of the motor starters can be started via the “commandOn” signal. The motor starters are operationally switched off via the “commandOff” signal. In addition, the reversing starter’s direction of rotation can be selected using “commandRight” and “commandLeft”.

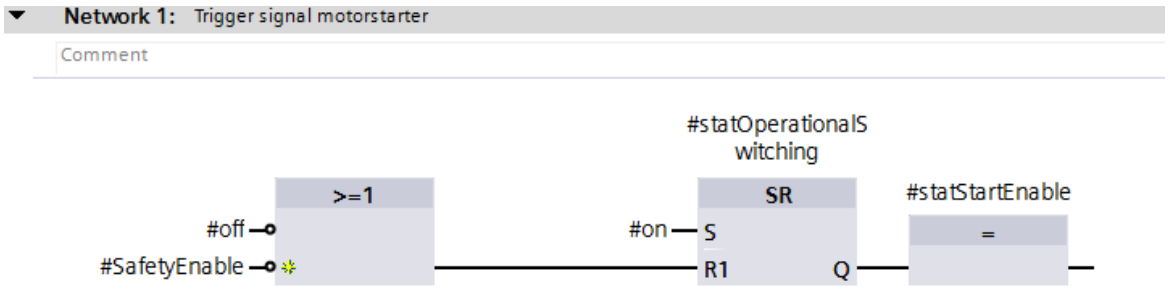
Program description

The operational signals of the motor starter are controlled in the standard user program.

- Network 1 defines the conditions for switching on and off and buffers the result to a static tag for further processing.

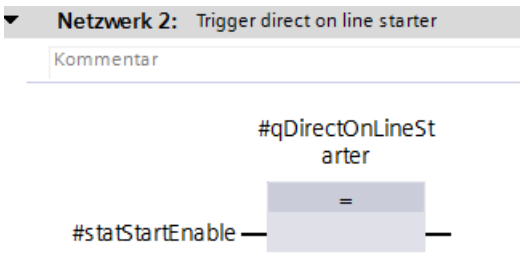
  During fail-safe shutdown using the emergency stop command device, no automatic restart must be performed; therefore, the inverse #SafetyEnable signal is included as a reset condition. If no safety enable has been given by the ESTOP1 block, the plant cannot be switched on.

Figure 5-5 Network 1



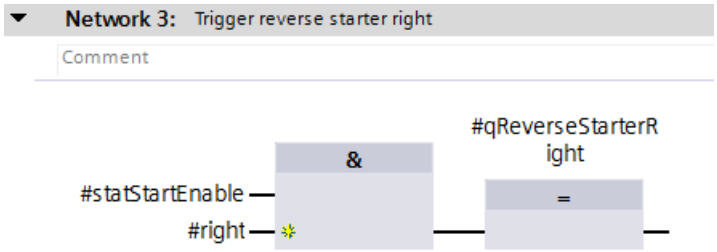
- Network 2 controls the direct-on-line starter’s output.

Figure 5-6 Network 2



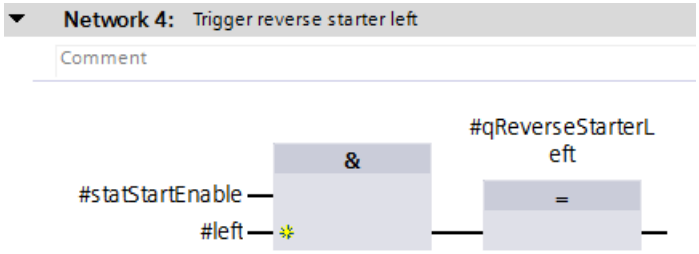
- Network 3 controls the reversing starter's direction of rotation right.

Figure 5-7 Network 3



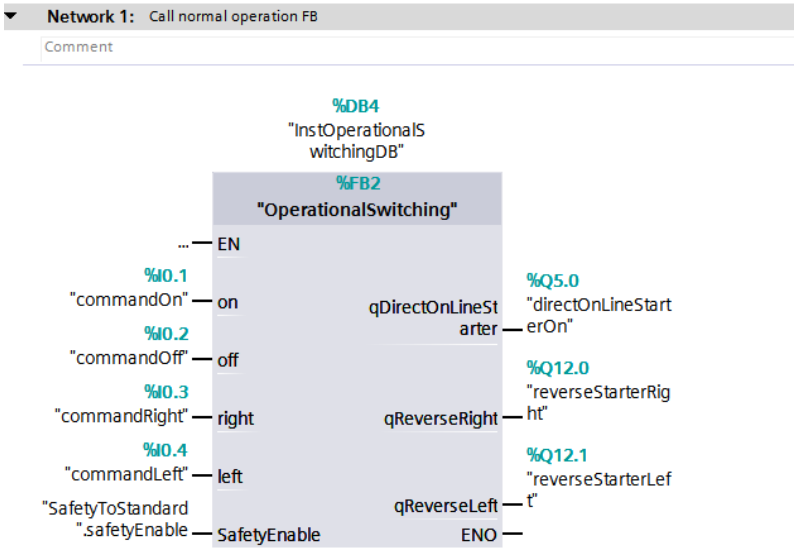
- Network 4 controls the reversing starter's direction of rotation left.

Figure 5-8 Network 4



The standard program is configured by the call in the "Main" OB 1.

Figure 5-9 Call of the standard program



6 Diagnostics

Due to the fail-safe shutdown by the F-PM-E, the 24 V DC supply voltage is removed on all modules in the potential group of the F-PM-E. As a result, the modules in the group can no longer be accessed after the shutdown and the “No supply voltage” diagnostic message is output on the modules. This diagnostic message can be deactivated as of firmware version V1.2.0 of the motor starter.

The evaluation of a fail-safe shutdown operation can be evaluated by interconnecting control signals (e.g., emergency stop signal and output on the F-PM-E).

The diagnostics concept has to be modified to the custom application and is therefore not included in the user program.

7 Links & Literature

Table 7-1

	Topic
\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/109748128
\3\	

8 History

Table 8-1

Version	Date	Modifications
V1.0	06/2017	First version
V1.1	09/2019	The diagnostic message “No supply voltage” can be deactivated as of firmware V1.2.0 of the motor starter.