



safety

INTEGRATED



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Safety applications
quickly and easily implemented

Safety Integrated

Safety applications quickly and easily implemented

Preliminary Remark

The functional examples dealing with "Safety Integrated" are fully functional and tested automation configurations based on A&D standard products for simple, fast and inexpensive implementation of automation tasks in safety engineering. Each of these functional examples covers a frequently occurring subtask of a typical customer problem in safety engineering. Apart from a list of all required hardware and software components and a description of the way they are connected to each other, the functional examples include the tested and commented code. This ensures that the functionalities described here can be reset in a short period of time and thus also be used as basis for individual expansions.

Note

The Safety Functional Examples are not binding and do not claim to be complete regarding the circuits shown, equipping and any eventuality. The 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. These Functional Examples do not relieve you of the responsibility in safely and professionally using, installing, operating and servicing equipment. When using these Functional Examples, you recognize that Siemens cannot be made liable for any damage/claims beyond the liability clause described above. We reserve the right to make changes to these Functional Examples at any time without prior notice. If there are any deviations between the recommendations provided in these Functional Examples and other Siemens publications - e.g. catalogs - then the contents of the other documents have priority.



Safety Integrated Functional Examples

March 2007

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Safety-related controls
SIRIUS Safety Integrated

Fail-safe Controllers
SIMATIC Safety Integrated

Safety Drives Systems

Warranty, Liability and Support
Contact partners



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Safety-related controls

SIRIUS Safety Integrated

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E-Stop with manual start Category 2 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by a positively-driven contact using a safety relay in accordance with Category 2 to EN 954-1. If the E-Stop button is pressed, the safety relay opens the contactor via the safety-related relay output using a positively-driven contact in accordance with stop Category 0 according to EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactor is de-energized (open).

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety relay	3TK2824	3TK2824-1BB40	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	
Contactor K1	Contactor, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	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 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Note

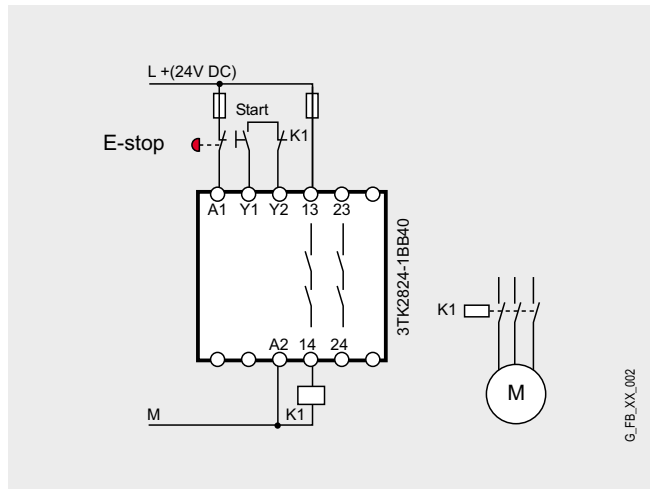
Using this circuit example, Category 2 acc. to EN 954-1 can only be fulfilled if, when the actuator fails, an alarm is automatically put out or the machine control initiates a safety condition. If this is not the case, a second shutdown path is required.

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



G_FB_XX_002

E-Stop with monitored start Category 4 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored using two positively-driven contacts using a safety relay in accordance with Category 4 to EN 954-1. If the E-Stop button is pressed, the safety relay opens the redundantly connected contactors via the safety-related relay outputs using positively-driven contacts in accordance with stop Category 0 according to EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether both contacts of the E-Stop command device are closed and both contactors are de-energized (open).

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
	1NC contact for base-mounting	3SB3 420-0C	1	
Safety relay	3TK2823	3TK2823-1CB30	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	
Contactors K1 / K2	Contactor, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	2	

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Note

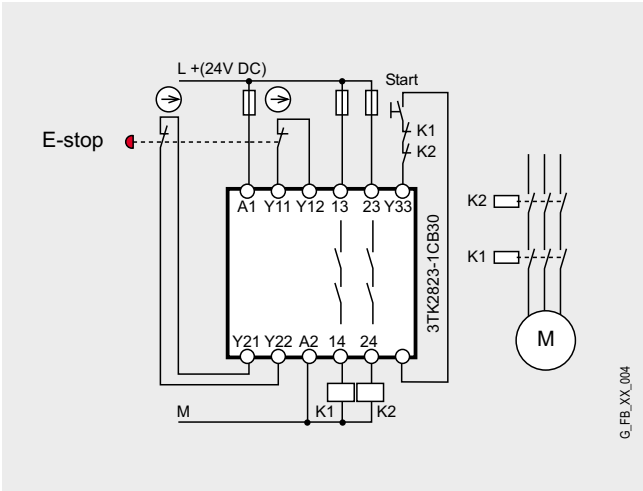
The functionality was tested using the specified hardware components. Products that are similar but deviate from this list can be used (e.g. another 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment)

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



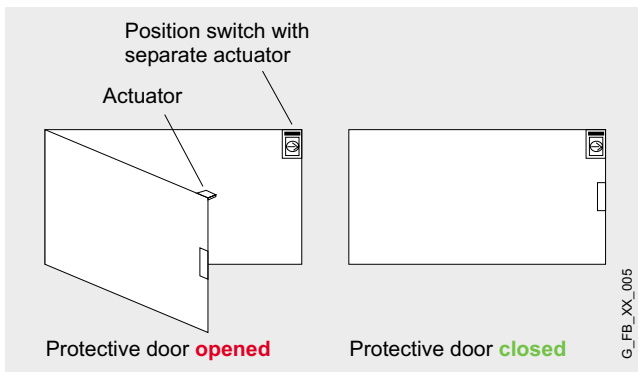
G_FB_XX_004

Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay

Function

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 is 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 using a SIRIUS position switch with positively-opening contact using a safety relay in accordance with Category 2 acc. to EN 954-1. If this protective door is opened, the safety relay opens the downstream contactor via the safety-related relay output with positively-driven contact according to stop Category 0 to EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed, after the position switch and downstream contactor have been checked, then the drive automatically starts.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety relay	3TK2824	3TK2824-1BB40	1	
Contactor K1 / K2	Contact, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	2	

Note

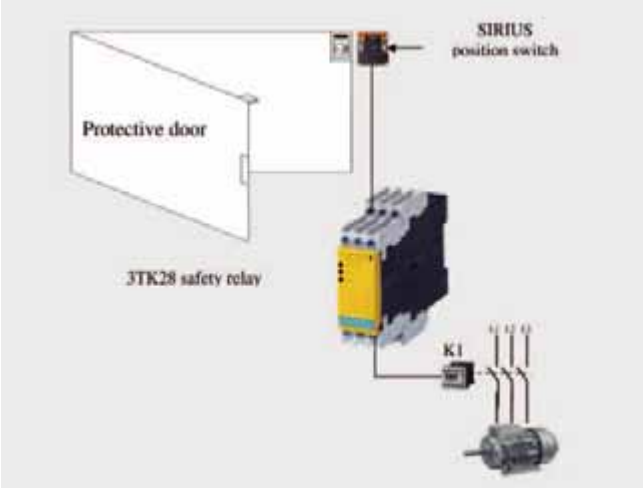
The functionality was tested using the specified hardware components. Products that are similar but deviate from this list can be used (e.g. another 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Note

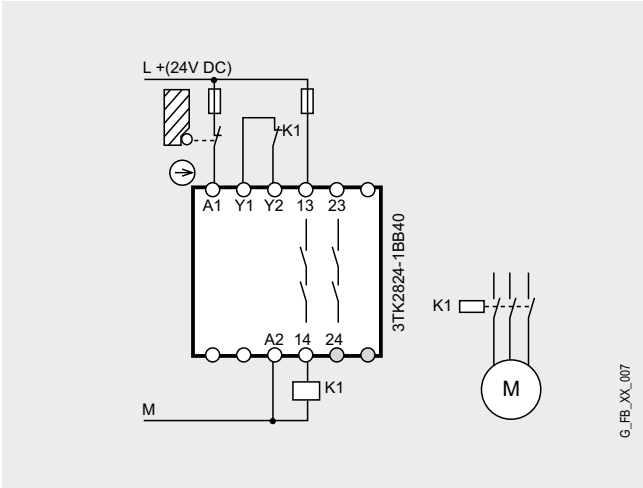
Using this circuit example, Category 2 acc. to EN 954-1 can only be fulfilled if, when the actuator fails, an alarm is automatically put out or the machine control initiates a safety condition. If this is not the case, a second shutdown path is required.

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



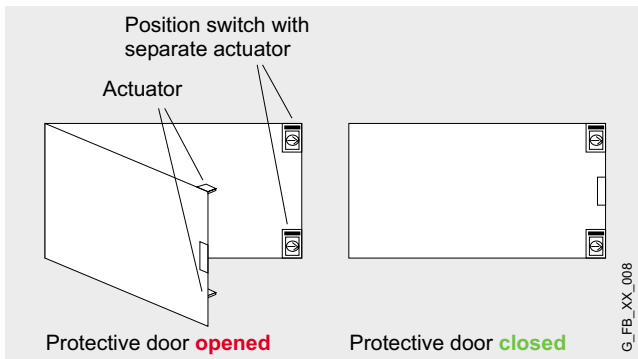
G_FB_XX_007

Protective door monitoring with automatic start Category 4 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay

Function

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 is 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 using two SIRIUS position switches with positively-opening contacts using a 3TK28 safety relay in accordance with Category 4 acc. to EN 954-1.

If this protective door is opened, the safety relay opens the downstream redundantly connected contactors via the safety-related relay outputs with positively-driven contacts according to stop Category 0 to EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed, after the position switch and downstream contactors have been checked, then the drive automatically starts.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

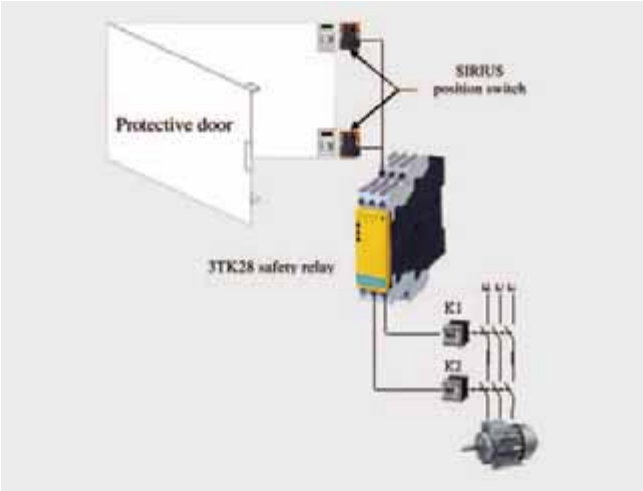
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	2	
Safety relay	3TK2822	3TK2822-1CB30	1	
Contactors K1 / K2	Contactors, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	2	

Note

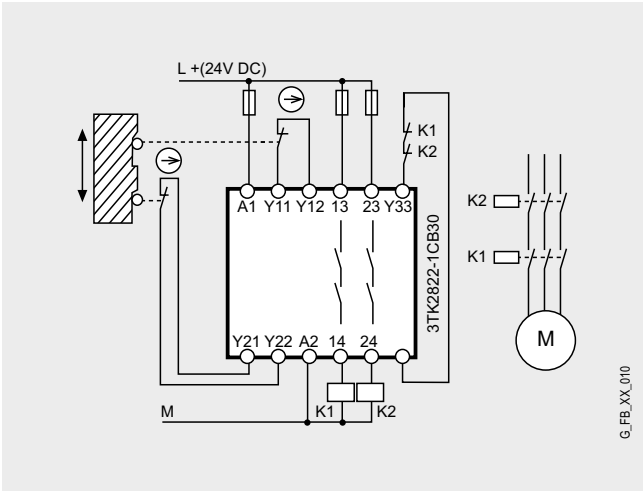
The functionality was tested using the specified hardware components. Products that are similar but deviate from this list can be used (e.g. another 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



G_FB_XX_010

E-Stop with monitored start Category 2 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay with contactor relays

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device with a positively-opening contact is monitored by a SIRIUS 3TK28 safety relay with contactor relays according to Category 2 in compliance with EN 954-1. If the E-Stop command device is actuated, the safety relay shuts down via its contactor relays with positively-opening contacts according to Stop Category 0 in compliance with EN 60204-1. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the E-Stop command device contact is closed and the contactor relays of the safety relay been de-energized.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

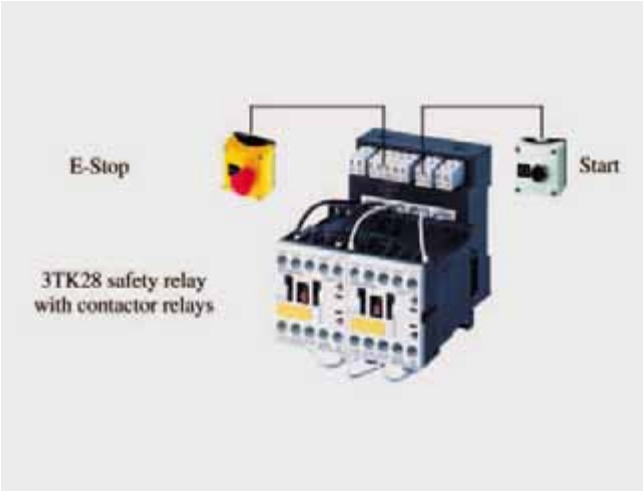
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety relay with contactor relays	3TK28	3TK2850-1BB40	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

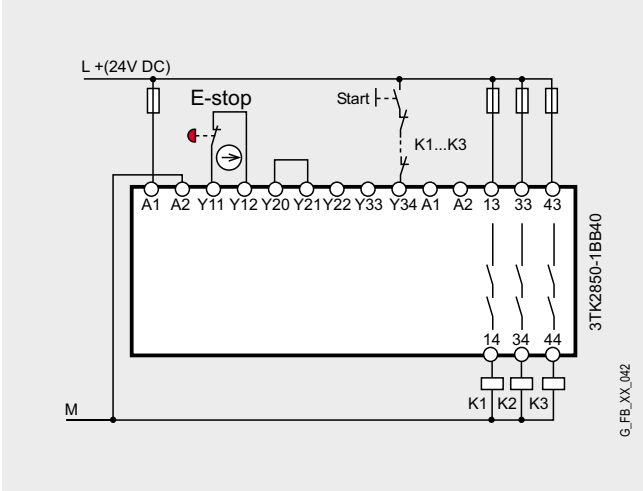
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 2 acc. to EN 954-1 with/without operational switching with a SIRIUS 3TK28 safety relay with contactor relays

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device with a positively-opening contact is monitored by a SIRIUS 3TK28 safety relay with contactor relays according to Category 2 in compliance with EN 954-1. If the E-Stop command device is actuated, the safety relay shuts down via its contactor relays with positively-opening contacts according to Stop Category 0 in compliance with EN 60204-1. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the E-Stop command device contact is closed and the contactor relays of the safety relay been de-energized. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 or a non-floating (non-electrically isolated) output (24 V DC) - e.g. from a stan-

dard PLC - at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 15).

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

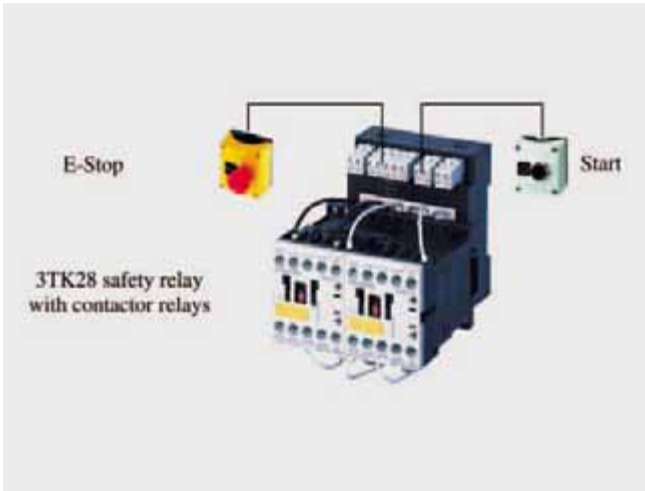
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety relay with contactor relays	3TK28	3TK2850-1BB40	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

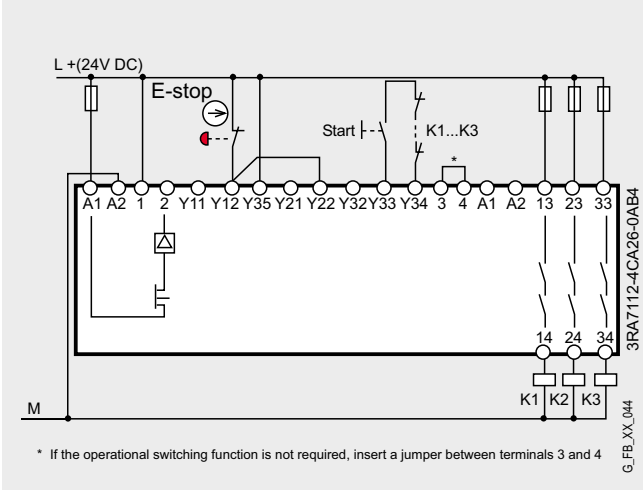
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 4 acc. to EN 954-1 with/without operational switching with a SIRIUS 3TK28 safety relay with contactor relays

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device with two positively-opening contacts is monitored by a SIRIUS 3TK28 safety relay with contactor relays according to Category 4 in compliance with EN 954-1. If the E-Stop command device is actuated, the safety relay shuts down via its contactor relays with positively-opening contacts according to Stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contacts of the E-Stop command device are closed and the contactors of the safety relay have dropped-out. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 or a non-floating

(non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 17).

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

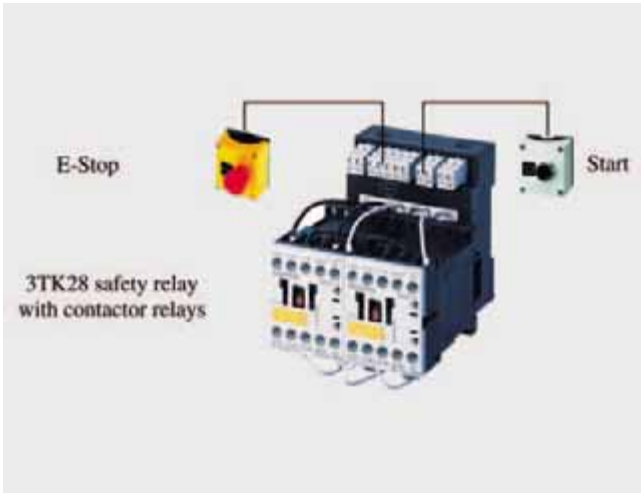
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
	1NC contact for base-mounting	3SB3 420-0C	1	
Safety relay with contactor relays	3TK28	3TK2850-1BB40	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

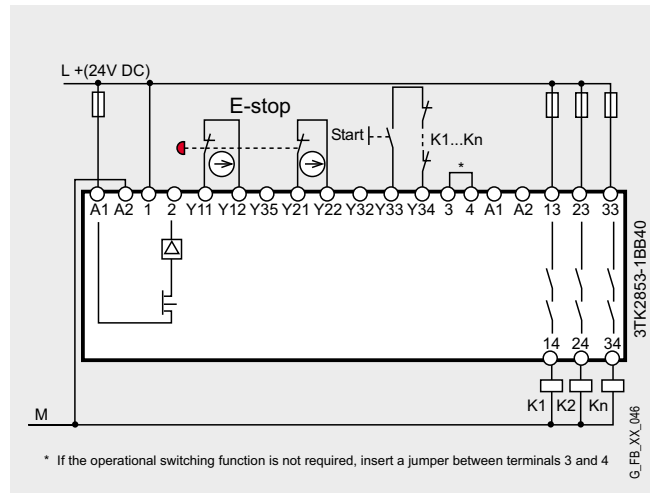
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

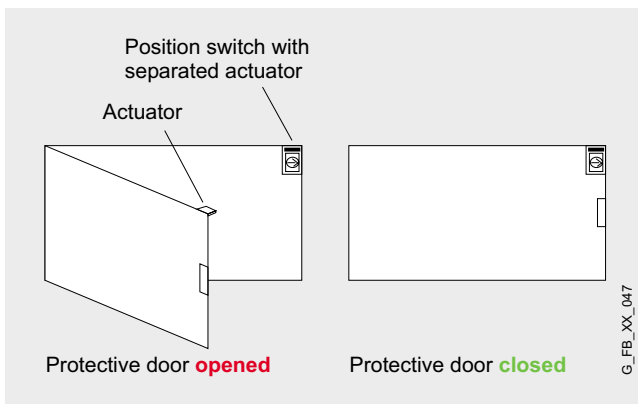


Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with a SIRIUS 3TK28 safety relay with contactor relays

Function

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 is 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 a SIRIUS position switch with positively-opening contacts using a SIRIUS 3TK28 safety relay with contactor relays according to Category 2 in compliance with EN 954-1. If this protective door is opened, the safety relay shuts down via its contactor relays with positively-opening contacts according to Stop Category 0 in compliance with EN 60204-1. If the protective door is closed and after the position switch and the contactors of the safety relay have been checked, the drive automatically starts.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

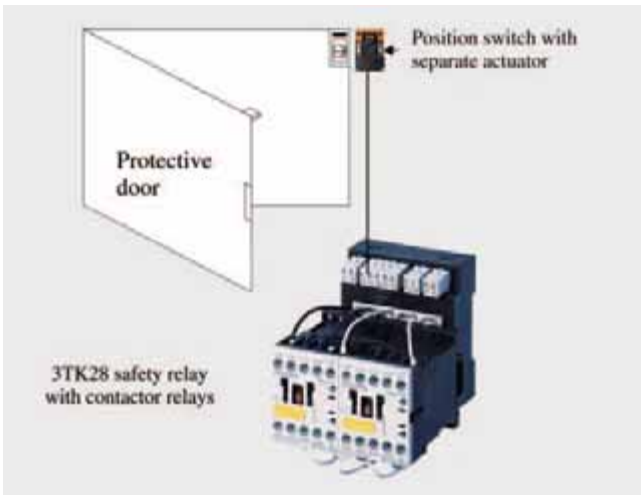
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
safety relay with contactor relays	3TK28	3TK2850-1BB40	1	

Note

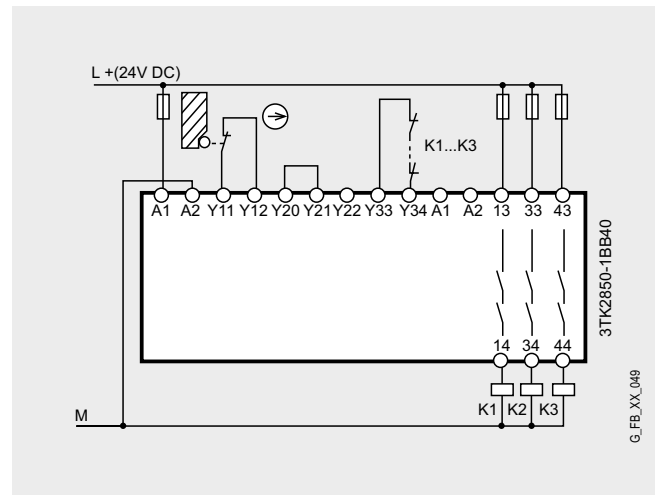
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

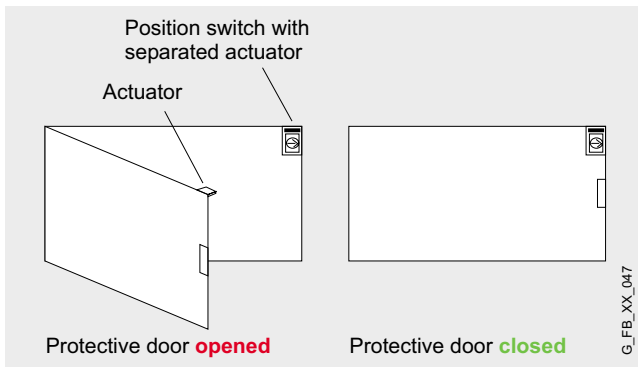


Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with/without operational switching with a SIRIUS 3TK28 safety relay with contactor relays

Function

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 is 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 a SIRIUS position switch with positively-opening contacts using a SIRIUS 3TK28 safety relay with contactor relays according to Category 2 in compliance with EN 954-1. If this protective door is opened, the safety relay shuts down via its contactor relays with positively

opening contacts according to Stop Category 0 in compliance with EN 60204-1. If the protective door is closed and after the position switch and the contactors of the safety relay are checked, the drive automatically starts. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 or a non-floating (non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 21).

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

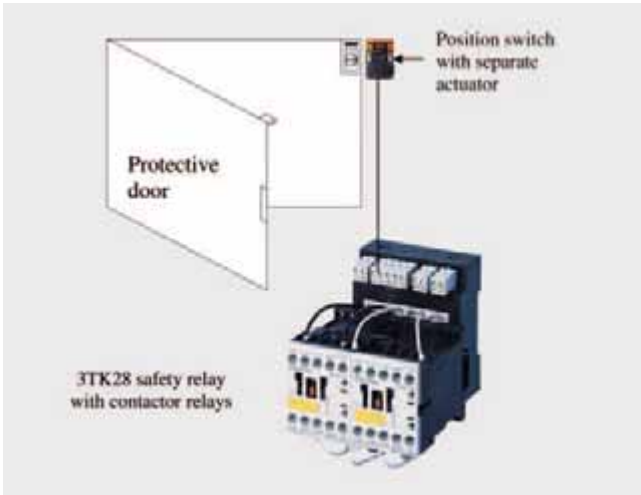
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety relay with contactor relays	3TK28	3TK2850-1BB40	1	

Note

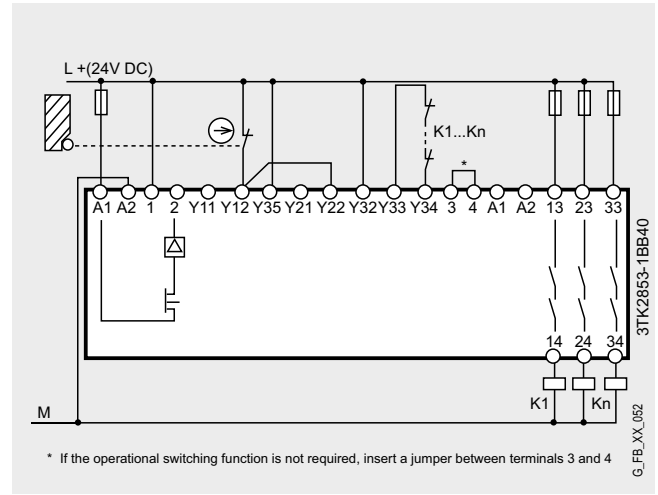
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

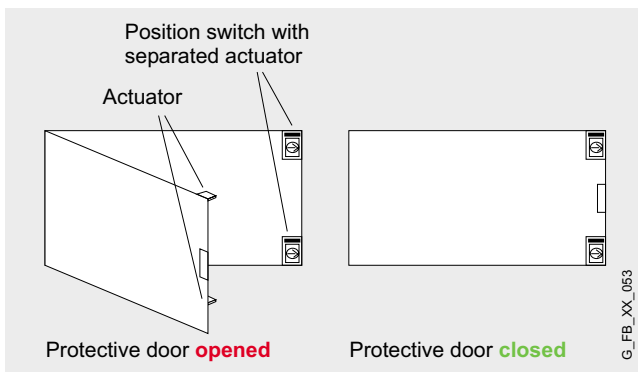


Protective door monitoring with automatic start Category 4 acc. to EN 954-1 with/without operational switching using a SIRIUS 3TK28 safety relay with contactor relays

Function

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 is 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 with positively-opening contacts using a SIRIUS 3TK28 safety relay with contactor relays according to Category 4 in compliance with EN 954-1. If this protective door is opened, the safety relay shuts down via its contactor relays

with positively-opening contacts according to Stop Category 0 in compliance with EN 60204. If the protective door is closed and after the position switch and the contactors of the safety relay are checked, the drive automatically starts. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 or a non-floating (non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 23).

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

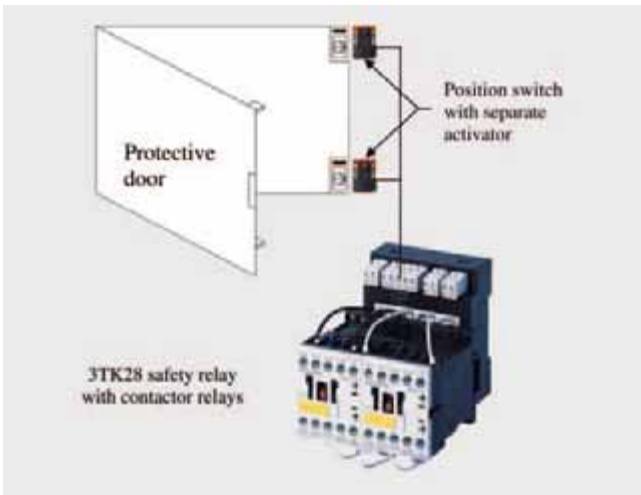
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	2	
Safety relay with contactor relays	3TK28	3TK2850-1BB40	1	

Note

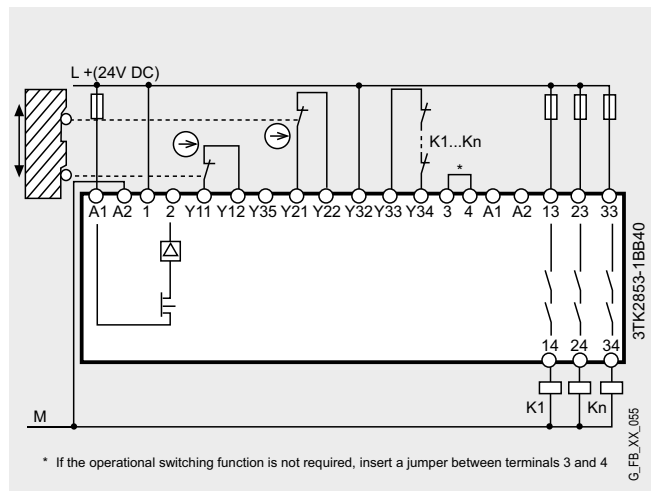
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

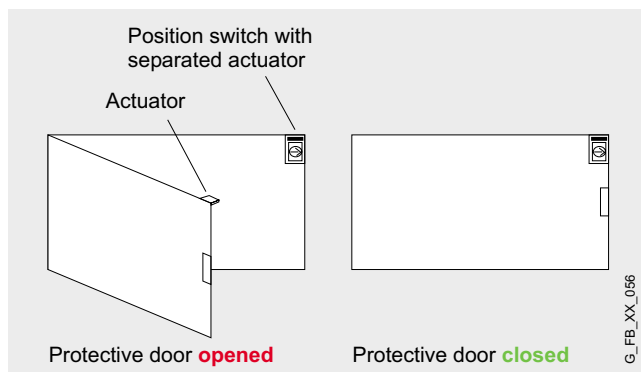


E-Stop with monitored start, protective door monitoring with automatic start and service mode, Category 2 acc. to EN 954-1 with a SIRIUS 3TK2845 safety relay

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. This Safety Functional example describes how an E-Stop command device and a guard in the form of a protective door are monitored. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards. An additional solution for plants and machines to secure hazardous areas is mechanically isolating protective equipment (guards) 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 opened.

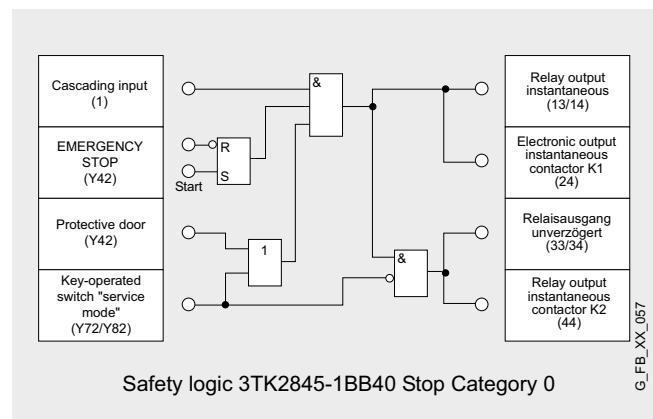


In this Safety Functional Example, the E-Stop command device with a positively-opening contact is monitored by a SIRIUS 3TK2845 safety relay according to Category 2 in compliance with EN 954-1. If the E-Stop button is pressed, the safety-relay opens, via safety outputs, the downstream contactors K1 and K2 with positively driven contacts according to stop Category 0 in compliance with EN 60204-1.

Before powering-up again and acknowledging the E-Stop device using the start button, a check is made as to whether the contact of the E-Stop command device is closed and both contactors have been de-energized (i.e. the contactors have dropped-out).

The protective with a SIRIUS position switch with positively-opening contact door is also monitored by the 3TK2845 safety relay according to Category 2 in compliance with EN 954-1. If this protective door is opened, the safety relay also opens the downstream contactors K1 and K2 via the positively driven safety-related outputs according to stop Category 0 in compliance with EN 60204-1. If the protective door is closed and after the position switch and downstream contactor have been checked, then the drive automatically starts.

If the "Service mode" key-operated switch is actuated, then contactor K2 drops-out and the protective door can be opened without contactor K1 dropping-out. After the "Service mode" has been completed, when the key-operated switch is reactivated, contactor K2 is automatically closed again. K1 and K2 switch two separate drives.



Note

Using this circuit example, Category 2 according to EN 954-1 can only be fulfilled if, when the actuator fails, an alarm is automatically output or the machine control initiates a safety condition. If this is not the case, a second shutdown path is required.

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

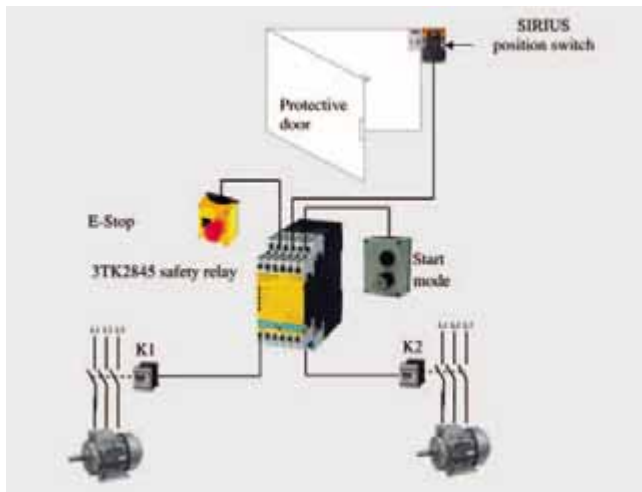
Hardwarekomponenten

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	
Start button and service mode	Empty enclosure of two command points	3SB3 802-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	2	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Key-operated switch CES	3SB3000-4LD01	1	
Safety relay	3TK2845	3TK2845-1BB40	1	
Contactors K1 / K2	Contactor, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	2	

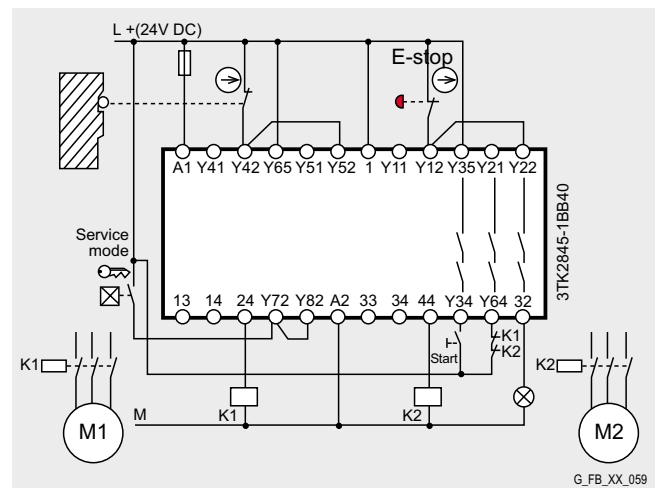
Note
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



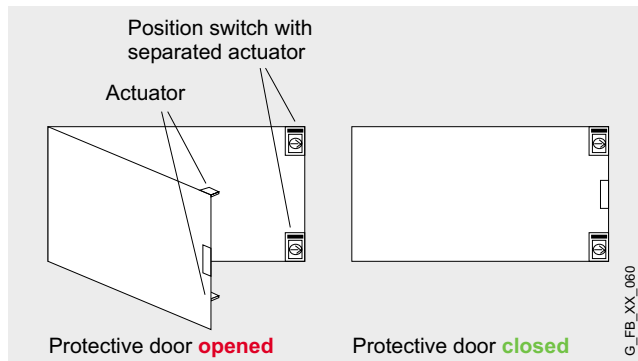
E-Stop with monitored start, protective door monitoring with automatic start and service mode, Category 4 acc. to EN 954-1 with a SIRIUS 3TK2845 safety relay

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment.

This Safety Functional example describes how an E-Stop command device and a guard in the form of a protective door are monitored. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards. An additional solution for plants and machines to secure hazardous areas is mechanically isolating protective equipment (guards) 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 opened.



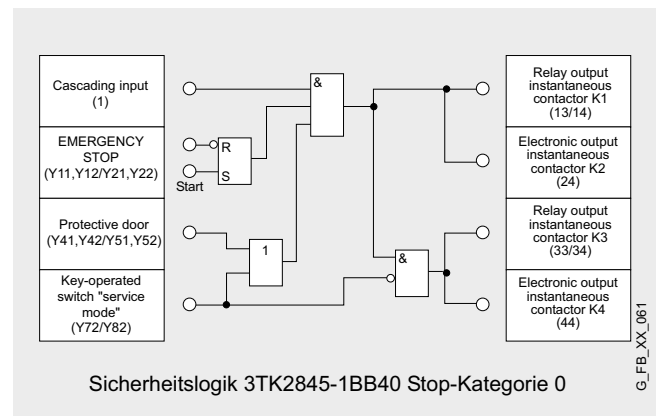
In this Safety Functional Example, the E-Stop device with two positively-opening contacts is monitored by a SIRIUS 3TK2845 safety relay according to Category 4 in compliance with EN 954-1. If the E-Stop button is pressed, the safety-relay opens, via safety outputs, the downstream contactors K1 and K2 and K3 and K4 with positively driven contacts according to stop Category 0 in compliance with EN 60204-1.

Before powering-up again and acknowledging the E-Stop device using the start button, a check is made as to whether the contacts of the E-Stop command device are closed and all four contactors have been de-energized (i.e. the contactors have dropped-out).

The protective with two SIRIUS position switches with positively-opening contact door is also monitored by the 3TK2845 safety relay according to Category 4 in compliance with EN 954-1. If this protective door is opened, the safety relay also opens the downstream contactors K1 and K2 and K3 and K4 via the positively driven safety-related outputs according to stop Category 0 in compliance with EN 60204-1. If the protective door is closed and after the position switches and down-

stream contactor have been checked, then the drive automatically starts.

If the "Service mode" key-operated switch is actuated, then contactors K3 and K4 drop-out and the protective door can be opened without contactors K1 and K2 dropping-out. After the "Service mode" has been completed, when the key-operated switch is re-actuated, contactors K3 and K4 are automatically closed again. K1, K2 and K3, K4 switch two separate drives.



Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

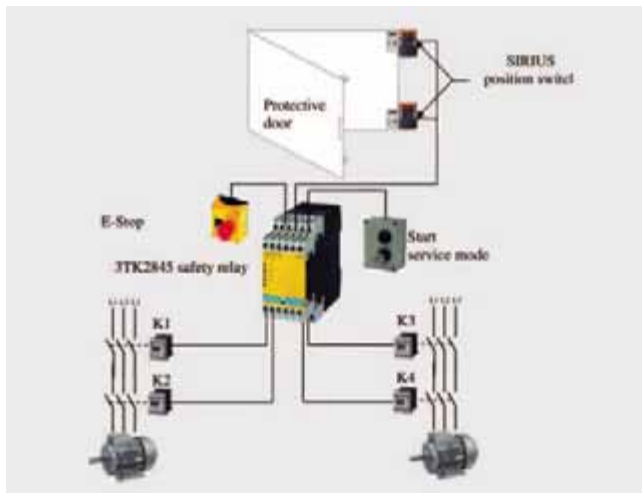
Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	2	
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	
	1NC contact for base-mounting	3SB3 420-0C	1	
Start button and service mode	Empty enclosure of two command points	3SB3 802-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	3	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Key-actuated switch CES	3SB3000-4LD01	1	
Safety relay	3TK2845	3TK2845-1BB40	1	
Contactors K1, K2 / K3, K4	Contactors, AC-3, 3KW/400V, 1NC, 24V DC, 3-pole, Size S00, screw connection	3RT1015-1BB42	4	

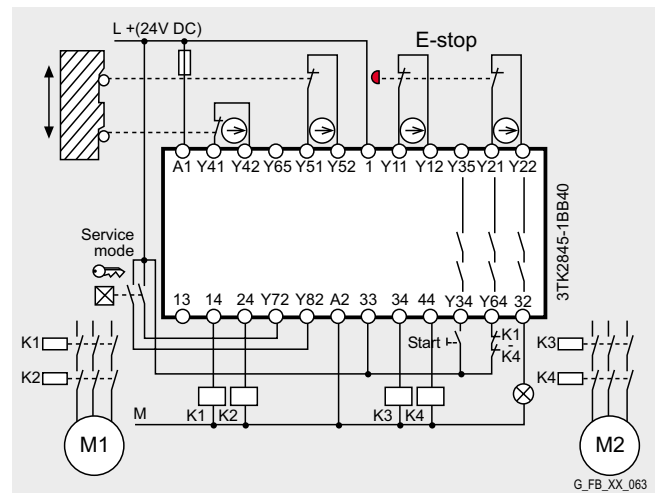
Note
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different 3TK28 safety relay). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 2 acc. to EN 954-1 with a safety fused load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by a positively-opening contact using a safety fused load feeder in accordance with Category 2 to EN 954-1. If the E-Stop button is pressed, the load feeder safely shuts-down in accordance with stop Category 0 according to EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactors of the load feeder have dropped-out (opened).

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety fused load feeder	3RA7	3RA7100-5AA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

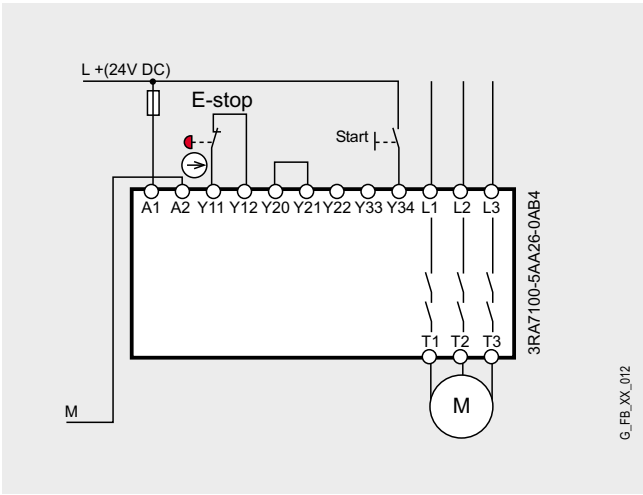
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 2 acc. to EN 954-1 with/without operational switching with a safety fused load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by a positively-opening contact using a safety fused load feeder in accordance with Category 2 to EN 954-1. If the E-Stop button is pressed, the load feeder is safely shut-down in accordance with stop Category 0 to EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactors of the load feeder have dropped-out (opened). It is possible to operationally switch the contactors (open and close them). Either a floating (electrically isolated) contact is connected between terminals 3 and 4 (refer to „Wiring of the hardware components“ page

31) or a non-floating (non electrically-isolated) output (24 V DC) is connected to terminal 4, e.g. from a standard PLC. The operational switching has a lower priority than the safety function. If operational switching is not required, then a wire jumper should be connected between terminals 3 and 4.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

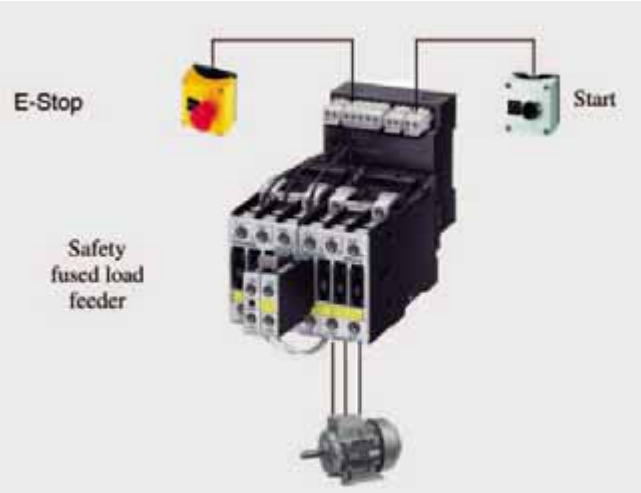
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety fused load feeder	3RA7	3RA7100-5AA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-OAA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-OAA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

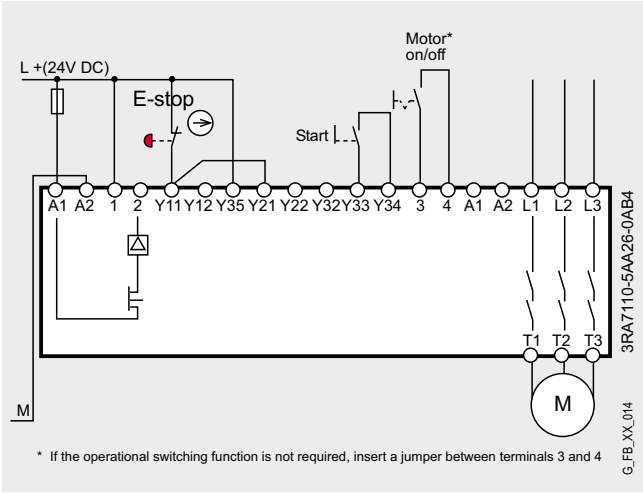
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 4 acc. to EN 954-1 with/without operational switching with a safety fused load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored using two positively-opening contacts using a safety fused load feeder in accordance with Category 4 to EN 954-1. If the E-Stop button is pressed, the load feeder safely switches-out the contactors, connected in series, with positively-driven contacts in accordance with stop Category 0 according to EN 60204-1.

