

Safety-related controls
SIRIUS Safety Integrated

Protective door monitoring with automatic start
up to SIL 3 acc. to IEC 62061 and
PL e acc. to ISO 13849-1
with ET 200S Safety Motorstarter Solution Local

safety
INTEGRATED

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Preliminary comment

Safety Functional Examples are functional and tested automation circuits based on standard I IA/DT products. They can be used to simply, quickly and cost-effectively implement applications in safety technology. Each of the Safety Functional Examples covers a sub-task of a typical customer application involving safety technology that is frequently encountered.

In addition to a list of all of the necessary software and hardware components, and a description of their interconnection, the Functional Examples also contain tested and commented code. This enables the functions described here to be adapted quickly, and thus used as a basis for individual extensions.

Important Note

The Safety Functional Examples are not binding and do not claim to be complete regarding the circuits shown, equipping and any eventuality. The Safety Functional Examples do not represent customer-specific solutions. They are only intended to provide support for typical applications. You are responsible in ensuring that the described products are correctly used.

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1 Warranty, liability and support

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2 Function

2.1 Description of the functionality

This Safety Functional Example describes a mechanically isolating protective mechanism in the form of a protective door. The most frequently used solution for plants and machines to secure hazardous areas are mechanically isolating protective equipment or access hatches. In this case, the function is to monitor unauthorized entry into plant and system areas as well as to prevent potentially hazardous machine functions if the protective equipment - in this case protective door - is not closed.

The protective door is monitored by two SIRIUS position switches each with a positively-opening contact using a PM-D-F2 safety. This setup is applicable up to SIL 3 according to IEC 62061 and PL e according to ISO 13849-1. If this protective door is opened, the PM-D-F2 safety module shuts down the motor starter assigned to it according to Stop Category 0 acc. to EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed, after the position switch is checked, the motor automatically starts.

This example only discusses the safety function. The motor starter is operationally switched using a standard PLC and is not considered any further here.

Note

The position switches must be arranged so that they are not damaged when they are approached and passed. This is the reason that they may not be used as mechanical endstop.

2.2 Advantages/customer benefits

- Pure hardware engineering without any software engineering for the safety-relevant technology.
- Extensive Profibus diagnostics of the motor starter and the PM-D-F2 safety module.
- As a result of the lower time/costs involved with materials and wiring, the mounting space in the cabinet is reduced and therefore the overall dimensions of the plants/system.

3 Components required

Hardware components

Component	Type	Order no / Order information	Qty.	Manufacturer
Protective door	SIRIUS position switch	3SE5 232-0RV40	2	Siemens AG
	Radius actuator for position switch	3SE5 000-0AV05	2	
ET200S - station	Direct starter, can be expanded 5.5 kW; 9.0 to 12 A	3RK1301-1KB00-0AA2	1	
	Terminal module for a direct starter with feeder cable connection	3RK1903-0AB00	1	
	TM for PM-D F1/2; single or higher-level safety circuit	3RK1903-1AA00	1	
	TM for connection module PM-X	3RK1903-1AB00	1	
	PM-D F2 power module for protective door; automatic start	3RK1903-1BA00	1	
	Failsafe kit for direct starter	3RK1903-1BB00	1	
	IM 151 Basic to connect ET200S to PROFIBUS DP	6ES7151-1CA00-0AB0	1	
	optional Supply block M45-PEN-F	3RK1903-2AA00	1	
Supply contactor	Supply contactor for max. expansion 40 A	3RT1035-1BB40	1	
	Auxiliary contact for supply contactor	3RH1921-1DA11	1	
	Connecting switch	3RA931-1A	1	
SIMATIC S7	Power supply PS307 5A	6ES73071EA00-0AA0	1	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	1	
	Micro Memory Card MMC 512 kB	6ES7953-08LJ10-0AA0	1	