In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactors of the load feeder have dropped-out (opened). It is possible to operationally switch the contactors (open and close them). Either a floating (electrically isolated) contact is connected between terminals

3 and 4 (refer to „Wiring of the hardware components“ page 33) or a non-floating (non electrically-isolated) output (24 V DC) is connected to terminal 4, e.g. from a standard PLC. The operational switching has a lower priority than the safety function. If operational switching is not required, then a wire jumper should be connected between terminals 3 and 4.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

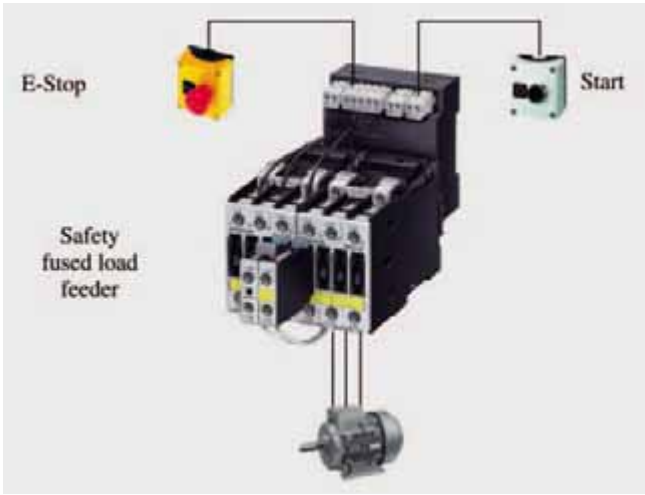
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
	1NC contact for base-mounting	3SB3 420-0C	1	
Safety fused load feeder	3RA7	3RA7100-5AA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

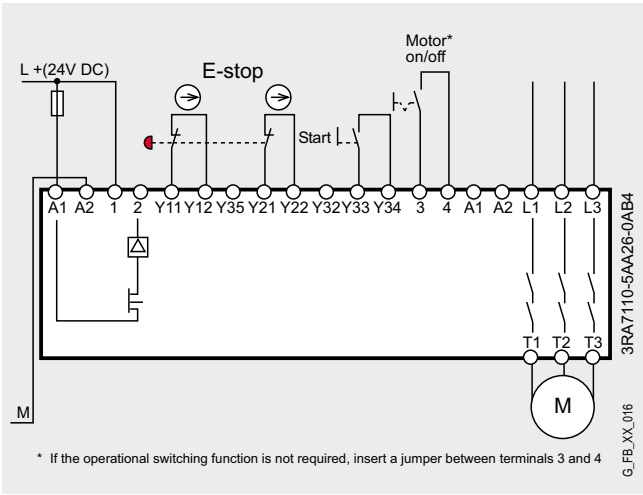
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

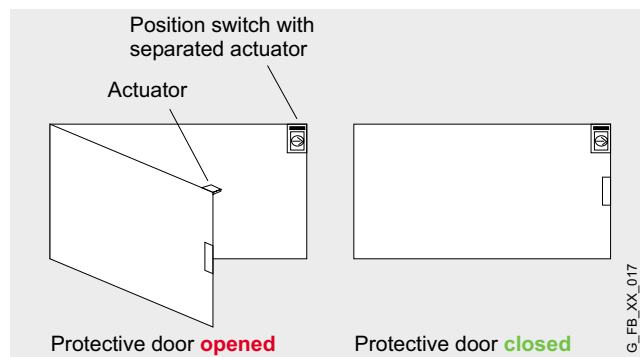


Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with a safety fused load feeder 3RA7

Function

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 is 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 using a SIRIUS position switch with a positively-opening contact using a safety fused load feeder in accordance with Category 2 to EN 954-1. If this protective door is opened, the load feeder safety shuts-down in accordance with stop Category 0 according to EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed, after checking the position switch and the contacts of the load feeder, the drive is automatically re-started.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

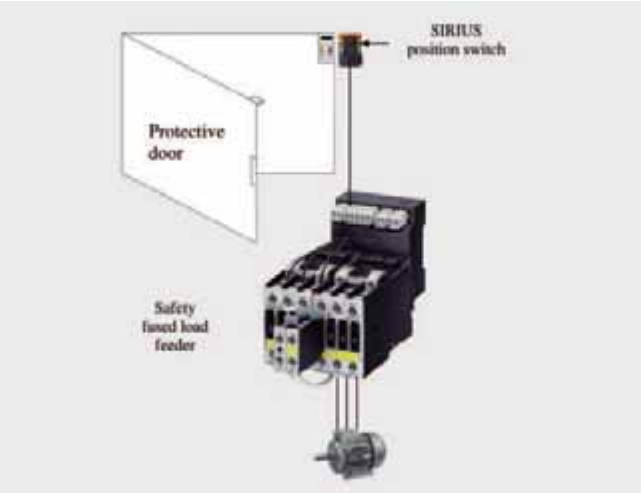
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety load feeder	3RA7	3RA7100-5AA26-0AB4	1	

Note

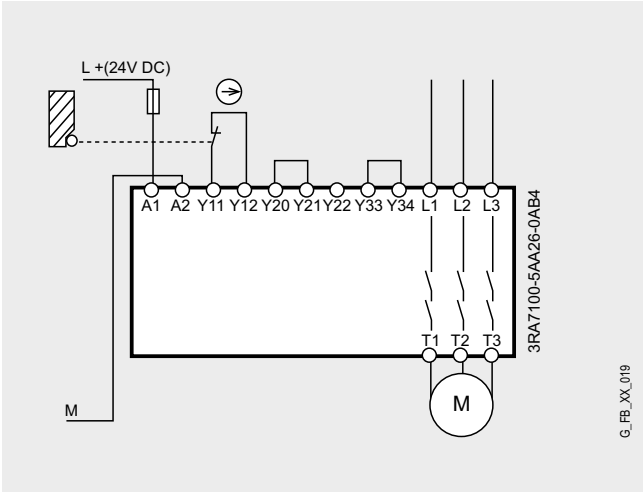
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



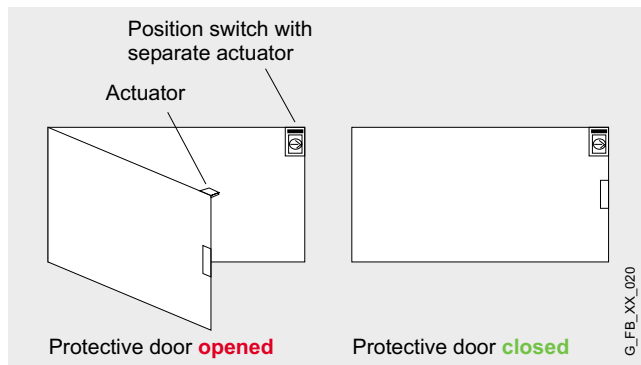
G_FB_XX_019

Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with/without operational switching with a safety fused load feeder 3RA7

Function

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 is 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 using a SIRIUS position switch with a positively-opening contact using a safety fused load feeder in accordance with Category 2 to EN 954-1. If this protective door is opened, the load feeder safety shuts-down in accordance with stop Category 0 according to EN 60204-1.

In this particular example, a drive is stopped. If the protective door is closed, after checking the position switch and the contactors of the load feeder, the drive is automatically re-started. It is possible to operationally switch the contactors (open and close them). Either a floating (electrically isolated) contact is connected between terminals 3 and 4 (refer to „Wiring of the hardware components“ page 37) or a non-floating (non electrically-isolated) output (24 V DC) is connected to terminal 4, e.g. from a standard PLC. The operational switching has a lower priority than the safety function. If operational switching is not required, then a wire jumper should be connected between terminals 3 and 4.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety load feeder	3RA7	3RA7100-5AA26-0AB4	1	

Note

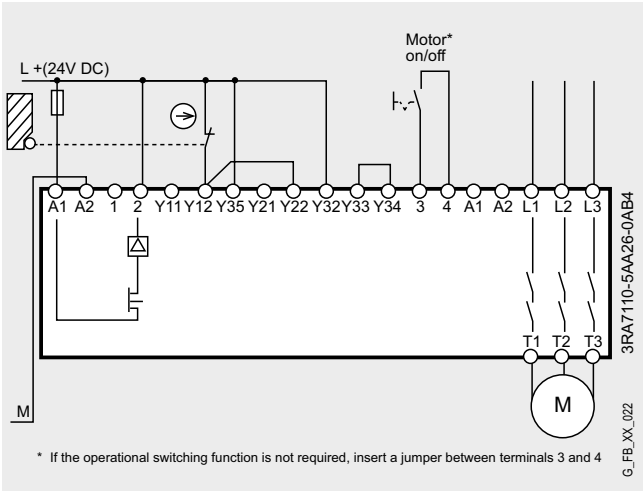
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

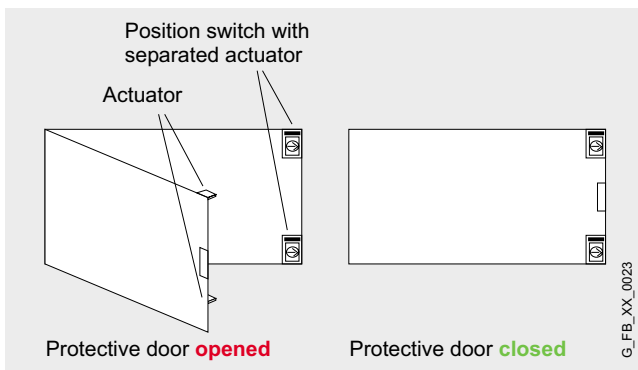


Protective door monitoring with automatic start Category 4 acc. to EN 954-1 with/without operational switching with a safety fused load feeder 3RA7

Function

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 is 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 using two SIRIUS position switches with positively-opening contacts using a safety fused load feeder in accordance with Category 4 acc. to EN 954-1. If this protective door is opened, the load feeder safety switches out the contactors, connected in series, with positively-driven

contacts in accordance with stop Category 0 according to EN 60204. In this particular example, a drive is stopped. If the protective door is closed, after the position switch and downstream contactors have been checked, then the drive automatically starts. It is possible to operationally switch the contactors (open and close them). Either a floating (electrically isolated) contact is connected between terminals 3 and 4 (refer to „Wiring of the hardware components“ page 39) or a non-floating (non electrically-isolated) output (24 V DC) is connected to terminal 4, e.g. from a standard PLC. The operational switching has a lower priority than the safety function. If operational switching is not required, then a wire jumper should be connected between terminals 3 and 4.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

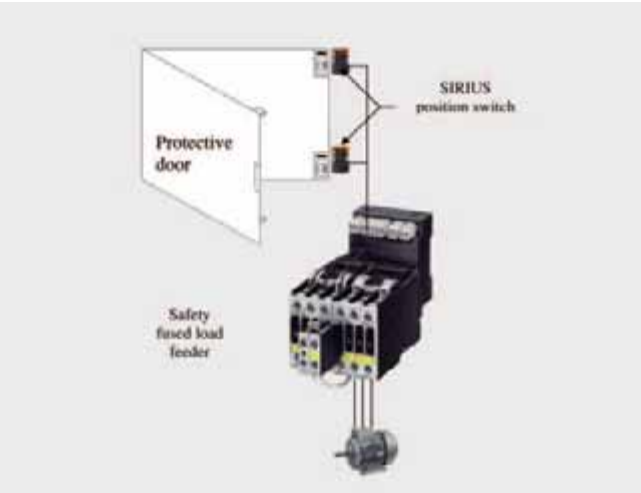
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	2	
Safety fused load feeder	3RA7	3RA7110-5AA26-0AB4	1	

Note

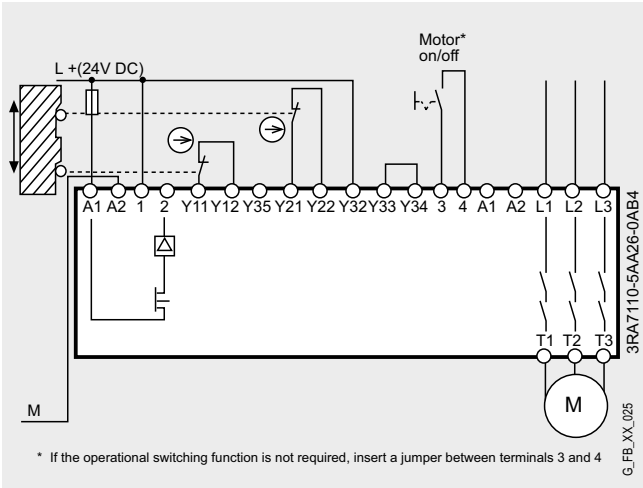
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. another safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start Category 2 acc. to EN 954-1 with a safety fuseless load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by a positively-driven contact using a safety, fuseless load feeder in accordance with Category 2 in compliance with EN 954-1. If the E-Stop button is pressed, the load feeder is safety shutdown according to Stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-STOP shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactors of the load feeder have dropped-out.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

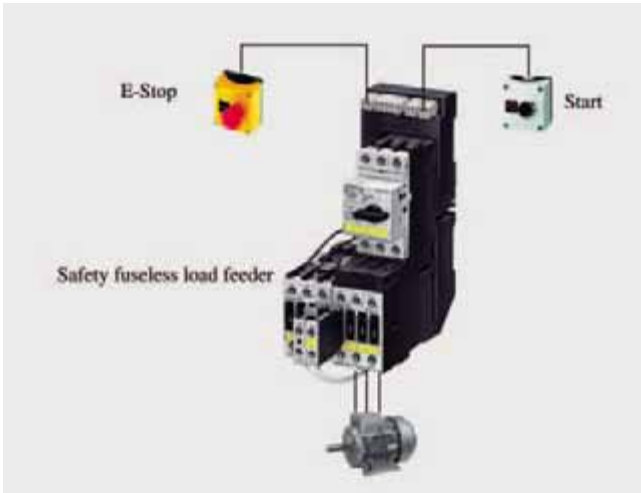
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety load feeder	3RA7	3RA7102-4CA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

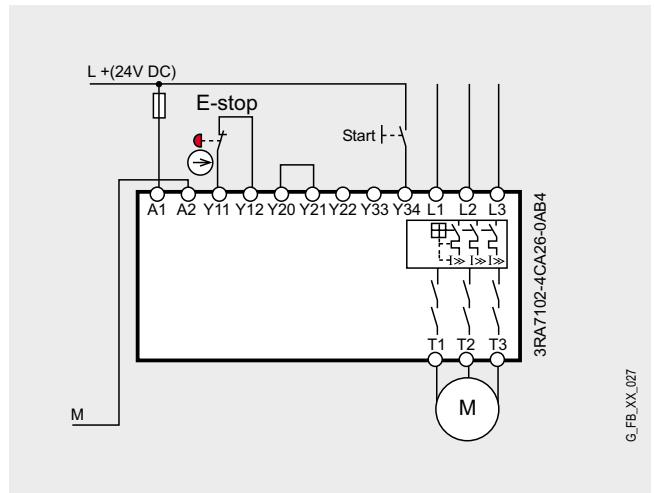
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



G_FB_XX_027

E-Stop with monitored start Category 2 acc. to EN 954-1 with/without operational switching with a safety fuseless load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by a positively-driven contact using a safety, fuseless load feeder in accordance with Category 2 in compliance with EN 954-1. If the E-Stop button is pressed, the load feeder is safety shutdown according to Stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contact of the E-Stop command device is closed and the contactors of the load feeder have dropped-out. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 43) or a non-floating (non-electrically iso-

lated) output (24 V DC) - e.g. from a standard PLC - is connected at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

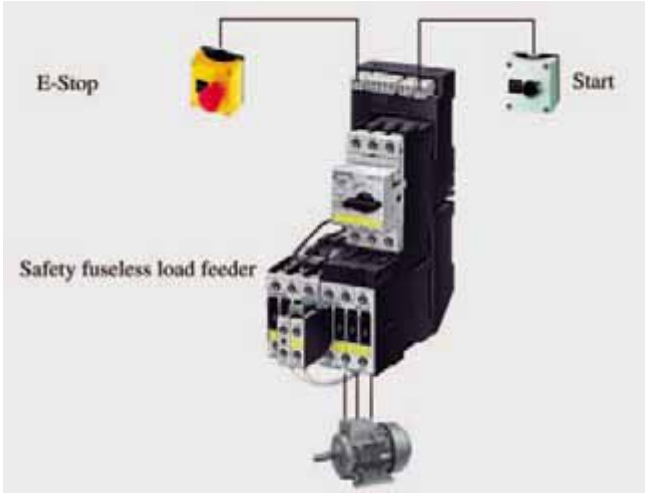
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
Safety load feeder	3RA7	3RA7102-4CA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

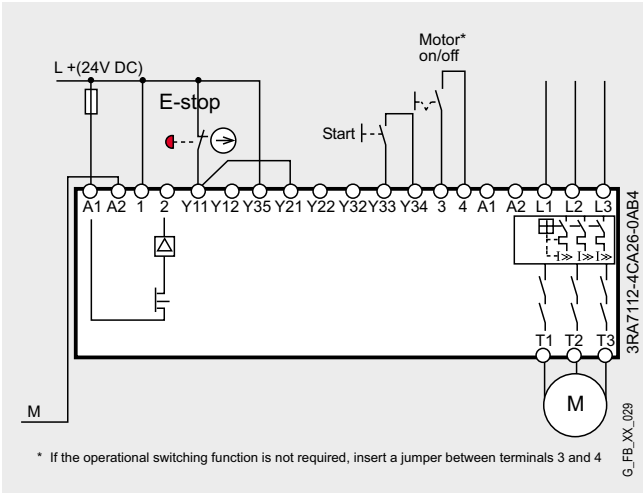
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



E-Stop with monitored start, Category 4 acc. to EN 954-1 with/without operational switching with a safety fuseless load feeder 3RA7

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The E-Stop command device represents a widely established component that protects people, plants/systems and the environment against potential hazards.

In this Safety Functional Example, the E-Stop command device is monitored by two positively-driven contacts using a safety, fuseless load feeder in accordance with Category 4 in compliance with EN 954-1. If the E-Stop command device is actuated, the load feeder safety shuts down (de-activates) the contactors, connected in series with positively-drive contacts according to stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the E-Stop shutdown using the start button, a check is made as to whether the contacts of the E-Stop command device are closed and the contactors of the load feeder have dropped-out. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 45) or a non-

floating (non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - is connected at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4.

Note

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

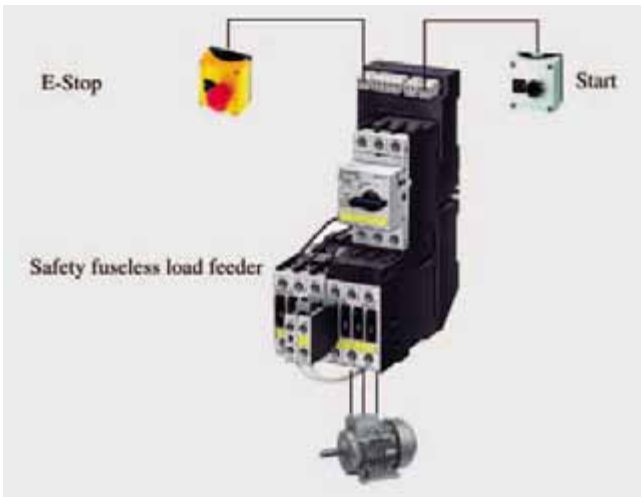
Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
	1NC contact for base-mounting	3SB3 420-0C	1	
Safety load feeder	3RA7	3RA7102-4CA26-0AB4	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	

Note

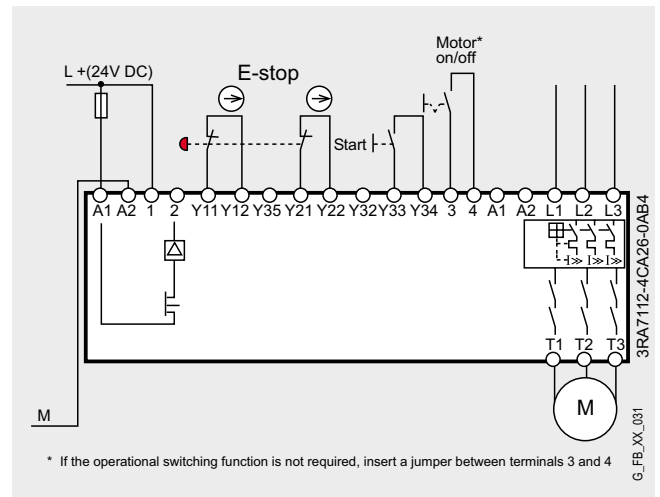
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

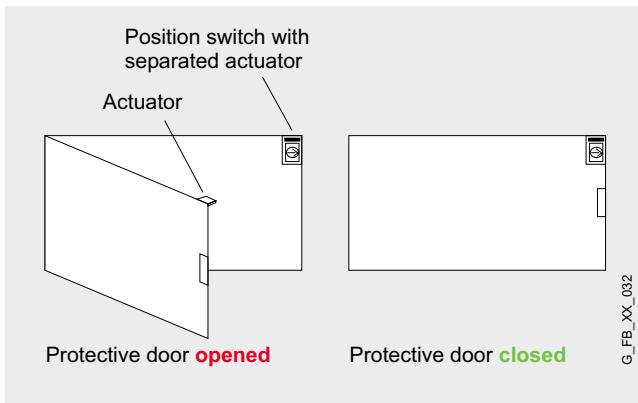


Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with a safety fuseless load feeder 3RA7

Function

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 is 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 a SIRIUS position switch with positively-opening contacts using a safety fuseless load feeder according to Category 2 in compliance with EN 954-1. If this protective door is opened, the load feeder safety shuts down according to Stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed and after the position switch and the contactors of the load feed are checked, the drive automatically starts.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety load feeder	3RA7	3RA7102-4CA26-0AB4	1	

Note

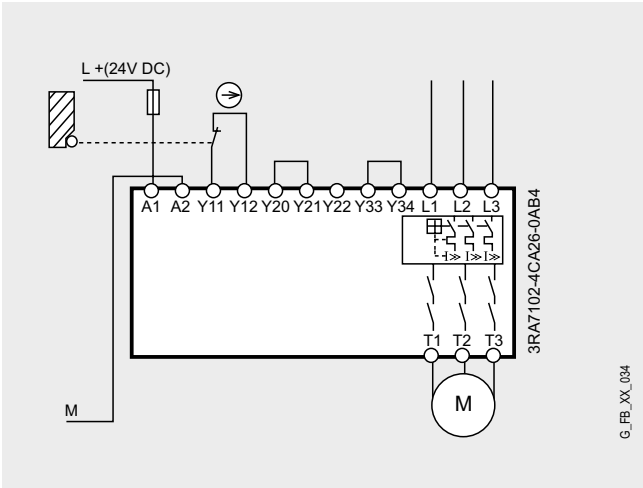
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



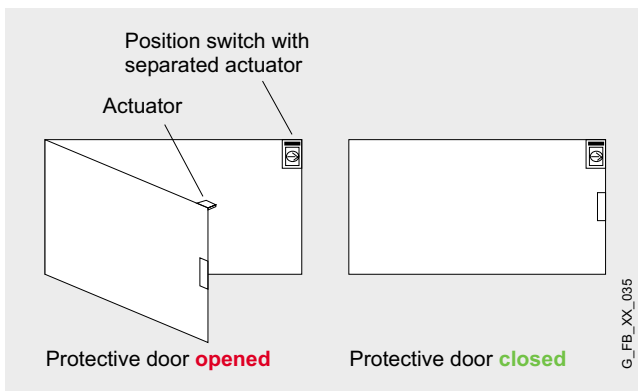
G_FB_XX_034

Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with/without operational switching with a safety fuseless load feeder 3RA7

Function

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 is 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 a SIRIUS position switch with positively-opening contacts using a safety fuseless load feeder according to Category 2 in compliance with EN 954-1. If this protective door is opened, the load feeder safety shuts

down according to Stop Category 0 in compliance with EN 60204-1. In this particular example, a drive is stopped. If the protective door is closed and after the position switch and the contactors of the load feed are checked, the drive automatically starts. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 49) or a non-floating (non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - is connected at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

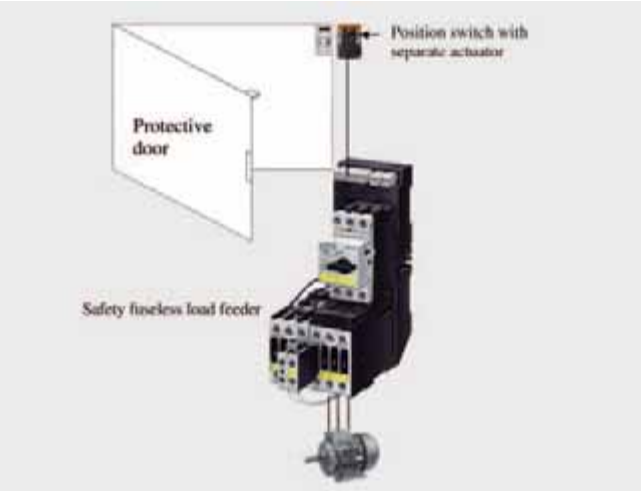
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety load feeder	3RA7	3RA7102-4CA26-0AB4	1	

Note

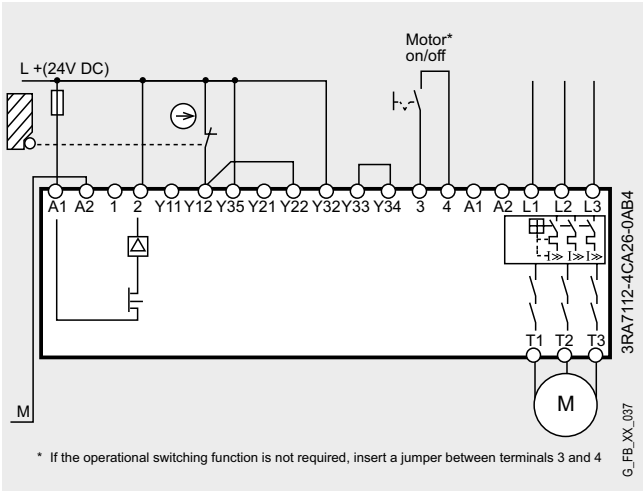
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components

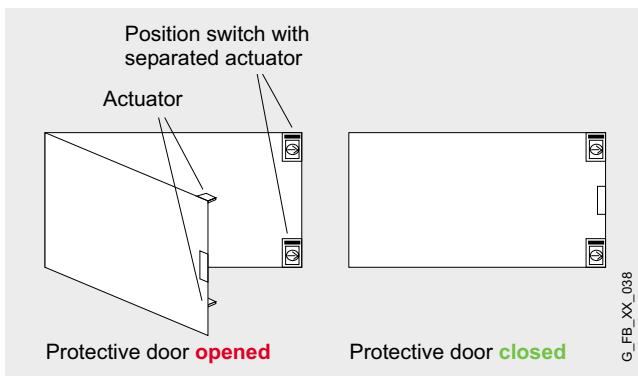


Protective door monitoring with automatic start Category 4 acc. to EN 954-1 with/without operational switching with a safety fuseless load feeder 3RA7

Function

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 is 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 with positively-opening contacts using a safety fuseless load feeder according to Category 4 in compliance with EN 954-1. If this protective door is opened, the load feeder safety shuts down (de-activates) the contactors, connected in series, with its positively-driven contacts according to stop

Category 0 in compliance with EN 60204. In this particular example, a drive is stopped. If the protective door is closed and after the position switch and downstream contactors have been checked, then the drive automatically starts. It is possible to operationally switch (in/out) the contactors. Either a floating (electrically isolated) contact is connected between terminal 3 and terminal 4 (refer to „Wiring of the hardware components“ page 51) or a non-floating (non-electrically isolated) output (24 V DC) - e.g. from a standard PLC - is connected at terminal 4. The operational switching has a lower priority than the safety function. If the operational switching is no longer required, a wire link (jumper) should be connected between terminal 3 and terminal 4.

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.

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software
- A low scope of simple wiring
- Space-saving design using our compact safety relay
- Can be simply expanded using expansion devices

Required components

Hardware components

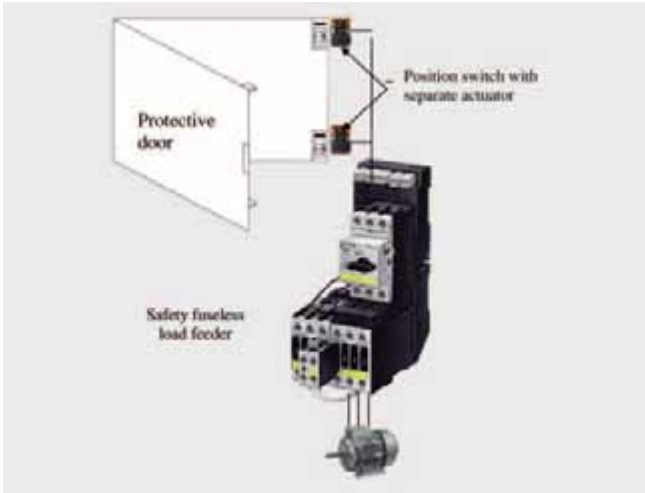
Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	Siemens AG
Actuator for position switch	Radius actuator	3SX3 228	2	
Safety load feeder	3RA7	3RA7112-4CA26-0AB4	1	

Note

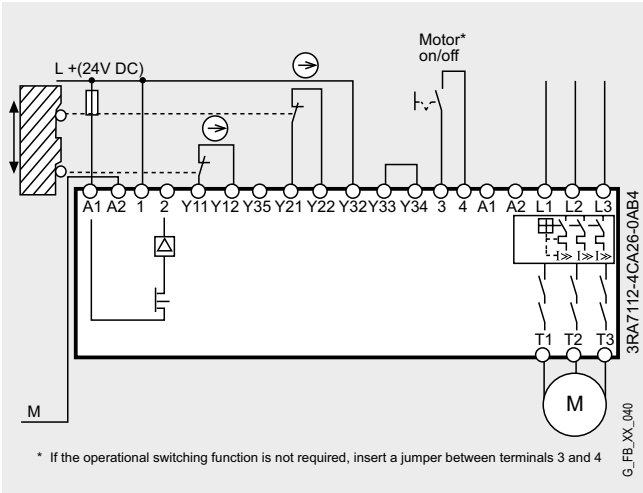
The functionality was tested using the specified hardware components. Products that are similar but deviate from the list above can be used (e.g. a different safety load feeder). However, in this case, please carefully note that it may be necessary to make modifications as to how the hardware components are connected-up (e.g. another connection assignment).

Structure and wiring

An overview of the hardware structure



Wiring of the hardware components



Emergency Stop with monitored start Category 2 acc. to EN 954-1 with ET200S Safety Motorstarter Solution Local

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The Emergency Stop control device represents a widely established component that protects man, machine and environment against potential hazards. In this Safety Functional Example, the Emergency Stop control device with positively-opening contacts is monitored by the PM-D-F 1 safety module. If the Emergency Stop control device is pressed, the PM-D-F1 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. Before restarting or acknowledging the Emergency Stop shutdown using the start button, it is checked as to whether the contacts of the Emergency Stop control device are closed and the motor starter has been shut down. 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

Equipment, functional aspects and design guidelines for E-Stop command devices are provided in EN 418 (EN ISO 13850 in draft status).

Advantages/customer benefits

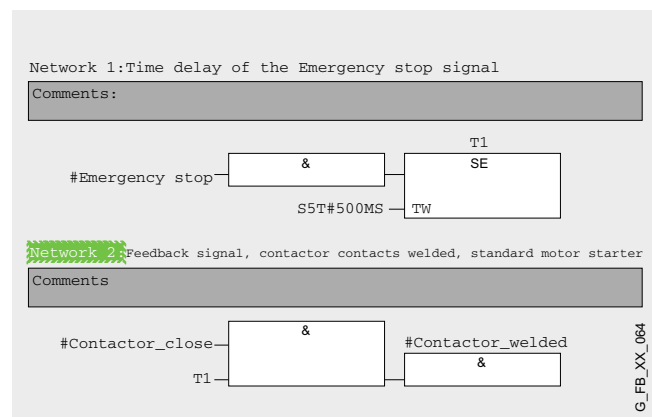
- Pure hardware engineering without having to configure/program software for the safety-relevant technology
- Extensive Profibus diagnostics of the motor starter and the PM-D-F1 safety module.
- As a result of the lower time/costs involved with materials and wiring, the mounting space in the cabinet is reduced and therefore the overall dimensions of the plants/system.

Contactor contacts welded signal

Using this circuit example, Category 2 according to EN 954-1 can only be fulfilled if, when the actuator fails, an alarm is automatically output or the machine control initiates a safe condition. If this is not the case, a second shutdown path is required.

This signal can be generated using the process image of the motor starter.

	ET200S Standard	ET200S HF
PAE	0.0 Ready	0.0 Ready (automatic)
	0.1 Close contactor	0.1 Start motor (current measurement)
	0.2 Circuit-breaker tripped	0.2 Group fault
		0.3 Group alarm
		0.4 Input 1
		0.5 Input 2
		0.6 Input 3
PAA		0.7 Input 4
		1.0-1.5 Motor current I_{act}
		1.6 Mode H-V-O
		1.7 Ramp mode (only DSS1e-x)
	0.0 Motor clockwise	0.0 Motor clockwise
		0.1 Motor counter-clockwise
	0.2 Brake	0.2 Release brake
		0.3 Trip reset
		0.4 Emergency start
		0.5 Self-test



Typical block: Signal, contactor contacts welded for motor starter standard

Using the standard output "contactor welded" an indicator light can be controlled. As a result of this signal, a second shutdown path is no longer required.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	1	Siemens AG
	Switching element with a switching contact, NC contact	3SB34 20-0C	1	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-0B	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	
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	3RK1903-1AB00	1	
	PM-D F1 power module for E-Stop application; monitored start	3RK1903-1BA00	1	
	Failsafe kit for direct starter	3RK1903-1CA00	1	
	IM 151 Basic to connect ET200S to PROFIBUS DP	6ES7151-1CA00-0AB0	1	
	Optional: Supply block M45-PEN-F	3RK1903-2AA00	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	6ES7953-8LJ10-0AA0	1	

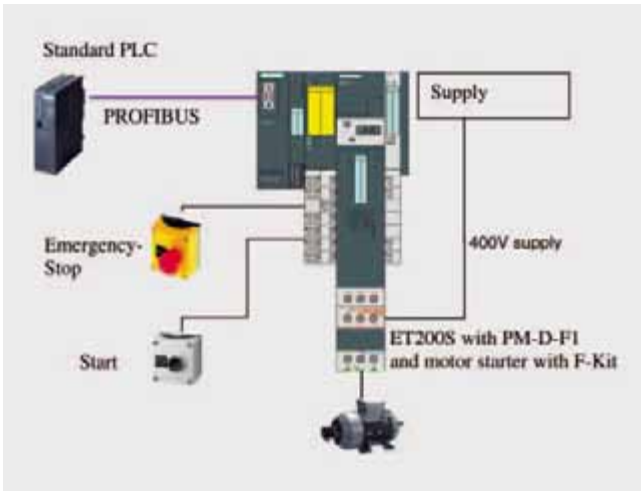
Note

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.

Structure and wiring

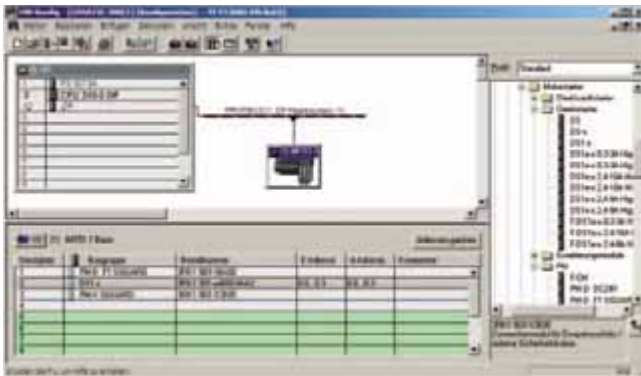
An overview of the hardware structure



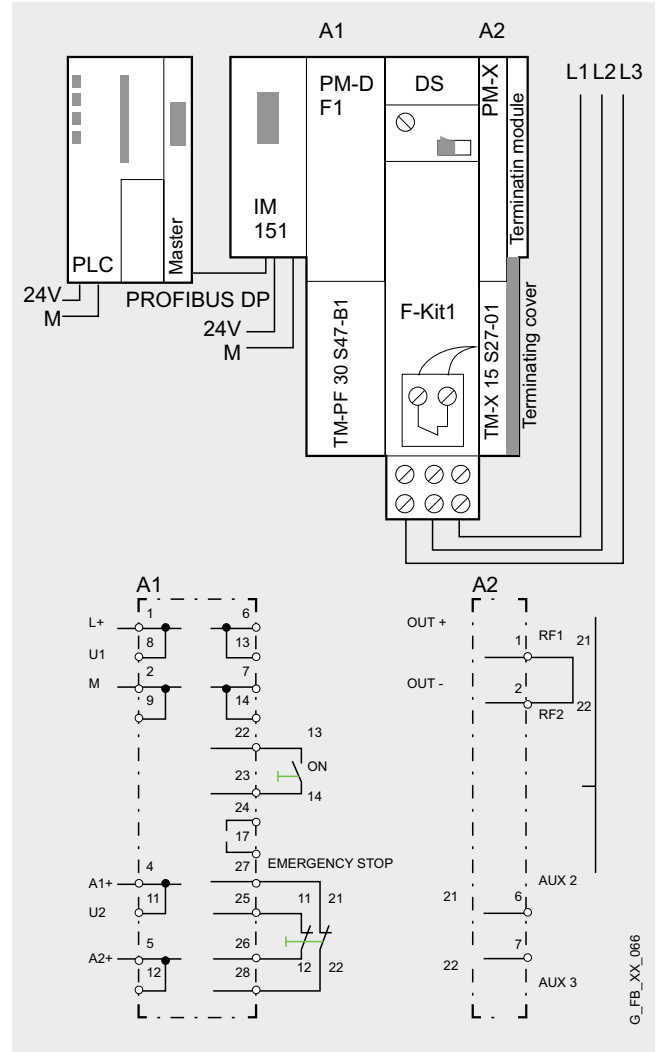
Additional motor starters can be inserted before the PM-X module in an ET 200S Station. These are then also shut down when the Emergency Stop control device is pressed (group stop).

Important hardware component settings

Some important settings from the STEP 7 hardware configuration are shown below as an overview.



Wiring of the hardware components



G_FB_XX_066

Emergency Stop with monitored start Category 4 acc. to EN 954-1 with ET200S Safety Motorstarter Solution Local

Ex. No.

3.2

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The Emergency Stop control device represents a widely established component that protects man, machine and environment against potential hazards. In this Safety Functional Example, the Emergency Stop control device is monitored using two positively-driven contacts using the PM-D-F1 safety module in accordance with Category 4 acc. to EN 954-1. If the Emergency Stop control device is pressed, the PM-D-F1 safety module shuts down the motor starter assigned to it and the supply contactor according to Stop Category 0 acc. to EN 60204-1. In this particular example, a drive is stopped. Before restarting or acknowledging the Emergency Stop shutdown using the start button, it is checked as to whether the contacts of the Emergency Stop control device are closed and the motor starter has been shut down. 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

Equipment, functional aspects and Design Guidelines for Emergency Stop control devices are provided in EN 418 (EN ISO 13850 being prepared).

Advantages/customer benefits

- Pure hardware engineering without having to configure/program software for the safety-relevant technology
- Extensive Profibus diagnostics of the motor starter and the PM-D-F1 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.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
E-Stop	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-ODG3	2	Siemens AG
	Switching element with a switching contact, NC contact	3SB34 20-OC	2	
Start button	Empty housing of a command point	3SB3 801-0AA3	1	
	1NO contact for base-mounting	3SB3 420-OB	1	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: Inscription plate "Start"	3SB3 906-1EL	1	
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	3RK1903-1AB00	1	
	PM-D F1 power module for Emergency Stop application; monitored start	3RK1903-1BA00	1	
	Failsafe kit for direct starter	3RK1903-1CA00	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	–	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	–	
	Micro Memory Card MMC 512 kB	6ES7953-8LJ10-0AA0	–	

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.

Protective door monitoring with automatic start Category 2 acc. to EN 954-1 with ET200S Safety Motorstarter Solution Local

Function

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 is 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 a SIRIUS position switch with positively-opening contacts using a PM-D-F2 safety module according to Category 2 in compliance with EN 954-1. 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.

Advantages/customer benefits

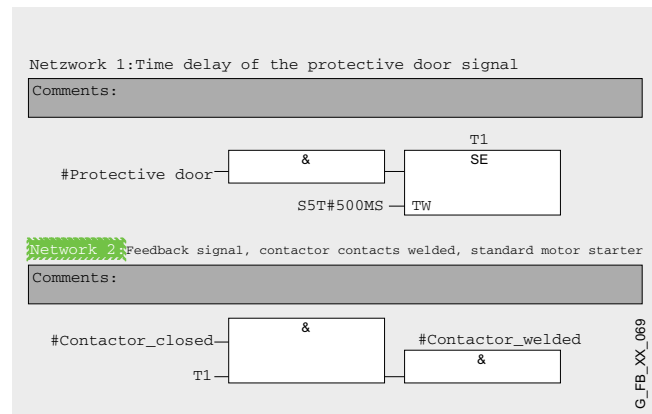
- Pure hardware engineering without having to configure/program software for the safety-relevant technology
- Extensive Profibus diagnostics of the motor starter and the PM-D-F2 safety module.
- As a result of the lower time/costs involved with materials and wiring, the mounting space in the cabinet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

Contactor contacts welded signal

Using this circuit example, Category 2 according to EN 954-1 can only be fulfilled if, when the actuator fails, an alarm is automatically output or the machine control initiates a safe condition. If this is not the case, a second shutdown path is required.

This signal can be generated using the process image of the motor starter.

	ET200S Standard	ET200S HF
PAE	0.0 Ready	0.0 Ready (automatic)
	0.1 Close contactor	0.1 Start motor (current measurement)
	0.2 Circuit-breaker tripped	0.2 Group fault
		0.3 Group alarm
		0.4 Input 1
		0.5 Input 2
		0.6 Input 3
		0.7 Input 4
	1.0-1.5 Motor current I_{act}	
	1.6 Mode H-V-O	
	1.7 Ramp mode (only DSS1e-x)	
PAA	0.0 Motor clockwise	0.0 Motor clockwise
		0.1 Motor counter-clockwise
	0.2 Brake	0.2 Release brake
		0.3 Trip reset
		0.4 Emergency start
		0.5 Self-test



Typical block: Signal, contactor contacts welded for motor starter standard

Using the standard output "contactor welded" an indicator light can be controlled. As a result of this signal, a second shutdown path is no longer required.

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.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Protective door	SIRIUS position switch	3SE2 243-0XX40	1	Siemens AG
	Radius actuator for position switch	3SX3 228	1	
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	3RK1903-1AB00	1	
	PM-D F1 power module for emergency stop application; monitored start	3RK1903-1BA00	1	
	Failsafe kit for direct starter	3RK1903-1CA00	1	
	IM 151 Basic to connect ET200S to PROFIBUS DP	6ES7151-1CA00-0AB0	1	
	Optional: Supply block M45-PEN-F	3RK1903-2AA00	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	6ES7953-8LJ10-0AA0	1	

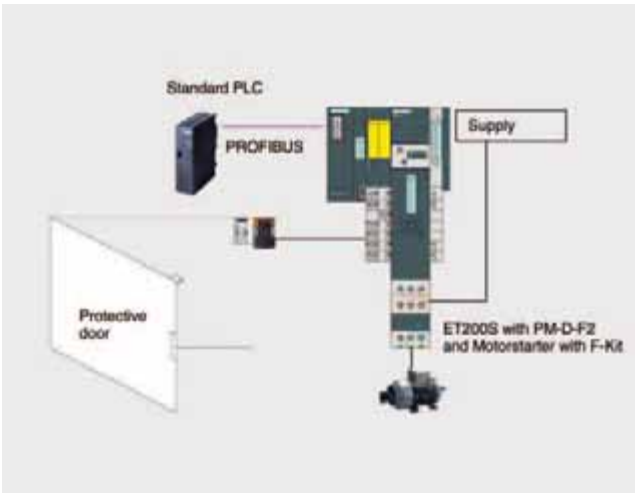
Note

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.

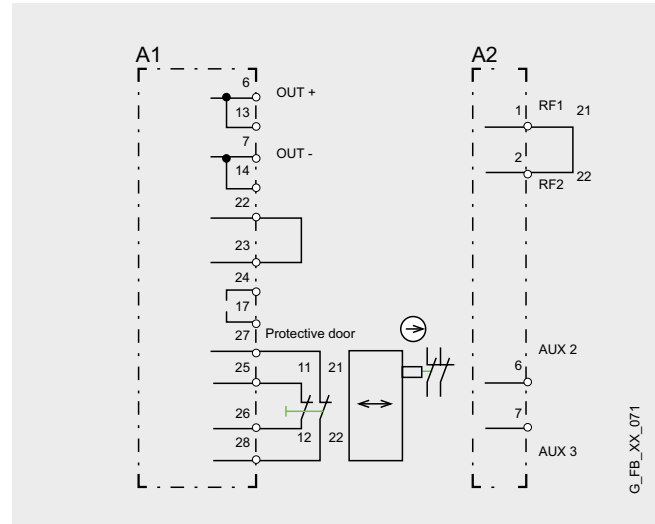
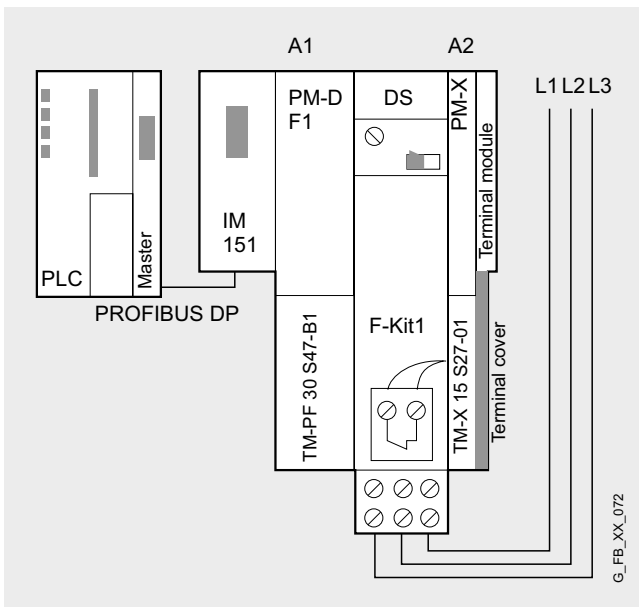
Structure and wiring

An overview of the hardware structure



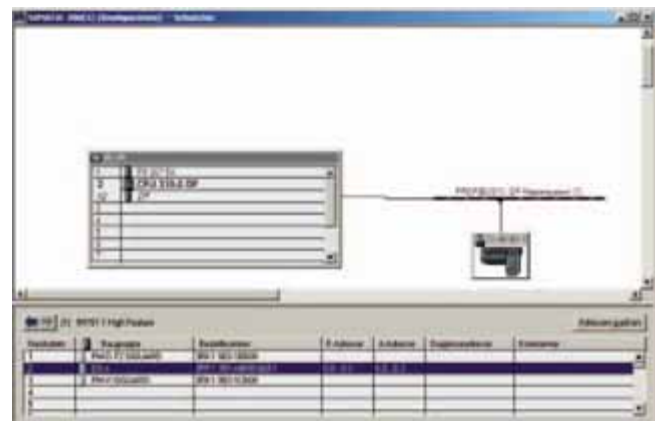
Additional motor starters can be inserted before the PM-X module in an ET 200S Station. These are then also shut down when the Emergency Stop control device is pressed (group stop).

Wiring of the hardware components



Important hardware component settings

Some important settings from the STEP 7 hardware configuration are shown below as an overview.



Protective door monitoring with automatic start Category 4 acc. to EN 954-1 with ET200S Safety Motorstarter Solution Local

Function

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 is 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 module according to Category 4 in compliance with EN 954-1. 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.

Required components

Hardware components

Komponente	Type	MRPD / Ordering data	Qty	Manufacturer
Protective door	SIRIUS position switch	3SE2 243-0XX40	2	Siemens AG
	Radius actuator for position switch	3SX3 228	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	3RK1903-1AB00	1	
	PM-D F1 power module for emergency stop application; monitored start	3RK1903-1BA00	1	
	Failsafe kit for direct starter	3RK1903-1CA00	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	6ES7953-8LJ10-0AA0	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 Motorstarter).

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 end-stop.

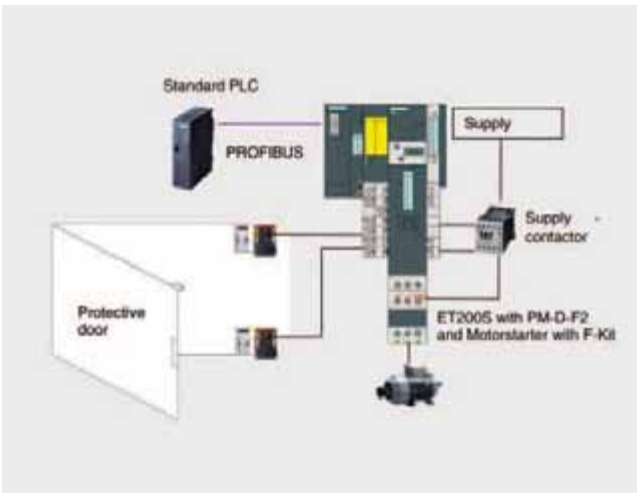
Advantages/customer benefits

- Pure hardware engineering without having to configure/program software 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

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

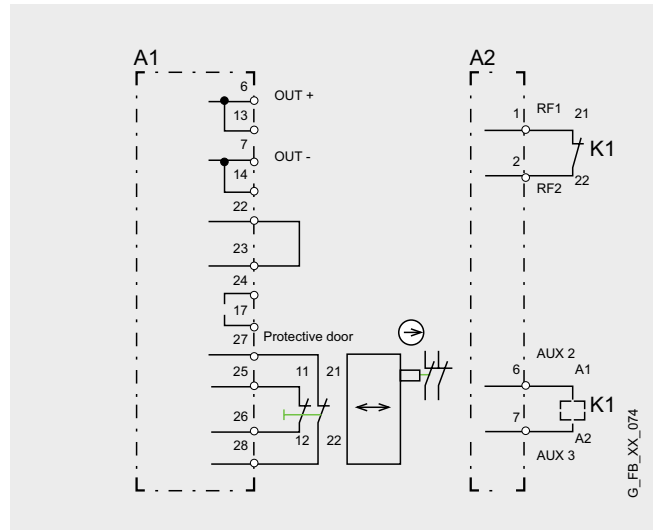
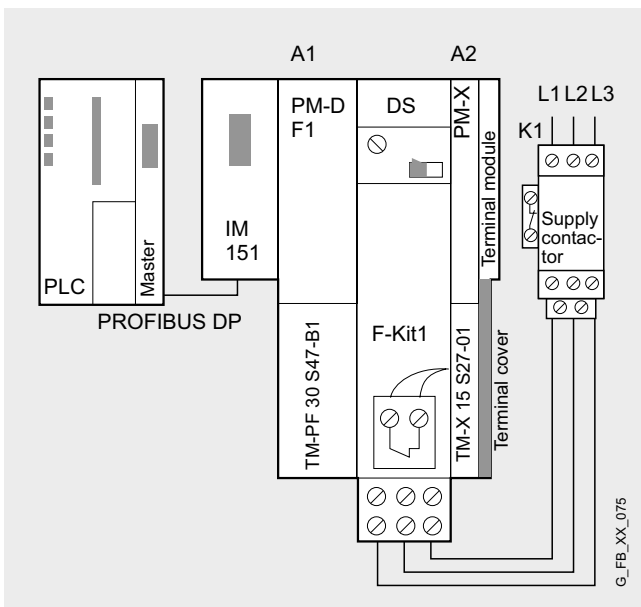
Structure and wiring

An overview of the hardware structure

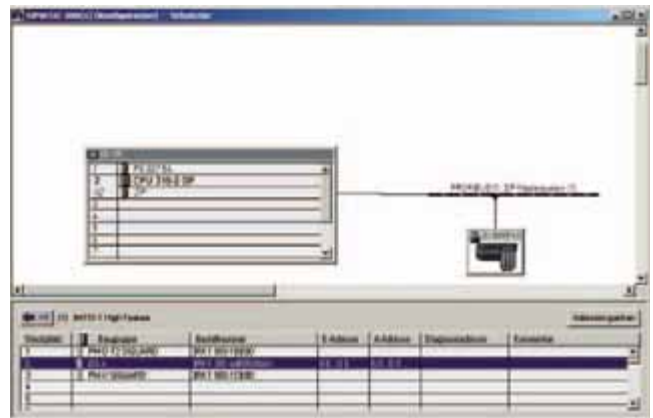


Additional motor starters can be inserted before the PM-X module in an ET 2005 Station. These are then also shut down when the Emergency Stop control device is pressed (group stop).

Wiring of the hardware components



Important hardware component settings



2 safety circuits in a cascade according to Category 4 in compliance with EN 954-1 (PM-D F X1 and Failsafe Motor Starter) with ET200S Safety Motor Starter Solution Local

Function

Description of the functionality

If people (in production technology) are close to machines, then they must be protected using the appropriate equipment. The EMERGENCY STOP command device represents a widely established component that protects man, machine and environment against potential hazards.

This safety function example will show how a cascaded EMERGENCY STOP shutdown with 2 motor starter groups can be implemented in an ET200S station.

A PM-D F X1 safety module can provide a total of 6 safety-related shutdown groups (refer to the ET200S Motor Starter Manual) by accessing the SG1 to SG6 buses (safety groups) of the Failsafe Motor Starter. It routes the safety-related control voltage of the safety shutdown groups SG1 to SG6 to the SG rail of the terminal module of the next Failsafe Motor Starter. The terminal modules of the Failsafe Motor Starter additionally have a coding block. This allows the motor starter to be assigned one of the six safety-related shutdown groups (refer to page 67). The shutdown is realized by a safety relay switching one of the 6 SG buses into a no-voltage condition.

The first two motor starters (refer to page 66) are, in this function example, connected to SG1 - the others to SG2. The motor starters can be shutdown in a safety-related fashion by shutting down an SG.

The EMERGENCY STOP command devices with positively-opening contacts are monitored by the 3TK2841 safety relays.

If the EMERGENCY STOP of group 1 is actuated, then the 3TK2841 (K1) shuts down its enable circuit according to stop Category 0 according to EN 60204-1. The SG1 and the 3TK2841 (K2) are shutdown. The 3TK2841 (K2) in turn shuts down the SG2.

If the EMERGENCY STOP of group 1.1 is actuated, the 3TK2841 (K2) shuts down its enable circuit according to stop Category 0 in compliance with EN 60204-1. SG2 is shutdown.

Drives are stopped in this particular function example. Before restarting or acknowledging the EMERGENCY STOP shutdown using the start button, it is checked as to whether the contacts of the EMERGENCY STOP commanding device are closed.

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

Note

Equipment, functional aspects and design guidelines for EMERGENCY STOP command devices are provided in EN 418.(EN ISO 13850 in draft status).

Advantages/customer benefits

- Planning and engineering
 - Lower time and costs for engineering and documentation: Motor starters are re-parameterized and documented using the standard Step 7 tool.
 - The PLC can handle all of the control functions of the motor starter.
 - Only 2 motor starter versions are required to cover the power range up to 7.5 kW.
- Installation and commissioning
 - Fast installation and mounting: Fast installation system of the ET 200S with self-establishing 50 A power bus
 - All of the various cable ducts and terminals are eliminated.
 - All of the load feeders - with the exception of the motor connection - are completely wired and connected-up
 - Every power supply voltage is only connected once and is automatically connected to the next modules
 - Optimum cabinet design without de-rating up to 60°C
 - Low space requirement (either few / smaller electrical cabinets):
 - The mounting space in the electrical cabinet is required due to the fewer materials and wiring - in turn this reduces the space required in the plant or system.
 - Fast commissioning: Reduced testing costs as a result of the modular and standardized plant/system concept - no risk of wiring mistakes/errors.
 - Simple acceptance at favorable costs (Machinery Directives): Motor starters and safety modules have been certified by the TÜV [German Technical Inspectorate]
- Operation
 - The availability and productivity have been increased: Faults are detected early on thanks to powerful diagnostic functions
 - Motor starter overloads can be simply acknowledged with a remote reset via PROFIBUS (or PROFINET)
 - Emergency Start function
 - Coordination type "2" for 50 kA
- Service and maintenance:
 - Simple and preventive service and maintenance: Single diagnostics, overload and short circuit are separately detected.
 - Short downtimes: Hot swapping (motor starters can be replaced in just a few seconds in operation without requiring any tools) - thanks to the pre-configured wiring
 - Self-coding motor starters (an incorrect motor starter cannot be inserted as it is mechanically interlocked)
 - The master automatically and remotely parameterizes the devices when replaced under voltage (hot swapping)
 - Full motor protection thanks to the overload protection - short circuit protection - dissymmetry - anti-stall protection - zero current detection, long motor starter lifetimes up to 10 million switching operations.
 - Lower costs when stocking spare parts: There are only 2 motor versions up to 7.5kW with wide setting ranges
- Upgrades and expansions
 - Existing plants and systems can be simply and quickly upgraded/expanded.

Failsafe Motor Starters



A Failsafe Motor Starter comprises a circuit-breaker with shunt release, a contactor with positively-driven auxiliary contacts and an electronic evaluation unit for fault detection.

The PM-D F X1 power module disconnects the contactor supply voltage. If the contactor control (energization) does not match the switching state of the positively-driven auxiliary contact, then the evaluation electronics detects a fault and opens the circuit-breaker.

In this case, the second shutdown element is therefore the circuit-breaker that is shutdown from a monitored shunt release when a fault occurs.

Components required

Hardware component

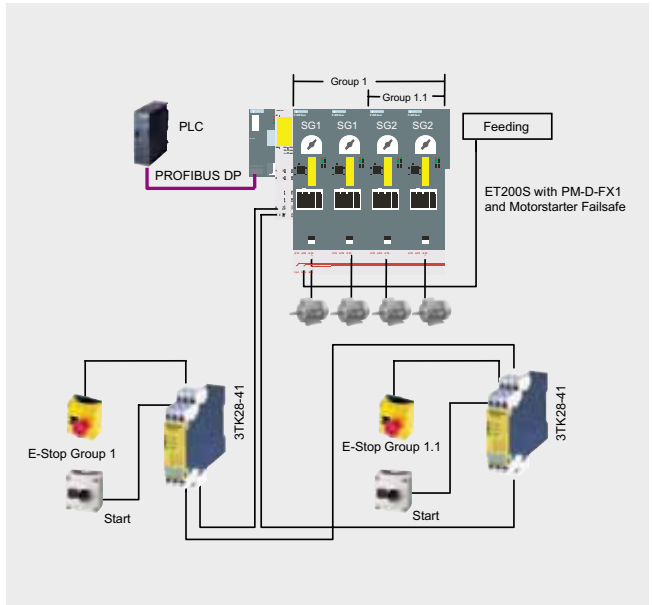
Components	Type	MRPD / Ordering data	Qty.	Manufacturer
EMERGENCY STOP	Mushroom head pushbutton, 1 NC, 40 mm, with yellow upper section without protective collar	3SB3 801-0DG3	2	Siemens AG
	Switching element with a switching contact, NC contact	3SB34 20-0C	2	
Start button	Empty enclosure of a command point	3SB3 801-0AA3	2	
	1NO contact for base-mounting	3SB3 420-0B	2	
	Pushbutton, black with flat actuator, 22 mm nominal diameter	3SB3 000-0AA11	2	
	Optional: Inscription plate "Start"	3SB3 906-1EL	2	
Safety relay	3TK2841 safety relay	3TK2841-1BB40	2	
ET 200S station	Failsafe direct starter; 2.4 to 8 A	3RK1301-0BB13-0AA2	4	
	Terminal module for a direct starter F with feeder cable connection	3RK1903-3AC00	1	
	Terminal module for a direct starter F without feeder cable connection	3RK1903-3AC10	3	
	Terminal module for the supply terminal module PM-D F X1; supply at the left	3RK1903-3AE00	1	
	PM-D F X1 power module (feed terminal module)	3RK1903-3DA00	1	
	IM 151 to connect ET200S to PROFIBUS DP	6ES7151-1AA03-0AB0	1	
	optional Supply block M65-PEN-F	3RK1903-2AC00	1	
	M65-PEN-S connection block	3RK1903-2AC10	3	
SIMATIC S7	Power supply PS307 5A	6ES7307-1EA00-0AA0	1	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	1	
	Micro Memory Card MMC 512 kB	6ES7953-8LJ10-0AA0	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).

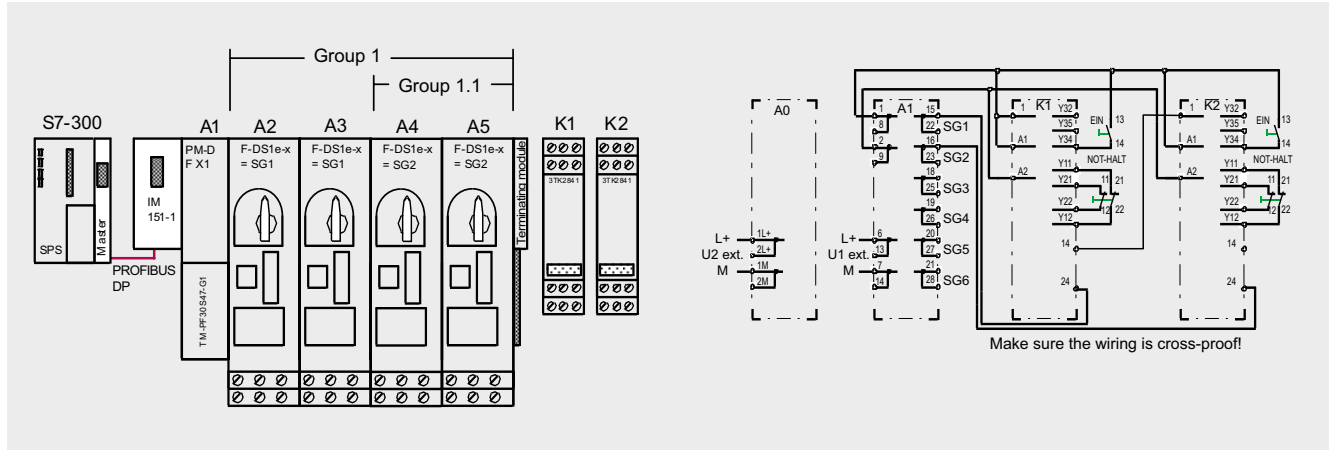
Structure and wiring

An overview of the hardware structure



Additional motor starters can be inserted in an ET 200S Station. These are assigned to a group and can be shutdown by actuating the appropriate EMERGENCY STOP command device.

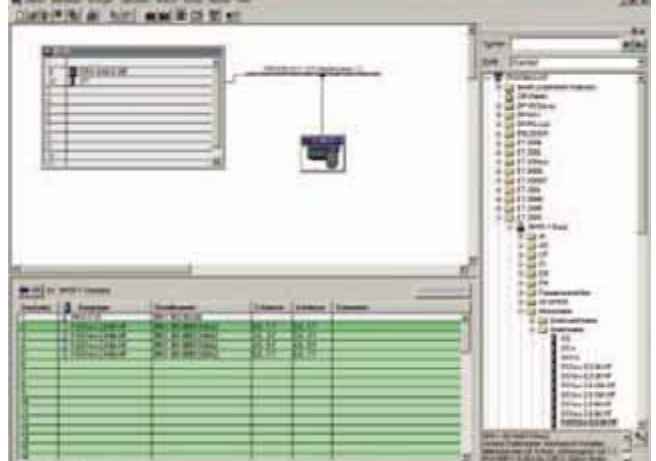
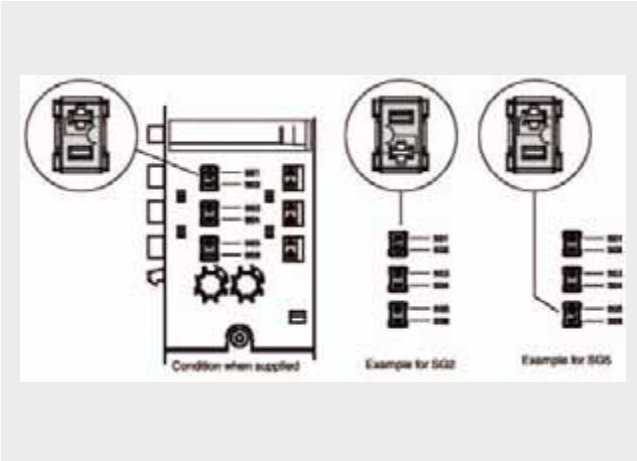
Connecting-up the hardware components



Important hardware component settings

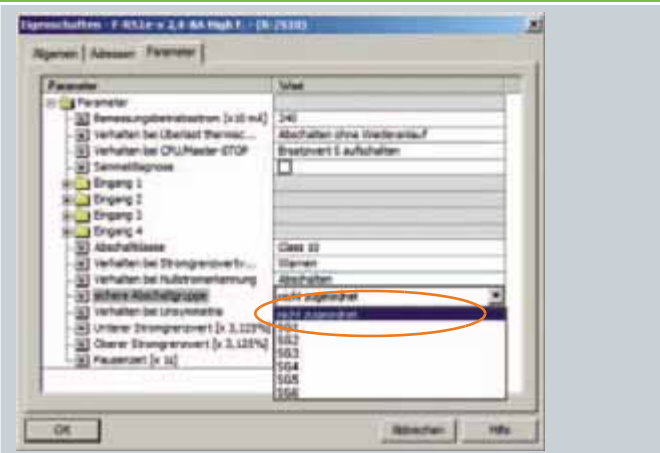
Set the safety-related shutdown group on the terminal module of the Failsafe Motor Starter.

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

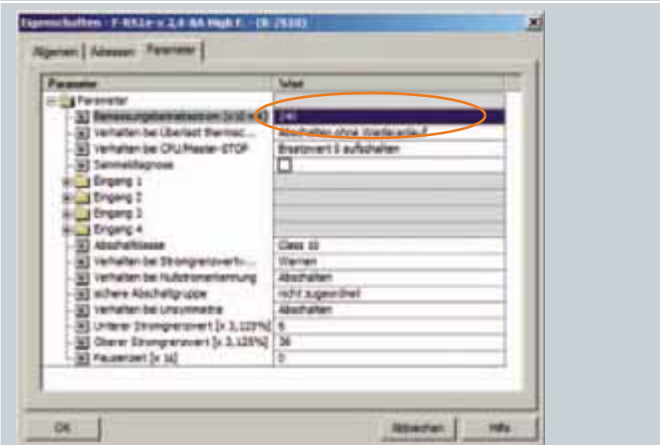


Note **Diagram**

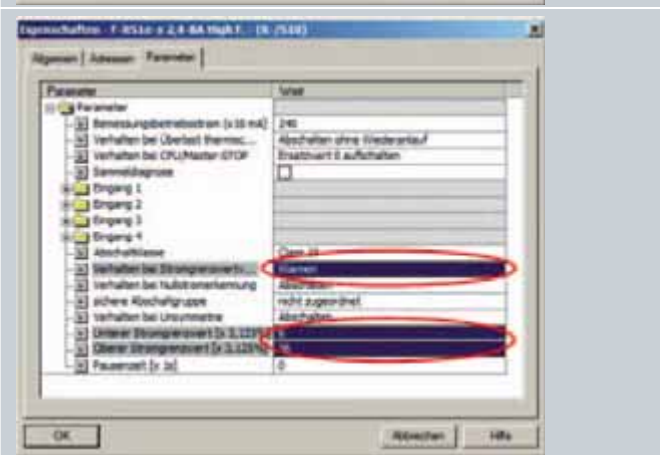
Safety shutdown group
 The safety shutdown group must be set.
 This number is compared with the safety-related mechanical assignment on the terminal module - this is not visible from outside - and must match this.
 Default: Not assigned



Rated operating current
 Here, the rated operating current is entered, which the feeder can conduct without any interruption (switching device and motor) (rated motor current). The current that can be set depends on the motor starter current range (e.g. 0.3 A to 3 A; 2.4 A to 8 A; 2.4 A to 16 A). This can be set in 10 mA steps within a specific range.
 -> Wide range setting
 Default: Minimum value



Current limit
Upper current limit:
 The mechanical system/equipment is more difficult to move - e.g. if the bearings are damaged, the mixture being mixed is too viscous
 -> current is greater than that set
Lower current limit:
 The mechanical system/equipment is easier to move, e.g. the material being processed in the plant or system is no longer present, drive belts broken
 -> current is less than that set
 Protection by evaluating how the current limit is violated
 Default: Alarm



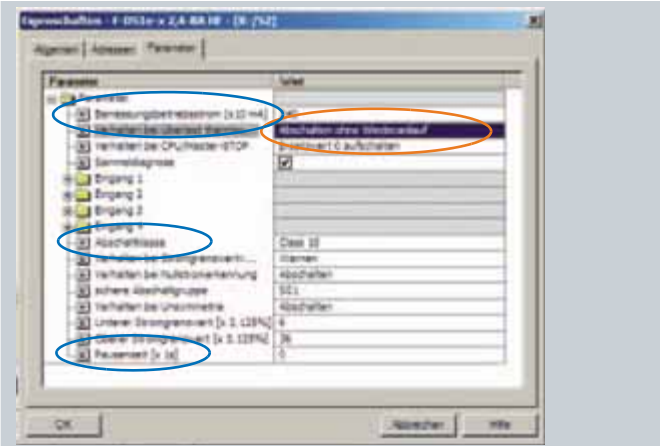
Note **Diagram**

Overload, thermal motor model
 The motor winding temperature is calculated from the measured motor currents and the device parameters, rated operating current and shutdown class. It is therefore possible to identify as to whether the motor is overloaded or is operating in the normal operating range.
 Default: Shutdown without restart

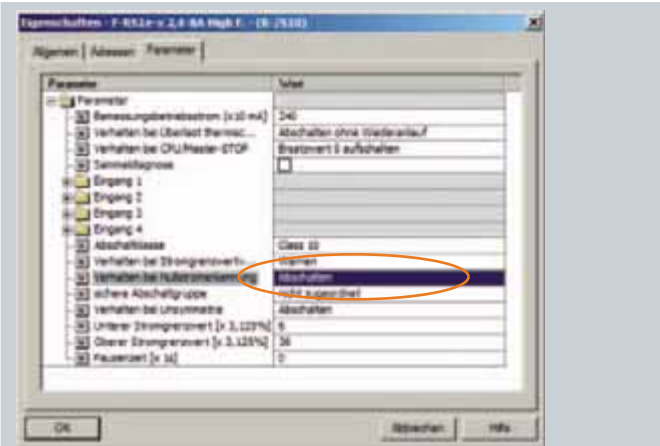
The pause time is the time that is specified for cooling-down after operational shutdowns, i.e. not as a result of overload trips. After this time has expired, the "thermal memory" of the motor starter is

- changed to 0 % for motor temperature rise < 50%
- reduced to 50 % for motor temperature rise > 50 %

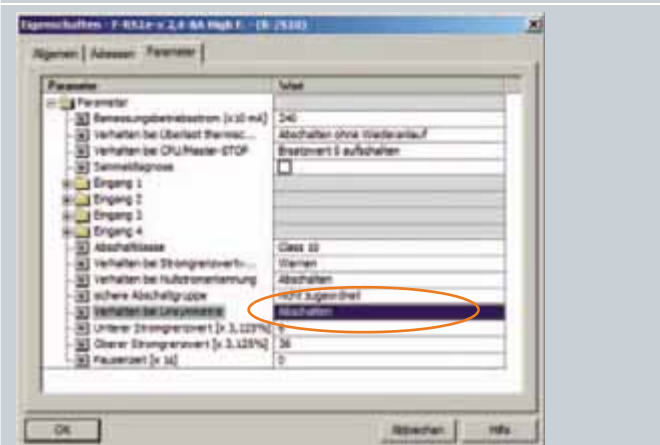
This means that frequent starting attempts are possible (jog mode).



Zero current detection
 Zero current is detected if the motor current in all phases is < 18.75 % of the selected rated operating current.
 Default: Shutdown



Dissymmetry
 Three-phase induction motors respond to low levels of dissymmetry of the line supply voltage by drawing a higher non-symmetrical current. This therefore increases the temperature of the stator and rotor windings.
 The dissymmetry limit value is a percentage value by which the motor current in the individual phases may deviate.
 Dissymmetry is present if the difference between the smallest and the highest phase current is greater than 30 %.
 Default: Shutdown



Emergency Stop and protective door monitoring with monitored start according to Category 2 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment.

The EMERGENCY-STOP control unit and protective door monitoring are widely used components for protecting persons, machines and the environment against danger.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

Functionality of the Functional Example

Problem

Implementation of EMERGENCY-STOP disconnection and protective door monitoring via ASIsafe. Category 2 of EN 954-1 is to be attained.

Solution

In this Safety Functional Example, the EMERGENCY-STOP control unit and a protective door are monitored by a K45F ASIsafe module according to Category 2 of EN 954-1. When the EMERGENCY-STOP is activated or the protective door is opened, the K45F ASIsafe module sends a signal to the safety monitor. The safety monitor then switches the downstream contactor with positively-driven contacts via the relay output according to Stop category 0 of EN 60204-1.

A drive is shut down in this example. Before renewed switching-on via the start button, a check is carried out to monitor whether the contact of the EMERGENCY-STOP control unit and the protective door are closed and whether the contactor has switched off.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/ASILINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
EMERGENCY-STOP stop control unit	40- mm mushroom pushbutton with 1NC and yellow top, without protective collar	3SB3 801-0DG3	1	
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	1	
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety monitor	Safety monitor with one OSSD	3RK1105-1AE04-0CA0	1	
K45F ASIsafe module	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	1	
	Mounting plate(for standard mounting rail)	3RK1901-2DA00	1	
	Optional: Mounting plate(for wall mounting)	3RK1901-2EA00	1	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	1	
Cable loom	PC configuration cable	3RK1901-5AA00	1	
	Transfer cable			
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

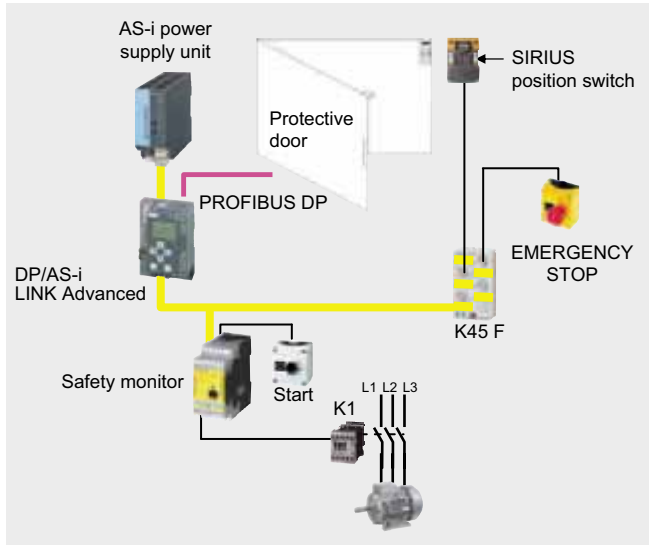
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

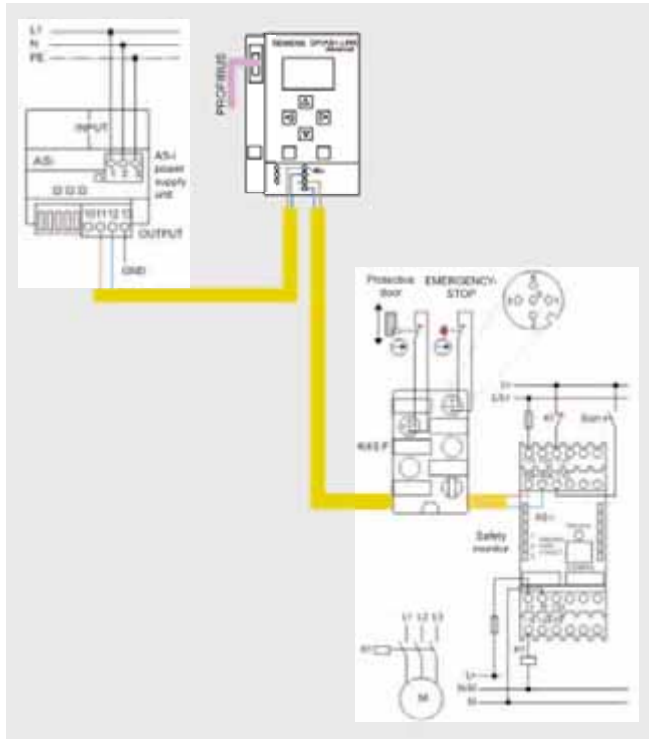
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

Overview of Hardware Setup



Hardware Component Wiring



Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation.
- Connect each AS-i slave to the AS-i line and allocate each the desired slave address (**K45F module, address 2**).

SYSTEM AS-i line 1 Lifelist Change address Change slave address

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM AS-i line 1 Lifelist Actual -> Defined Actual -> Adopt defined


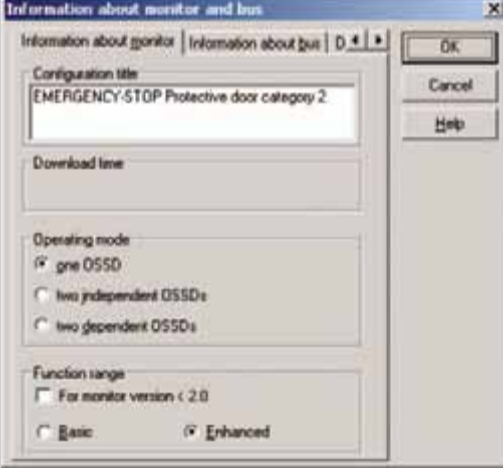

Result:

All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

Description	Parameters
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>	
<p>Enter a name for the configuration in the Information about monitor tab, select the operating mode and the function range of the AS Interface safety monitor ("Basic" or "Enhanced").</p>	
<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	

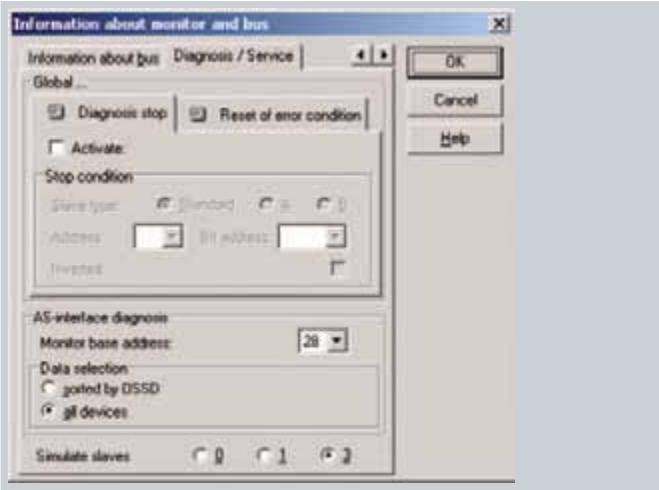
Description

In the **Diagnosis / Service** tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis.

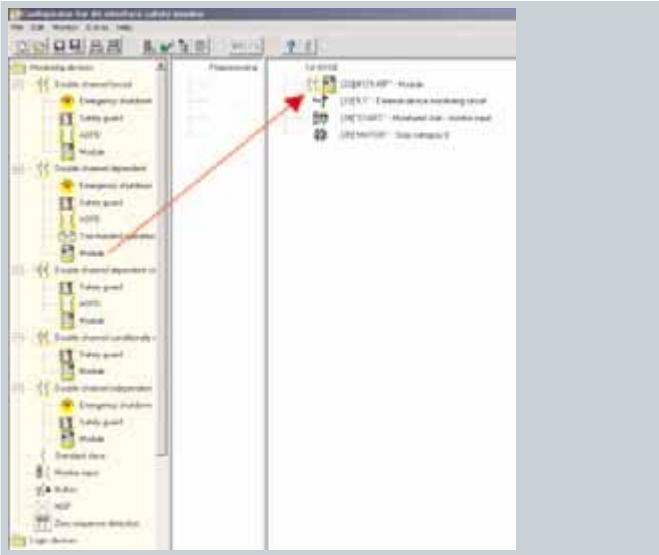
Simulating slaves

If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box **Simulate slaves**. At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.

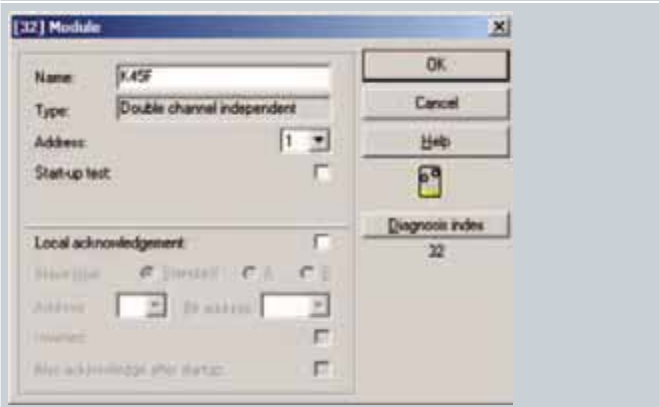
Parameters



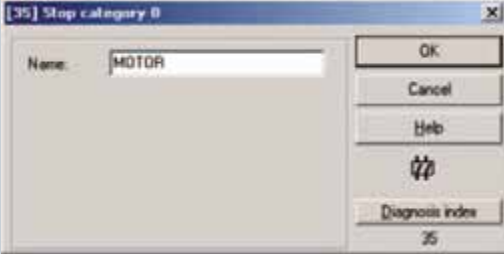


Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).



The **K45F module** is monitored via **two channels independently**. For the "double channel independent" monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals are independently monitored. There is no synchronization time.



Description	Parameters
<p>The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The external device monitoring circuit device is active = ON (switched on).</p> <p>After the safety output has been switched off, the external device monitoring circuit device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.</p> <p>Thereafter, the contactor control input is active = ON again. When the external device monitoring circuit device is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position.</p> <p>After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.</p> <p>The Monitored start - monitor input device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the monitored start - monitor input start device relays the enabling request to the output device.</p>	 
<p>When the circuit is enabled (ON), the signal output and the output circuit are simultaneously activated by the Stop category 0 output device. When the circuit is switched off (OFF), the signal output and the output circuit are immediately switched off without a delay.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

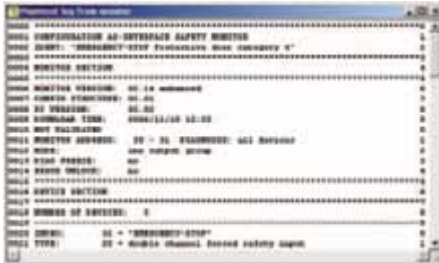
The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.



The provisional configuration log is displayed in **asimon** in its own window.

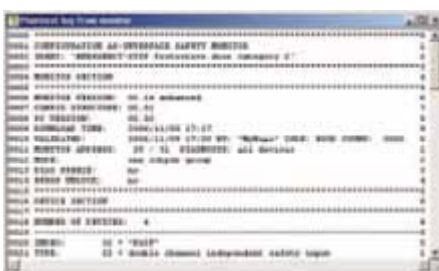
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor

The safety monitor is running in protective operation

If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

Emergency stop and protective door monitoring with monitored start according to Category 4 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment. The EMERGENCY-STOP control unit and protective door monitoring are widely used components for protecting persons, machines and the environment against danger.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

Functionality of the Functional Example

Problem

Implementation of EMERGENCY-STOP disconnection and protective door monitoring with monitored start via ASIsafe. Category 4 of EN 954-1 is to be attained.

Solution

In this Safety Functional Example, the EMERGENCY-STOP control unit and a protective door are monitored by a K45F ASIsafe module according to Category 4 of EN 954-1. When the EMERGENCY-STOP is activated or the protective door is opened, the K45F ASIsafe module sends a signal to the safety monitor. The safety monitor then switches the downstream contactor with positively-driven contacts via the safe relay output according to Stop category 0 of EN 60204-1.

A drive is shut down in this example. Before renewed switching-on via the start button, a check is carried out to monitor whether the contact of the EMERGENCY-STOP control unit and the protective door are closed and whether the contactors have switched off.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
EMERGENCY-STOP	40-mm mushroom pushbutton with 1NC and yellow top	3SB3 801-0DG3	1	
	1NO contact block	3SB3 420-0C	1	
SIRIUS position switch	Position switch with separate actuator	3SE2 243-0XX40	2	
Actuator for position switch	Radius actuator	3SX3 228	2	
Safety monitor	Safety monitor with one OSSD	3RK1105-1AE04-0CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	2	
	Mounting plate (for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate (for wall mounting)	3RK1901-2EA00	2	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-0B	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 / K2 contactor	Contact, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable	3RK1901-5AA00	1	
	Transfer cable			
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

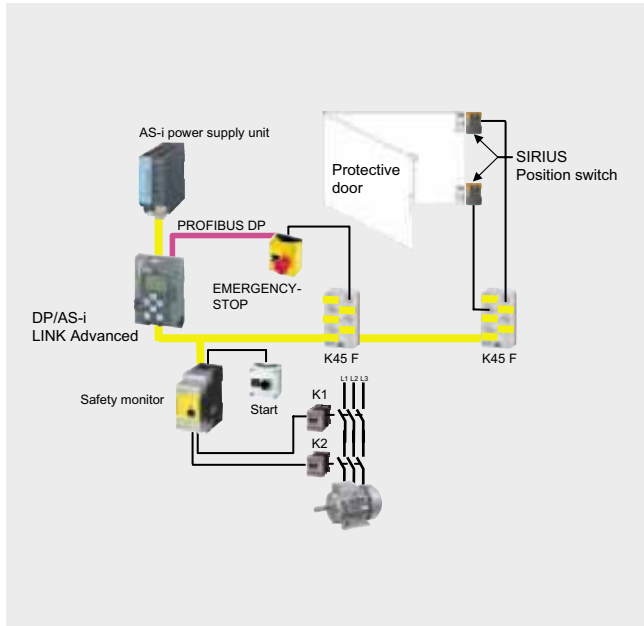
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

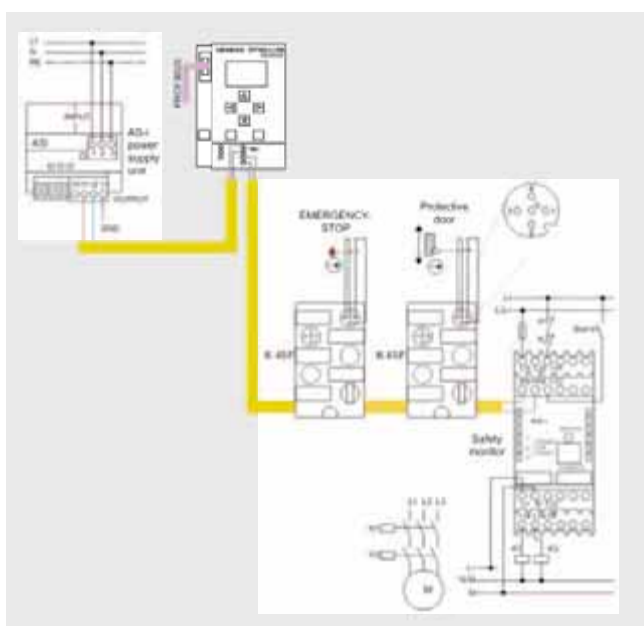
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

Overview of Hardware Setup



Hardware Component Wiring



Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
- Connect each AS-i slave to the AS-i line and allocate each the desired slave address (**K45F module, address 2**).

SYSTEM

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM




Result:

All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

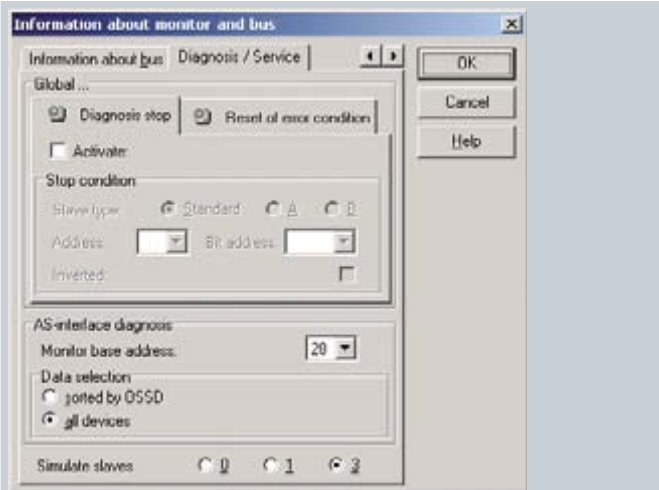
Description	Parameters
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>	
<p>Enter a name for the configuration in the Information about monitor tab, select the operating mode and the function range of the AS Interface safety monitor ("Basic" or "Enhanced").</p>	
<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	

Description Parameters

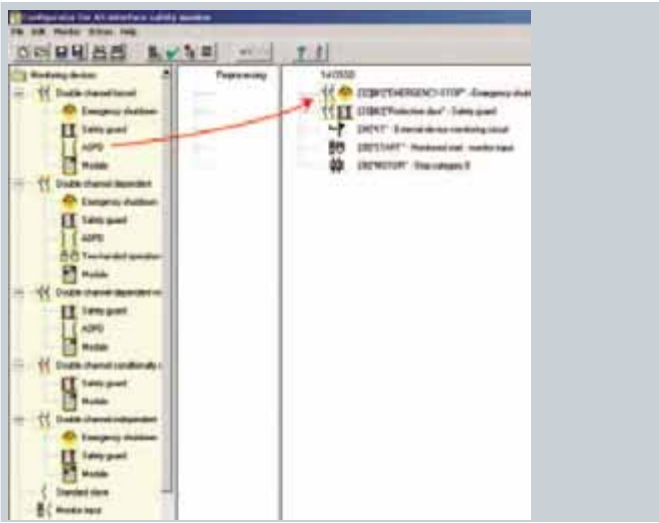
In the **Diagnosis / Service** tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis.

Simulating slaves

If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box **Simulate slaves**. At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.

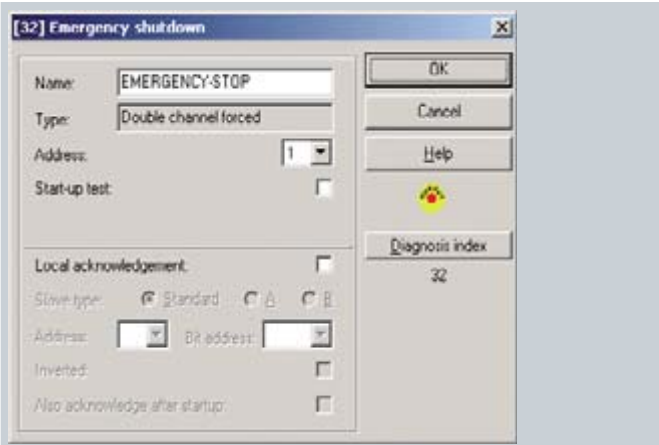


Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).



For the **double channel forced** monitoring device, the switching signal of the corresponding safe AS-Interface slave affects all 4 bits of the transfer sequence.

As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box **Always** is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.



Description

For the **double channel forced** monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed.

As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box **Always** is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.

Parameters

The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The **external device monitoring circuit** device is active = ON (switched on).


After the safety outputs have been switched off, the **external device monitoring circuit** device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.

Thereafter, the contactor control input is active = ON again. When the **external device monitoring circuit** is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position.

After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.

The **Monitored start - monitor input** device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the **monitored start - monitor input** start device relays the enabling request to the output device.

Ex. -No.
4.2

Description	Parameters
<p>When the circuit is enabled (ON), the signal output and the output circuit are simultaneously activated by the Stop category 0 output device. When the circuit is switched off (OFF), the signal output and the output circuit are immediately switched off without a delay.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the **Monitor** menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

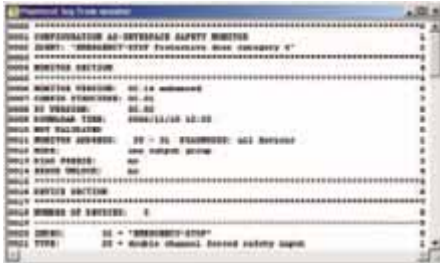
The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

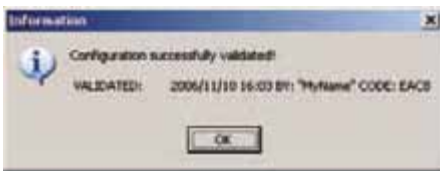


The provisional configuration log is displayed in **asimon** in its own window.

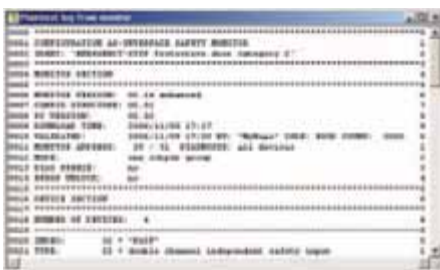
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor



If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

Protective door with door interlocking via a spring-actuated lock according to Category 3 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Locking mechanisms equipped with a tumbler are mechanical or electrical mechanisms which only allow a machine to be operated when the door is closed and locked. The interlocking remains in place until there is no longer any risk of injury due to dangerous machine functions or movements. Monitoring is usually carried out by a speed monitor or a standstill monitor. In this example, machine movement/standstill is simulated by the door release button.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

The protective door is monitored via a SIRIUS position switch equipped with a spring-actuated lock by an ASIsafe K45F module according to Category 3 of EN 954-1. When the door release is activated, the safety monitor switches the downstream contactors with positively-driven contacts via the first OSSD according to Stop category 0 of EN 60204-1. The protective door interlock is enabled with a delay.

A drive is shut down in this example. When the protective door is closed, a manual start is carried out after the position switch and the downstream contacts have been checked.

Functionality of the Functional Example

Problem

Implementation of a protective door interlock with a spring-actuated lock via ASIsafe. Category 3 of EN 954-1 is to be attained.

Solution

In the example presented here, an actuator mounted in the door moves into a form-fit mounted position switch with a tumbler. During the potential danger (machine in operation), the actuator is kept in position (and thus the door also remains closed) by the power supply being disconnected from a magnet in the position switch. This type of interlocking is referred to as a spring-actuated lock.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination
- Simple configuration via the asimon software
- The protective door remains locked even if there is a power outage.