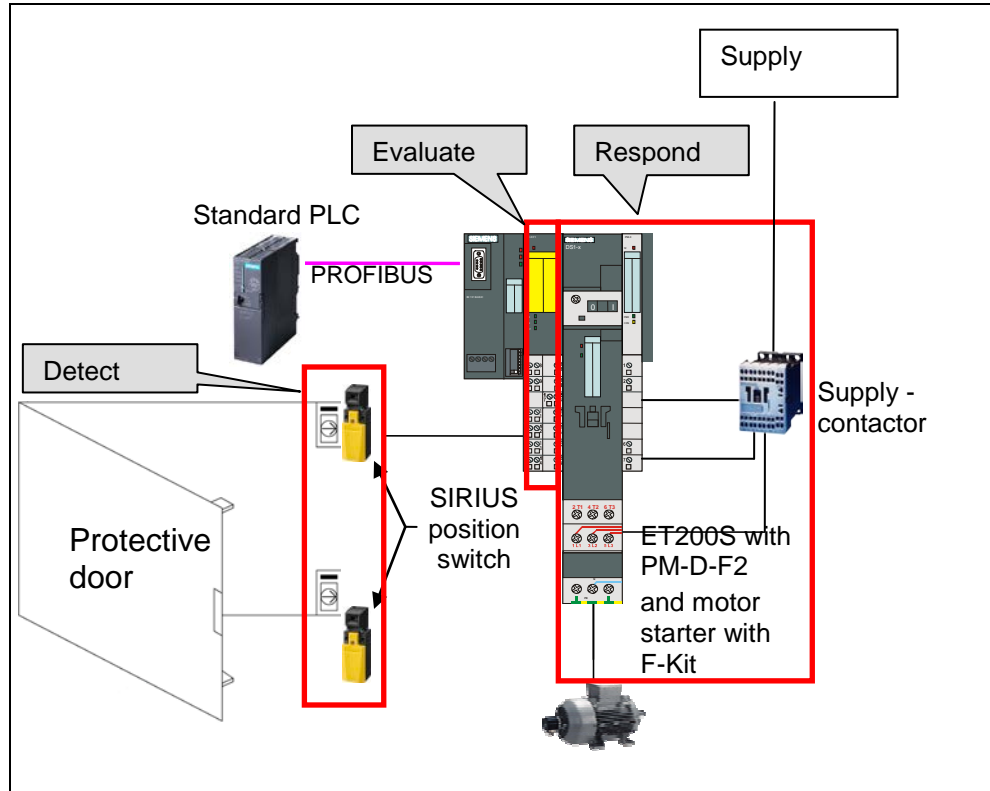
Note

The functionality was tested using the specified hardware components. Products that are similar but deviate from this list can be used (e.g. another ET200S motor starter).

When the ET200S Motor Starter High Feature is used, the F-Kit is not required as this is already integrated in the motor starters.