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
SIRIUS position switch	Position switch with a spring-actuated lock, 2 NC/2 NC	3SE2840-6XX00	1	
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety monitor	Safety monitor with two OSSDs	3RK1105-1BE04-2CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	1	
ASi Safe module K45F	Compact module with 4 standard inputs	3RK1200-0CQ20-0AA3	1	
Accessories for K45 modules	Mounting plate(for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate(for wall mounting)	3RK1901-2EA00	2	
Door unlocking device	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Toggle switch with 2 switch positions	3SB30 00-2KA11	1	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 / K2 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable	3RK1901-5AA00	1	
	Transfer cable			
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

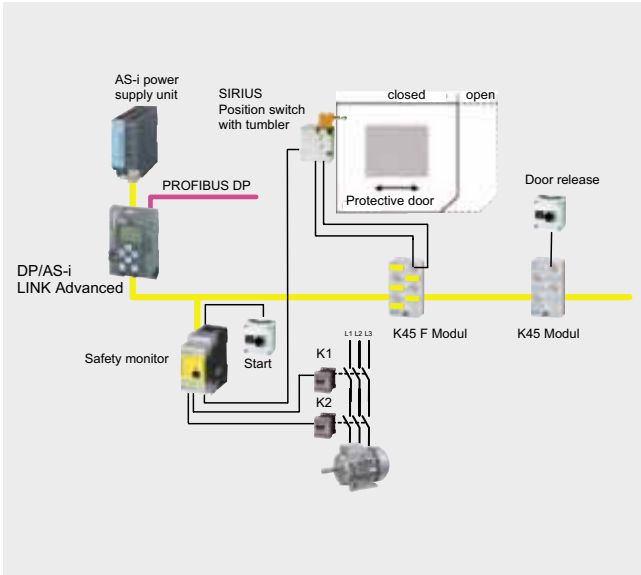
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

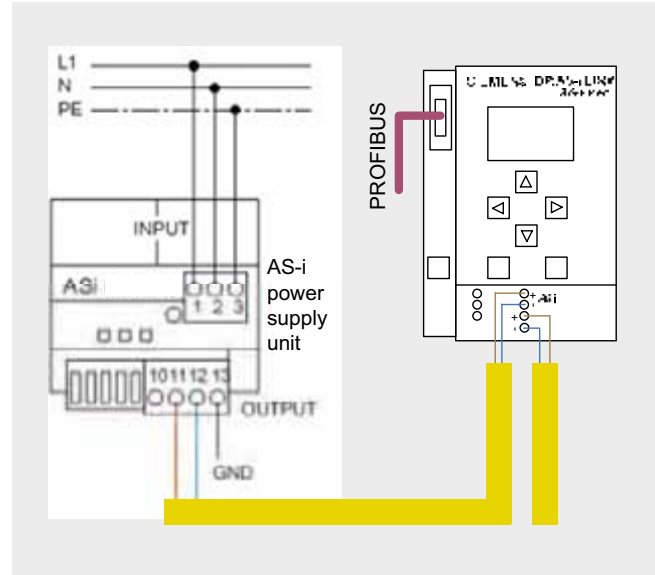
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

Overview of Hardware Setup



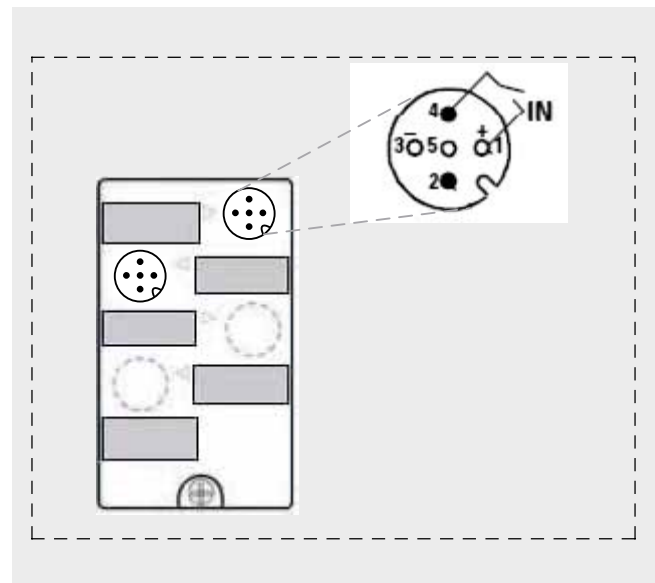
Hardware Component Wiring



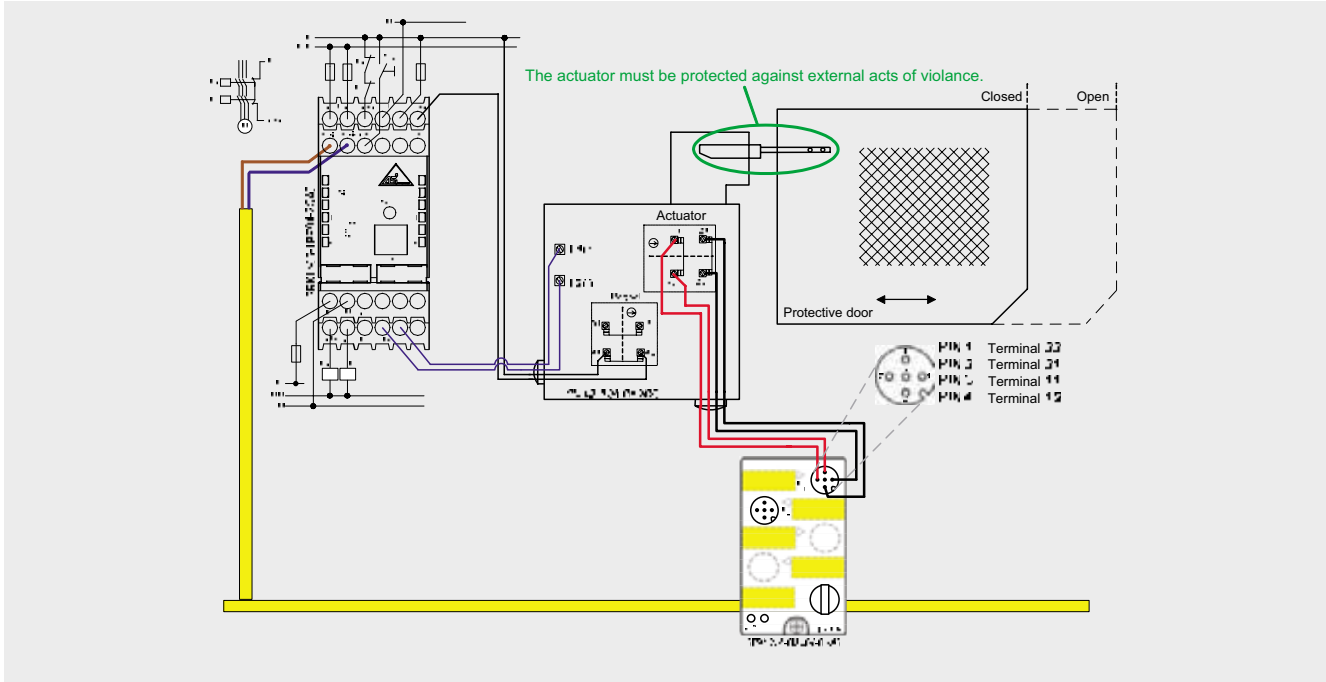
AS-i power supply unit and DP/AS-i Link wiring

Note

The actuator of the SIRIUS position switch must be protected against external acts of violence.



Wiring of the K45 module release



Wiring of the protective door and the safety monitor

Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
- Connect each AS-i slave to the AS-i line and allocate the desired slave address (**K45F module, address 1 / K45 standard module, address 2**).

SYSTEM

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM



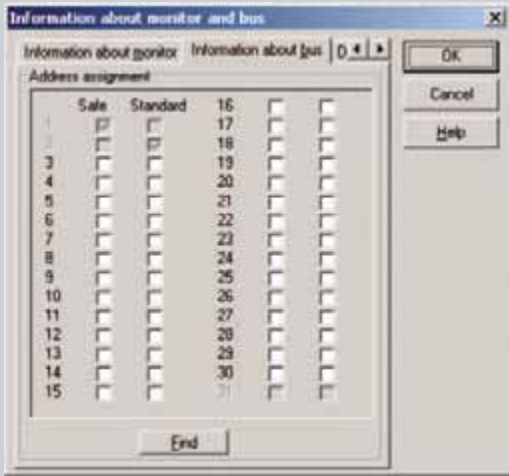
Result:

All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

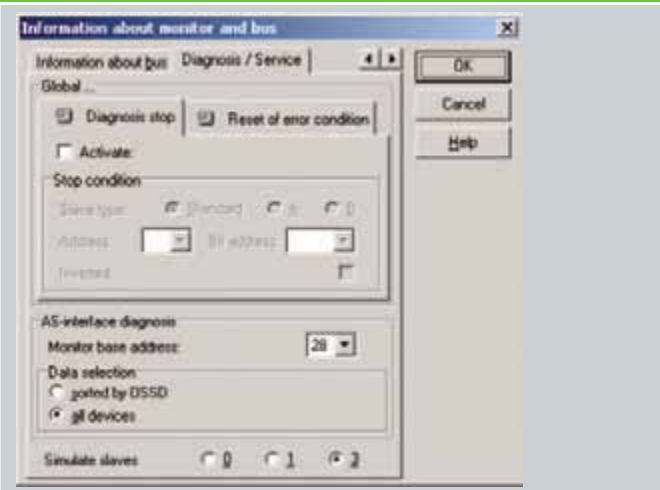
Description	Parameters																																																																
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>																																																																	
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<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	 <table border="1"> <thead> <tr> <th></th> <th>Safe</th> <th>Standard</th> <th>16</th> </tr> </thead> <tbody> <tr><td>1</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>2</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>3</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>4</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>5</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>6</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>7</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>8</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>9</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>10</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>11</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>12</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>13</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>14</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> <tr><td>15</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr> </tbody> </table>		Safe	Standard	16	1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	11	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	13	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	14	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	15	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Description **Parameters**

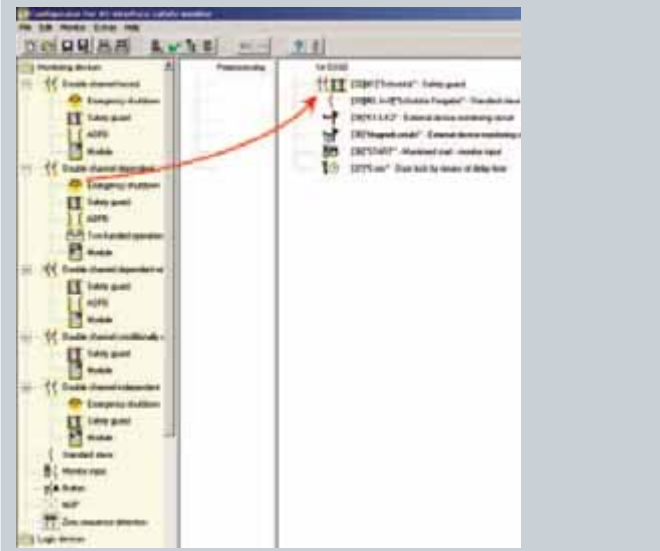
In the **Diagnosis / Service** tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis.




Simulating slaves



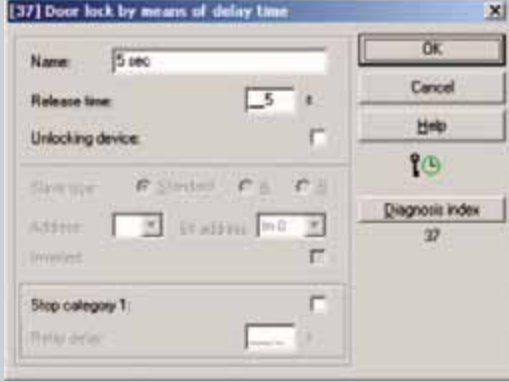
If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box **Simulate slaves**. At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.



Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).



Description	Parameters
<p>For the double channel dependent monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed.</p> <p>As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box Always is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.</p>	
<p>The Standard slave monitoring device is used to integrate a bit (input or output) of a standard AS-Interface slave that is not safety-oriented as an additional switching signal for standard switching of the AS-Interface safety monitor relay(s) in an OSSD.</p> <p>The protective door is unlocked via this device.</p>	
<p>The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The external device monitoring circuit device is active = ON (switched on).</p> <p>After the safety outputs have been switched off, the external device monitoring circuit device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.</p> <p>Thereafter, the contactor control input is active = ON again. When the external device monitoring circuit device is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position.</p> <p>After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.</p>	

Description	Parameters
<p>The external device monitoring circuit for a dependent, second OSSD has the same function as the standard external device monitoring circuit.</p> <p>This circuit monitors the second channel, but does not have any effect on the enabling of channel 1.</p> <p>In this example, the magnet contact is monitored by the second external device monitoring circuit.</p>	
<p>The Monitored start - monitor input device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the Monitored start - monitor input start device relays the enabling request to the output device.</p>	
<p>After the first output circuit is switched off, the second output circuit is switched on after the set delay time elapses. The delay time can be set between 1 s and 300 s in 1 s increments. The second output circuit must be switched off before the first output circuit is switched on.</p> <p>If the door is enabled, status ON, before the second output circuit is switched on, the first output circuit is switched on again and the second output circuit remains switched off.</p> <p>Unlocking function</p> <p>After the first output circuit is switched off via the door release and the set delay time has elapsed (or via the standstill monitor), the second output circuit switches on, so that in turn the doors are unlocked. This type of unlocking is not always desired.</p> <p>By activating the Unlocking device checkbox, a standard slave can be specified whose status (LOCK signal) determines whether or not the interlocking should remain after the delay time has elapsed.</p> <p>When the machine is switched off, the LOCK signal enables the door interlock to be switched on or off as desired.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

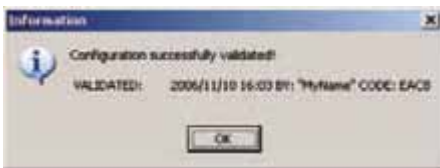


The provisional configuration log is displayed in **asimon** in its own window.

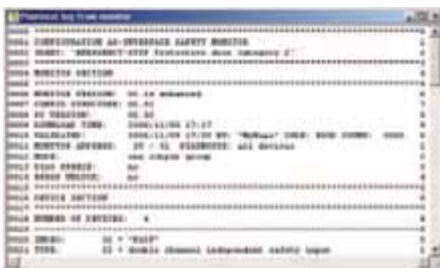
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor



If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

Protective door with door interlocking via a spring-actuated lock according to Category 4 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Locking mechanisms equipped with a tumbler are mechanical or electrical mechanisms which only allow a machine to be operated when the door is closed and locked. The interlocking remains in place until there is no longer any risk of injury due to dangerous machine functions or movements. Monitoring is usually carried out by a speed monitor or a standstill monitor. In this example, machine movement/standstill is simulated by the door release button.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

The protective door is monitored via a SIRIUS position switch equipped with a spring-actuated lock by an ASIsafe K45F module according to Category 4 of EN 954-1. When the door release is activated, the safety monitor switches the downstream contactors with positively-driven contacts via the first OSSD according to Stop category 0 of EN 60204-1. The protective door interlock is enabled with a delay.

A drive is shut down in this example. When the protective door is closed, a manual start is carried out after the position switch and the downstream contacts have been checked.

Functionality of the Functional Example

Problem

Implementation of a protective door interlock with a spring-actuated lock via ASIsafe. Category 4 of EN 954-1 is to be attained.

Solution

In the example presented here, an actuator mounted in the door moves into a form-fit mounted position switch with a tumbler. During the potential danger (machine in operation), the actuator is kept in position (and thus the door also remains closed) by the power supply being disconnected from a magnet in the position switch. This type of interlocking is referred to as a spring-actuated lock.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination
- Simple configuration via the asimon software
- The protective door remains locked even if there is a power outage.

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES7307-1EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
SIRIUS position switch	Position switch with a spring-actuated lock, 2 NC/2 NC	3SE2840-6XX00	1	
	Position switch with a twist lever	3SE2120-1GW	1	
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety monitor	Safety monitor with two OSSDs	3RK1105-1BE04-2CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	1	
ASi Safe module K45F	Compact module with 4 standard inputs	3RK1200-0CQ20-0AA3	1	
Accessories for K45 modules	Mounting plate(for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate(for wall mounting)	3RK1901-2EA00	2	
Door unlocking device	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Toggle switch with 2 switch positions	3SB30 00-2KA11	1	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 / K2 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable Transfer cable	3RK1901-5AA00	1	
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

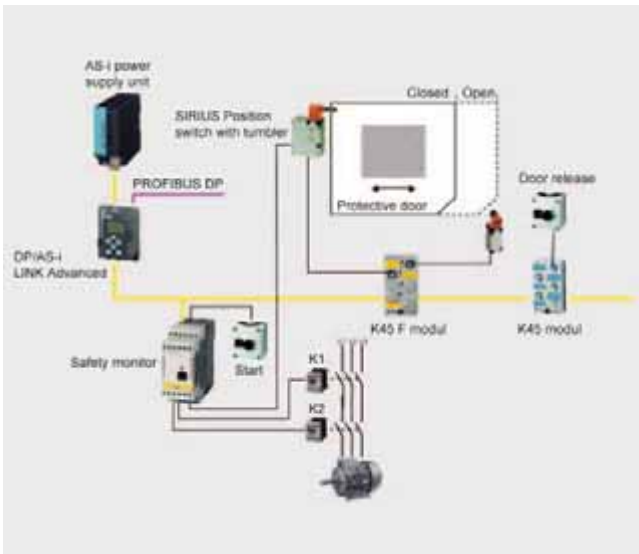
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

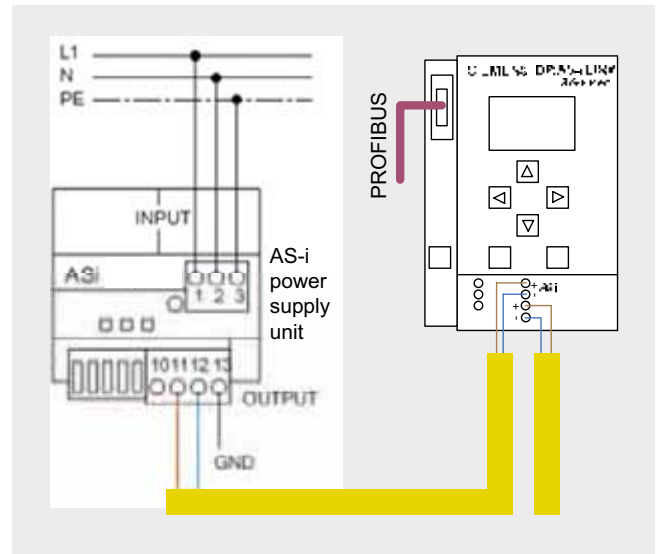
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

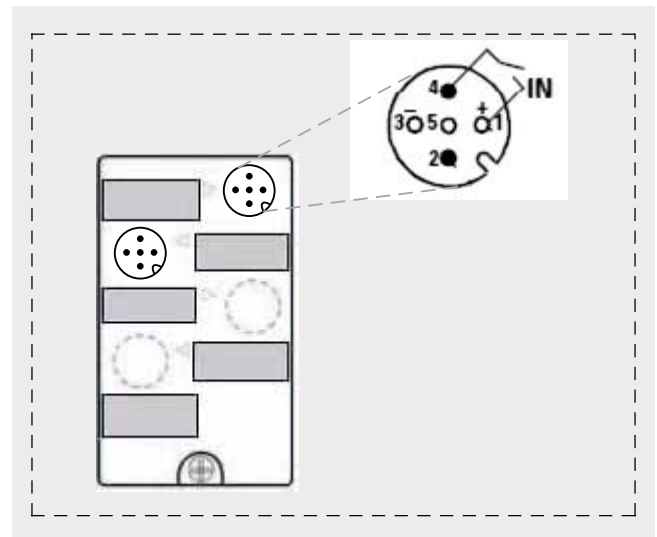
Overview of Hardware Setup



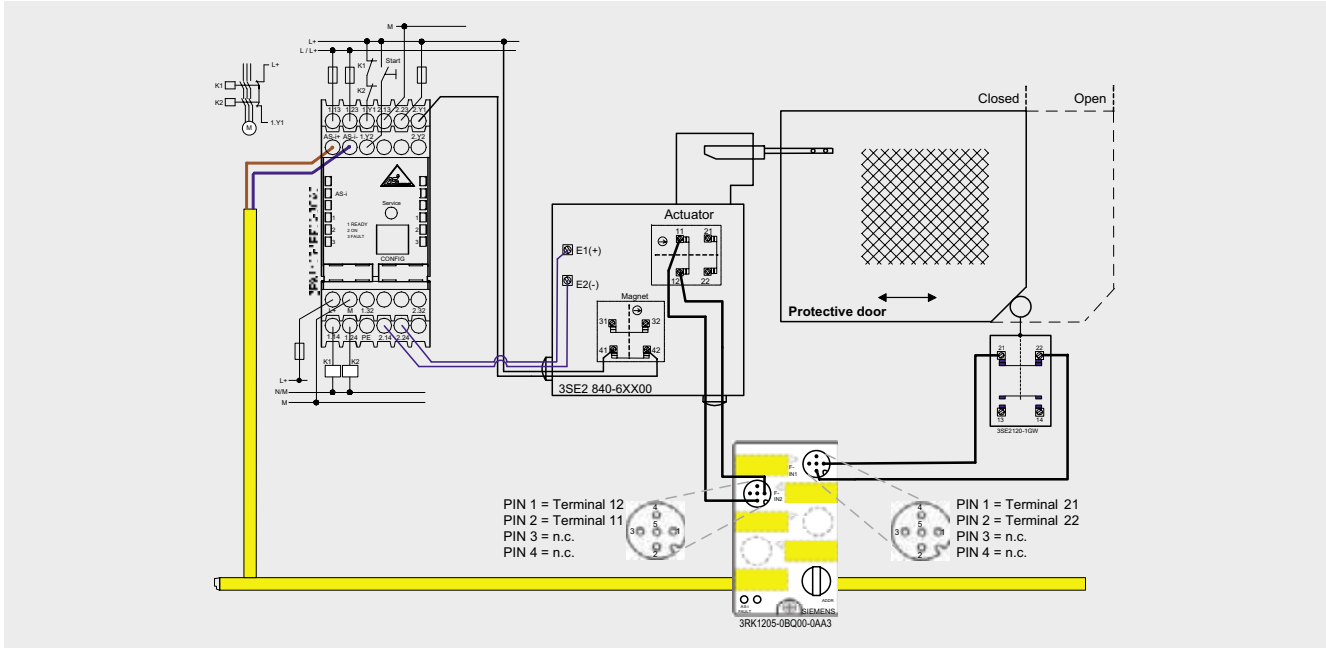
Hardware Component Wiring



AS-i power supply unit and DPIAS-i Link wiring



Wiring of the K45 module door release



Wiring of the protective door and the safety monitor

Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
- Connect each AS-i slave to the AS-i line and allocate the desired slave address (**K45F module, address 1 / K45 standard module, address 2**).

SYSTEM AS-i line 1 Lifelist Change address Change slave address

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM AS-i line 1 Lifelist Actual -> Defined Actual -> Adopt defined




Result:




All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.




Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

Description	Parameters
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>	
<p>Enter a name for the configuration in the Information about monitor tab, and select the operating mode and the function range of the AS Interface safety monitor ("Basic" or "Enhanced").</p> <p>When the operating mode two dependent OSSDs is selected, the second OSSD is dependent on the first OSSD.</p>	
<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	

Description	Parameters
<p>For the double channel dependent monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed.</p> <p>As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box Always is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.</p>	
<p>The Standard slave monitoring device is used to integrate a bit (input or output) of a standard AS-Interface slave that is not safety-oriented as an additional switching signal for standard switching of the AS-Interface safety monitor relay(s) in an OSSD.</p> <p>The protective door is unlocked via this device.</p>	
<p>The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The external device monitoring circuit is active = ON (switched on).</p> <p>After the safety outputs have been switched off, the external device monitoring circuit device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.</p> <p>Thereafter, the contactor control input is active = ON again. When the external device monitoring circuit is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position.</p> <p>After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.</p>	

Description	Parameters
<p>The external device monitoring circuit for a dependent, second OSSD has the same function as the standard external device monitoring circuit.</p> <p>This circuit monitors the second channel, but does not have any effect on the enabling of channel 1.</p> <p>In this example, the magnet contact is monitored by the second external device monitoring circuit.</p>	
<p>The Monitored start - monitor input device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the monitored start - monitor input start device relays the enabling request to the output device.</p>	
<p>After the first output circuit is switched off, the second output circuit is switched on after the set delay time elapses. The delay time can be set between 1 s and 300 s in 1 s increments. The second output circuit must be switched off before the first output circuit is switched on. If the door is enabled, status ON, before the second output circuit is switched on, the first output circuit is switched on again and the second output circuit remains switched off.</p> <p>Unlocking function</p> <p>After the first output circuit is switched off via the door release and the set delay time has elapsed (or via the standstill monitor), the second output circuit switches on, so that in turn the doors are unlocked. This type of unlocking is not always desired.</p> <p>By activating the Unlocking device checkbox, a standard slave can be specified whose status (LOCK signal) determines whether or not the interlocking should remain after the delay time has elapsed.</p> <p>When the machine is switched off, the LOCK signal enables the door interlock to be switched on or off as desired.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the AS-Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

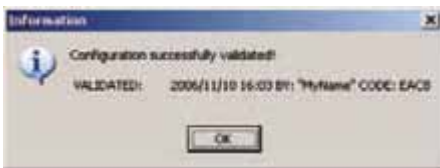


The provisional configuration log is displayed in **asimon** in its own window.

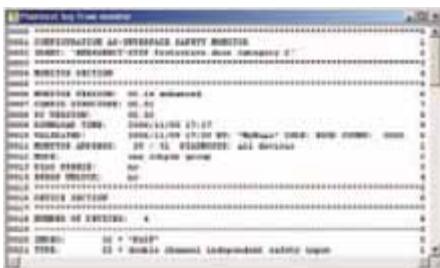
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor



If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

Protective door with door interlocking via a magnet-field lock according to Category 3 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Locking mechanisms equipped with a tumbler are mechanical or electrical mechanisms which only allow a machine to be operated when the door is closed and locked. The interlock remains in place until there is no longer any risk of injury due to dangerous machine functions or movements. Monitoring is usually carried out by a speed monitor or a standstill monitor. In this example, machine movement/standstill is simulated by the door release button.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

The protective door is monitored via a SIRIUS position switch equipped with a magnet-field lock by an ASIsafe K45F module according to Category 3 of EN 954-1. When the door release is activated, the safety monitor switches the downstream contactors with positively-driven contacts via the first OSSD according to Stop category 0 of EN 60204-1. The protective door interlock is enabled with a delay.

A drive is shut down in this example. When the protective door is closed, a manual start is carried out after the position switch and the downstream contacts have been checked.

Functionality of the Functional Example

Problem

Implementation of a protective door interlock with a magnet-field lock via ASIsafe. Category 3 of EN 954-1 is to be attained.

Solution

In the example presented here, an actuator mounted in the door moves into a form-fit mounted position switch with a tumbler. During the potential danger (machine in operation), the actuator is kept in position (and thus the door also remains closed) by the power supply being supplied to a magnet in the position switch. This type of interlocking is referred to as a magnet-field lock.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination
- Simple configuration via the asimon software
- The protective door is no longer locked in the case of a power outage.

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
SIRIUS position switch	Position switch with a spring-actuated lock, 2 NC/2 NC	3SE2 830-6XX00	1	
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety monitor	Safety monitor with two OSSDs	3RK1105-1BE04-2CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	1	
ASi Safe module K45F	Compact module with 4 standard inputs	3RK1200-0CQ20-0AA3	1	
Accessories for K45 modules	Mounting plate(for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate(for wall mounting)	3RK1901-2EA00	2	
Door unlocking device	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Toggle switch with 2 switch positions	3SB30 00-2KA11	1	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 / K2 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable	3RK1901-5AA00	1	
	Transfer cable			
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

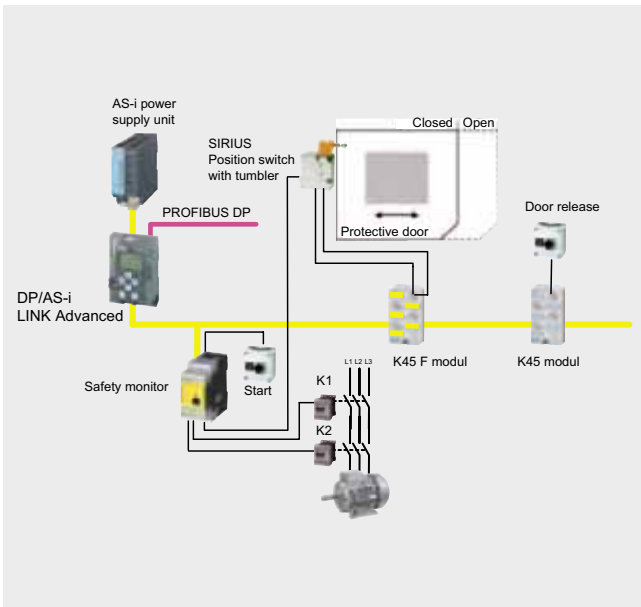
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

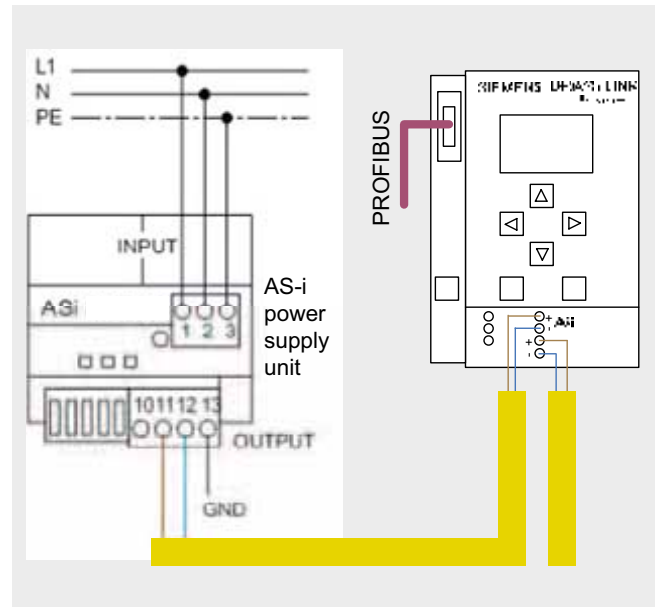
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

Overview of Hardware Setup



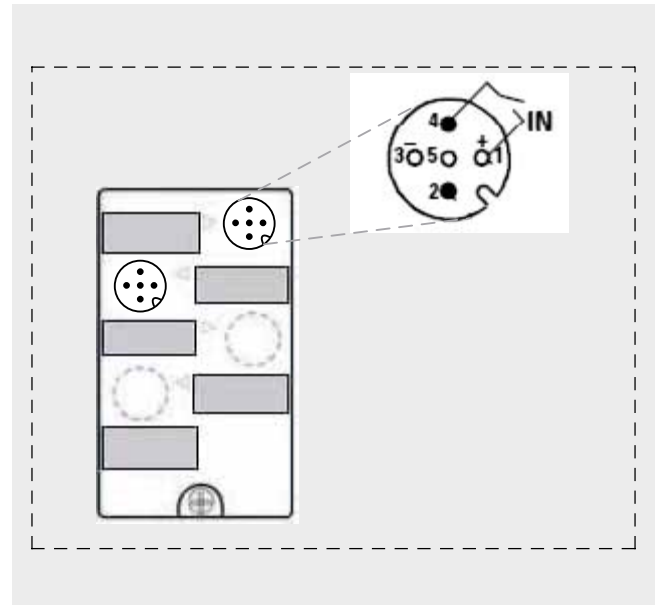
Hardware Component Wiring



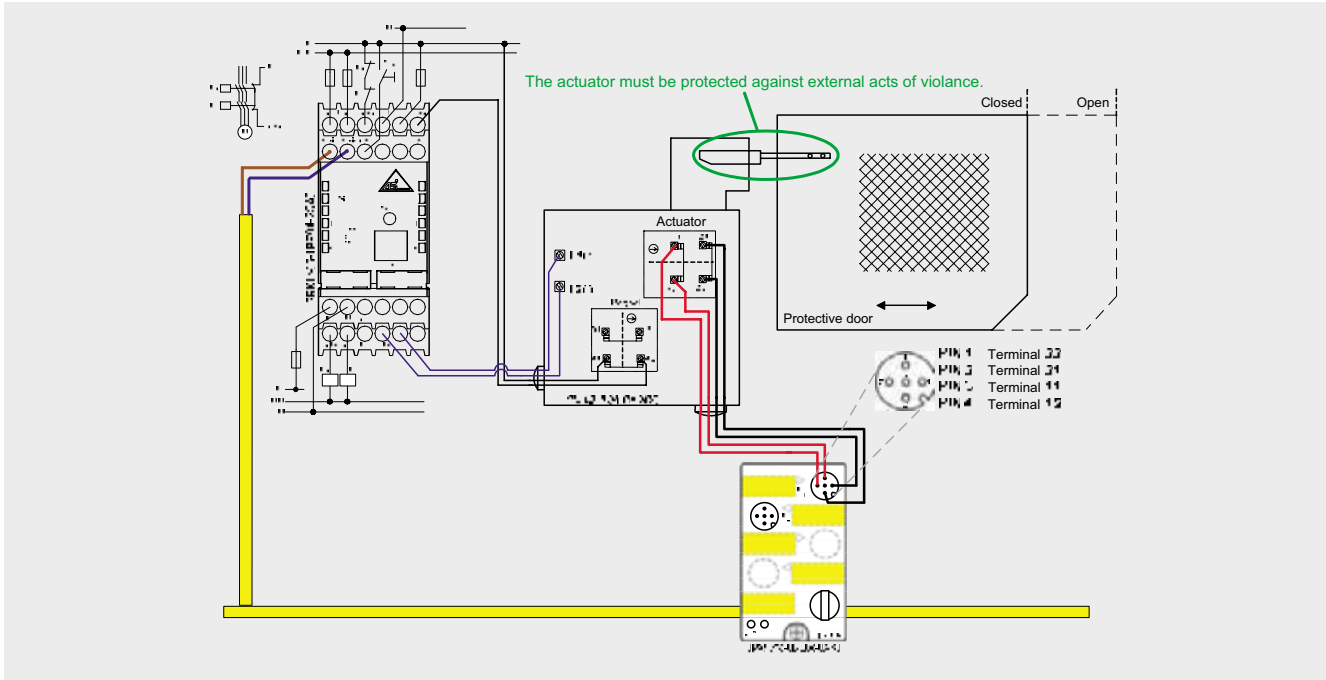
AS-i power supply unit and DP/AS-i Link wiring

Note

The actuator of the SIRIUS position switch must be protected against external acts of violence.



Wiring of the K45 module door release



Wiring of the protective door and the safety monitor

Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
- Connect each AS-i slave to the AS-i line and allocate the desired slave address (**K45F module, address 1 / K45 standard module, address 2**).

SYSTEM AS-i line 1 Lifelist Change address
Change slave address

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM AS-i line 1 Lifelist Actual -> Defined
Actual -> Adopt defined



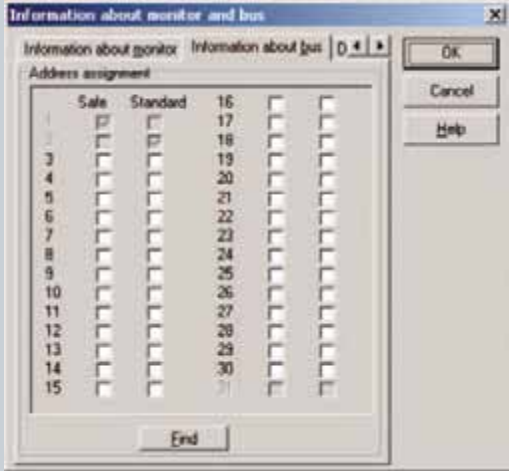
Result:

All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

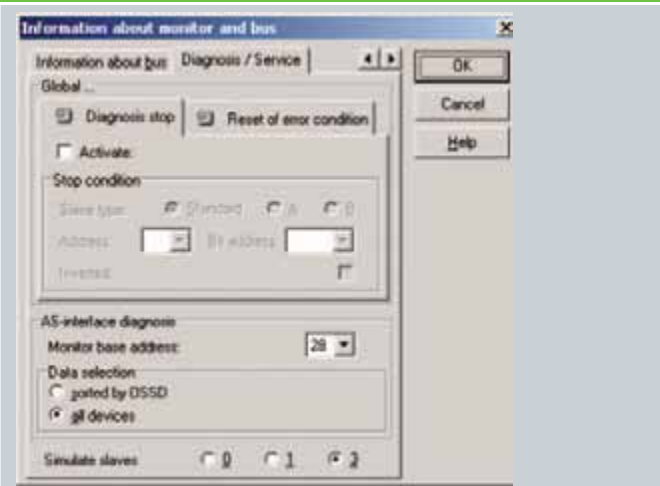
Description	Parameters
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>	
<p>Enter a name for the configuration in the Information about monitor tab, and select the operating mode and the function range of the AS Interface safety monitor ("Basic" or "Enhanced").</p> <p>When the operating mode two dependent OSSDs is selected, the second OSSD is dependent on the first OSSD.</p>	
<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	

Description Parameters

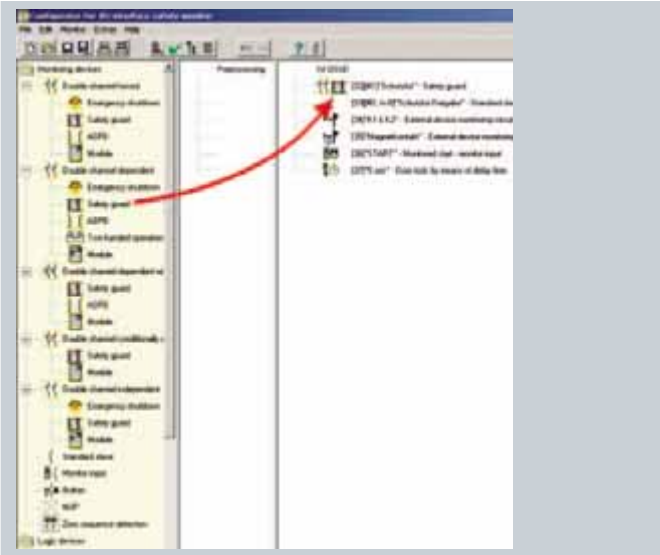
In the **Diagnosis / Service** tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis.




Simulating slaves



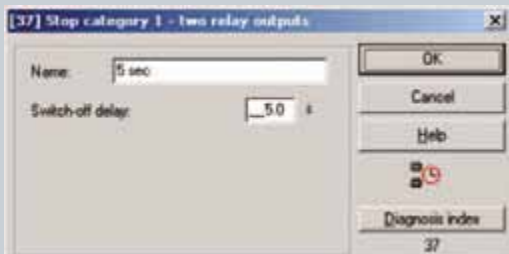
If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box **Simulate slaves**. At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.



Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).



Description	Parameters
<p>For the double channel dependent monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed.</p> <p>As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box Always is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.</p>	
<p>The Standard slave monitoring device is used to integrate a bit (input or output) of a standard AS-Interface slave that is not safety-oriented as an additional switching signal for standard switching of the AS-Interface safety monitor relay(s) in an OSSD.</p> <p>The protective door is unlocked via this device.</p>	
<p>The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The external device monitoring circuit is active = ON (switched on).</p> <p>After the safety outputs have been switched off, the external device monitoring circuit device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.</p> <p>Thereafter, the contactor control input is active = ON again. When the external device monitoring circuit is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position. After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.</p>	

Description	Parameters
<p>The external device monitoring circuit for a dependent, second OSSD has the same function as the standard external device monitoring circuit. This circuit monitors the second channel, but does not have any effect on the enabling of channel 1.</p> <p>In this example, the magnet contact is monitored by the second external device monitoring circuit.</p>	
<p>The Monitored start - monitor input device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the monitored start - monitor input start device relays the enabling request to the output device.</p>	
<p>When the circuit is enabled (ON), the output circuits (2 relays each) of both OSSDs are simultaneously activated by the Stop category 1 - two relay outputs output device.</p> <p>When the circuit is switched off (OFF), the output circuit of OSSD 1 is immediately switched off without a delay. The output circuit of the dependent OSSD is switched off after the set switch-off delay has elapsed. The switch-off delay can be set between 0 s and 300 s in 100 ms increments. It is not possible to switch the system on again until both output circuits have switched off.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

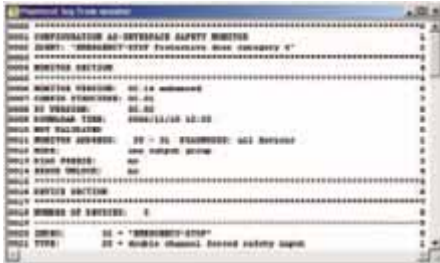
The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

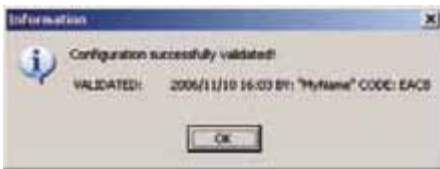


The provisional configuration log is displayed in **asimon** in its own window.

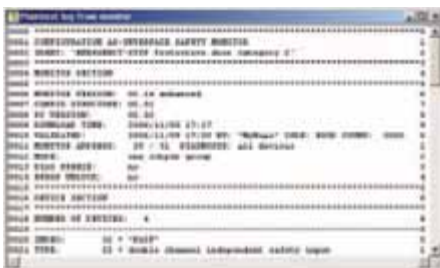
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor

The safety monitor is running in protective operation

If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

Protective door with door interlocking via a magnet-field lock according to Category 4 of EN 954-1

Automation Function

Scope of Validity of this Functional Example

Locking mechanisms equipped with a tumbler are mechanical or electrical mechanisms which only allow a machine to be operated when the door is closed and locked. The interlocking remains in place until there is no longer any risk of injury due to dangerous machine functions or movements. Monitoring is usually carried out by a speed monitor or a standstill monitor. In this example, machine movement/standstill is simulated by the door release button.

A standard AS-i network consists of control/master, power supply unit, a yellow AS-i cable and various slaves. Only two further components are necessary for safe usage: A safety monitor and safe slaves.

Each safe slave is programmed with a factory-default code table that clearly identifies each slave for the safety monitor.

At each master prompt, correlation is checked between the code value expected by the comparator (safety monitor) and the code value actually sent by the slave. In the case of deviations or time-outs, disconnection via 2-channel OSSDs occurs on the safety monitor.

The protective door is monitored via a SIRIUS position switch equipped with a magnet-field lock by an ASIsafe K45F module according to Category 4 of EN 954-1. When the door release is activated, the safety monitor switches the downstream contactors with positively-driven contacts via the first OSSD according to Stop category 0 of EN 60204-1. The protective door interlock is enabled with a delay.

A drive is shut down in this example. When the protective door is closed, a manual start is carried out after the position switch and the downstream contacts have been checked.

Functionality of the Functional Example

Problem

Implementation of a protective door interlock with a magnet-field lock via ASIsafe. Category 4 of EN 954-1 is to be attained.

Solution

In the example presented here, an actuator mounted in the door moves into a form-fit mounted position switch with a tumbler. During the potential danger (machine in operation), the actuator is kept in position (and thus the door also remains closed) by the power supply being supplied to a magnet in the position switch. This type of interlocking is referred to as a magnet-field lock.

Advantages / Customer Benefits

- Secure and non-secure data on one bus
- Simple assembly thanks to standardized AS-i technology
- Existing system can be quickly and easily expanded
- Integration of safety signals in the system diagnosis
- Failsafe PLC or special master not required
- Space-saving design thanks to compact safety combination
- Simple configuration via the asimon software
- The protective door is no longer locked in the case of a power outage.

Required Components

This chapter contains an overview of the hardware and software components required for the Functional Example.

Hardware components

Component	Type	Order No. / Order Information	Quantity	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
AS-i power supply unit	3 A power supply unit	3RX9501-0BA00	1	
DP/AS-i LINK Advanced	IP20 degree of protection, router from PROFIBUS DP to AS-Interface	6GK1415-2BA10	1	
SIRIUS position switch	Position switch with a spring-actuated lock, 2 NC/2 NC	3SE2 830-6XX00	1	
	Position switch with a twist lever	3SE2120-1GW	1	
Actuator for position switch	Radius actuator	3SX3 228	1	
Safety monitor	Safety monitor with two OSSDs	3RK1105-1BE04-2CA0	1	
ASi Safe module K45F	Compact module with two safe inputs	3RK1205-0BQ00-0AA3	1	
ASi Safe module K45F	Compact module with 4 standard inputs	3RK1200-0CQ20-0AA3	1	
Accessories for K45 modules	Mounting plate(for standard mounting rail)	3RK1901-2DA00	2	
	Optional: Mounting plate(for wall mounting)	3RK1901-2EA00	2	
Door unlocking device	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Toggle switch with 2 switch positions	3SB30 00-2KA11	1	
Start button	Empty command point enclosure	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22 mm nominal diameter	3SB3 000-0AA11	1	
	Optional: "Start" designation plate	3SB3 906-1EL	1	
K1 / K2 contactor	Contactor, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00, screw terminal	3RT1015-1BB42	2	
Cable loom	PC configuration cable	3RK1901-5AA00	1	
	Transfer cable			
AS-i shaped cable	Yellow rubberized cable	3RX9010-0AA00	1	

Note

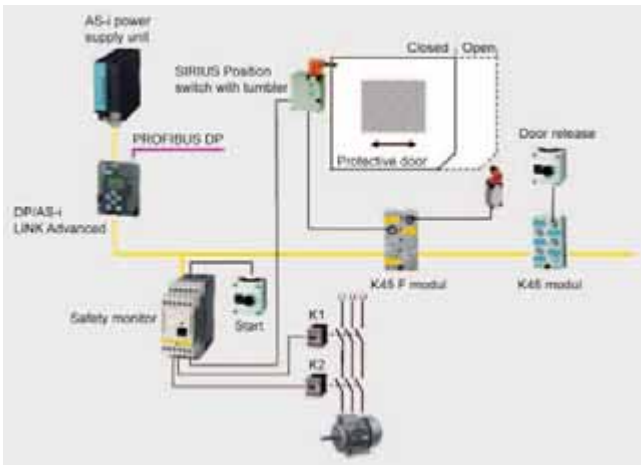
Functionality was tested with the hardware components listed above. Similar products not found in this list may also be used. If this is the case, please note that it may be necessary to change the example code (e.g. change the settings of other addresses).

Software components

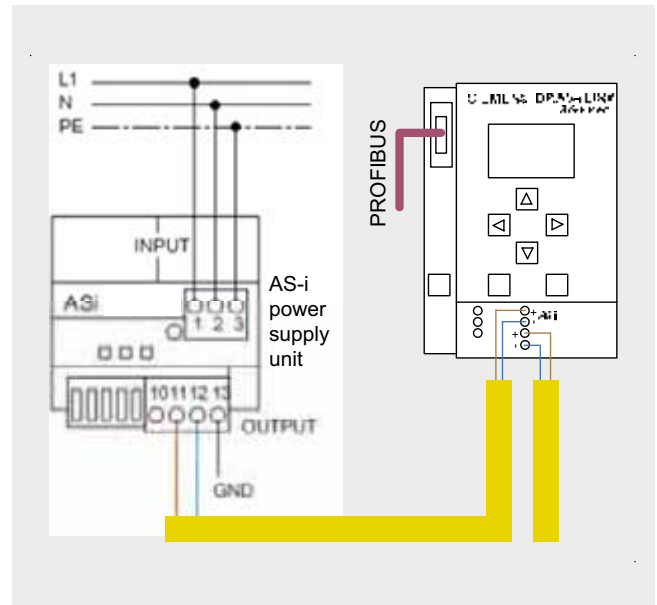
Component	Type	Order No. / Order Information	Quantity	Manufacturer
asimon	Safety monitor configuration	3RK1802-2FB06-0GA0	1	Siemens AG

Assembly and Wiring

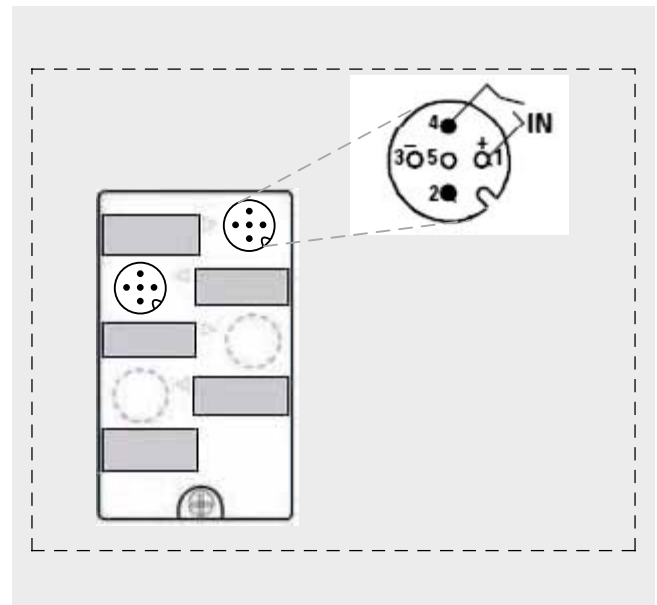
Overview of Hardware Setup



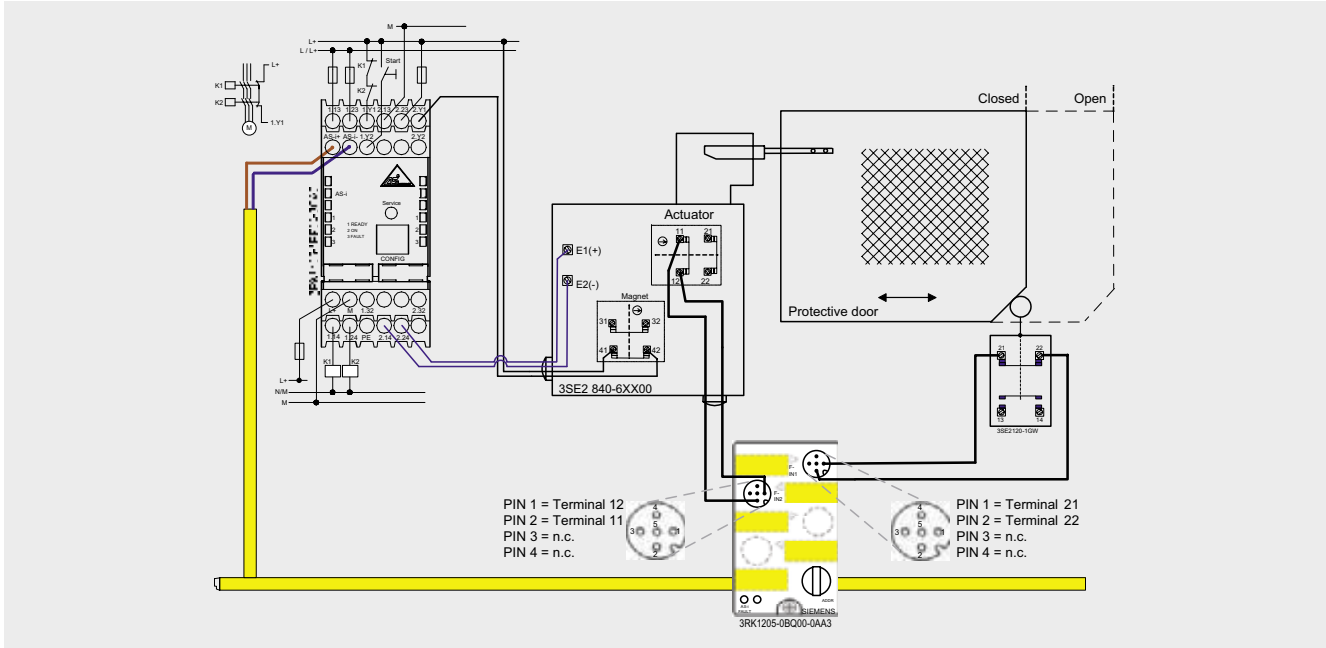
Hardware Component Wiring



AS-i power supply unit and DPLAS-i Link wiring



AS-i power supply unit and DPLAS-i Link wiring



Wiring of the protective door and the safety monitor

Important Hardware Component Settings

DP/AS-i LINK Advanced

Prerequisites:

- The DP/AS-INTERFACE LINK Advanced is mounted and connected to the AS-i line.
- The AS-i power supply unit is connected to the AS-i line.
- The AS-i slaves are not yet connected.
- The slaves that are to be connected have default address "0" (delivery status).

Procedure/Working on the DP/AS-INTERFACE LINK Advanced:

- Switch on the AS-i power supply unit so that the DP/AS-INTERFACE LINK Advanced is in operation
- Connect each AS-i slave to the AS-i line and allocate the desired slave address (**K45F module, address 1 / K45 standard module, address 2**).

SYSTEM AS-i line 1 Lifelist Change address Change slave address

- Adopt the actual configuration of the slave as the defined configuration in the DP/AS-INTERFACE LINK Advanced

SYSTEM AS-i line 1 Lifelist Actual -> Defined Actual -> Adopt defined

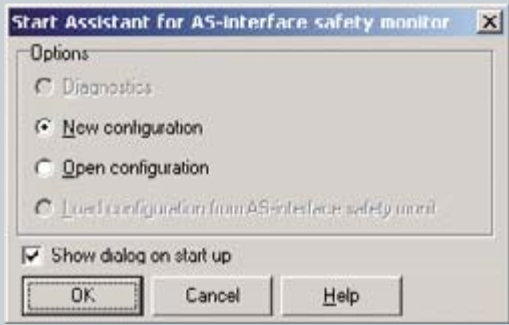

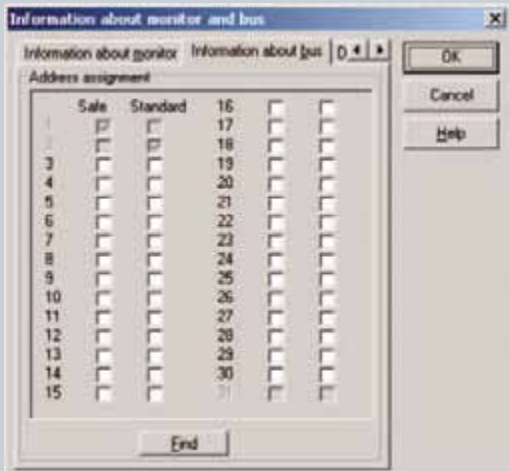
Result:

All displays for the AS-i line on the DP/AS-INTERFACE LINK Advanced are off or green, i.e. all slaves have been successfully integrated.

Example Code

This chapter describes which functions are implemented and how the asimon program is structured.

Description of the asimon Program

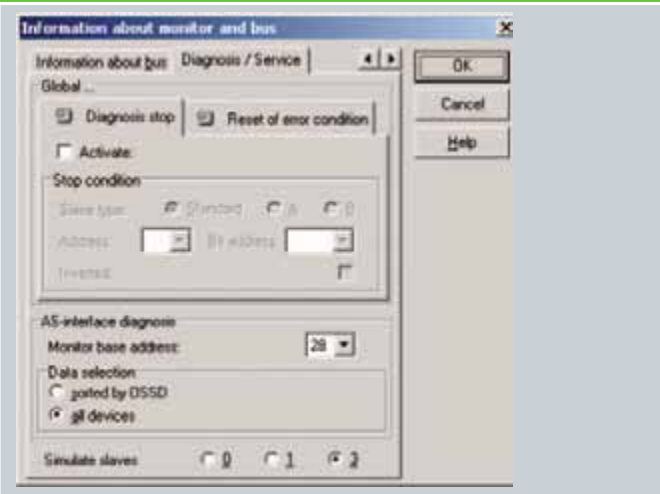
Description	Parameters
<p>After the asimon software has been started, the start assistant is used to create a new safety monitor configuration.</p>	
<p>Enter a name for the configuration in the Information about monitor tab, and select the operating mode and the function range of the AS-Interface safety monitor ("Basic" or "Enhanced").</p> <p>When the operating mode two dependent OSSDs is selected, the second OSSD is dependent on the first OSSD.</p>	
<p>In the Information about bus tab, you must enter the AS-Interface bus addresses of the standard slaves used and the safety-oriented AS-Interface slaves in this network.</p>	

Description **Parameters**

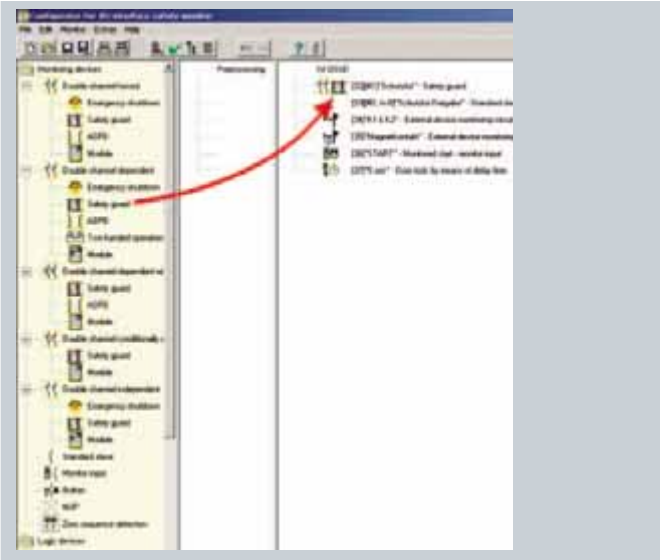
In the **Diagnosis / Service** tab you can adjust the settings for "Diagnosis stop" and "Reset of error condition" as well as configure the AS-Interface bus diagnosis.




Simulating slaves

If less than 4 safe or standard AS-Interface slaves are connected to the AS-Interface bus, you must activate the control box **Simulate slaves**. At least 4 slave addresses must be activated to ensure that the AS-Interface safety monitor functions correctly.



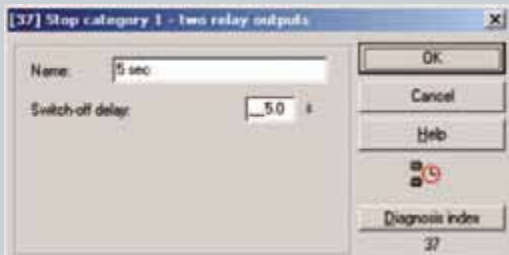


Configuration of an AS-Interface safety monitor with asimon software is graphic interactive, i.e. you can select and collectively configure the safe AS-Interface slaves that are to be monitored and further function devices from a symbol library that is classified according to devices (left window).



Description	Parameters
<p>For the double channel dependent monitoring device, each of the two switching signals of the corresponding safe AS-Interface slaves affects 2 bits of the transfer sequence. Both switching signals must be received within the synchronization time defined by the user. If only one contact opens, the second contact must also open before both contacts can be once again closed.</p> <p>As an option, a start-up test and/or a local acknowledgement can be carried out. When the control box Always is activated, a local acknowledgement must also always be carried out whenever the AS-Interface safety monitor is switched on or a communication error (warm restart of the AS-Interface safety monitor) occurs.</p>	
<p>The Standard slave monitoring device is used to integrate a bit (input or output) of a standard AS-Interface slave that is not safety-oriented as an additional switching signal for standard switching of the AS-Interface safety monitor relay(s) in an OSSD.</p> <p>The protective door is unlocked via this device (door release).</p>	
<p>The contactor control input of the AS-Interface safety monitor must be active = ON as long as the safety outputs are switched off. After the safety outputs are switched on (enabled), the contactor control input is no longer relevant for the set switching time. Thereafter, the input must be inactive = OFF. The external device monitoring circuit is active = ON (switched on).</p> <p>After the safety outputs have been switched off, the external device monitoring circuit device becomes inactive = OFF (switched off) and the contactor control input is no longer queried for the duration of the set switching time.</p> <p>Thereafter, the contactor control input is active = ON again. When the external device monitoring circuit is inactive = OFF, the safety outputs cannot be switched on again until the downstream contactor has reached its resting position.</p> <p>After switching on the AS-Interface safety monitor, the contactor control input must be active = ON.</p>	

Ex. No.
4.6

Description	Parameters
<p>The external device monitoring circuit for a dependent, second OSSD has the same function as the standard external device monitoring circuit. This circuit monitors the second channel, but does not have any effect on the enabling of channel 1.</p> <p>In this example, the magnet contact is monitored by the second external device monitoring circuit.</p>	
<p>The Monitored start - monitor input device requires activation of the start input of the corresponding OSSD as an additional start requirement. If the AND link of all the monitoring, linking and external device monitoring circuit devices of an OSSD delivers an ON result, and if the start requirements have been fulfilled, the monitored start - monitor input start device relays the enabling request to the output device.</p>	
<p>When the circuit is enabled (ON), the output circuits (2 relays each) of both OSSDs are simultaneously activated by the Stop category 1 - two relay outputs output device.</p> <p>When the circuit is switched off (OFF), the output circuit of OSSD 1 is immediately switched off without a delay. The output circuit of the dependent OSSD is switched off after the set switch-off delay has elapsed. The switch-off delay can be set between 0 s and 300 s in 100 ms increments. It is not possible to switch the system on again until both output circuits have switched off.</p>	

Commissioning the AS Interface Safety Monitor

Transferring a configuration to the AS Interface safety monitor



To transfer the current asimon configuration to the connected AS-Interface safety monitor, select the **Monitor** menu and then the **PC -> Monitor** command.

The configuration is then transferred to the AS-Interface safety monitor. Transfer takes several seconds.

After successful completion of the data transfer to the AS-Interface safety monitor, the configuration is saved in the AS-Interface safety monitor.

After transferring a configuration to a connected AS-Interface safety monitor, the safe configuration has to be "learned". To this end, the code tables of the safe AS-Interface slaves that are to be monitored are read in via the AS-Interface. The code table of each safe AS-Interface slave that is to be monitored is stored in the configuration log.

Learning the safe configuration

Before the safe configuration can be learned, the-AS Interface bus including all safe AS-Interface slaves that are to be monitored must be commissioned, and all safe AS-Interface slaves that are to be monitored must be switched ON. Only then can the AS-Interface safety monitor learn the code tables of all the relevant safe AS-Interface slaves.

To learn the code tables, select the **Teach safe configuration** in the Monitor menu and confirm the question "**Do you want to learn the code sequence?**" with **Yes**.

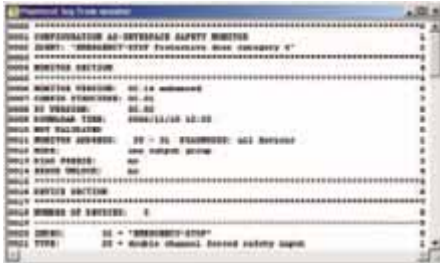
The code tables are then learned by the AS-Interface safety monitor. Learning takes several seconds. Progress is displayed in a window.

Once the code tables of all the safe AS-Interface slaves that are to be monitored have been successfully learned, a provisional configuration log will be immediately transferred to **asimon**.



The progress of the transfer of the provisional configuration log is displayed in a window.

An information window will then prompt you to have the configuration checked by the safety appointee responsible for the application using the configuration log.

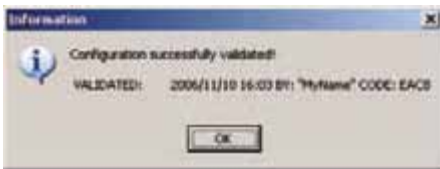


The provisional configuration log is displayed in **asimon** in its own window.

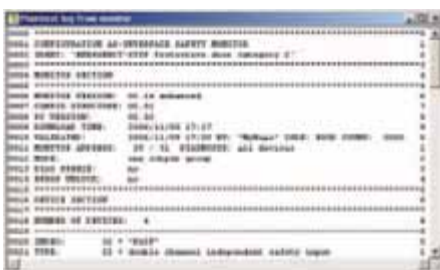
Configuration validation



To validate a configuration, select the **Validate** command in the **Monitor** menu. A window will appear in which you can validate a configuration by entering your name and password.



Confirm your entry with the **OK** button. An information window will then confirm that the configuration has been successfully validated.



The configuration log will then be immediately transferred. Progress of the transfer of the final configuration log is displayed in a window.

The final configuration log is displayed in **asimon** in its own window. To illustrate that the configuration has been validated and to differentiate between a validated and a provisional configuration log, the validation information will be displayed in Line 10.

Starting the AS-Interface safety monitor

The safety monitor is running in protective operation

If a valid, validated configuration is available on the AS-Interface safety monitor, you can switch the AS-Interface safety monitor from configuration mode to protection mode via the **Start** command in the **Monitor** menu. After the protection mode has been started, the status line will indicate the change to the new operating mode.

SIMOCODE pro direct starters with safety technology

Emergency stop monitoring with monitored start

Category 4 according to EN 954-1

Function

Description of the Functionality

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment. The EMERGENCY STOP control unit is a widely used component for protecting persons, machines and the environment against danger.

SIMOCODE pro is a flexible, modular motor management system for low-voltage motors with constant speeds. It optimizes the connection between I&C and the motor feeder, increases plant availability while helping to cut planning and commissioning costs during plant operation and maintenance. Integrated in the low-voltage switchgear, SIMOCODE pro is the intelligent connection between the higher-level automation system and the motor feeder.

In this Safety Functional Example, the EMERGENCY STOP control unit with positive opening contacts is monitored by a SIRIUS 3TK2823 safety switching device as per category 4 according to EN 954-1. If the EMERGENCY STOP is activated, the 3TK2823 safety switching device switches off its corresponding drive as per Stop Category 0 according to EN 60204-1.

Activation of the EMERGENCY STOP is signaled to the SIMOCODE pro via the IN4 input. This signal is used to activate the switching state in SIMOCODE when the EMERGENCY STOP is activated. If this contact reports "zero", SIMOCODE issues the OFF command. After the EMERGENCY STOP has been released and the safety switching device has been acknowledged, the signal at the IN4 input is active and the drive can be restarted.

A yellow LED on the operator panel will light up if the 3TK2823 trips. The operator can start the drive again as soon as the LED turns off.

The same signal is sent to the higher-level PLC via the Cyclic Send 1 function, and can be used here to release the switch-on function in the remote operating mode.

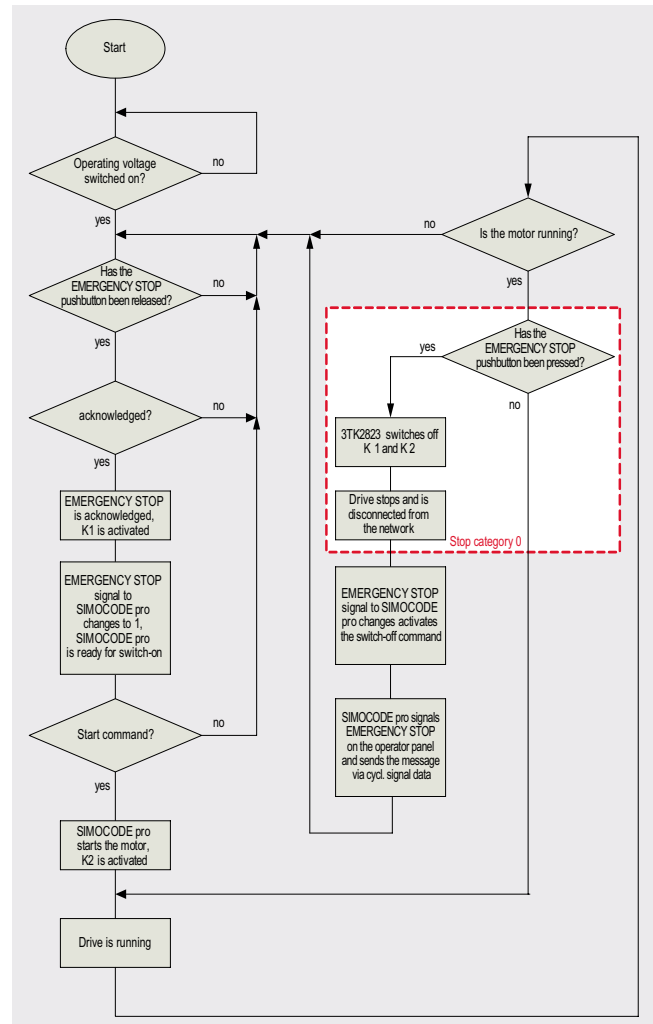
This example takes the safety function into particular consideration. Operational switching of the motor feeder is via a standard PLC and is not taken into further consideration here.

Note

Equipment, functional aspects and design guidelines for EMERGENCY STOP control units can be found in EN 418 (ISO 73850).

Flow Diagram

The following flow diagram illustrates functional interrelationships (for reasons of clarity, operational stopping has not been included)



Advantages/Customer Benefits

- The combination of SIMOCODE pro and 3TK28 safety switching device provides the customer with a flexible, modular motor management system and safe switching-off of the device.
- All 3TK28 signal statuses can be sent on to the higher-level PLC via PROFIBUS.
- Comprehensive motor feeder protection thanks to SIMOCODE's combination of various, multi-level protection and monitoring functions.
- No further auxiliary contacts are required for the contactors, the safety switching device and the EMERGENCY STOP pushbutton.
- All necessary control logic functions are already available as active logic modules in SIMOCODE.
- By using fewer devices and less cabling, the installation space required in switchgear cabinets and, hence, plant floor space, is reduced.
- Standardized integration of the motor feeder in the automation system, thanks to the integrated PROFIBUS DP interface.
- Compliance with all relevant safety standards.

Required Components

Hardware components

Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
EMERGENCY STOP	2NC 40-mm mushroom pushbutton with yellow top, without protective collar	3SB3 801-0EG3	1	Siemens AG
Start button	Empty enclosure, one command station	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22-mm nominal diameter	3SB3 000-0AA11	1	
Safety switching device	3TK2823	3TK2823-2CB30	1	
Contactors K1 / K2	Contactors, AC-3, 3 kW/400 V, 1NC, DC 24 V, 3-pole, size S00 Screw terminal	3RT1015-1BB42	2	
Circuit breaker for motor protection	Release 0.35 ... 0.5 A	3RV1011-0FA1	1	
SIMOCODE pro	SIMOCODE pro C Basic unit 1	3UF7 000-1AB00-0	1	
	Current measurement module 0.3 ... 3 A	3UF7 100-1AA00-0	1	
	Operator panel	3UF7 200-1AA00-0	1	
	0.1-m connection cable	3UF7 931-0AA00-0	1	
	0.5-m connection cable	3UF7 932-0AA00-0	1	
SIMATIC S7	PS307 5A power supply	6ES7307-1EA00-0AA0	1	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	1	
	MMC 512 kB Micro Memory Card	6ES7953-8LJ10-0AA0	1	

Note

Functionality has been tested with the hardware listed. Similar products not found in this list can also be used. If this is the case, remember that it could be necessary to modify the example code (e.g. other addresses) and/or the hardware wiring (e.g. a different connection assignment).

Note

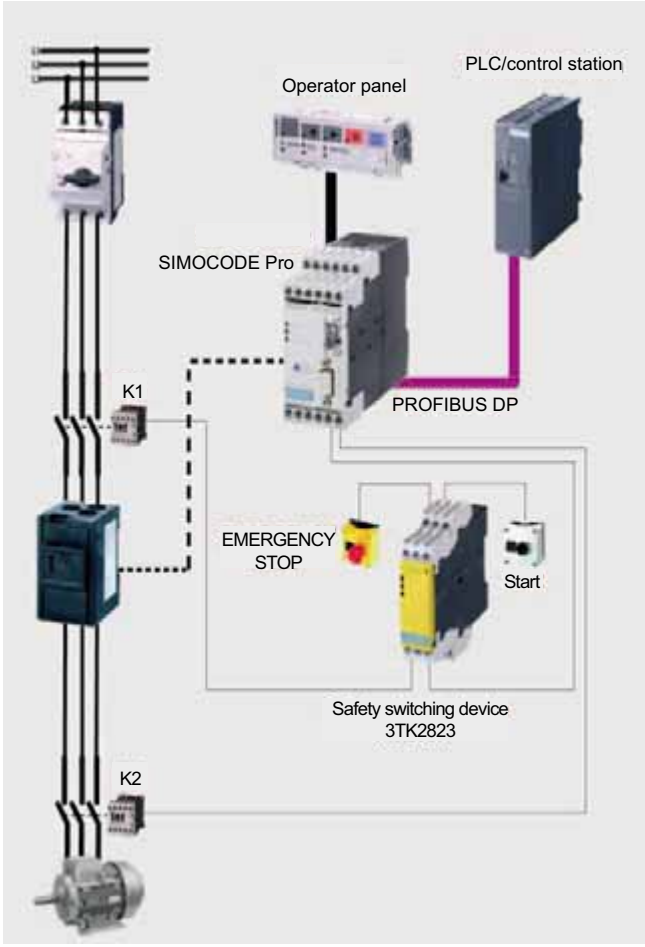
This Functional Example has been carried out and tested with SIMOCODE pro C. It can, of course, be carried out with SIMOCODE pro V.

Configuration software/tools

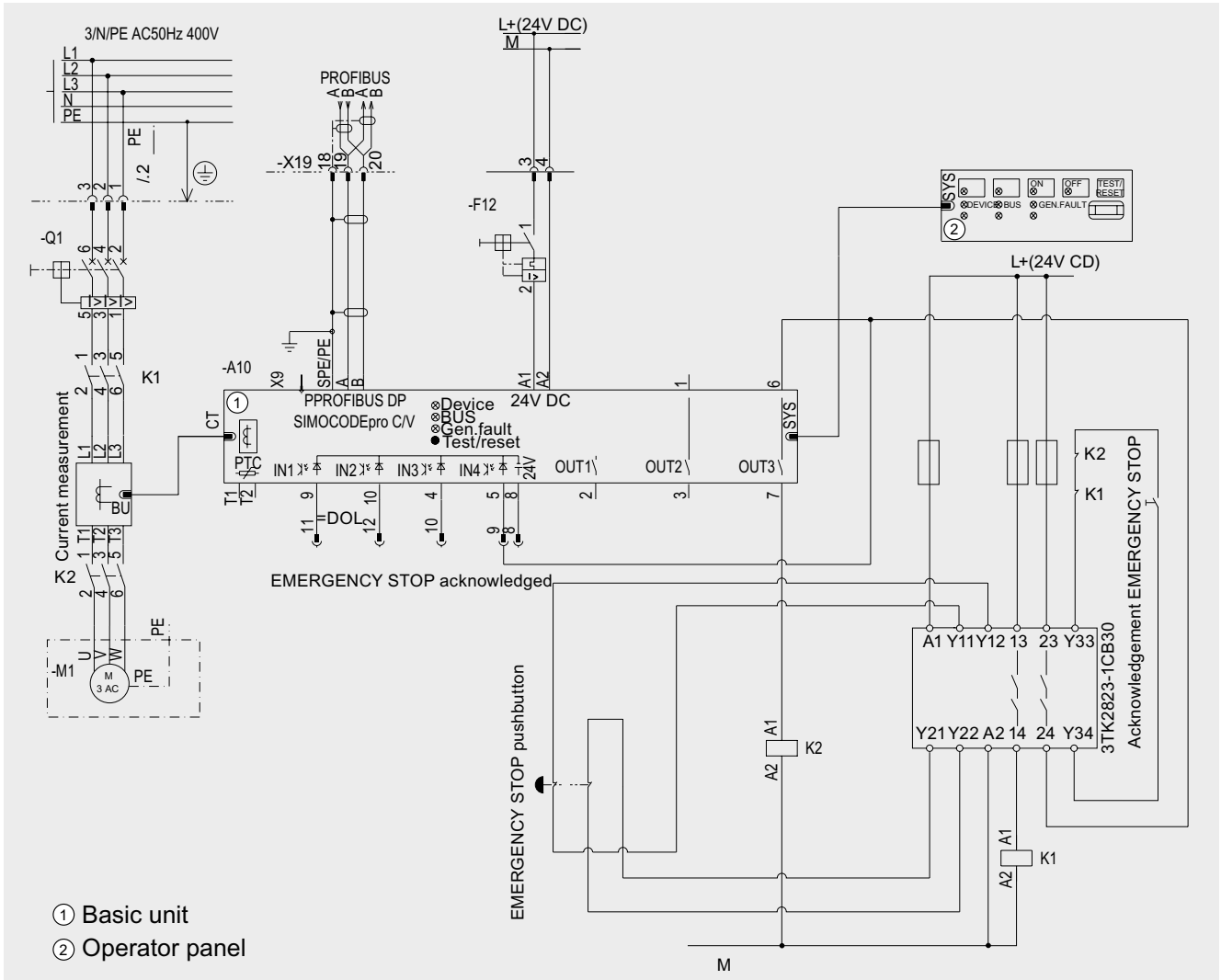
Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7 810-4CC07-0YA5	1	Siemens AG
SIMOCODE ES Professional 2004	V1.0 + SP1 + HF2	3ZS1 312-2CC10-0YA0	1	
SIMOCODE ES Graphic 2005	V1.0	3ZS1 312-3CC10-0YA0	1	

Assembly and Wiring

Overview of Hardware Assembly



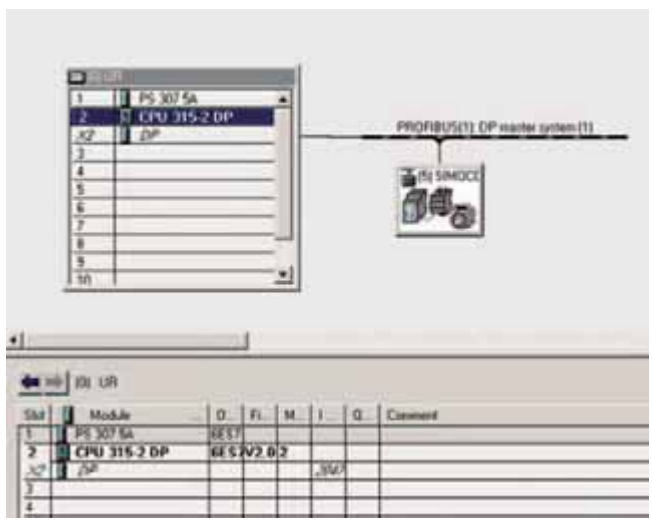
Wiring of Hardware Components



Important Hardware Component Settings

An overview of important STEP 7 hardware configuration settings follows. These settings can also be found in the STEP 7 project supplied.

Overview illustration



CPU 315-2DP settings

The CPU 315-2DP settings can be adopted.

SIMOCODE pro C settings in HW config

To have SIMOCODE available as DP slave in the HW configurator of the SIMATIC manager, the corresponding GSD file must be installed. The necessary GSD files can be downloaded via the following link:

<http://support.automation.siemens.com/WW/view/de/113630>

The following GSD files are available for SIMOCODE pro C:

- SI0180FD.GSG (German)
- SI0180FD.GSE (English)

The following GSD files are available for SIMOCODE pro V:

- SI1180FD.GSG (German)
- SI1180FD.GSE (English)

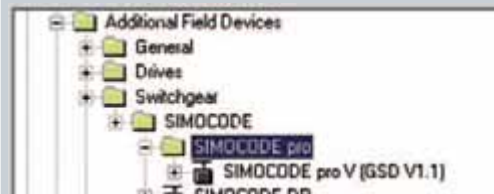
To install the GSD file, start STEP 7 and select the **Extras > Install new GSD file** menu command in HW Config.

Select the GSD file to be installed in the following dialog and confirm with **OK**.

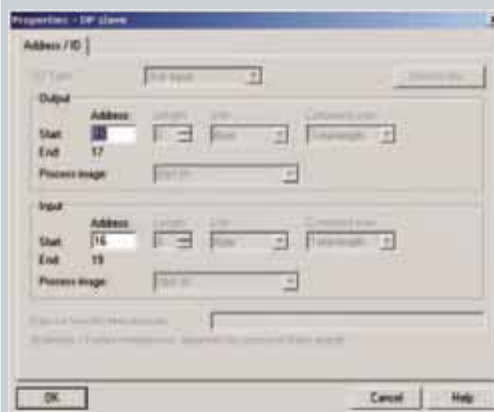
Note

SIMOCODE is inserted into the system as a standard slave via the GSD file. The field device is found in the **PROFIBUS DP** directory under **Further field devices > Switching devices > SIMOCODE > SIMOCODE pro**, and inserted in PROFIBUS.

Screenshot

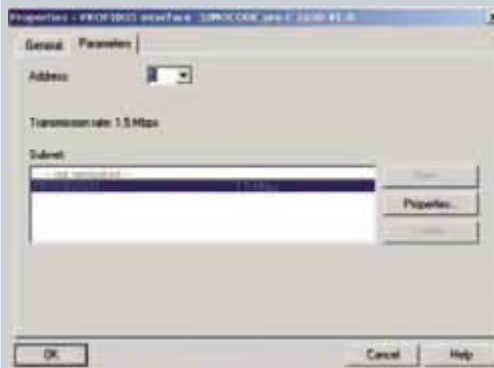


The properties can be accessed via a double click on slot 1 in SIMOCODE. The input and output address is changed here to 16 (for example).



The PROFIBUS address is set to 5.

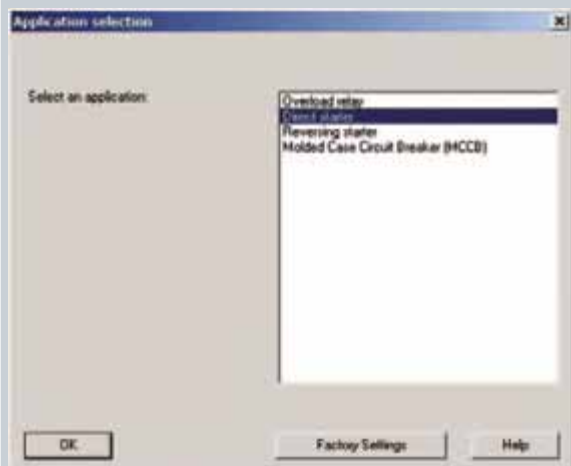
The menu for setting the PROFIBUS address can be accessed via **Properties - DP slave** via double click on the **PROFIBUS** button.



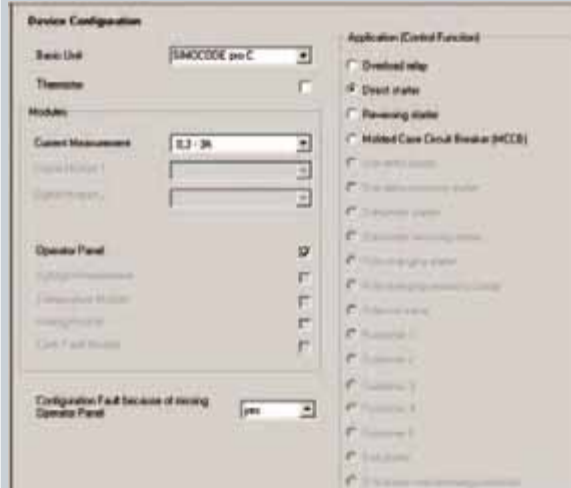
Parameterizing SIMOCODE pro C in SIMOCODE ES

Parameterization of SIMOCODE with SIMOCODE ES Professional is illustrated in the following.

Application selection

Note	Screenshot
The direct starter is selected in the application selection menu.	

Device configuration

Note	Screenshot
SIMOCODE pro C is selected in the device configuration.	

Parameter settings

Note

Parameterization control stations
Deselect the marked defaults of the control station.

Screenshot



Parameterization mode selector



The PROFIBUS DP address is set to 5.



Example Code

Preliminary remark

Enclosed you will find the SIMOCODE pro and STEP 7 Project example codes with which you can reconstruct the functionality described here.

The example code is always assigned to the components used in the Function Examples and functions as necessary. Any further problems to be solved must be dealt with individually by the user. However, the example code can serve as a basis.

Downloading the STEP 7 Project

To access the corresponding project file, open the proffered "CD-FE-I-037-V10-proC.zip" file and extract this into any directory.

To download the S7 Project in the CPU you must have a connection between the MPI interface of your PG/PC and the MPI interface of the CPU.

Please proceed as follows:

- First load the hardware configuration in the S7 CPU
- Change to SIMATIC Manager
- Activate the **Module** folder
- Click the **Load** button

The assignment of the cyclical control and signal data that has been exchanged between the DP Master and SIMOCODE once in each DP mode is listed in the following table. The control data is sent to SIMOCODE from the DP Master. SIMOCODE answers by sending the signal data to the master module. The CPU 315-2DP is the master in this example. In the PLC program, access to the cyclical data is via the inputs (signal data) and the outputs (control data).

Note

The program code for creating the control commands to switch the direct starter on and off must be individually created by the user.

The program code for further processing the "EMERGENCY STOP" signal in the PLC must be individually created by the user.

The "EMERGENCY STOP" signal is not safety oriented.

Table of controls at the PLC interface

Cyclical control data	
Bit 0.0	Not assigned
Bit 0.1	OFF
Bit 0.2	ON
Bit 0.3	Not assigned
Bit 0.4	Not assigned
Bit 0.5	REMOTE operating mode
Bit 0.6	Not assigned
Bit 0.7	Not assigned

Table of signals at the PLC interface

Cyclical signal data	
Bit 0.0	Not assigned
Bit 0.1	OFF
Bit 0.2	ON
Bit 0.3	Pre-warning Overload
Bit 0.4	Not assigned
Bit 0.5	REMOTE operating mode
Bit 0.6	General Fault
Bit 0.7	General Warning
Bit 1.0	EMERGENCY STOP
Bit 1.1	Not assigned
Bit 1.2	Not assigned
Bit 1.3	Not assigned
Bit 1.4	Not assigned
Bit 1.5	Not assigned
Bit 1.6	Not assigned
Bit 1.7	Not assigned

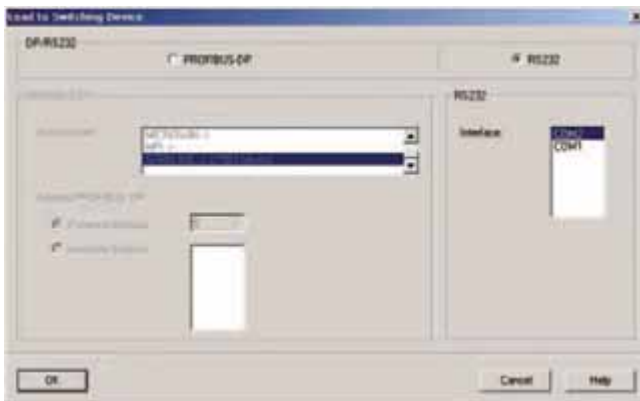
Downloading the SIMOCODE pro project

To access the corresponding project file, copy the proffered file "CD-FE-I-037-V10-Direkt-NH-Kat4.sdp" into any directory.

Open the project via the **Switching devices > Open** menu

You can choose between a PROFIBUS DP or an RS232 connection to download the SIMOCODE pro project into the control unit.

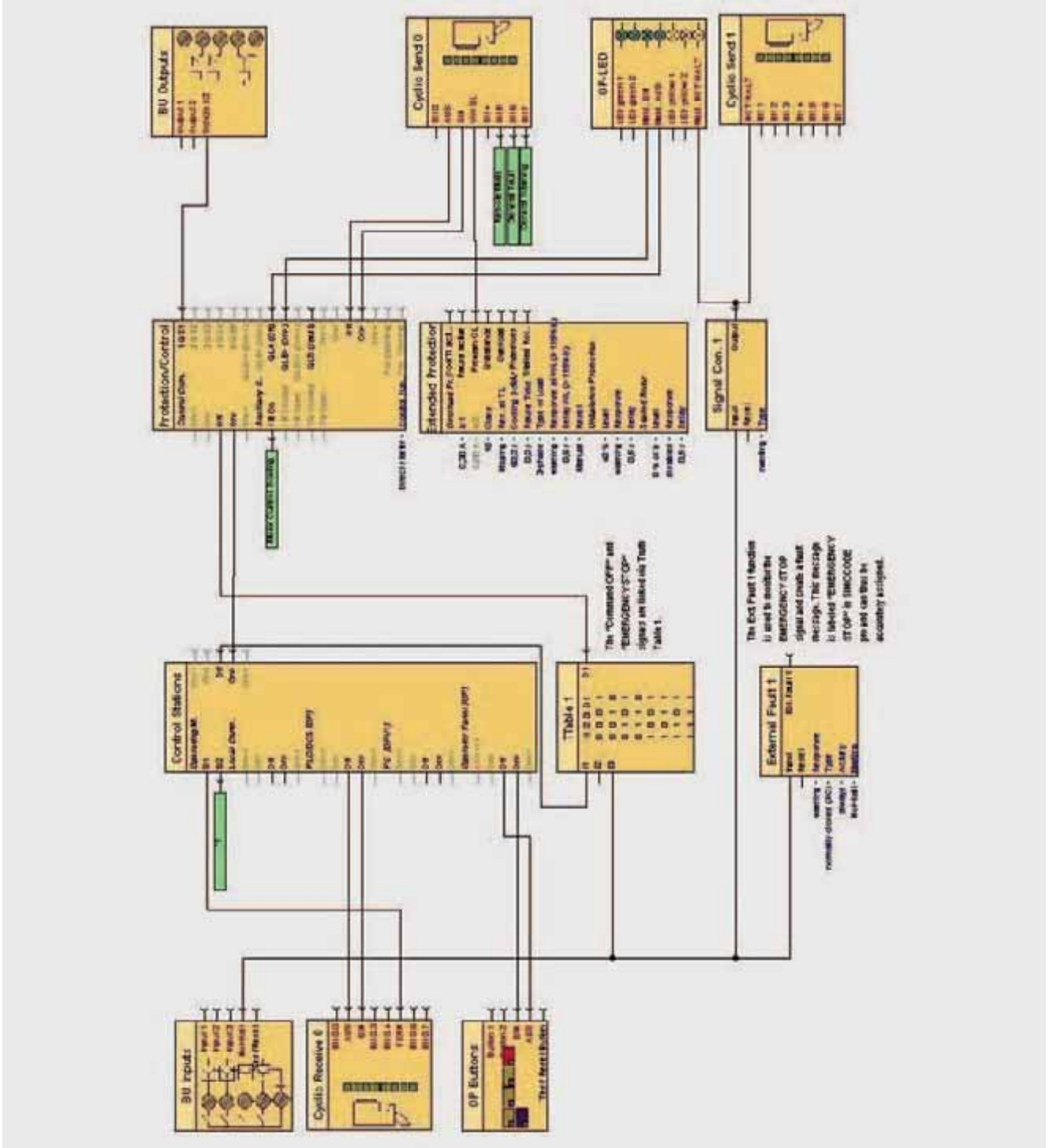
The following window will open when you activate the **Load in switching device** button:



Select the desired interface and confirm with **OK**.

A PROFIBUS cable is required for the download via PROFIBUS DP. For downloading via RS232, a PC cable with the order number 3UF7 940-0AA00-0 is required.

SIMOCODE pro C parameterization



The displayed link is parameterized in the SIMOCODE ES Professional software graphic editor to activate the EMERGENCY STOP function.

A truth table is switched between the "OFF" socket of the control station and the "OFF" plug of the "protecting/controlling" function. The "EMERGENCY STOP" signal from BU input 4 is assigned to the "E3" plug of the truth table. The truth table wiring is illustrated as follows.

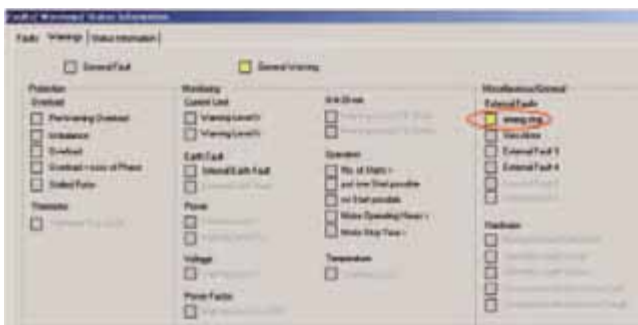
Truth Table 1 31/10

Truth Table 31/10

	I1	I2	I3	O	
Truth Table - Input 1	Released Control Command - Off	0	0	0	1
		0	0	1	0
		0	1	0	1
		0	1	1	0
Truth Table - Input 2	Not connected	1	0	0	1
		1	0	1	1
		1	1	0	1
Truth Table - Input 3	BU - Input 4	1	1	1	1

The "Cyclic Send 1" function is used to signal the EMERGENCY STOP to the higher-level PLC. In this case, the "EMERGENCY STOP" signal from the BU input is assigned to Bit 0. The yellow 3 LED is used to visually indicate the EMERGENCY STOP on the operator panel (see the figure on page 138).

SIMOCODE issues a warning via the External Fault 1 function whenever the EMERGENCY STOP is activated.



Function Test

After the hardware components have been wired and the S7 and SIMOCODE pro projects have been downloaded, the assigned inputs and outputs can be checked for functionality.

Assigned inputs and outputs

No.	HW component	Terminal	Symbol	Signal (default value)	Note	Device
1	EMERGENCY STOP input	IN4	EMERGENCY STOP	1	EMERGENCY STOP activated at 0	SIMO
2	EMERGENCY STOP push-button contact 1	Y11 - Y12		1		3TK2823
3	EMERGENCY STOP push-button contact 2	Y21 - Y22		1		3TK2823
4	Acknowledge EMERGENCY STOP button	Y33 - Y34		0		3TK2823
5	Contactor K1	14	K1			3TK2823
6	Operational switching	OUT3	Output 3	0	Start 3TK28 at 1	SIMO
7	ON button OP buttons		ON			OP
8	OFF button OP buttons		OFF			OP

Testing inputs and outputs

No.	Action	Reaction	Note
1	Ensure that the EMERGENCY STOP push-button is released	If the EMERGENCY STOP has been activated, the 3TK28 must be acknowledged. The contacts K1 and K2 are closed.	
2	Press the Acknowledge EMERGENCY STOP button.	Contactor K1 responds and there is voltage on contact 24 of the 3TK28.	3TK28 is acknowledged and the load can be started via SIMOCODE
3	Press the ON button on the SIMOCODE operator panel	Output OUT3 switches voltage to contactor K2, this responds	The motor runs
4	Press the EMERGENCY STOP pushbutton.	Contactors K1 and K2 release, activation of the EMERGENCY STOP is signaled to SIMOCODE via contact 24 of the 3TK28. SIMOCODE switches output OUT3 to 0.	The load is stopped safely SIMOCODE has activated the EMERGENCY STOP, no fault is signaled.
5	Release the EMERGENCY STOP push-button.	Contacts K1 and K2 are closed	
6	Press the Acknowledge EMERGENCY STOP button.	Contactor K1 responds and there is voltage on contact 24 of the 3TK28.	3TK28 is acknowledged and the load can be started via SIMOCODE

SIMOCODE pro reversing starters with safety technology

Emergency stop monitoring with monitored start

Category 4 according to EN 954-1

Function

Description of the Functionality

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment. The EMERGENCY STOP control unit is a widely used component for protecting persons, machines and the environment against danger.