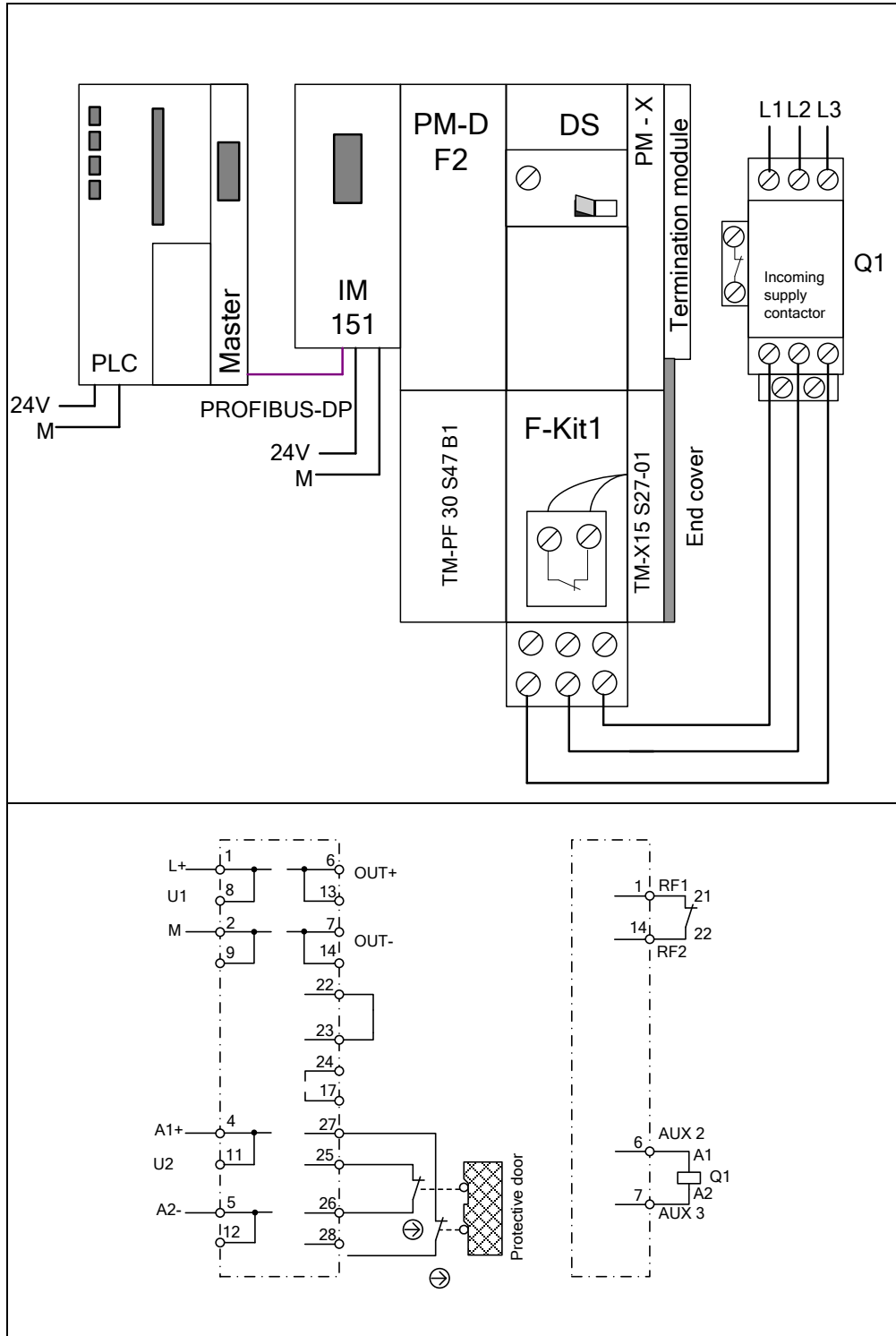
4 Structure and wiring

4.1 An overview of the hardware structure



Additional motor starters can be inserted before the PM-X module in an ET200S Station. These are then also shut down when the Emergency Stop control device is pressed (group stop).

4.2 Connecting-up the hardware components



4.3 Important hardware component settings

Some important settings from the STEP7 hardware configuration are shown below as an overview.

The screenshot displays the HW Config software interface for a SIMATIC 300 station. The main window shows a rack configuration with the following modules:

Slot	Module	Order Number	I Address	Q Address	Comment
1	PM-D F2 SIGUARD	3RK1 903-1BB00			
2	DS-x	3RK1 301-xx800-0AA1	0.0...0.3	0.0...0.3	
3	PM-X SIGUARD	3RK1 903-1CB00			
4					
5					
6					
7					
8					
9					
10					
11					
12					

The rack diagram shows the following components:

- Slot 1: PS 307 5A
- Slot 2: CPU 315-2 DP
- Slot 3: DP
- Slot 4: IM151-1

The IM151-1 module is connected to a PROFIBUS DP master system (1). The software interface also shows a tree view of the hardware components, including:

- DS-x
- DS1-x
- DS1e-x 0.3-3A HF
- DS1e-x 0.3-3A HF
- DS1e-x 2.4-16A HF
- DS1e-x 2.4-16A HF
- DS1e-x 2.4-8A HF
- DS1e-x 2.4-8A HF
- DS1e-x 2.4-8A HF
- F-DS1e-x 0.3-3A HF
- F-DS1e-x 0.3-3A HF
- F-DS1e-x 2.4-16A HF
- F-DS1e-x 2.4-16A HF
- F-DS1e-x 2.4-8A HF
- F-DS1e-x 2.4-8A HF

The software interface also shows a search bar with the text "3RK1 301-1KB0" and a profile dropdown menu set to "Standard".

5 Evaluation acc. to IEC 62061 and ISO 13849-1:2006

5.1 Safety function

Safety functions

Further considerations are based on the following safety functions:

Safety function	
SF 1	The motor must be switched off when the "Protective door" is opened.

The safety function listed above is evaluated below according to the two standards IEC 62061 and ISO 13849-1:2006.

5.2 Evaluation according to IEC 62061

Parameters for the calculation of PFH_D for position switch as well as motor starter and contactor
(Motor starter and contactor are seen as equal disconnection paths for this consideration)