SIMOCODE pro is a flexible, modular motor management system for low-voltage motors with constant speeds. It optimizes the connection between I&C and the motor feeder, increases plant availability while helping to cut planning and commissioning costs during plant operation and maintenance. Integrated in the low-voltage switchgear, SIMOCODE pro is the intelligent connection between the higher-level automation system and the motor feeder.

In this Safety Functional Example, the EMERGENCY STOP control unit with positive opening contacts is monitored by a SIRIUS 3TK2823 safety switching device as per category 4 according to EN 954-1. If the EMERGENCY STOP is activated, the 3TK2823 safety switching device switches off its corresponding drive as per Stop Category 0 according to EN 60204-1.

Activation of the EMERGENCY STOP is signaled to the SIMOCODE pro via the IN4 input. This signal is used to activate the switching state in SIMOCODE when the EMERGENCY STOP is activated. If this contact reports "zero", SIMOCODE issues the OFF command. After the EMERGENCY STOP has been released and the safety switching device has been acknowledged, the signal at the IN4 input is active and the drive can be restarted.

A yellow LED on the operator panel will light up if the 3TK2823 trips. The operator can start the drive again as soon as the LED turns off.

The same signal is sent to the higher-level PLC via the Cyclic Send 1 function, and can be used here to release the switch-on function in the remote operating mode.

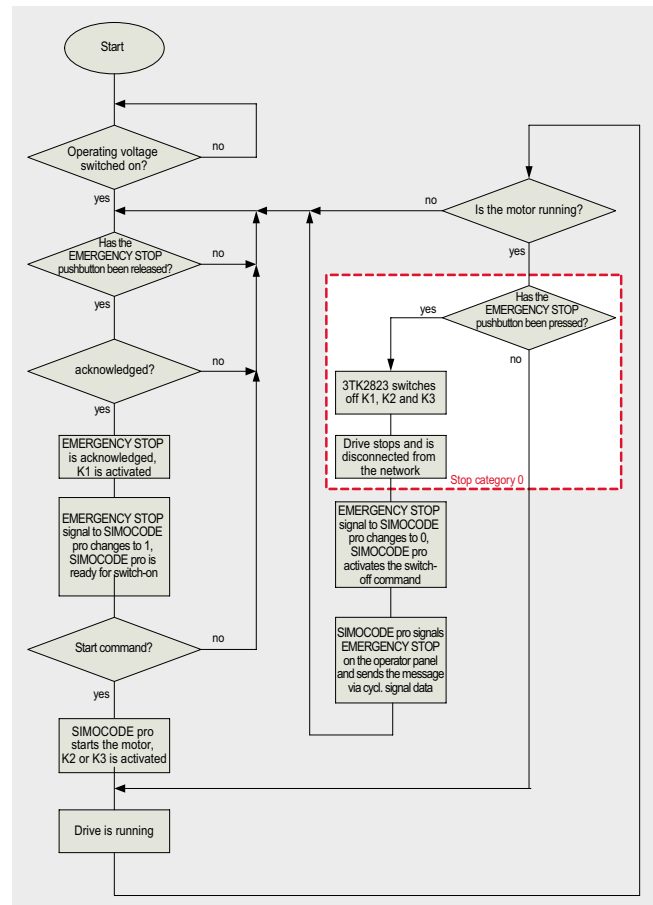
This example takes the safety function into particular consideration. Operational switching of the motor feeder is via a standard PLC and is not taken into further consideration here.

Note

Equipment, functional aspects and design guidelines for EMERGENCY STOP control units can be found in EN 418 (ISO 73850).

Flow Diagram

The following flow diagram illustrates functional interrelationships (for reasons of clarity, operational stopping has not been included)



Advantages/Customer Benefits

- The combination of SIMOCODE pro and 3TK28 safety switching device provides the customer with a flexible, modular motor management system and safe switching-off of the device.
- All 3TK28 signal statuses can be sent on to the higher-level PLC via PROFIBUS.
- Comprehensive motor feeder protection thanks to SIMOCODE's combination of various, multi-level protection and monitoring functions.
- No further auxiliary contacts are required for the contactors, the safety switching device and the EMERGENCY STOP pushbutton.
- All necessary control logic functions are already available as active logic modules in SIMOCODE.
- By using fewer devices and less cabling, the installation space required in switchgear cabinets and, hence, plant floor space, is reduced.
- Standardized integration of the motor feeder in the automation system, thanks to the integrated PROFIBUS DP interface.
- Compliance with all relevant safety standards.

Required Components

Hardware components

Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
EMERGENCY STOP	2NC 40-mm mushroom pushbutton with yellow top, without protective collar	3SB3 801-0EG3	1	Siemens AG
Start button	Empty enclosure, one command station	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22-mm nominal diameter	3SB3 000-0AA11	1	
Safety switching device	3TK2823	3TK2823-2CB30	1	
Contactors K1 / K2 /K3	Contactors, AC-3, 3 KW/400 V, 1NC, DC 24 V, 3-pole, size S00 Screw terminal	3RT1015-1BB42	3	
Circuit breaker for motor protection	Release 0.35 ... 0.5 A	3RV1011-0FA1	1	
SIMOCODE pro	SIMOCODE pro C Basic unit 1	3UF7 000-1AB00-0	1	
	Current measurement module 0.3 ... 3 A	3UF7 100-1AA00-0	1	
	Operator panel	3UF7 200-1AA00-0	1	
	0.1-m connection cable	3UF7 931-0AA00-0	1	
	0.5-m connection cable	3UF7 932-0AA00-0	1	
SIMATIC S7	PS307 5A power supply	6ES7307-1EA00-0AA0	1	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	1	
	MMC 512 kB Micro Memory Card	6ES7953-8LJ10-0AA0	1	

Note

Functionality has been tested with the hardware listed. Similar products not found in this list can also be used. If this is the case, remember that it could be necessary to modify the example code (e.g. other addresses) and/or the hardware wiring (e.g. a different connection assignment).

Note

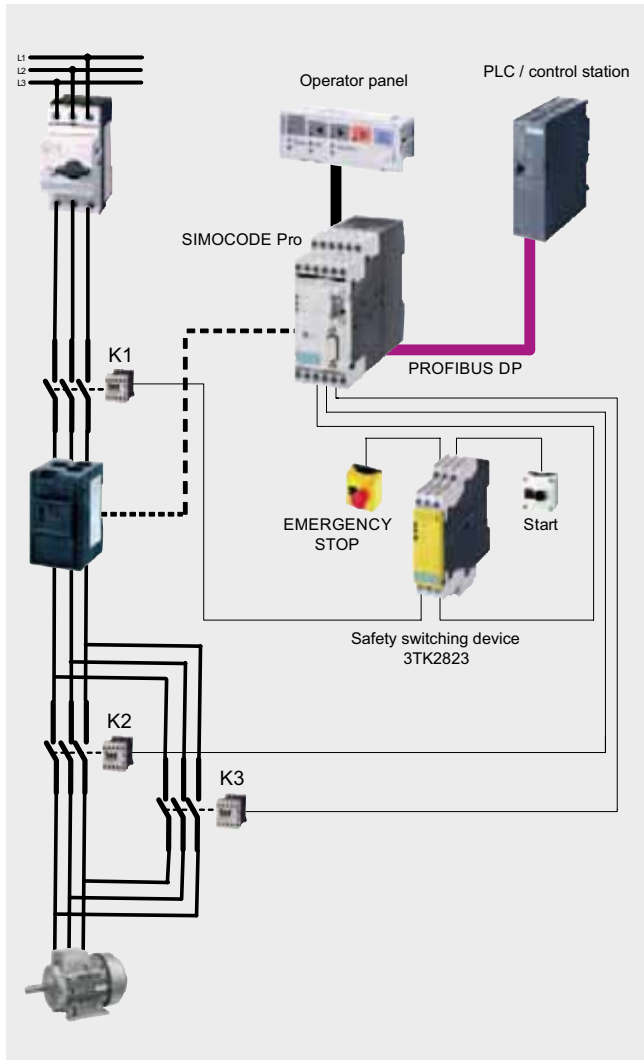
This Functional Example has been carried out and tested with SIMOCODE pro C. It can, of course, be carried out with SIMOCODE pro V.

Configuration software/tools

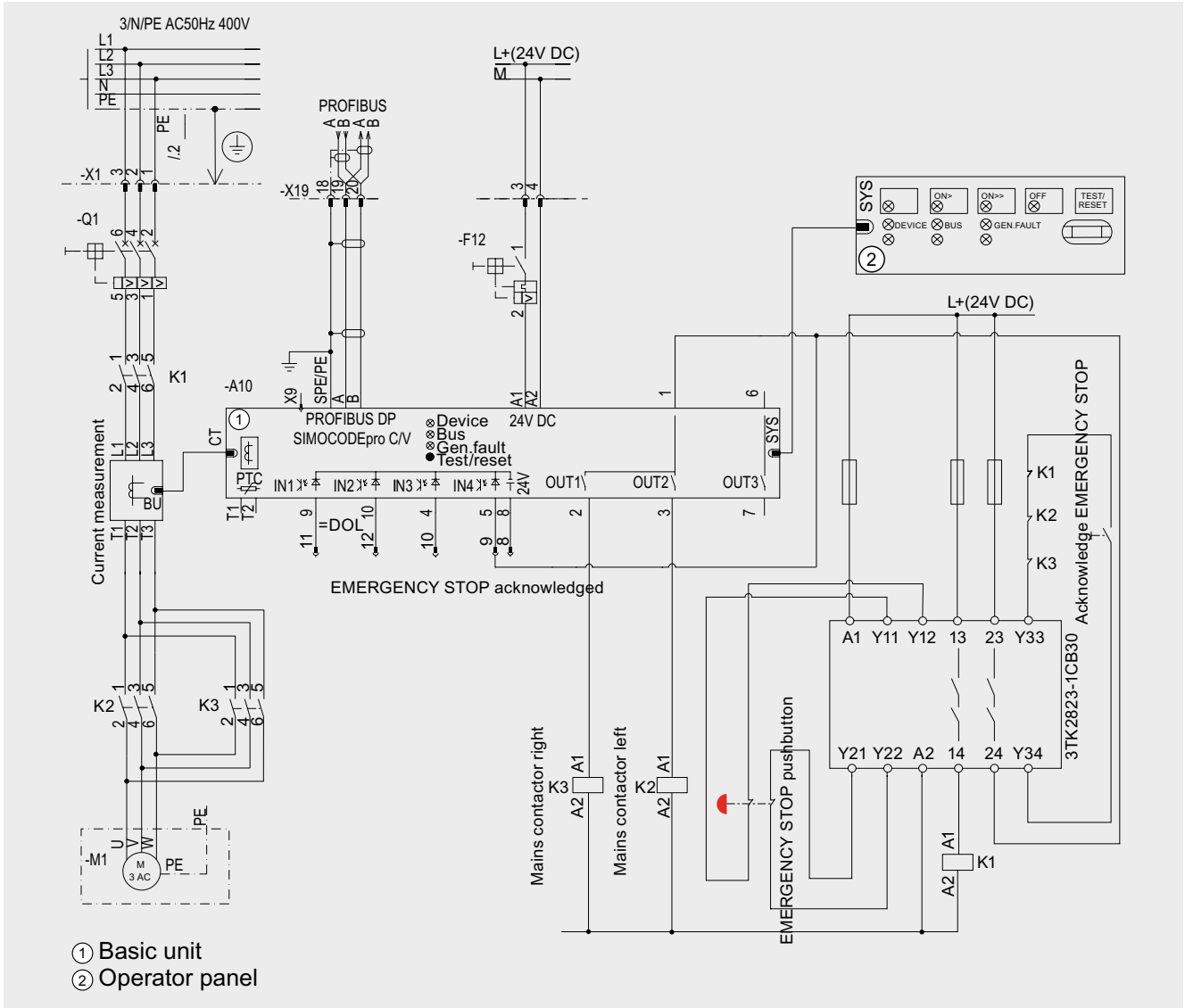
Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7 810-4CC07-0YA5	1	Siemens AG
SIMOCODE ES Professional 2004	V1.0 + SP1 + HF2	3ZS1 312-2CC10-0YA0	1	
SIMOCODE ES Graphic 2005	V1.0	3ZS1 312-3CC10-0YA0	1	

Assembly and Wiring

Overview of Hardware Assembly



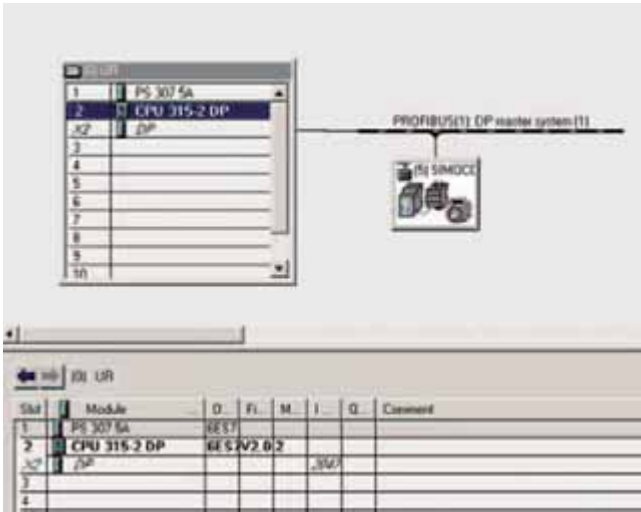
Wiring of Hardware Components



Important Hardware Component Settings

An overview of important STEP 7 hardware configuration settings follows. These settings can also be found in the STEP 7 project supplied.

Overview illustration



CPU 315-2DP settings

The CPU 315-2DP settings can be adopted.

SIMOCODE pro C settings in HW config

To have SIMOCODE available as DP slave in the HW configurator of the SIMATIC manager, the corresponding GSD file must be installed. The necessary GSD files can be downloaded via the following link:

<http://support.automation.siemens.com/WWW/view/de/113630>

The following GSD files are available for SIMOCODE pro C:

- SI0180FD.GSG (German)
- SI0180FD.GSE (English)

The following GSD files are available for SIMOCODE pro V:

- SI1180FD.GSG (German)
- SI1180FD.GSE (English)

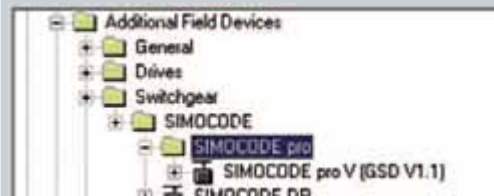
To install the GSD file, start STEP 7 and select the **Extras > Install new GSD file** menu command in HW Config.

Select the GSD file to be installed in the following dialog and confirm with **OK**.

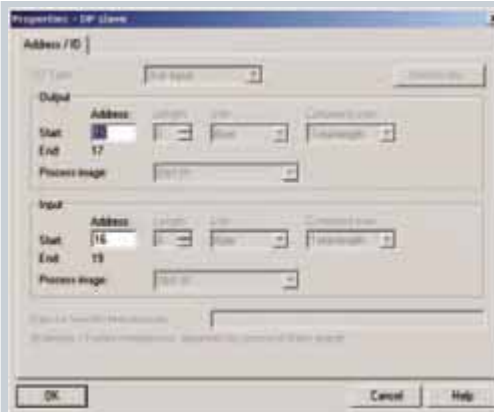
Note

SIMOCODE is inserted into the system as a standard slave via the GSD file. The field device is found in the **PROFIBUS DP** directory under **Further field devices > Switching devices > SIMOCODE > SIMOCODE pro**, and inserted in PROFIBUS.

Screenshot



The properties can be accessed via a double click on slot 1 in SIMOCODE. The input and output address is changed here to 16 (for example).



The PROFIBUS address is set to 5.

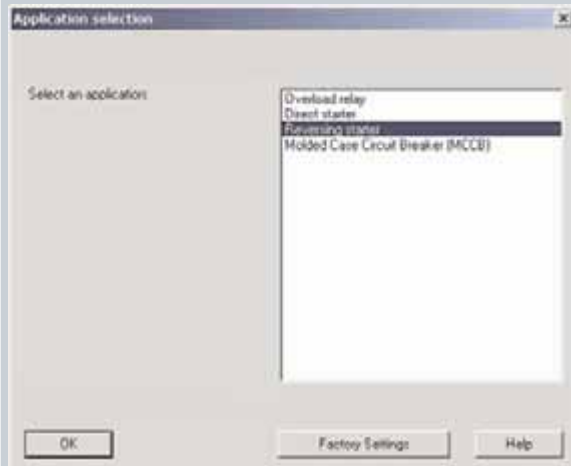
The menu for setting the PROFIBUS address can be accessed via **PROFIBUS - DP slave** via double click on the **PROFIBUS** button.



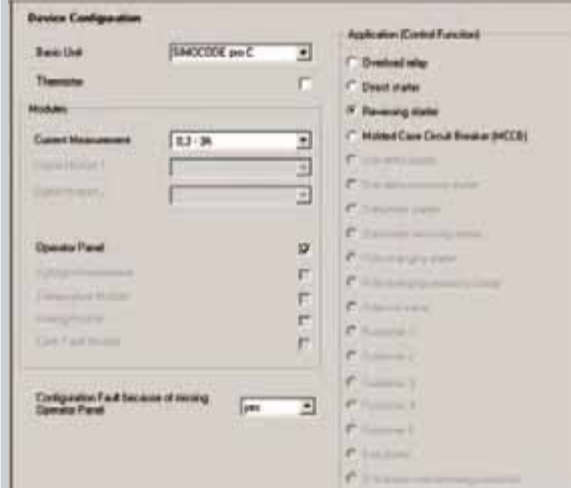
Parameterizing SIMOCODE pro C in SIMOCODE ES

Parameterization of SIMOCODE with SIMOCODE ES Professional is illustrated in the following.



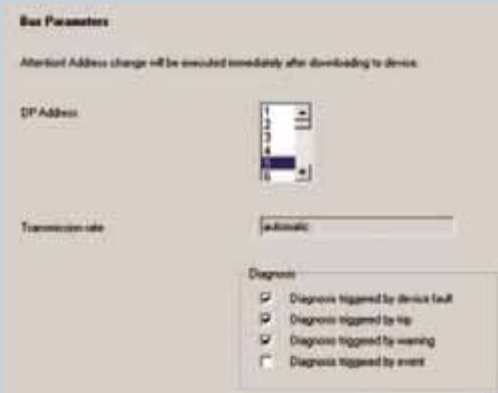
Application selection

Note	Screenshot
The reversing starter is selected in the application selection menu.	

Device configuration

Note	Screenshot
SIMOCODE pro C is selected in the device configuration.	

Parameter settings

Note	Screenshot
<p>Parameterization control stations Deselect the marked defaults of the control station.</p>	
<p>Parameterization mode selector</p>	
<p>The PROFIBUS DP address is set to 5.</p>	

Example Code

Preliminary remark

Enclosed you will find the SIMOCODE pro and STEP 7 Project example codes with which you can reconstruct the functionality described here.

The example code is always assigned to the components used in the Function Examples and functions as necessary. Any further problems to be solved must be dealt with individually by the user. However, the example code can serve as a basis.

Downloading the STEP 7 Project

To access the corresponding project file, open the proffered "CD-FE-I-039-V10-proC.zip" file and extract this into any directory.

To download the S7 Project in the CPU you must have a connection between the MPI interface of your PG/PC and the MPI interface of the CPU.

Please proceed as follows:

- First load the hardware configuration in the S7 CPU
- Change to SIMATIC Manager
- Activate the **Module** folder
- Click the **Load** button

The assignment of the cyclical control and signal data that has been exchanged between the DP Master and SIMOCODE once in each DP mode is listed in the following table. The control data is sent to SIMOCODE from the DP Master. SIMOCODE answers by sending the signal data to the master module. The CPU 315-2DP is the master in this example. In the PLC program, access to the cyclical data is via the inputs (signal data) and the outputs (control data).

Note

The program code for creating the control commands to switch the direct starter on and off must be individually created by the user.

The program code for further processing the "EMERGENCY STOP" signal in the PLC must be individually created by the user.

The "EMERGENCY STOP" signal is not safety oriented.

Table of controls at the PLC interface

Cyclical control data	
Bit 0.0	ON<
Bit 0.1	OFF
Bit 0.2	ON>
Bit 0.3	Not assigned
Bit 0.4	Not assigned
Bit 0.5	Mode Selector S1
Bit 0.6	Not assigned
Bit 0.7	Not assigned

Table of signals at the PLC interface

Cyclical signal data	
Bit 0.0	ON<
Bit 0.1	OFF
Bit 0.2	ON>
Bit 0.3	Pre-warning Overload
Bit 0.4	Interlocking time active
Bit 0.5	REMOTE operating mode
Bit 0.6	General Fault
Bit 0.7	General Warning
Bit 1.0	EMERGENCY STOP
Bit 1.1	Actuator failure
Bit 1.2	Not assigned
Bit 1.3	Not assigned
Bit 1.4	Not assigned
Bit 1.5	Not assigned
Bit 1.6	Not assigned
Bit 1.7	Not assigned

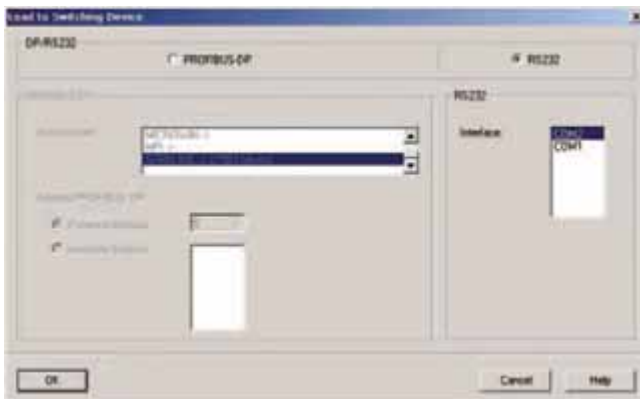
Downloading the SIMOCODE pro project

To access the corresponding project file, copy the proffered file "CD-FE-I-039-V10-Direkt-NH-Kat4.sdp" into any directory.

Open the project via the **Switching devices > Open** menu

You can choose between a PROFIBUS DP or an RS232 connection to download the SIMOCODE pro project into the control unit.

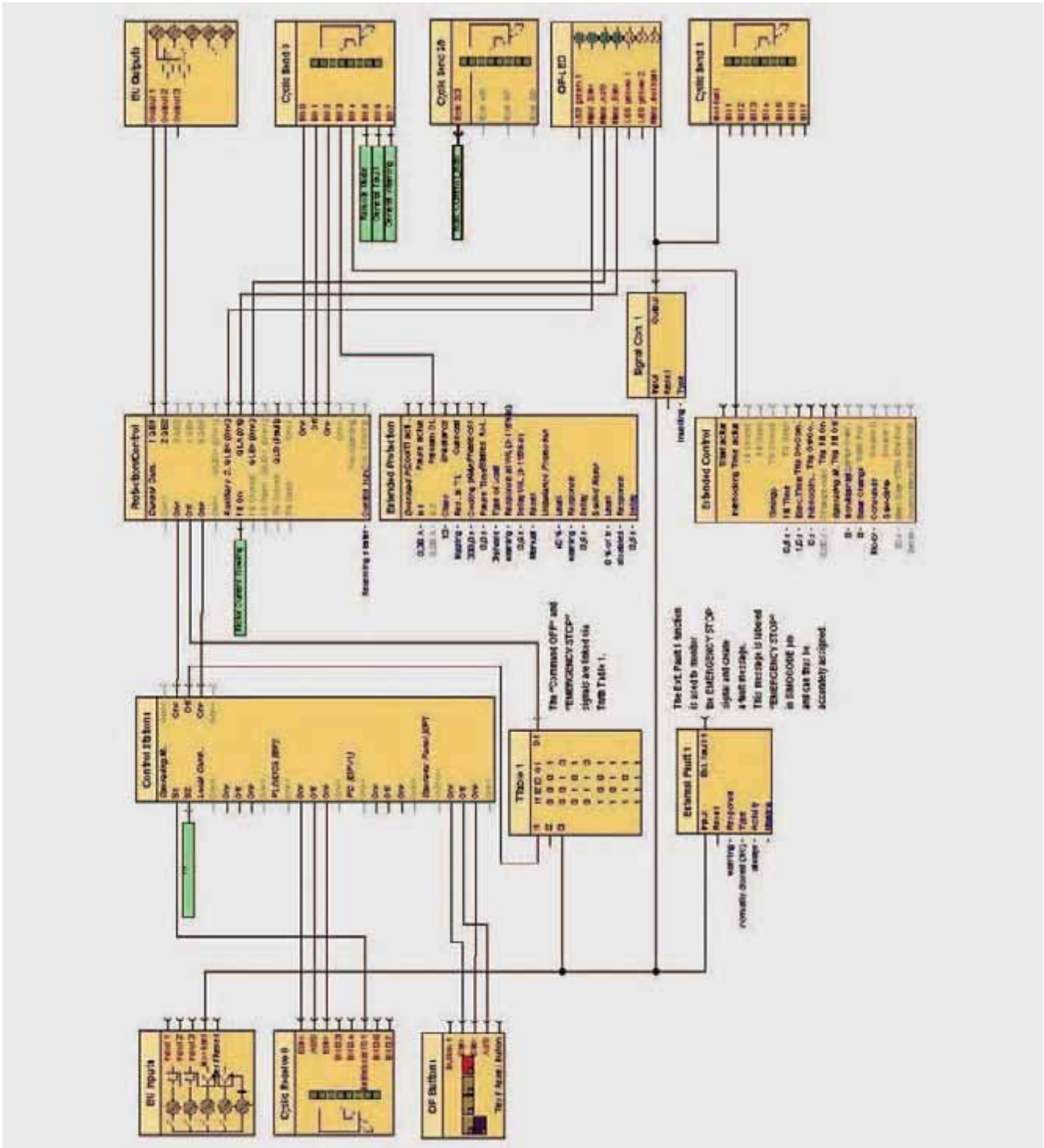
The following window will open when you activate the **Load in switching device** button:



Select the desired interface and confirm with **OK**.

A PROFIBUS cable is required for the download via PROFIBUS DP. For downloading via RS232, a PC cable with the order number 3UF7 940-0AA00-0 is required.

SIMOCODE pro C parameterization



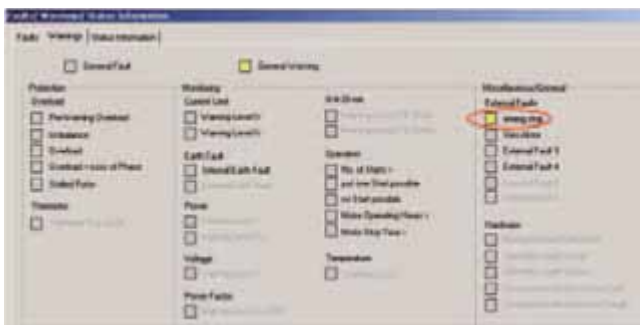
The displayed link is parameterized in the SIMOCODE ES Professional software graphic editor to activate the EMERGENCY STOP function.

A truth table is switched between the "OFF" socket of the control station and the "OFF" plug of the "protecting/controlling" function. The "EMERGENCY STOP" signal from BU input 4 is assigned to the "E3" plug of the truth table. The truth table wiring is illustrated as follows.

Truth Table 1 3I/1O		Truth Table 3I/1O			
		I1	I2	I3	O
Truth Table - Input 1	Released Control Command - Off	0	0	0	1
		0	0	1	0
		0	1	0	1
Truth Table - Input 2	Not connected	0	1	1	0
		1	0	0	1
		1	0	1	1
Truth Table - Input 3	BU - Input 4	1	1	0	1
		1	1	1	1

The "Cyclic Send 1" function is used to signal the EMERGENCY STOP to the higher-level PLC. In this case, the EMERGENCY STOP signal from the BU input is assigned to Bit 0. The yellow 3 LED is used to visually indicate the EMERGENCY STOP on the operator panel (see the figure on page 152).

SIMOCODE issues a warning via the External Fault 1 function whenever the EMERGENCY STOP is activated.



Function Test

After the hardware components have been wired and the S7 and SIMOCODE pro projects have been downloaded, the assigned inputs and outputs can be checked for functionality.

Assigned inputs and outputs

No.	HW component	Terminal	Symbol	Signal (default value)	Note	Device
1	EMERGENCY STOP input	IN4	EMERGENCY STOP	1	EMERGENCY STOP activated at 0	SIMO
2	EMERGENCY STOP push-button contact 1	Y11 - Y12		1		3TK2823
3	EMERGENCY STOP push-button contact 2	Y21 - Y22		1		3TK2823
4	Acknowledge EMERGENCY STOP button	Y33 - Y34		0		3TK2823
5	Contact K1	14	K1			3TK2823
6	Operational switching right	OUT1	Output 1	0	Start 3TK28 at 1	SIMO
7	Operational switching left	OUT2	Output 2	0	Start 3TK28 at 1	SIMO
8	ON> button OP buttons		ON>			OP
9	OFF button OP buttons		OFF			OP
10	ON< button OP buttons		ON<			OP

Testing inputs and outputs

No.	Action	Reaction	Note
1	Ensure that the EMERGENCY STOP push-button is released	If the EMERGENCY STOP has been activated, the 3TK28 must be acknowledged. The contacts K1, K2 and K3 are closed.	
2	Press the Acknowledge EMERGENCY STOP button.	Contact K1 responds and there is a voltage on contact 24 of the 3TK28	3TK28 is acknowledged and the load can be started via SIMOCODE
3	Press the ON> or ON< button on the SIMOCODE operator panel	Output OUT2 switches voltage to contactor K2 or output OUT1 switches voltage to contactor K3. The contactors respond accordingly.	The motor runs
4	Press the EMERGENCY STOP pushbutton.	Contactors K1, K2 and K3 release, activation of the EMERGENCY STOP is signaled to SIMOCODE via contact 24 of the 3TK28. SIMOCODE switches outputs OUT1 and OUT2 to 0	The load is stopped safely SIMOCODE has activated the EMERGENCY STOP, no fault is signaled.
5	Release the EMERGENCY STOP push-button.	The contacts K1, K2 and K3 are closed	
6	Press the Acknowledge EMERGENCY STOP button.	Contact K1 responds and there is a voltage on contact 24 of the 3TK28	3TK28 is acknowledged and the load can be started via SIMOCODE

SIMOCODE pro star-delta starters with safety technology

Emergency stop monitoring with monitored start

Category 4 according to EN 954-1

Function

Description of the Functionality

Persons near machines (e.g. in production engineering) must be suitably protected by technical equipment. The EMERGENCY STOP control unit is a widely used component for protecting persons, machines and the environment against danger.

SIMOCODE pro is a flexible, modular motor management system for low-voltage motors with constant speeds. It optimizes the connection between I&C and the motor feeder, increases plant availability while helping to cut planning and commissioning costs during plant operation and maintenance. Integrated in the low-voltage switchgear, SIMOCODE pro is the intelligent connection between the higher-level automation system and the motor feeder.

In this Safety Functional Example, the EMERGENCY STOP control unit with positive opening contacts is monitored by a SIRIUS 3TK2823 safety switching device as per category 4 according to EN 954-1. If the EMERGENCY STOP is activated, the 3TK2823 safety switching device switches off its corresponding drive as per Stop Category 0 according to EN 60204-1.

Activation of the EMERGENCY STOP is signaled to the SIMOCODE pro via the IN4 input. This signal is used to activate the switching state in SIMOCODE when the EMERGENCY STOP is activated. If this contact reports "zero", SIMOCODE issues the OFF command. After the EMERGENCY STOP has been released and the safety switching device has been acknowledged, the signal at the IN4 input is active and the drive can be restarted.

A yellow LED on the operator panel will light up if the 3TK2823 trips. The operator can start the drive again as soon as the LED turns off.

The same signal is sent to the higher-level PLC via the Cyclic Send 1 function, and can be used here to release the switch-on function in the remote operating mode.

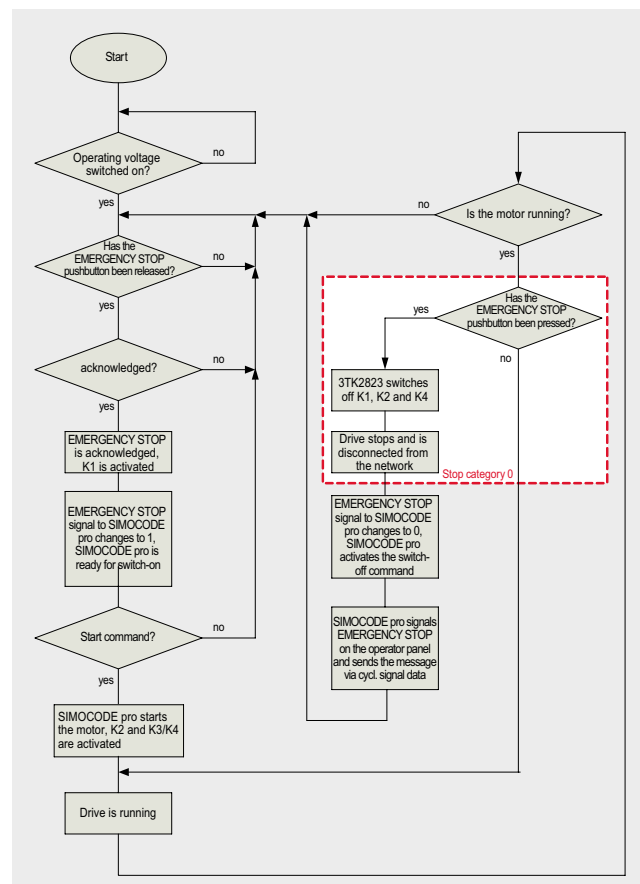
This example takes the safety function into particular consideration. Operational switching of the motor feeder is via a standard PLC and is not taken into further consideration here.

Note

Equipment, functional aspects and design guidelines for EMERGENCY STOP control units can be found in EN 418 (ISO 73850).

Flow Diagram

The following flow diagram illustrates functional interrelationships (for reasons of clarity, operational stopping has not been included)



Advantages/Customer Benefits

- The combination of SIMOCODE pro and 3TK28 safety switching device provides the customer with a flexible, modular motor management system and safe switching-off of the device.
- All 3TK28 signal statuses can be sent on to the higher-level PLC via PROFIBUS.
- Comprehensive motor feeder protection thanks to SIMOCODE's combination of various, multi-level protection and monitoring functions.
- No further auxiliary contacts are required for the contactors, the safety switching device and the EMERGENCY STOP pushbutton.
- All necessary control logic functions are already available as active logic modules in SIMOCODE.
- By using fewer devices and less cabling, the installation space required in switchgear cabinets and, hence, plant floor space, is reduced.
- Standardized integration of the motor feeder in the automation system, thanks to the integrated PROFIBUS DP interface.
- Compliance with all relevant safety standards.

Required Components

Hardware components

Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
EMERGENCY STOP	2NC 40-mm mushroom pushbutton with yellow top, without protective collar	3SB3 801-0EG3	1	Siemens AG
Start button	Empty enclosure, one command station	3SB3 801-0AA3	1	
	1NO contact block for base mounting	3SB3 420-OB	1	
	Black pushbutton with flat button, 22-mm nominal diameter	3SB3 000-0AA11	1	
Safety switching device	3TK2823	3TK2823-2CB30	1	
Contactors K1 / K2 /K3	Contactors, AC-3, 3 kW/400 V, 1NC, DC 24 V, 3-pole, size S00 Screw terminal	3RT1015-1BB42	3	
Circuit breaker for motor protection	Release 0.35 ... 0.5 A	3RV1011-0FA1	1	
SIMOCODE pro	SIMOCODE pro V Basic unit 2	3UF7 010-1AB00-0	1	
	Current measurement module 0.3 ... 3 A	3UF7 100-1AA00-0	1	
	Operator panel	3UF7 200-1AA00-0	1	
	0.1-m connection cable	3UF7 931-0AA00-0	1	
	0.5-m connection cable	3UF7 932-0AA00-0	1	
SIMATIC S7	PS307 5A power supply	6ES7307-1EA00-0AA0	1	
	SIMATIC S7-300, CPU 315-2DP	6ES7315-2AG10-0AB0	1	
	MMC 512 kB Micro Memory Card	6ES7953-8LJ10-0AA0	1	

Note

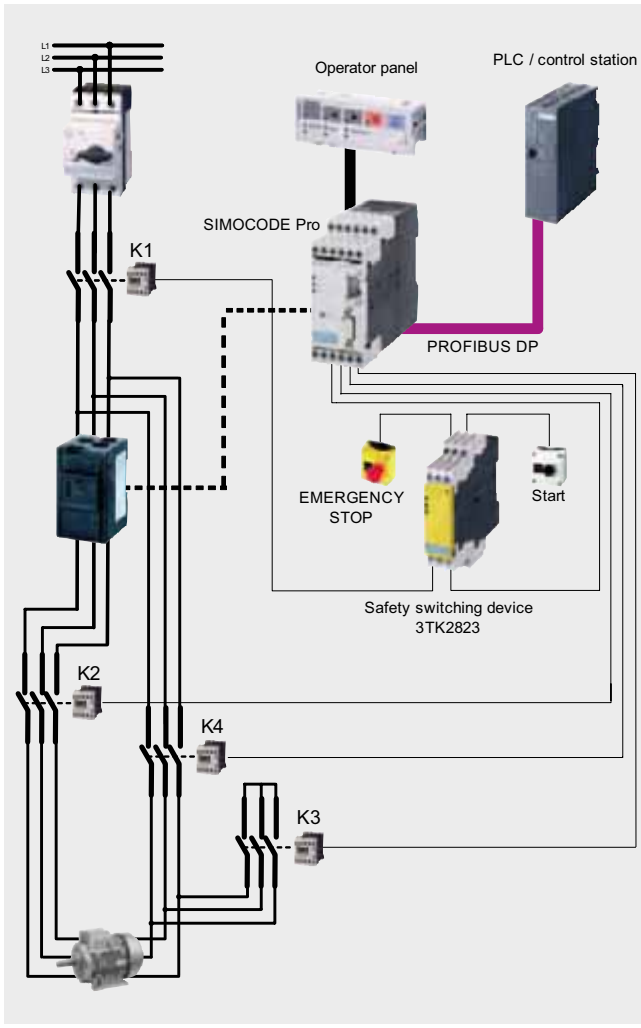
Functionality has been tested with the hardware listed. Similar products not found in this list can also be used. If this is the case, remember that it could be necessary to modify the example code (e.g. other addresses) and/or the hardware wiring (e.g. a different connection assignment).

Configuration software/tools

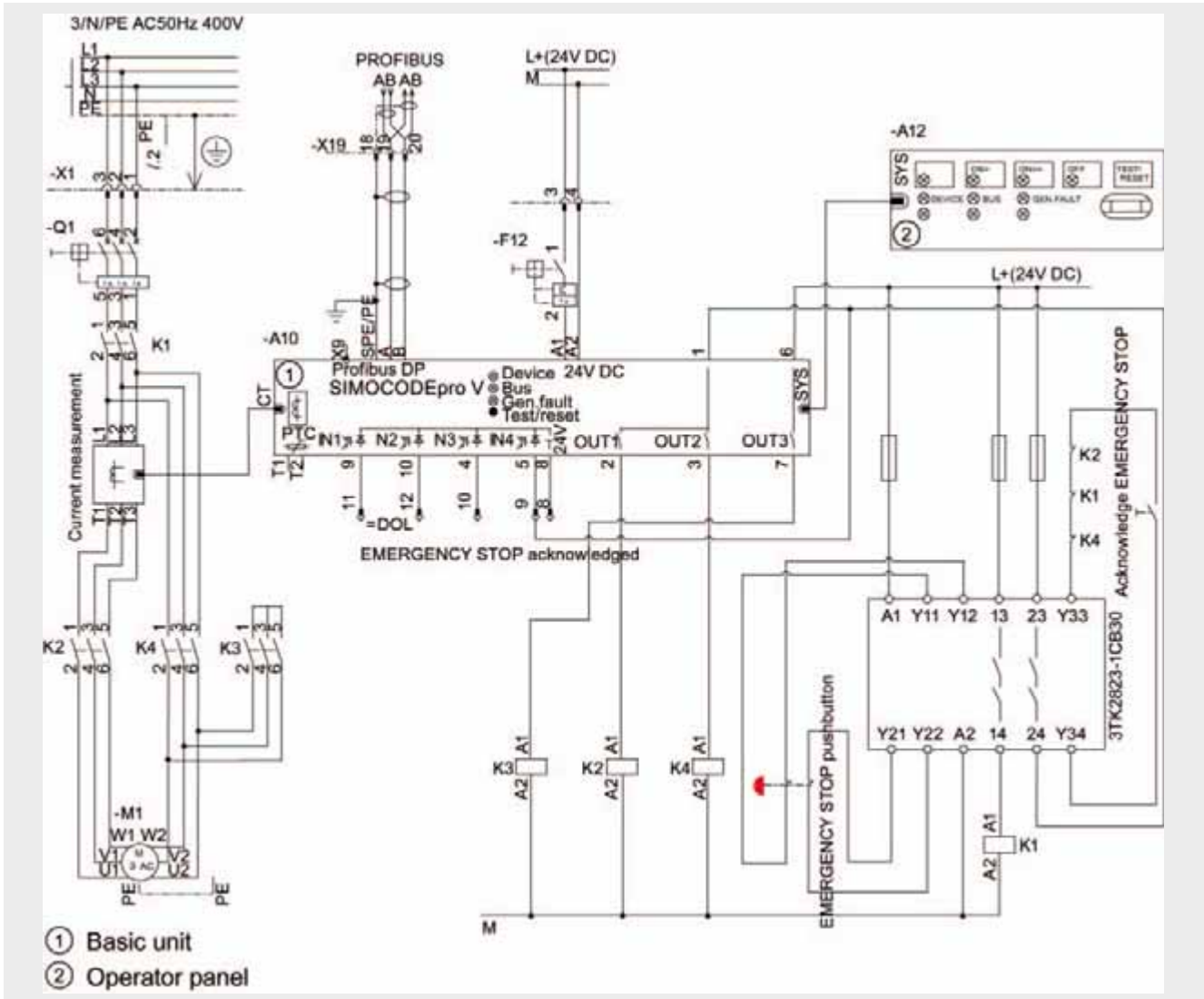
Component	Type	Order Nr. / Order Information	Quantity	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7 810-4CC07-0YA5	1	Siemens AG
SIMOCODE ES Professional 2004	V1.0 + SP1 + HF2	3ZS1 312-2CC10-0YA0	1	
SIMOCODE ES Graphic 2005	V1.0	3ZS1 312-3CC10-0YA0	1	

Assembly and Wiring

Overview of Hardware Assembly



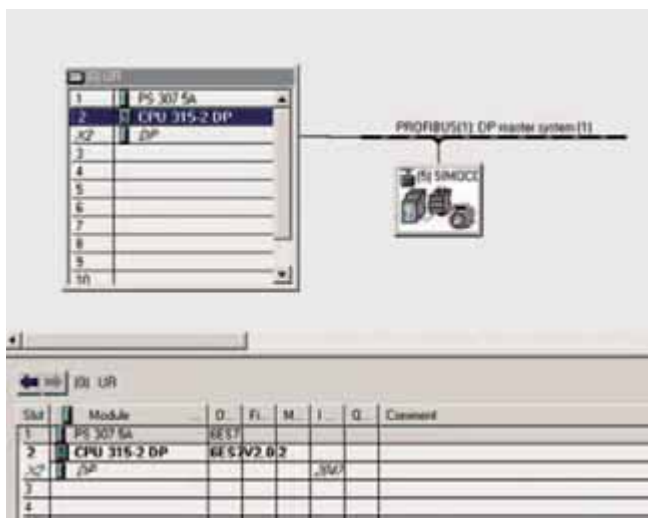
Wiring of Hardware Components



Important Hardware Component Settings

An overview of important STEP 7 hardware configuration settings follows. These settings can also be found in the STEP 7 project supplied.

Overview illustration



CPU 315-2DP settings

The CPU 315-2DP settings can be adopted.

SIMOCODE pro C settings in HW config

To have SIMOCODE available as DP slave in the HW configurator of the SIMATIC manager, the corresponding GSD file must be installed. The necessary GSD files can be downloaded via the following link:

<http://support.automation.siemens.com/WW/view/de/113630>

The following GSD files are available for SIMOCODE pro C:

- SI0180FD.GSG (German)
- SI0180FD.GSE (English)

The following GSD files are available for SIMOCODE pro V:

- SI1180FD.GSG (German)
- SI1180FD.GSE (English)

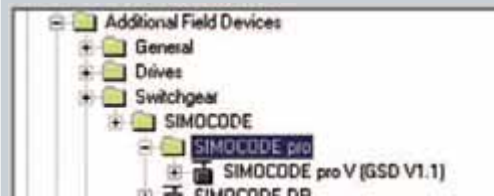
To install the GSD file, start STEP 7 and select the **Extras > Install new GSD file** menu command in HW Config.

Select the GSD file to be installed in the following dialog and confirm with **OK**.

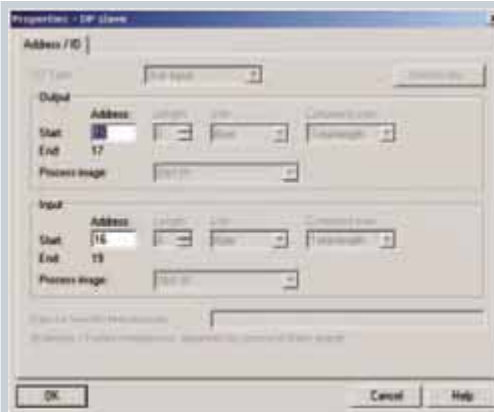
Note

SIMOCODE is inserted into the system as a standard slave via the GSD file. The field device is found in the **PROFIBUS DP** directory under **Further field devices > Switching devices > SIMOCODE > SIMOCODE pro**, and inserted in PROFIBUS.

Screenshot

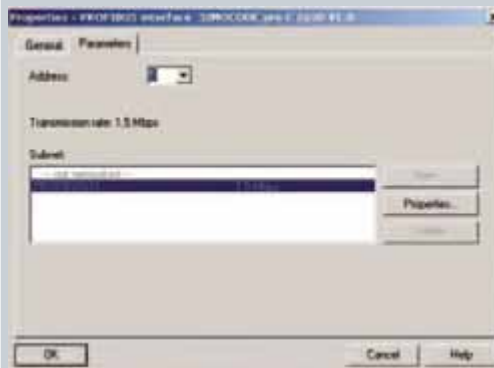


The properties can be accessed via a double click on slot 1 in SIMOCODE. The input and output address is changed here to 16 (for example).



The PROFIBUS address is set to 5.

The menu for setting the PROFIBUS address can be accessed via **PROFIBUS - DP slave** via double click on the **PROFIBUS** button.



Parameterizing SIMOCODE pro C in SIMOCODE ES

Parameterization of SIMOCODE with SIMOCODE ES Professional is illustrated in the following.



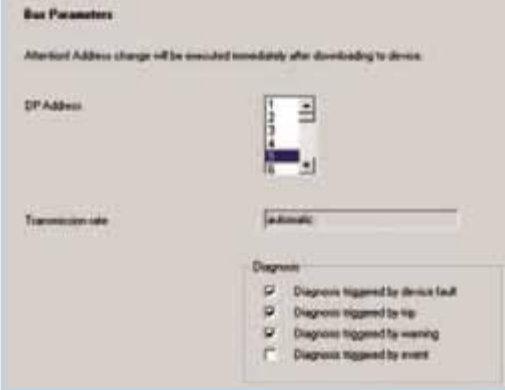
Application selection

Note	Screenshot
The reversing starter is selected in the application selection menu.	

Device configuration

Note	Screenshot
SIMOCODE pro C is selected in the device configuration.	

Parameter settings

Note	Screenshot
<p>Parameterization control stations Deselect the marked defaults of the control station.</p>	
<p>Parameterization mode selector</p>	
<p>The PROFIBUS DP address is set to 5.</p>	

Example Code

Preliminary remark

Enclosed you will find the SIMOCODE pro and STEP 7 Project example codes with which you can reconstruct the functionality described here.

The example code is always assigned to the components used in the Function Examples and functions as necessary. Any further problems to be solved must be dealt with individually by the user. However, the example code can serve as a basis.

Downloading the STEP 7 Project

To access the corresponding project file, open the proffered "CD-FE-I-042-V10-proC.zip" file and extract this into any directory.

To download the S7 Project in the CPU you must have a connection between the MPI interface of your PG/PC and the MPI interface of the CPU.

Please proceed as follows:

- First load the hardware configuration in the S7 CPU
- Change to SIMATIC Manager
- Activate the **Module** folder
- Click the **Load** button

The assignment of the cyclical control and signal data that has been exchanged between the DP Master and SIMOCODE once in each DP mode is listed in the following table. The control data is sent to SIMOCODE from the DP Master. SIMOCODE answers by sending the signal data to the master module. The CPU 315-2DP is the master in this example. In the PLC program, access to the cyclical data is via the inputs (signal data) and the outputs (control data).

Note

The program code for creating the control commands to switch the direct starter on and off must be individually created by the user.

The program code for further processing the "EMERGENCY STOP" signal in the PLC must be individually created by the user.

The "EMERGENCY STOP" signal is not safety oriented.

Table of controls at the PLC interface

Cyclical control data	
Bit 0.0	Not assigned
Bit 0.1	OFF
Bit 0.2	ON
Bit 0.3	Not assigned
Bit 0.4	Not assigned
Bit 0.5	Mode Selector S1
Bit 0.6	Not assigned
Bit 0.7	Not assigned

Table of signals at the PLC interface

Cyclical signal data	
Bit 0.0	Not assigned
Bit 0.1	OFF
Bit 0.2	ON>
Bit 0.3	Pre-warning Overload
Bit 0.4	Change-Over Pause active
Bit 0.5	REMOTE operating mode
Bit 0.6	General Fault
Bit 0.7	General Warning
Bit 1.0	EMERGENCY STOP
Bit 1.1	Not assigned
Bit 1.2	Not assigned
Bit 1.3	Not assigned
Bit 1.4	Not assigned
Bit 1.5	Not assigned
Bit 1.6	Not assigned
Bit 1.7	Not assigned

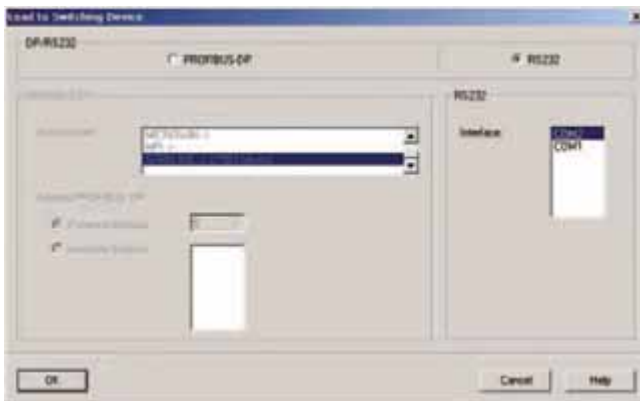
Downloading the SIMOCODE pro project

To access the corresponding project file, copy the proffered file "CD-FE-I-042-SternDrei-NH-Kat4.sdp" into any directory.

Open the project via the **Switching devices > Open** menu.

You can choose between a PROFIBUS DP or an RS232 connection to download the SIMOCODE pro project into the control unit.

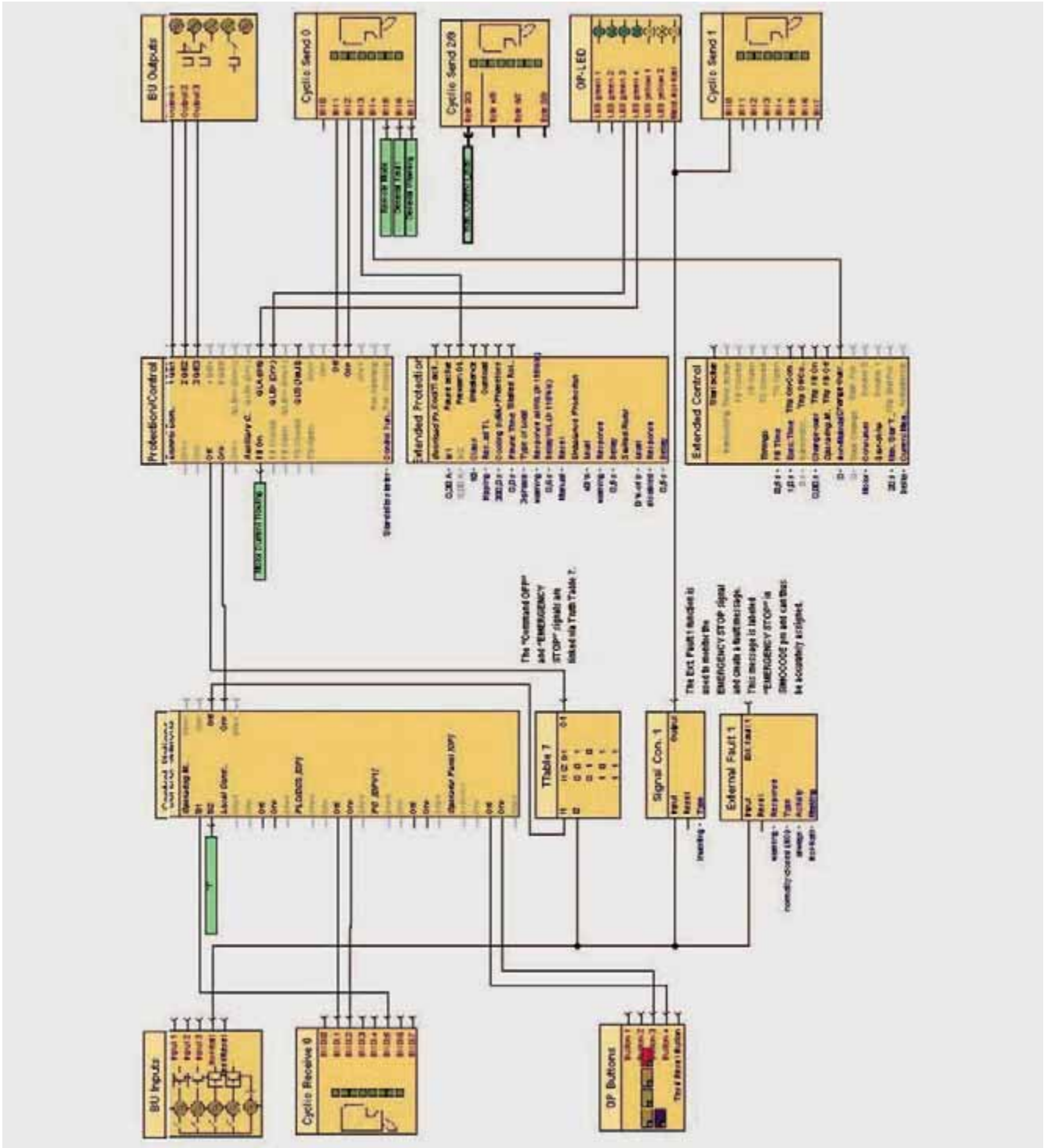
The following window will open when you activate the **Load in switching device** button:



Select the desired interface and confirm with **OK**.

A PROFIBUS cable is required for the download via PROFIBUS DP. For downloading via RS232, a PC cable with the order number 3UF7 940-0AA00-0 is required.

SIMOCODE pro C parameterization



The displayed link is parameterized in the SIMOCODE ES Professional software graphic editor to activate the EMERGENCY STOP function.

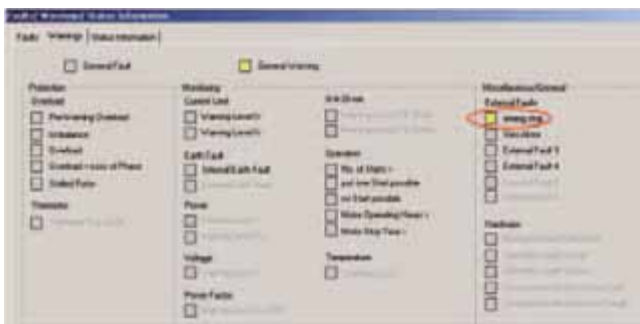
A truth table is switched between the "OFF" socket of the control station and the "OFF" plug of the "protecting/controlling" function. The "EMERGENCY STOP" signal from BU input 4 is assigned to the "E3" plug of the truth table.

The truth table wiring is illustrated as follows.

Truth Table 7 2I/1O		Truth Table 2I/1O		
Truth Table - Input 1	Released Control Command - Off	I1	I2	O
Truth Table - Input 2	BU - Input 4	0	0	1
		0	1	0
		1	0	1
		1	1	1

The "Cyclic Send 1" function is used to signal the EMERGENCY STOP to the higher-level PLC. In this case, the EMERGENCY STOP signal from the BU input is assigned to Bit 0. The yellow 3 LED is used to visually indicate the EMERGENCY STOP on the operator panel (see the figure on page 166).

SIMOCODE issues a warning via the External Fault 1 function whenever the EMERGENCY STOP is activated.



Function Test

After the hardware components have been wired and the S7 and SIMOCODE pro projects have been downloaded, the assigned inputs and outputs can be checked for functionality.

Assigned inputs and outputs

No.	HW component	Terminal	Symbol	Signal (default value)	Note	Device
1	EMERGENCY STOP input	IN4	EMERGENCY STOP	1	EMERGENCY STOP activated at 0	SIMO
2	EMERGENCY STOP pushbutton contact 1	Y11 - Y12		1		3TK2823
3	EMERGENCY STOP pushbutton contact 2	Y21 - Y22		1		3TK2823
4	Acknowledge EMERGENCY STOP button	Y33 - Y34		0		3TK2823
5	Contact K1	14	K1			3TK2823
6	Operational switching	OUT1	Output 1	0	Start 3TK28 at 1	SIMO
7	Operational switching star-delta	OUT2	Output 2	0	Start 3TK28 at 1	SIMO
8	ON button OP buttons		ON			OP
9	OFF button OP buttons		OFF			OP

Testing inputs and outputs

No.	Action	Reaction	Note
1	Ensure that the EMERGENCY STOP pushbutton is released	If the EMERGENCY STOP has been activated, the 3TK28 must be acknowledged. The contacts K1, K2 and K4 are closed.	
2	Press the Acknowledge EMERGENCY STOP button.	Contact K1 responds and there is voltage on contact 24 of the 3TK28.	3TK28 is acknowledged and the load can be started via SIMOCODE
3	Press the ON> or ON>> button on the SIMOCODE operator panel	Output OUT1 switches voltage to contactor K2, and the outputs OUT2 and OUT3 switch voltage to the contactors K4 and K3 as per star-delta switching. The contactors respond accordingly.	The motor runs
4	Press the EMERGENCY STOP pushbutton.	Contactors K1, K2 and K4 release, activation of the EMERGENCY STOP is signaled to SIMOCODE via contact 24 of the 3TK28. SIMOCODE switches outputs OUT1 and OUT2 to 0.	The load is stopped safely SIMOCODE has activated the EMERGENCY STOP, no fault is signaled.
5	Release the EMERGENCY STOP pushbutton.	Contacts K1, K2 and K4 are closed	
6	Press the Acknowledge EMERGENCY STOP button.	Contact K1 responds and there is voltage on contact 24 of the 3TK28.	3TK28 is acknowledged and the load can be started via SIMOCODE

Fail-safe Controllers SIMATIC Safety Integrated



170	1. Emergency Stop with Acknowledgement in Category 4 acc. to EN 954-1
179	2. Safety Door with Spring-Loaded Engagement in Category 4 acc. to EN 954-1
193	3. Safety Door with Magnetic Engagement in Category 4 acc. to EN 954-1
207	4. Safety Door without Guard Locking in Category 4 acc. to EN 954-1
219	5. Light Curtain in Category 4 with Muting Function acc. to EN 954-1
233	6. Two-Hand Control Panel with Integrated Emergency Stop in Category 4 acc. to EN 954-1
245	7. Integration of the Readback Signal in an Application of Category 4 acc. to EN 954-1
259	8. Safety Shutdown in the Stop Categories 0 and 1 in Safety Category 4 according to EN 954-1
277	9. Single and Group Shutdown of Actuators in Safety Category 4 acc. to EN 954-1
292	10. Distributed application of laser-scanner LS4-4 in Category 3 according to EN 954-1
317	11. Passivation and Reintegration of F-I/O considering as example the ET 200S
364	12. Safe Standstill Detection and Safely Reduced Speed with F-CPU and MASTERDRIVES in Category 3 of EN 954-1 or SIL 2 of IEC 62061

Emergency Stop with Acknowledgement in Category 4 acc. to EN 954-1

Ex. No.

1

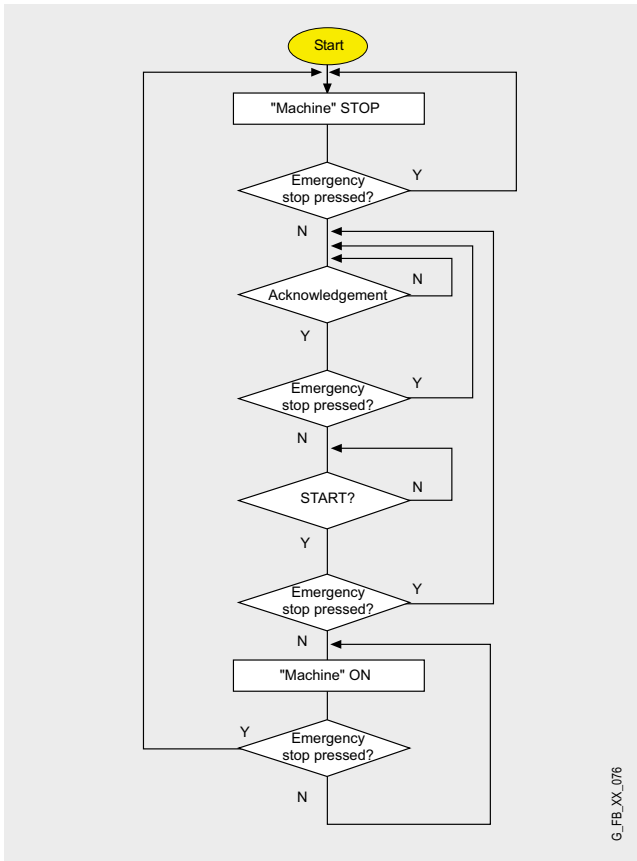
Automation Function

Description of the functionality

If persons (e.g. in manufacturing engineering) work in the vicinity of machines, they have to be adequately protected by technical devices. Emergency stop is an additional safety measure in order to protect people and plants from hazards. Emergency stop must have priority over all other functionalities.

Devices, functional aspects and basic design principles of the emergency stop push button are laid down in **EN 418**, and additionally, **EN 60204-1 : 1997** must be observed.

In this example, an actuated emergency stop push button disables an output of a failsafe digital output module at which e.g. a hazardous machine is operated. All other outputs of this output module remain in their current status. Prior to a renewed machine start the emergency stop push button must be reset manually. This requires an acknowledgement signal. The flowchart below illustrates the relation.



Note

In this example, the hazardous machine is simulated by an indicator light. When using other actuators than this indicator light, safe switching-off function of the loads including signal feedback is to be supplemented.

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet: <http://support.automation.siemens.com/WW/view/en/19138505>.

Prefabricated blocks and network templates from the Distributed Safety library were used to implement the emergency stop functionality. Alternatively, you can also access the respective block from the Distributed Safety library (from Distributed Safety V5.3) for the realization.

Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Only one S7-CPU is required, since within the CPU failsafe and standard program parts run on a coexistent basis.
- Programming the failsafe program with STEP 7 engineering tools.
- Editor user interface within the failsafe program is used as familiar from STEP 7.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200M	IM 153-2	6ES7153-2AA02-0XB0	1	
Digital input module	SM321 DI16xDC24V	6ES7321-7BH00-0AB0	1	
Safety protector	-	6ES7195-7KF00-0XA0	1	
Digital input module, failsafe	SM326 DI24xDC24V	6ES7326-1BK00-0AB0	1	
Digital output module, failsafe	SM326 DO10xDC24V/2A	6ES7326-2BF01-0AB0	1	
Rack	482.6 mm	6ES7390-1AE80-0AA0	2	
Optional: Indicator light incl. incandescent lamp	yellow	3SB3217-6AA30	1	
Emergency stop	Mushroom-head pushbutton 1NC	3SB3801-0DG3	1	
Contact (for Emergency stop)	1NC, screw-type connection	3SB3420-0C	1	
Push button	green, 1NO	3SB3801-0DA3	2	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list (e.g. a different digital input module) can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

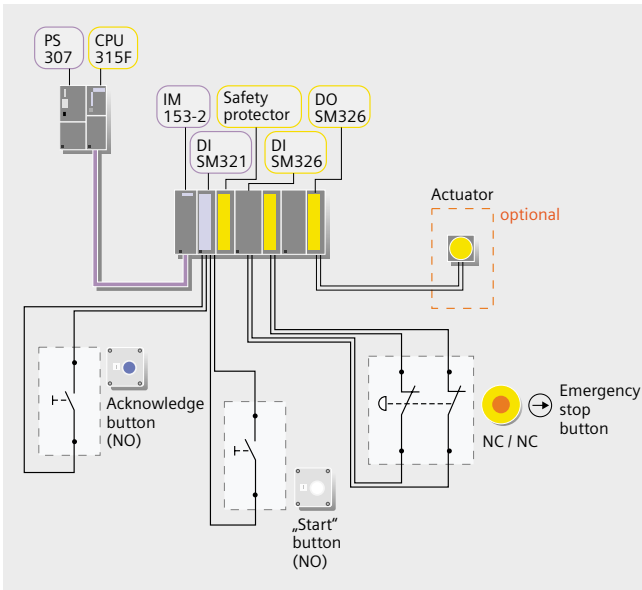
Warning!

In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.

The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example No. 7 „Integration of the Readback Signal in an Application of Category 4 acc. to EN 954-1“ provides a detailed description of "Read back".

An overview of the hardware structure

The arrangement to implement the emergency stop functionality consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200M as DP slave. The ideally used indicator light simulates the hazardous "machine". The indicator light can be replaced by actuators in accordance with their requirements.



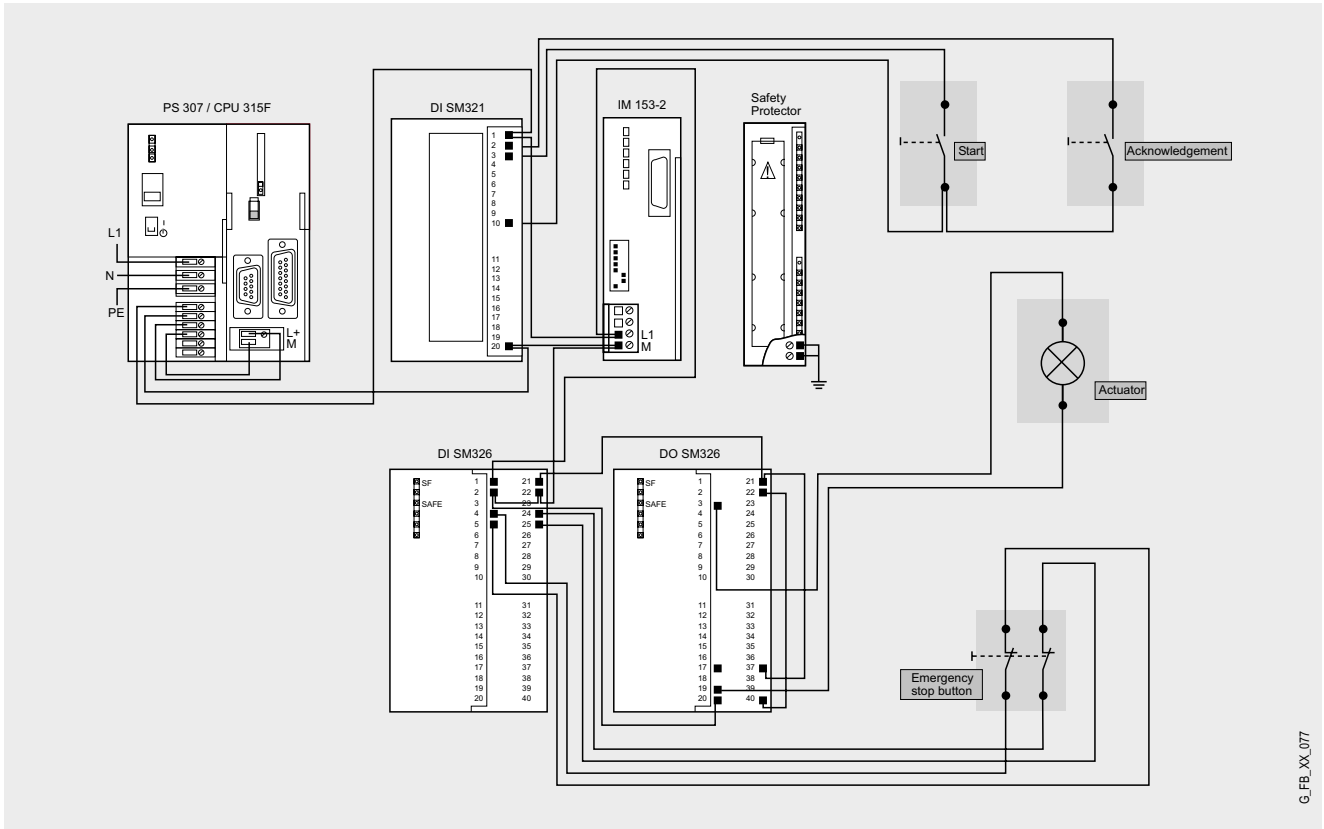
Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

Hardware component	Address to be set	Note
IM 153-2	6 (PROFIBUS address)	Can be changed
DI (SM326)	8	<p>You can change the address areas of the module via inputs (DIL button at the back of the module).</p> <p>Please note the following: During safety operation, input and output address have to be identical, divisible by 8 and they must have a value between 8 and 8176 (see screenshot).</p>
DO (SM326)	24	<p>You can change the address areas of the module via inputs (DIL button at the back of the module).</p> <p>Please note the following: During safety operation, input and output address have to be identical, divisible by 8 and they must have a value between 8 and 8176 (see screenshot).</p>

Note

The DP interface of the CPU 315F must be connected with the DP interface of the IM 153-2.



G_FB_XX_077

Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

No.	Hardware component	Address	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	ACK	"0"	Acknowledgement
2	Push button (NO)	E 0.1	START	"0"	Start
3	Emergency stop push button (NC/NC)	E 8.0	ESTP	"1"	–
4	Actuator (Indicator light)	A 24.0	ACTUATOR	"0"	"1": "Machine" active

Testing inputs and outputs

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

No.	Instruction	Response A24.0	Note
1	None	"0"	After start of the S7-CPU
2	Press ACK and release the button	"0"	Acknowledgement
3	Press START and release the button	"1"	"Machine" (here simulated by indicator light) runs
4	Press ESTP	"0"	Emergency stop pressed

Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

The safety protector is not listed in the hardware configuration of STEP 7.

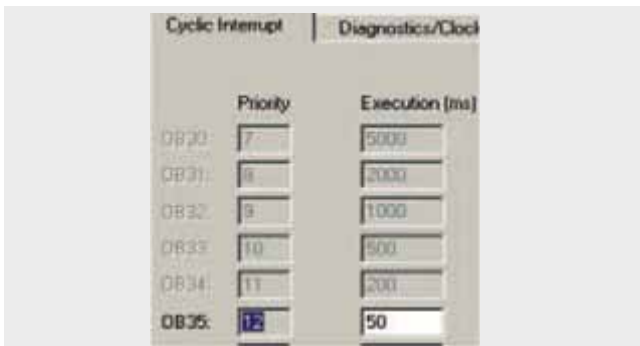
Overview picture



The PROFIBUS address at IM 153-2 is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens

Settings of the failsafe DI (SM 326)

The settings are displayed after double-clicking "DI24xDC24V" (see "Overview picture").

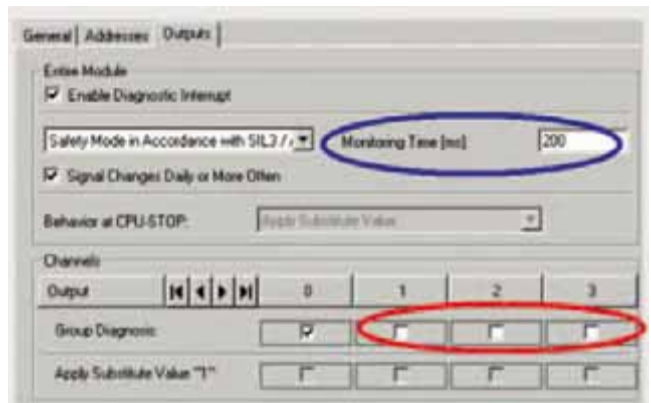


Setting the monitoring time.

Channels which are not used are to be deactivated.

Settings of the failsafe DO (SM 326)

The settings are displayed after double-clicking "DO10xDC24V/2A" (see "Overview picture").



Setting the monitoring time.

Channels which are not used are to be deactivated.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2	approx. 0,08 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 42,9 k	approx. 1,1 k	approx. 41,8 k
Main memory	approx. 31,1 k	approx. 0,4 k	approx. 30,6 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	10 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the described emergency stop functionality.

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

Password

In all cases, the passwords used for the safety-relevant part is „**siemens**“.

Use of the STEP 7 Project

An indicator light (simulates a machine) is switched on via a push-button (START). The emergency stop button is used for switching off. Restarting requires an acknowledge signal (ACK button).

Operation related switching off is not implemented in this example, however, on the following pages it will be illustrated how to include this signal.

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21064024>

To call the corresponding project file, open the "as_fe_i_001_v10_code_estop.zip" file offered as a separate download and extract it into a user defined directory.

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container
- Menu "Options" -> Edit safety program
- Click the "Download" button
- Finally, set the mode switch of the F-CPU from STOP to RUN

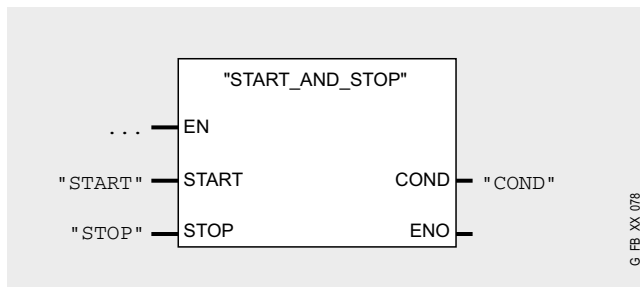
The sample code with the given configurations enables the following:

- Resetting a failsafe digital output after actuating the emergency stop push button
- Renewed setting (= start of the application) of the failsafe digital output requires the following:
 1. User acknowledgement (does not automatically start the application)
 2. Starting the application (only possible in case of previous acknowledgement)

Program procedure

FC "START_AND_STOP" (FC10)

The (non-failsafe) FC "START_AND_STOP" (FC 10) is called from OB 1 (see following figure).



Parameter	Adress	Explanation
START	E 0.1	Push button (NO) for the start requirement.
STOP	M 90.5	Dummy. If the operation related stop is to be implemented, replace the memory bit by an input Ex.y.
COND	M 90.0	Saves the information start/ stop of the "machine".

The information of the memory bit "COND" is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB35 for the following reason:

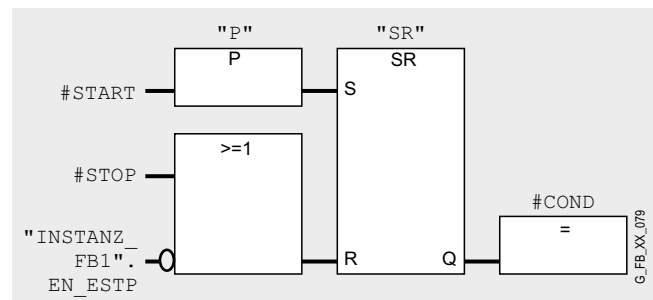
When reading data, which may be changed by the standard user program or an operation control and monitoring system during running of an F runtime group, from the standard user program (memory bits or PAE of standard I/O), in the safety program, it is necessary to use separate memory bits (here COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been implemented. Generally, however, the following applies:

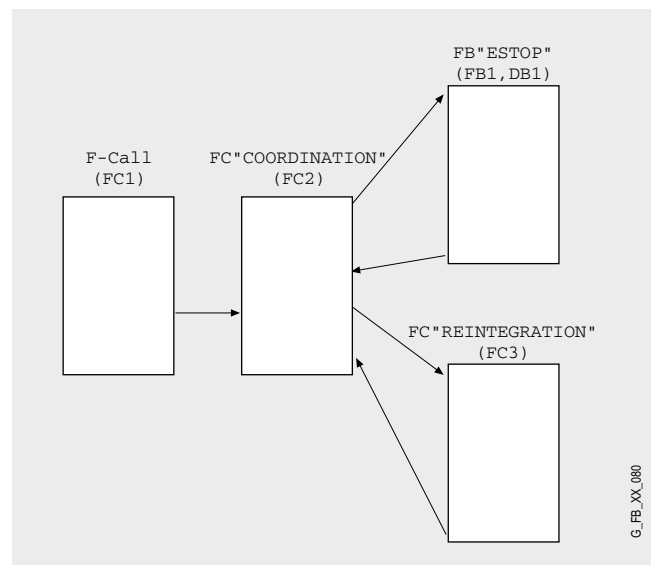
Note

If the above section is not observed the F CPU may go to STOP mode.

The FC "START_AND_STOP" (FC 10) in the following figure sets/resets #COND whose signal status ("0" or "1") starts or stops the "machine" in the failsafe program. #COND can only become "1" if the emergency stop button has been unlocked and acknowledged prior to the start (occurs in the safety program). This is ensured by the "Instanz_FB1".EN_ESTP bit from the instance data block DB 1 of FB 1 (from the safety program). This bit must have been set for a possible start. If this bit is "0" the "1" signal lies at the R entry of the flipflop, which makes the output Q always "0", even if with #START the S entry receives the "1" signal (resetting has priority with the used flipflop).



The failsafe program has the following program sequence:



F-CALL (FC1)

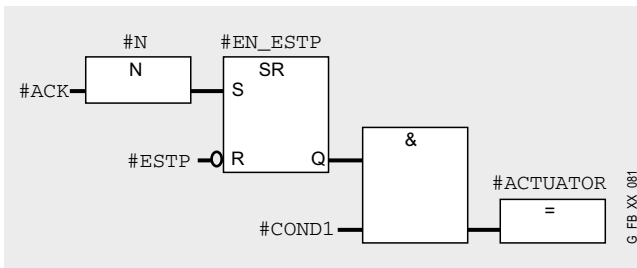
F-CALL (FC1) is the F runtime group and is called from the cyclic interrupt OB (OB 35). F-CALL calls the F-programme block (here: FC2).

FC "COORDINATION" (FC2)

For modularity reasons all further failsafe blocks are called from here.

FB "ESTOP" (FB1, DB1)

The emergency stop is implemented as follows:



The signal status of #COND1 is defined in the user program (see FC 10 or OB 35). #COND1="1" is the first condition for a start of the "machine" (#ACTUATOR="1"). The second condition is the acknowledgement required before the start. The flipflop is set with #ACK="1" (#EN_ESTP="1"). In the standard user program (FC 10) the static variable #EN_ESTP is read as bit of the instance DB of FB1 and ensures, that only after acknowledgment the COND bit (or COND1 in the safety program) is set there by the start signal.

By pressing the emergency stop button #ESTP becomes = "0" which sets the flipflop of the output Q back to "0" (resetting has the priority at this flipflop procedure), which makes #ACTUATOR also "0". ("machine" is switched off).

FC "REINTEGRATION" (FC3)

This FC ensures the reintegration of the passivated failsafe modules (F-DI and/or F-DO). For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be re-integrated. A passivation is indicated at the failsafe module via LED. The reintegration of an F module may take approx. one minute.

Note

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

Operating instructions

The table below will help you during operation.

No.	Instruction	Result/Note
1	Press the acknowledgement push button ACK and release it.	–
2	Press the push button for START instruction and release it.	Indicator light goes on ("machine" active).
3	Press the emergency stop push button.	Indicator light goes off. The output of the failsafe digital output module is reset.
4	Unlock emergency stop push button.	Perform action 1.

Safety Door with Spring-Loaded Engagement in Category 4 acc. to EN 954-1

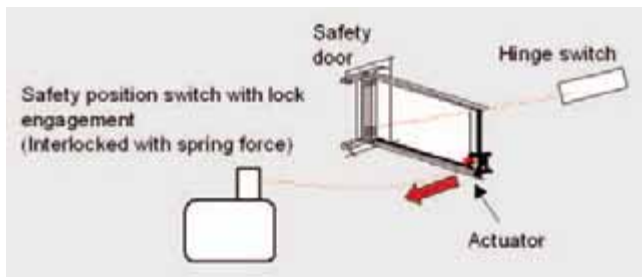
Automation Function

Description of the functionality

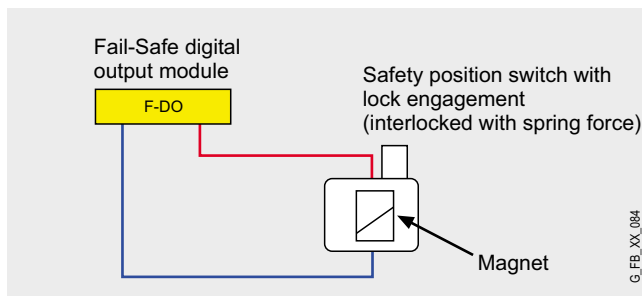
Interlocking devices with guard locking are mechanical or electrical devices which only enable operation of a machine if the door is closed and guard locked. Interlock and guard locking is maintained until the risk of injury caused by hazardous machine functions or motions is excluded. This monitoring is usually performed by overspeed trips or standstill monitors. In this example, motion/stoppage of a machine is simulated by a NO contact.

In this example, an actuator installed on the door moves form fit into a safety position switch with locked engagement. During the potential hazard (machine in RUN), the actuator is held (and thus the door guard locked) by the fact that the voltage applied to a magnet in the safety position switch is removed. This type of interlock is referred to as spring-actuated lock.

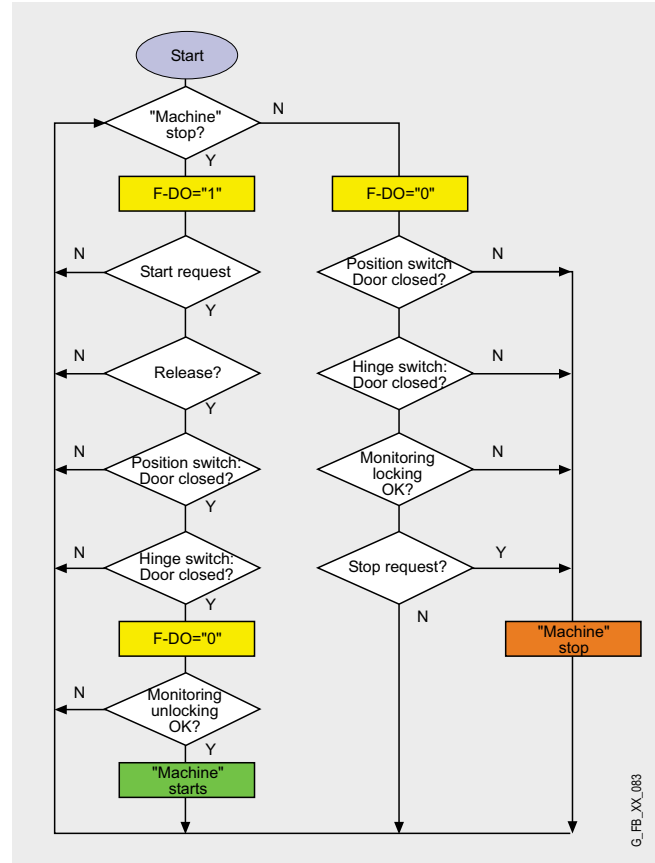
If the safety position switch fails, the safety function is maintained by the hinge switch (also detects the opened safety door). This ensures that the requirements of the **EN 954 : 1996** standard (Category 4) are met which prescribes redundant installation of all safety-relevant parts for position monitoring of the safeguard (here: Safety door).



The voltage applied to the magnet is removed by resetting a failsafe digital output channel of the ET 200S; this channel is linked to the magnet. The other way, the magnet is supplied with voltage to be able to open the safety door by setting this output.



The diagram below illustrates the concept of safety door monitoring:



Note

In this example, no real machine is controlled; the concept of a safety door monitoring with guard locking (on sensor side) is shown. If you want to additionally integrate a real machine or other actuators, you can of course use the parameters described in the corresponding STEP 7 as basis.

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet:

<http://support.automation.siemens.com/WW/view/en/19138505>

Advantages/customer benefits

- In case of power failure, the safety door remains interlocked
- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU
- Programming the failsafe program with STEP 7 engineering tools

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	4DI HF DC24V	6ES7131-4BD00-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	1	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Optional: Indicator light incl. incandescent lamp	yellow	3SB3217-6AA30	1	
Safety position switch with locked engagement	interlocked with spring force	3SE2840-6XX01	1	
Actuator	–	3SX3197	1	
SIGUARD hinge switch	1NO, 1NC	3SE2200-1GA11	1	
Push button	green, 1NO	3SB3801-0DA3	2	
Push button	red, 1NC	3SB3801-0DB3	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

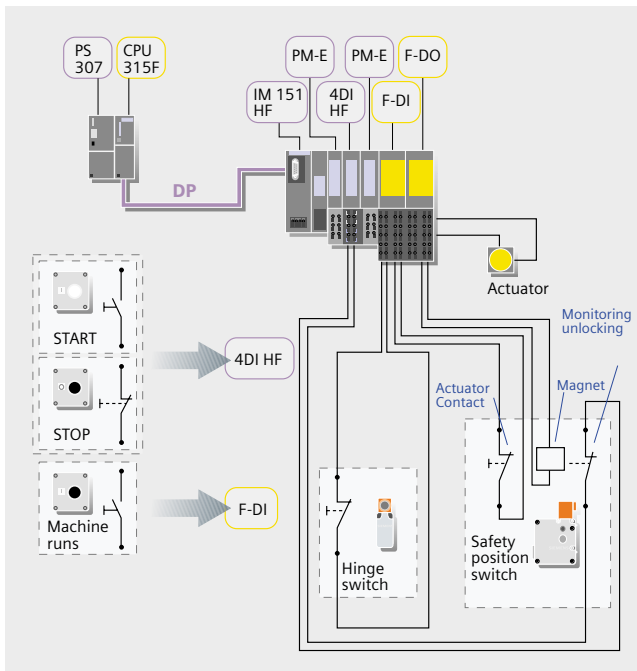
Setup and Wiring

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

Warning!
 In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.
 The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example No. 7 „Integration of the Readback Signal in an Application of Category 4 acc. to EN 954-1“ provides a detailed description of "Read back".

An overview of the hardware structure

The arrangement to implement the safety door interlock consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave. Below, the wiring of conventional modules is shown only partly to provide greater clarity.



Warning!

A speed or standstill monitor for monitoring hazardous slowing down of a machine is simulated in this example with a button (NO) which is connected as single-channel to the failsafe input module (F-DI). When using real speed or standstill monitors they must be connected to the F-DI as double-channels (1oo2 evaluation).

Note

The "high feature" electronic modules can also be replaced by standard modules.

Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

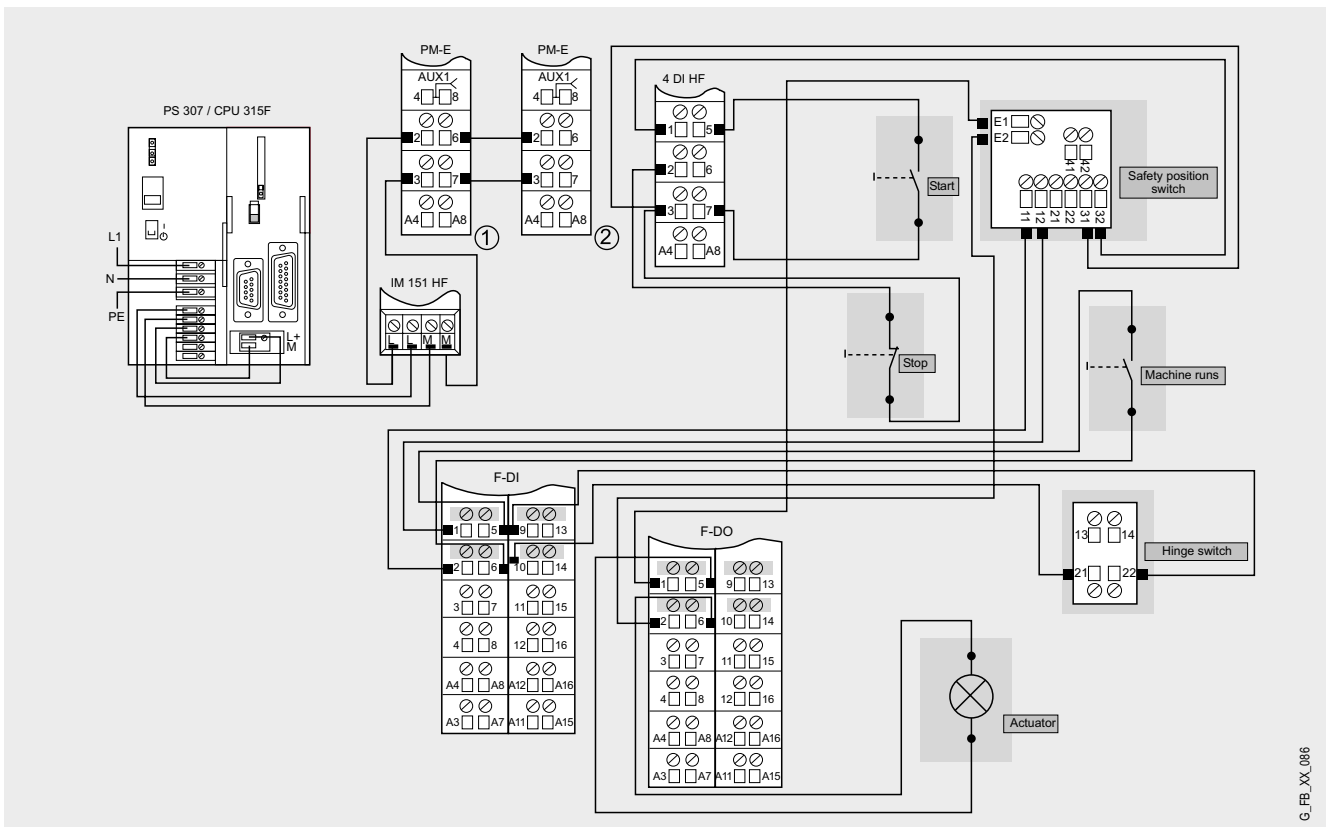
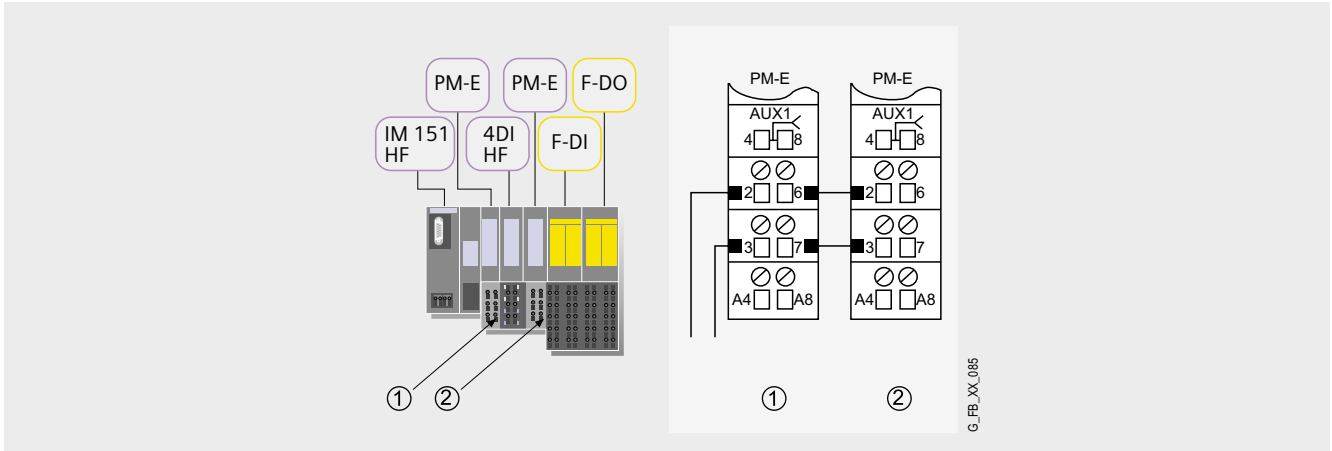
Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note

The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

The values listed in the "Signal (default value)" column refer to the following (error-free) state:

- Closed safety door
- Stoppage of a hazardous machine

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Monitoring unlocking of the safety position switch (NC)	E 0.0	E_MAGNET	"0"	"0" signal if U=24V at the magnet of the safety position switch
2	Push button (NO)	E 0.1	START	"0"	-
3	Push button (NC)	E 0.2	STOP	"1"	-
4	Actuator contact in the safety position switch (NC)	E 0.2	SEP_ACT	"1"	Contact picking up the separate actuator. "1" signal, if actuator in the safety position switch
5	Hinge switch (NC)	E 2.4	HINGED_SW	"1"	"1" signal, if door closed.
6	Push button (NO)	E 2.1	ACT_PAS	"0"	Simulates motion of a hazardous machine "0" means stoppage
7	Magnet in the safety position switch	A 8.0	COIL	"1"	"1": Door can be opened
8	Indicator light	A 8.1	ACTUATOR	"0"	Simulates hazardous machine

Testing inputs and outputs

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

No.	Instruction	Response		Note
		A 8.0	A 8.1	
1	None	"1"	"0"	Safety door can be opened
2	Press E 0.1 and release	"0"	"1"	Pressing then holding E2.1 (simulated movement). Safety door cannot be opened
3	Press E 0.2 and release	"0"	"0"	Keep E2.1 pressed (machine is switched off, however hazardous slowing down), Safety door cannot be opened
4	Release E 2.1	"1"	"0"	Machine stoppage. Safety door can be opened

Important hardware component settings

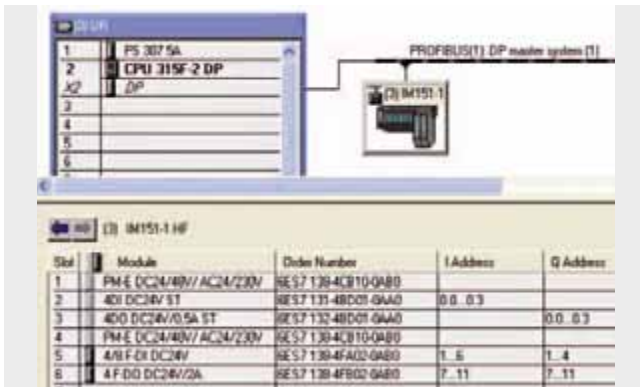
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of safety functions.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

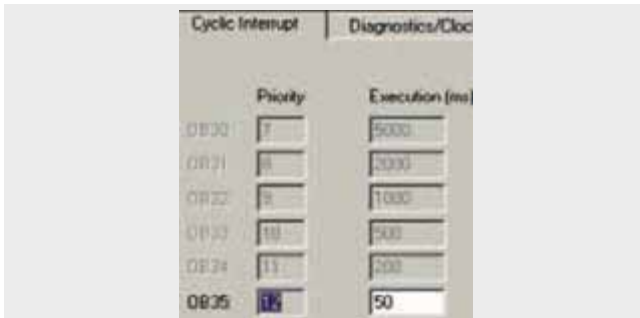
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



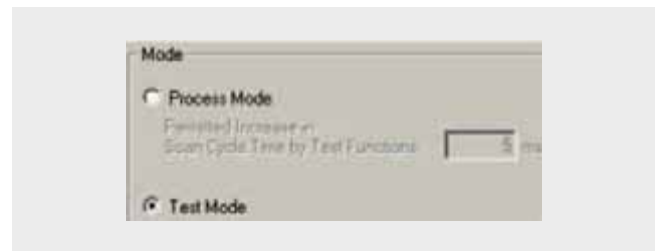
Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



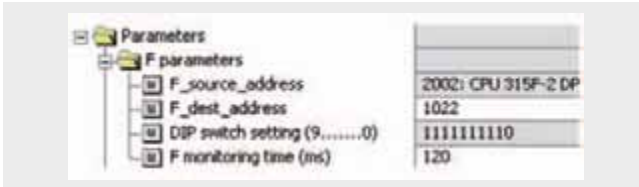
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



DIL switch settings

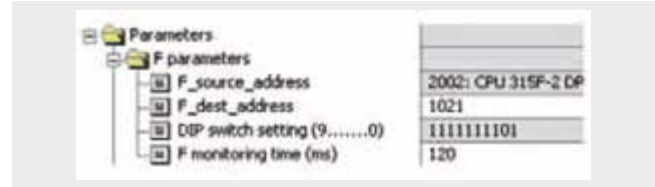
This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

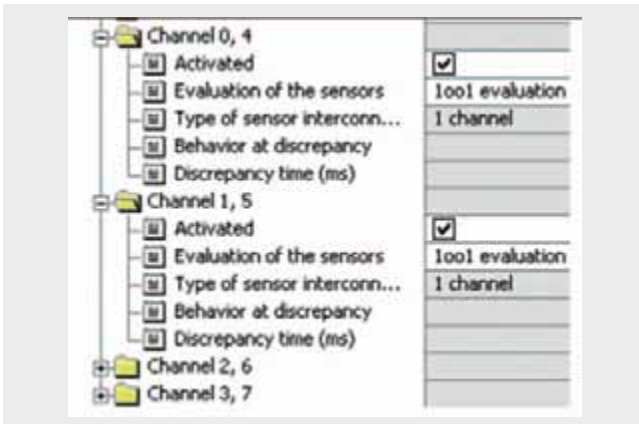


DIL switch settings

This value has to be set on the module (F-DI).