Parameters	Value	Reason	Definition
B10 position switch contactor and motor starter	$1 * 10^6$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures position switch contactor and motor starter	0.2 0.73	Manufacturer specifications (20%) (73%)	
T1 Service life	175,200h (20 years)	Manufacturer specifications	
C Number of operations of position switches Number of operations of contactor and motor starter	0.125/hrs 0.125/hrs	Assumptions: Actuated once per shift, i.e. every 8 hours. Actuated once per shift, i.e. every 8 hours. Actuation takes place every day of the year (365 days)	User
T2 Diagnostics test interval position switch Diagnostic test interval contactor and motor starter	8hrs 8hrs	When the protective door is opened, a defective contact is detected in the PM-D F1 module. An actuation takes place once per shift, i.e. every 8 hours (see "C"). When actuated, a defective contactor and/or a defective motor starter is detected in the PM-D F1 module. An actuation takes place once per shift, i.e. every 8 hours (see "C").	
β (CCF factor) Prone to failures as a result of common cause	0.1	If installed according to IEC 62061, a CCF factor of 0.1 (10%) can be assumed. With this value, the user errs on the side of caution ("conservative value").	
DC Degree of diagnostic coverage	0.99 (99%)	Discrepancy evaluation for position switches; evaluation of read-back signals (positively-driven contacts) of the contactor and the motor starter	

Evaluation parameters

Parameters	Component	Value	Definition
PFH_D (PM-D F1)	PM-D F2 module	$9.01 * 10^{-09}$	Siemens

Result

IEC 62061			
		SILCL	PFH_D
Detect	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$2.50 * 10^{-10}$ Architecture: Basic sub-system architecture D
Evaluate	3	Manufacturer specifications	$9.01 * 10^{-09}$ Manufacturer specifications
Respond	3	Hardware error tolerance: HFT = 1 Proportion of safe failures: SFF ≥ 0.99 (99%)	$9.12 * 10^{-10}$ Architecture: Basic sub-system architecture D
Result	3	SILCL of all tasks of the supplementary safety function is at least 3. PFH_D ($=1.01 * 10^{-09}$) of the entire supplementary safety function fulfills SIL 3.	

5.3 Evaluation according to ISO 13849-1:2006

Parameters for the calculation of $MTTF_d$ for position switch as well as motor starter and contactor

(Motor starter and contactor have the same safety characteristics)

Parameters	Value	Reason	Definition
B10 - position switch contactor	$1 * 10^6$ $1 * 10^6$	Manufacturer specifications	Siemens
Proportion of hazardous failures position switch contactor	0.2 0.73	Manufacturer specifications	
d_{op} Mean operating time in days per year	365 days per year	Assumption: Actuation takes place every day of the year	User
h_{op} Mean operating time in hours per day	24 hours per day		
t_{cycle} Mean time between the start of two consecutive cycles of the component position switch contactor	8hrs/cycle 8hrs/cycle	Assumption: There is an interval of 8 hours between each protective door opening and contactor actuation (one shift)	

Interim results (are identical in this example for the position switch and the motor starter/contactactor):

Interim results		Reason
MTTF _d	High	MTTF _d ≥ 30 years
DC	High	DC=99% Discrepancy evaluation for position switch; evaluation of read-back signals (positively-driven contacts) of motor starter / contactor
Measures against CCF	Fulfilled	It is assumed that the necessary measures are taken by the user.
Category	4	System behavior: A single fault does not result in the loss of the safety function. The single fault is detected. MTTF _d : high, DC: high, measures against CCF: fulfilled

Evaluation parameters

Parameters	Component	Value	Definition
PFH _D (PMD-F2)	PM-D F2 module	$9.01 * 10^{-09}$	Siemens

Result

ISO 13849-1:2006		
	PL	PFH _D
Detect	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Evaluate	e	$9.01 * 10^{-09}$
Respond	e	$2.47 * 10^{-08}$ (from Annex K; see note)
Result	e	PL of all tasks of the supplementary safety function is at least e. The number of tasks is less than or equal to 3.

Note: The MTTF_d for each channel is limited to max. 100 years!

5.4 Summary

	IEC 62061		ISO 13849-1:2006	
	SILCL	PFH _D	PL	PFH _D
Detect 1	3	$2.50 * 10^{-10}$	e	$2.47 * 10^{-08}$
Evaluate	3	$9.01 * 10^{-09}$	e	$9.01 * 10^{-09}$
Respond	3	$9.12 * 10^{-10}$	e	$2.47 * 10^{-08}$
Result	SIL 3		PL e	

6 Contact partners

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7 History

Table 7-1 History

Version	Date	Change
V1.0	05.06.2005	First issue
V2.0	11.08.2009	<ul style="list-style-type: none"> - Update of the order numbers of the position switch - Revision of the hardware assembly overview - New chapter: Evaluation according to IEC 62061 and ISO 13849-1
V3.0	13.09.2013	<ul style="list-style-type: none"> - Revision of title and description of functionality - Adjustment of Proportion of hazardous failures for contactors to 73% and resulting PFH_D values