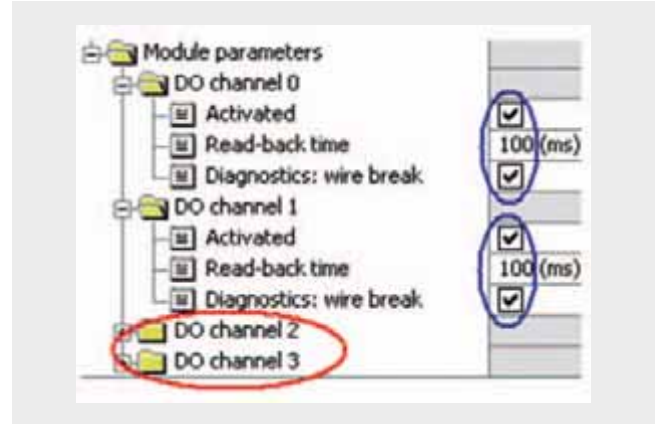
F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Also in the "Parameter" tab.

The safety position switch is assigned to channel 0, the hinge switch to channel 4 and the simulation of the speed or standstill monitor to channel 1. All three sensors are connected as single-channel. The other channels are deactivated.



Activate used channels, deactivate channels which are not used. The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 44,8 k	approx. 1,3 k	approx. 43,5 k
Main memory	approx. 32,5 k	approx. 0,5 k	approx. 32,0 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	9 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the described emergency stop functionality.

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

Password

In all cases, the passwords used for the safety-relevant part is „siemens“.

Use of the STEP 7 Project

The STEP 7 project shows the possibility of a safety door locking in safety category 4. In this example, the hazardous machine is simulated by an indicator light. The conditions necessary for the actuators to reach safety category 4 (e.g. read back of actuator signals) are not considered in this example.

Note

With this example, no real machine is controlled. The indicator lights simulate the state of a hazardous machine activity. The state "Machine in STOP" or "Machine in RUN" is simulated by a (NO) push button ("0" signal means: "Machine in STOP").

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21063946>

To call the corresponding project file, open the "as_fe_i_002_v10_code_sdoorspring.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

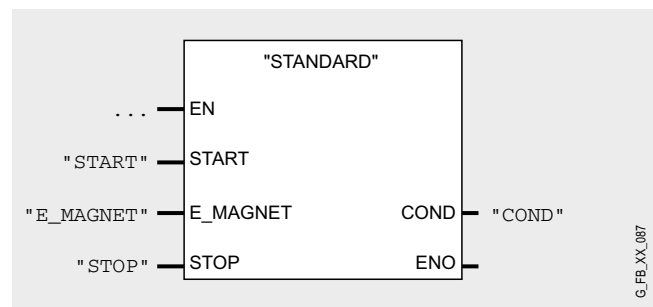
- First load the hardware configuration into the S7-CPU.
- Switch to the SIMATIC Manager.
- Select the "Blocks" container
- Menu "Options" -> Edit safety program.
- Click the "Download" button

The sample code with the given configurations enables the following:

- A safety door is guard locked until the hazardous action (example of a "machine" in RUN) is over.
- The safety door can always be opened with the keylock switch on the safety position switch (e.g. in case of an emergency).
- The safety door is interlocked/unlocked by resetting/setting a failsafe module (F-DO) of the ET 200S.

Program procedure

The (non-failsafe) FC "STANDARD" (FC 3) is called from OB 1 (see following figure).



Parameter	Adress	Explanation
START	E 0.1	Push button (NO) for the start requirement.
E_MAGNET	E 0.0	Position monitoring of the unlocking magnet in the safety position switch.
CONDSTOP	E 0.2	Button (NC) for the stop requirement.
COND	M 90.0	Saves the information start/ stop of the "machine".

The information of the memory bit "COND" is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB35 for the following reason:

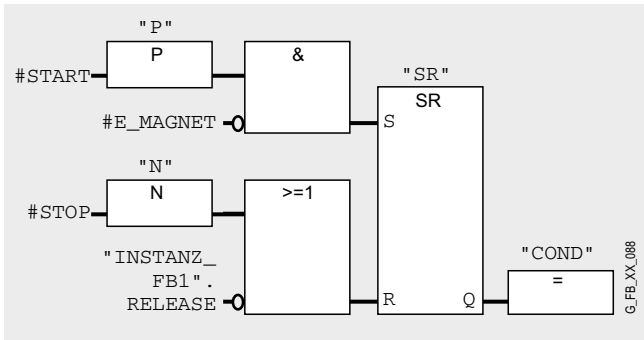
When reading data, which may be changed by the standard user program or an operation control and monitoring system during running of an F runtime group, from the standard user program (memory bits or PAE of standard I/O), in the safety program, it is necessary to use separate memory bits (here COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been implemented. Generally, however, the following applies:

Note
If the above section is not observed the F CPU may go to STOP mode.

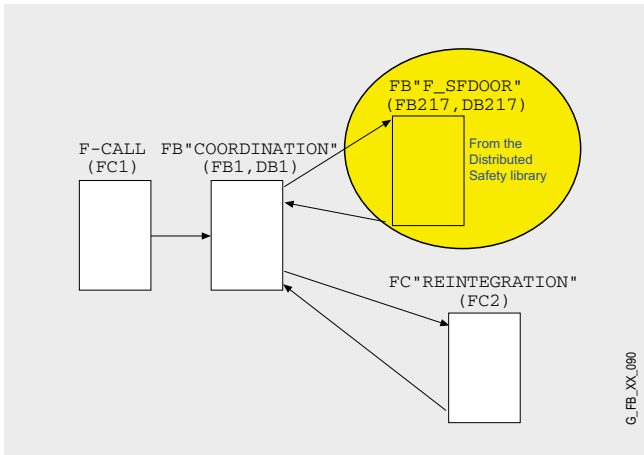
FC "STANDARD" (FC 3)

The FC "STANDARD" (FC 3) in the following figure sets/resets #COND whose information starts or stops the "machine" in the failsafe program.



"INSTANZ_FB1".RELEASE is a bit from the instance data block (DB 1) of the FB 1, which is processed in the safety program. The static variable "RELEASE" is set or reset. Here in FC 3 the standard user program will read this information, as the machine must only be operated with "RELEASE"="1".

The failsafe program has the following program sequence:

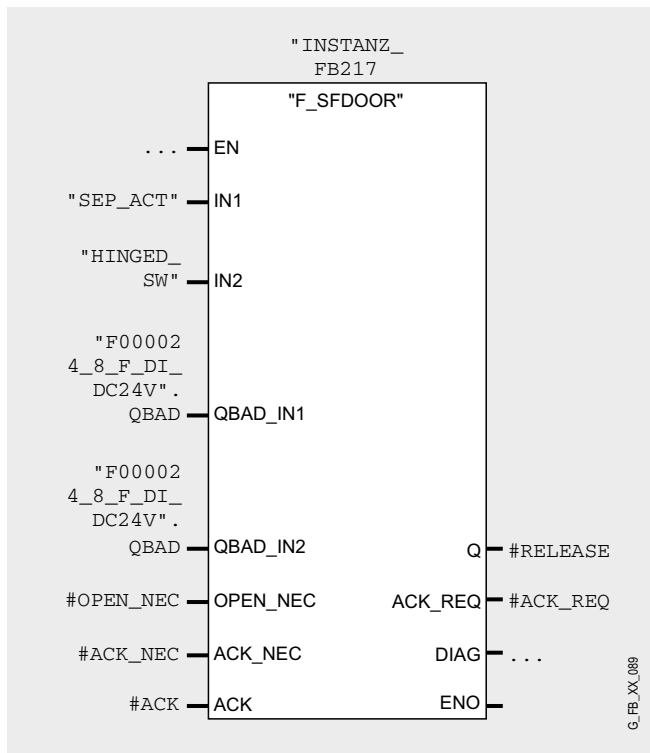


F-CALL (FC1)

F-CALL (FC1) is the F runtime group and is called from the cyclic interrupt OB (OB35). F-CALL calls the F-programme block (here the FB 1)

FB "F_SFDOOR" (FB217, DB217)

FB "COORDINATION" (FB1, DB1) is the first to call the FB "F_SFDOOR" (FB217, DB217). FB 217 is a certified block from the library of distributed safety, which from version 5.3 on is available for safety door monitoring.



The enable signal Q (#RELEASE) decides whether

- the actuator is switched on/off
- whether the safety door must be opened

The inputs of the safety position switch "SEP_ACT" and the hinge switch are allocated to the inputs IN1 and IN2 of the FB 217. As soon as one of the two inputs IN1 and IN2 has the signal status "0", it is interpreted as opening the safety door. The enable signal is thereby reset to '0'.

The enable signal can only be reset to 1 if:

- prior to closing the door both inputs IN1 and IN2 have the signal status 0 (safety door completely opened). This uncovers the error of a broken actuator still in the position switch despite of an opened door.
- subsequently both inputs IN1 and IN2 take on signal status 1 (safety door closed)
- an acknowledgement is given

The acknowledgement for the enable is given at the input ACK_NEC depending on the parameters:

- For ACK_NEC = 0 an automatic acknowledgement is given (as implemented in this example).
- For ACK_NEC = 1 you must first acknowledge ACK at the input by means of a rising edge.

In order for the F application block to recognize whether the inputs IN1 and IN2 are only "0" due to a passivation of the respective F-periphery, you must supply the inputs QBAD_IN1 and QBAD_IN2 with the variable QBAD of the respective F periphery DB. This prevents for example that for a passivation of the F-periphery the safety door must be completely opened prior to acknowledgement.

Warning!

The parameterization of the variables ACK_NEC=0 is only permitted, if an automatic restart of the respective process is excluded otherwise.

Should you supplement the example by means of a manual acknowledgement, please note the following:

Note

For safety door applications, the acknowledge signal must be read via a failsafe input module (F-DI), if it is an accessible hazardous area. For a non-accessible hazardous area, the acknowledge signal can also be read via a standard input module.

The F-application module supports the requirements according to EN954-1 and EN 1088.

After restarting the F system, the enable signal Q is reset to "0". The acknowledgement for the enable is given at the input OPEN_NEC and ACK_NEC depending on the parameters:

- For OPEN_NEC = 0 an automatic acknowledge is given **independent** of ACK_NEC, as soon as both inputs IN1 and IN2 have the signal status 1 for the first time after reintegration of the respective F periphery (safety door is closed). **In this example this variant has not been activated.**
- For OPEN_NEC = 1 **or** if at least one of both inputs IN1 and IN2 also has the F periphery signal status "0" after reintegration, there will be an automatic acknowledgement dependent on ACK_NEC or you must acknowledge ACK at the input by means of a rising edge. Prior to acknowledgement both inputs IN1 and IN2 must have had the signal status 0 (safety door completely opened) and subsequently signal status 1 (safety door closed).

Warning!

The parameterization of the variables OPEN_NEC=0 is only permitted, if an automatic restart of the respective process is excluded otherwise.

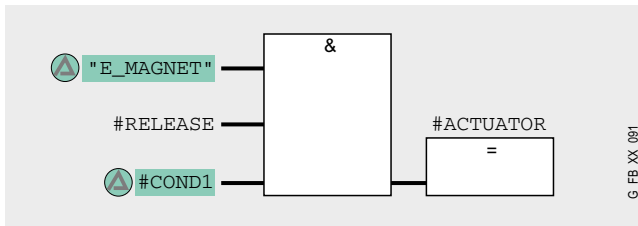
At the output DIAG a non-failsafe information on occurred errors is provided for service purposes. You can read it out via HMI systems or if necessary evaluate them in your standard user program.

Note

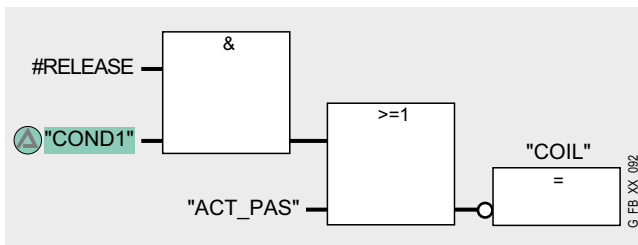
The safety program does not allow accessing the output DIAG!

FB "COORDINATION" (FB1, DB1)

After processing the FB 217, processing is continued in FB 1:
Network 2



The machine must only start at valid enable from FB 217 (#RELEASE="1") and the start request ("COND1"="1") from the standard user program. Additionally the tumbler (E_MAGNET) must be monitored (see "Network 3" below). The "machine" stops by a failure locking.

Network 3

The safety door locks ("COIL"="0"), if

- the machine is active or
- a movement of the machine (slowing down movement) has been detected

Only in case of locked door (COIL="0") E_MAGNET will be "1". E_MAGNET="1" is necessary for a start of the "machine" (see "Network 2"). The locking will be active with the start signal. The start will be active (ACTUATOR="1") one programme cyclus later as COIL="0".

FC "REINTEGRATION" (FC2)

Network 4 of FB1 calls the FC2, where in case of a passivation of F-DI or F-DO the reintegration will be implemented. For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

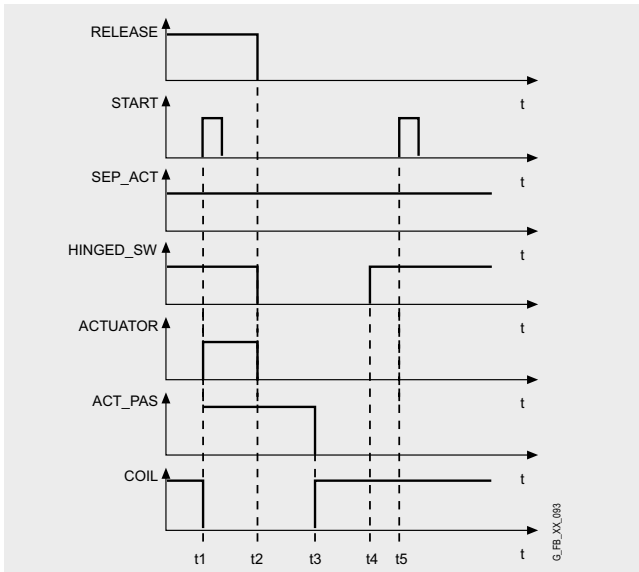
A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

No.	Instruction	Result/Note
1	Plug the actuator into the safety position switch.	Safety door is closed (safety position switch and hinge switch deliver "1" signal)
2	Check the position of the hinge switch.	
3	Press the START button	"Machine" starts (here: indicator light goes on)
4	Press the and hold the ACT_PAS button	Simulation of machine movement:
5	Press the STOP button	Indicator light goes off, however, safety door cannot be opened (if still pressing down ACT_PAS).
6	Release ACT_PAS	Simulated machine stoppage. Safety door can be opened (actuator outside positioning switch and hinge switch turned).
7	Repeat no. 1 to 4	–
8	Turn the hinge switch until the "0" signal.	Enable signal is reset and machine stops.
9	Release hinge switch and ACT_POS button.	–
10	Press the START button	"Machine" does not start! Safety door must first be opened completely for the enable signal to return to "1".

Timing diagram

The timing diagram below (explanation is provided after the diagram) illustrates the following case: While the hazardous machine is active, the door is opened (by force); during this process, the actuator breaks off the door and gets stuck in the safety position switch.



Time	t1	t2	t3	t4	t5
Bit					
RELEASE	Enable given	Enable reset			Stays reset
START	Start request				Start request
SEP_ACT	Door closed	Door open, however actuator breaks and stays in the position switch		Door closed	For enable, the door must be completely opened (error uncovered)
HINGED_SW		Door open,			
ACTUATOR	"Machine" rotates	"Machine" stops			No start of the "machine"
ACT_PAS		Slowing down movement	"Machine" in standstill		
COIL	Door locked		Door unlocked		

Alternative

In the case of the principle of interlock by spring force used here, the safety door remains locked in case of a power failure. This is the reason why professional associations prefer spring-actuated lock.

An alternative is the principle according to which the safety door remains closed due to magnetic force. A voltage must be applied to the magnet of the safety position switch to keep the door interlocked. This principle is described in the Safety Integrated Functional example No. 3 „Safety Door with Magnetic Engagement in Category 4 acc. to EN 954-1“.

Safety Door with Magnetic Engagement in Category 4 acc. to EN 954-1

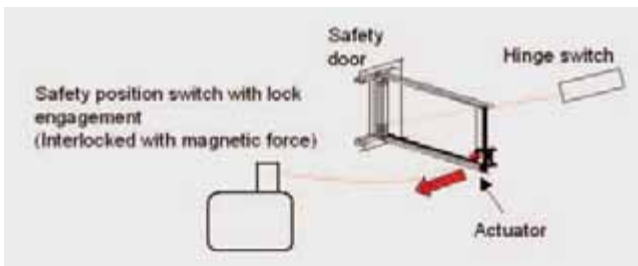
Automation Function

Description of the functionality

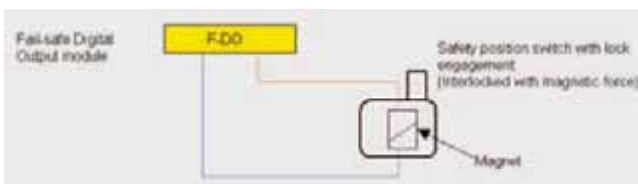
Interlocking devices with guard locking are mechanical or electrical devices which only enable operation of a machine if the door is closed and guard locked. Interlock and guard locking is maintained until the risk of injury caused by hazardous machine functions or motions is excluded. This monitoring is usually performed by overspeed trips or standstill monitors. In this example, motion/stoppage of a machine is simulated by a NO contact.

In this example, an actuator installed on the door moves form fit into a safety position switch with locked engagement. During the potential hazard (machine in RUN), the actuator is held (and thus the door guard locked) by the fact that voltage is applied to a magnet in the safety position switch. This type of interlock is referred to as **magnet-field lock**.

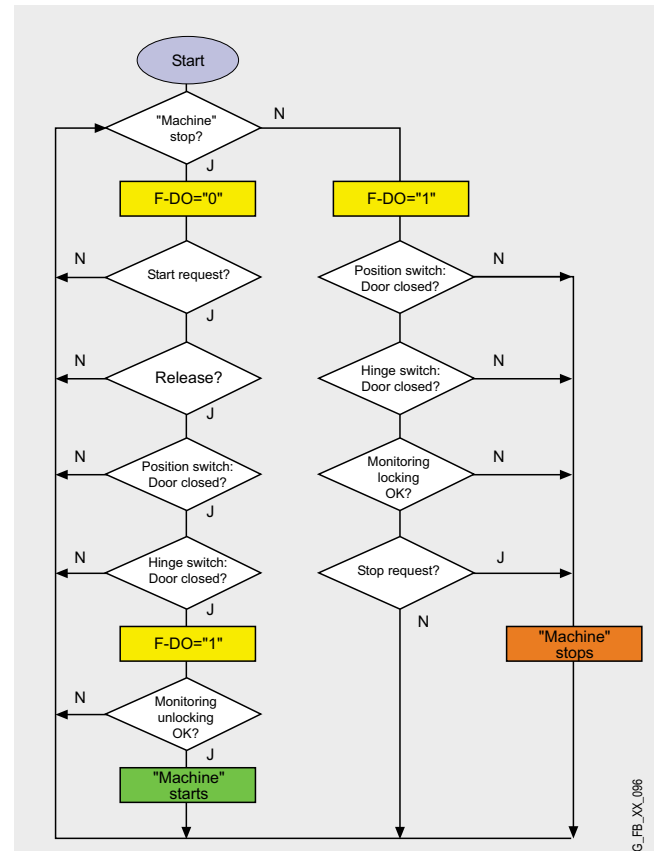
If the safety position switch fails, the safety function is maintained by the hinge switch (also detects the opened safety door). This ensures that the requirements of the **EN 954 : 1996** standard (Category 4) are met which prescribes redundant installation of all safety-relevant parts for position monitoring of the safeguard (here: Safety door).



The voltage is applied to the magnet of the safety position switch via a failsafe digital output module (F-DO) of the ET 200S.



The diagram below illustrates the concept of safety door monitoring:



Note

In this example, no real machine is controlled; the concept of a safety door monitoring with guard locking (on sensor side) is shown. If you want to additionally integrate a real machine or other actuators, you can of course use the parameters described in the corresponding STEP 7 as basis.

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet: <http://support.automation.siemens.com/WW/view/en/19138505>

Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the failsafe program with STEP 7 engineering tools
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7153-2AA02-0XB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	4DI HF DC24V	6ES7131-4BD00-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	1	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Optional: Indicator light incl. incandescent lamp	yellow	3SB3217-6AA30	1	
Safety position switch with locked engagement	interlocked with magnetic force	3SE2830-6XX00	1	
Actuator	–	3SX3197	1	
SIGUARD hinge switch	1NO, 1NC	3SE2200-1GA11	1	
Push button	green, 1NO	3SB3801-0DA3	2	
Push button	red, 1NC	3SB3801-0DB3	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

Warning!

In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.

The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example AS-FE-I-007-V10-EN provides a detailed description of "Read back".

Warning!

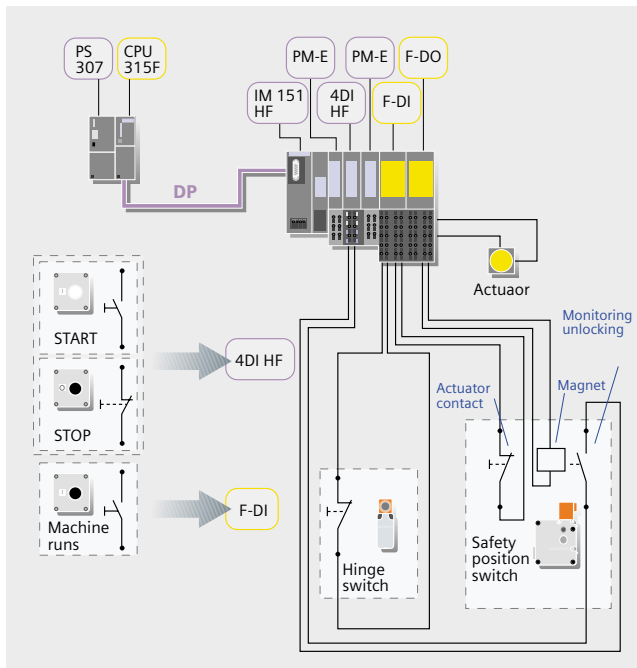
A speed or standstill monitor for monitoring hazardous slowing down of a machine is simulated in this example with a button (NO) which is connected as single-channel to the failsafe input module (F-DI). When using real speed or standstill monitors they must be connected to the F-DI as double-channels (1oo2 evaluation).

Note

The "high feature" electronic modules can also be replaced by standard modules.

An overview of the hardware structure

The arrangement to implement the safety door interlock consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave. Below, the wiring of conventional modules is shown only partly to provide greater clarity.



Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

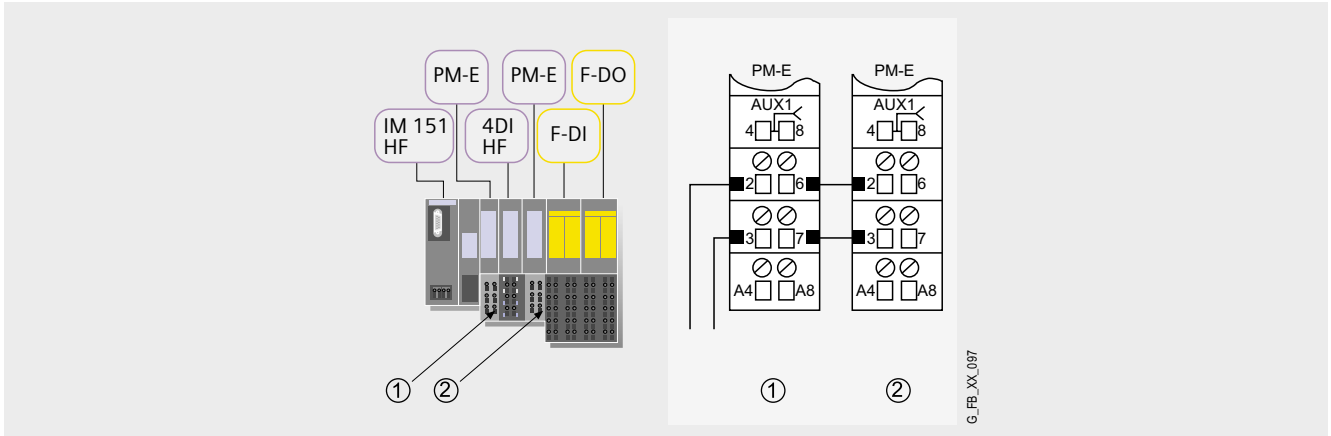
Hardware component	Einzustellende Adress	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note

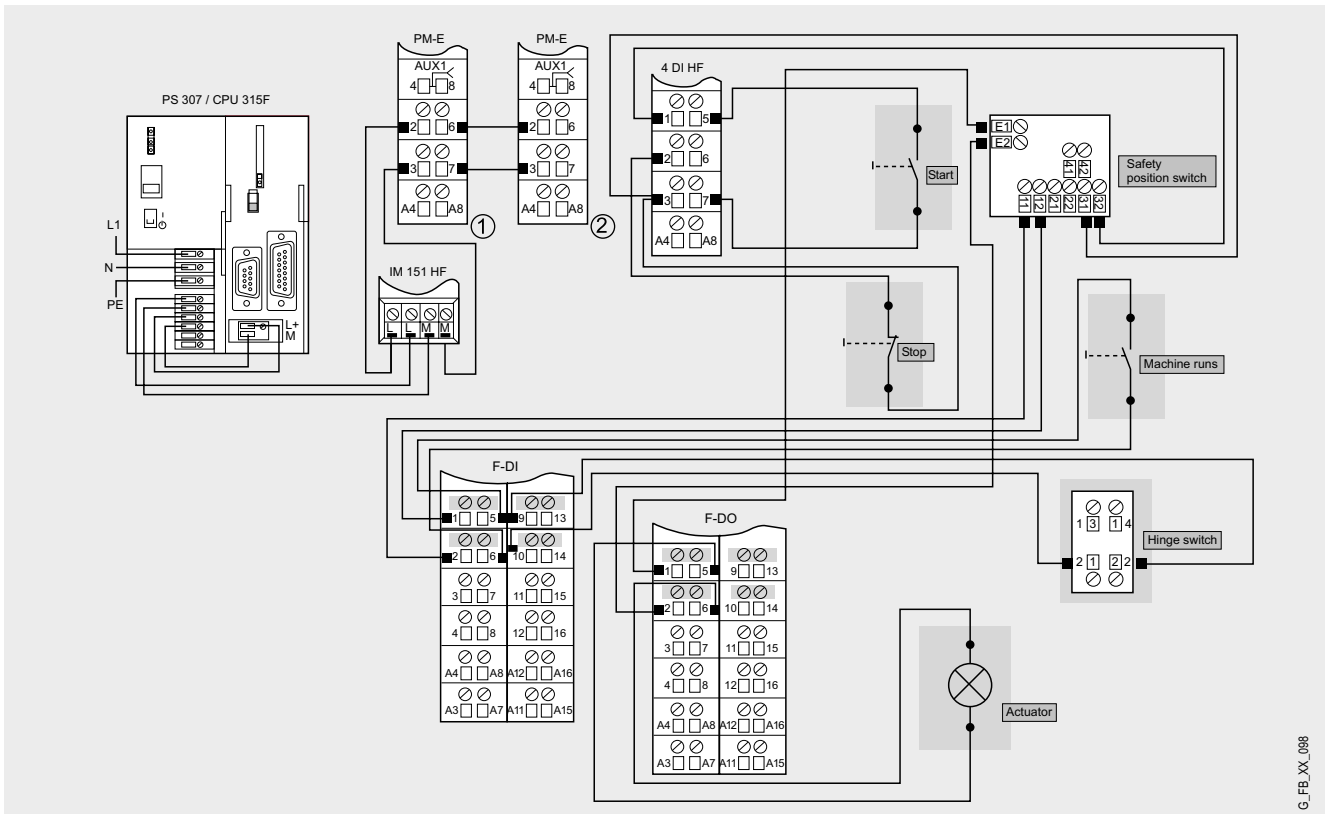
The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



G_FB_XX_097



G_FB_XX_098

Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

The values listed in the "Signal (default value)" column refer to the following (error-free) state:

- Closed safety door
- Stoppage of a hazardous machine

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Monitoring unlocking of the safety position switch (NO)	E 0.0	E_MAGNET	"0"	"0" signal if U=0 V at the magnet of the safety position switch
2	Push button (NO)	E 0.1	START	"0"	–
3	Push button (NC)	E 0.2	STOP	"1"	–
4	Actuator contact in the safety position switch (NC)	E 2.0	SEP_ACT	"1"	Contact picking up the separate actuator. "1" signal, if actuator in the safety position switch
5	Hinge switch (NC)	E 2.4	HINGED_SW	"1"	"1" signal, if door closed.
6	Push button (NO)	E 2.1	ACT_PAS	"0"	Simulates motion of a hazardous machine "0" means stoppage
7	Magnet in the safety position switch	A 8.0	COIL	"0"	"0": Door can be opened
8	Indicator light	A 8.1	ACTUATOR	"0"	Simulates hazardous machine

Testing inputs and outputs

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

No.	Instruction	Response		Note
		A 8.0	A 8.1	
1	None	"0"	"0"	Safety door can be opened
2	Press E 0.1 and release	"1"	"1"	Pressing then holding E2.1 (simulated movement). Safety door cannot be opened
3	Press E 0.2 and release	"1"	"0"	Keep E2.1 pressed (machine is switched off, however hazardous slowing down), Safety door cannot be opened
4	Release E 2.1	"0"	"0"	Machine stoppage. Safety door can be opened

Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of safety functions.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

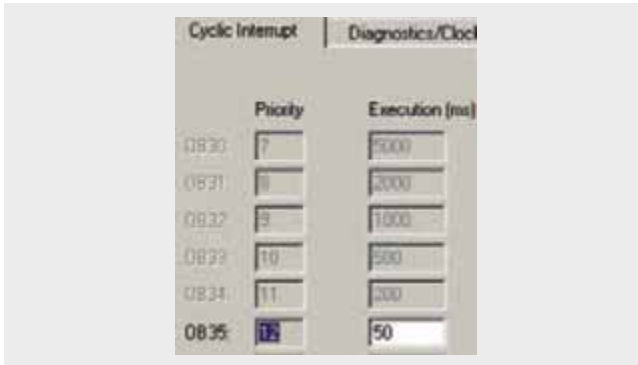
Overview picture

Slot	Module	Order Number	I Address	Q Address
1	PM-E DC24V/ AC120/230V	6ES7 130-4CB10-0AB0		
2	4DI DC24V HF	6ES7 131-4E000-0AB0	0.0 - 0.3	
3	PM-E DC24V/ AC120/230V	6ES7 130-4CB10-0AB0		
4	4x8 F-DI DC24V	6ES7 130-4FA01-0AB0	2 - 7	2 - 5
5	4 F-DO DC24V/2A	6ES7 130-4FB01-0AB0	8 - 12	8 - 12

The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



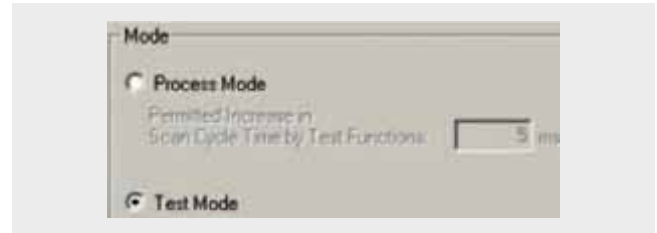
Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



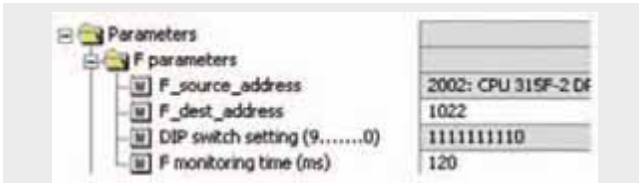
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").

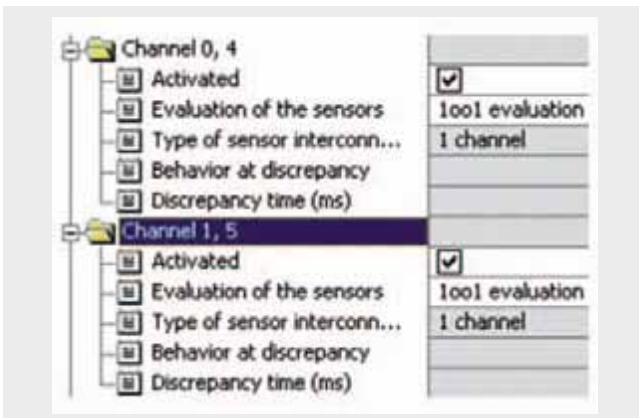


DIL switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

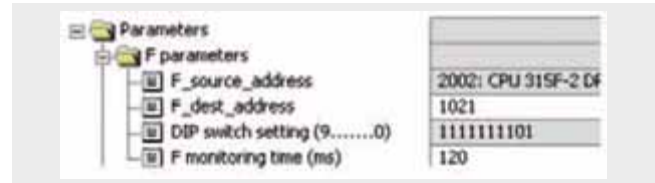


Also in the "Parameter" tab.

The safety position switch is assigned to channel 0, the hinge switch to channel 4 and the simulation of the speed or standstill monitor to channel 1. All three sensors are connected as single-channel. The other channels are deactivated.

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

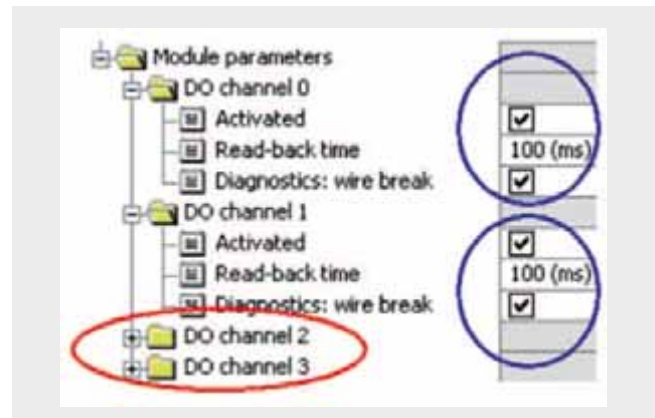


DIL switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Activate used channels, deactivate channels which are not used.

The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 44,6 k	approx. 1,1 k	approx. 43,5 k
Main memory	approx. 32,5 k	approx. 0,5 k	approx. 32,0 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	9 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the described emergency stop functionality.

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

Password

In all cases, the passwords used for the safety-relevant part is „siemens“.

Use of the STEP 7 Project

The STEP 7 project shows the possibility of a safety door locking in safety category 4. In this example, the hazardous machine is simulated by an indicator light. The conditions necessary for the actuators to reach safety category 4 (e.g. read back of actuator signals) are not considered in this example.

Note

With this example, no real machine is controlled. The indicator lights simulate the state of a hazardous machine activity. The state "Machine in STOP" or "Machine in RUN" is simulated by a (NO) push button ("0" signal means: "Machine in STOP").

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21064258>

To call the corresponding project file, open the "as_fe_i_003_v10_code_sdoormag.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory. For downloading the project into the F-CPU please proceed as follows:

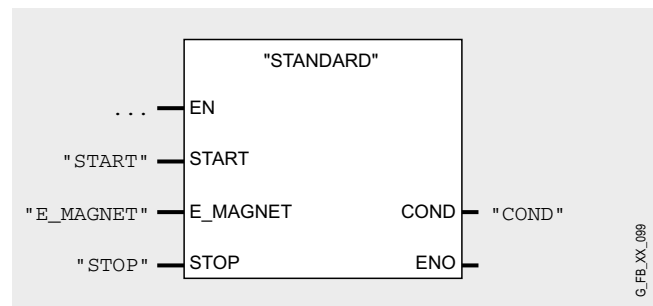
- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container
- Menu "Options" -> Edit safety program
- Click the "Download" button

The sample code with the given configurations enables the following:

- A safety door is guard locked until the hazardous action (example of a "machine" in RUN) is over.
- The safety door is interlocked and unlocked by setting/resetting a failsafe module (F-DO) of the ET 200S.

Program procedure

The (non-failsafe) FC "STANDARD" (FC 3) is called from OB 1 (see following figure).



Parameter	Adress	Explanation
START	E 0.1	Push button (NO) for the start requirement.
E_MAGNET	E 0.0	Position monitoring of the unlocking magnet in the safety position switch.
STOP	E 0.2	Button (NC) for the stop requirement.
COND	M 90.0	Saves the information start/ stop of the "machine".

The information of the memory bit "COND" is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB35 for the following reason:

When reading data, which may be changed by the standard user program or an operation control and monitoring system during running of an F runtime group, from the standard user program (memory bits or PAE of standard I/O), in the safety program, it is necessary to use separate memory bits (here COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

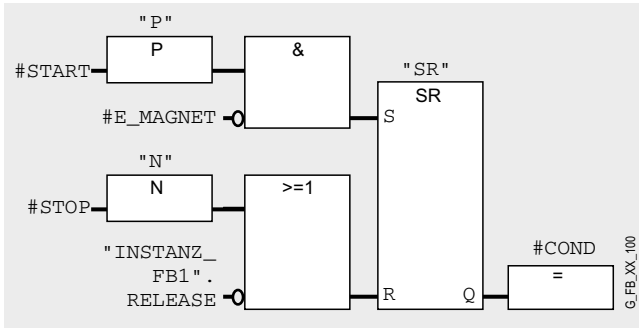
In this example it has already been implemented. Generally, however, the following applies:

Note

If the above section is not observed the F CPU may go to STOP mode.

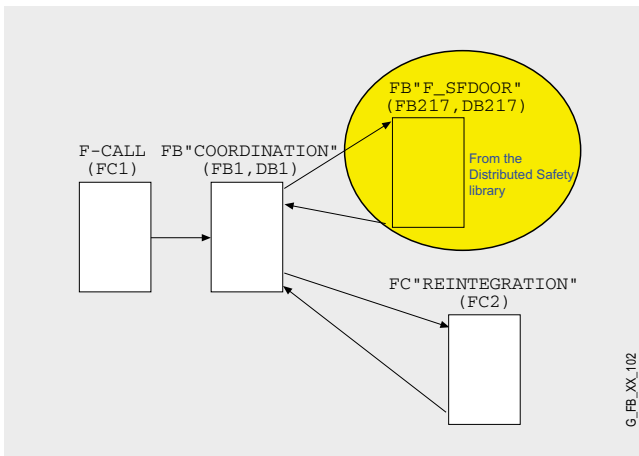
FC "STANDARD" (FC 3)

The FC "STANDARD" (FC 3) in the following figure sets/resets #COND whose information starts or stops the "machine" in the failsafe program.



"INSTANZ_FB1".RELEASE is a bit from the instance data block (DB 1) of the FB 1, which is processed in the safety program. The static variable "RELEASE" is set or reset. Here in FC 3 the standard user program will read this information, as the machine must only be operated with "RELEASE"="1".

The failsafe program has the following program sequence:

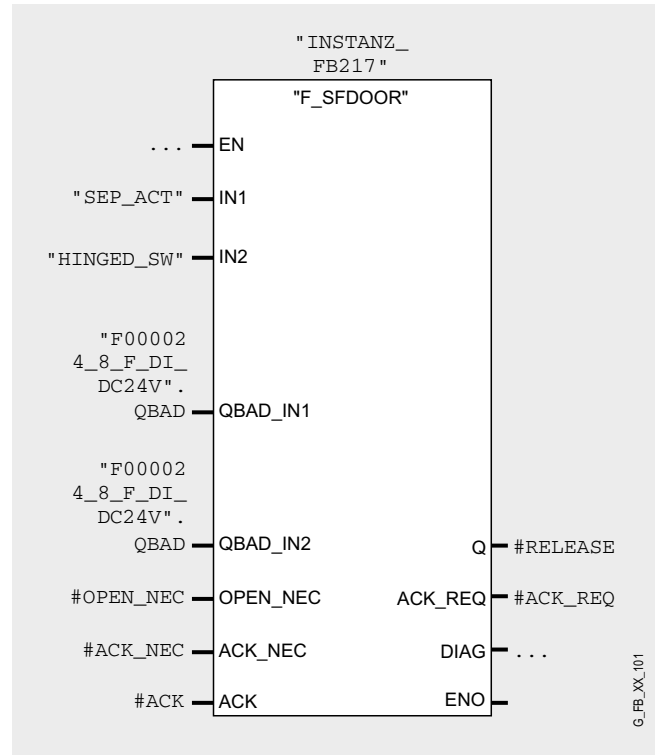


F-CALL (FC1)

F-CALL (FC1) is the F runtime group and is called from the cyclic interrupt OB (OB35). F-CALL calls the F programe block (here the FB 1).

FB "F_SFDOOR" (FB217, DB217)

FB "COORDINATION" (FB1, DB1) is the first to call the FB "F_SFDOOR" (FB217, DB217). FB 217 is a certified block from the library of distributed safety, which from version 5.3 on is available for safety door monitoring.



The enable signal Q (#RELEASE) decides whether

- the actuator is switched on/off
- whether the safety door must be opened

Enable is given at #RELEASE="1".

The inputs of the safety position switch "SEP_ACT" and the hinge switch are allocated to the inputs IN1 and IN2 of the FB 217. As soon as one of the two inputs IN1 and IN2 has the signal status "0", it is interpreted as opening the safety door. The enable signal is thereby reset to '0'.

The enable signal can only be reset to 1 if:

- prior to closing the door both inputs IN1 and IN2 have the signal status 0 (safety door completely opened). This uncovers the error of a broken actuator still in the position switch despite of an opened door.
- subsequently both inputs IN1 and IN2 take on signal status 1 (safety door closed)
- an acknowledgement is given

The acknowledgement for the enable is given at the input ACK_NEC depending on the parameters:

- For ACK_NEC = 0 an automatic acknowledgement is given (as implemented in this example).
- For ACK_NEC = 1 an enable requires acknowledging ACK at the input by means of a rising edge.

In order for the F application block to recognize whether the inputs IN1 and IN2 are only "0" due to a passivation of the respective F-periphery, you must supply the inputs QBAD_IN1 and QBAD_IN2 with the variable QBAD of the respective F periphery DB. This prevents for example that for a passivation of the F-periphery the safety door must be completely opened prior to acknowledgement.

Warning!

The parameterization of the variables ACK_NEC=0 is only permitted, if an automatic restart of the respective process is excluded otherwise.

Should you supplement the example by means of a manual acknowledgement, please note the following:

Note

For safety door applications, the acknowledge signal must be read via a failsafe input module (F-DI), if it is an accessible hazardous area. For a non-accessible hazardous area, the acknowledge signal can also be read via a standard input module.

The F-application module supports the requirements according to EN954-1 and EN 1088.

After restarting the F system, the enable signal Q is reset to "0". The acknowledgement for the enable is given at the input OPEN_NEC and ACK_NEC depending on the parameters:

- For OPEN_NEC = 0 an automatic acknowledge is given **independent** of ACK_NEC, as soon as both inputs IN1 and IN2 have the signal status 1 for the first time after reintegration of the respective F periphery (safety door is closed). **In this example this variant has not been activated.**
- For OPEN_NEC = 1 or if at least on of both inputs IN1 and IN2 have the signal status "0" even after reintegration of the respective periphery, an automatic acknowledgement is given depending on ACK_NEC, or the enable requires acknowledging ACK at the input by means of a rising edge. Prior to acknowledgement both inputs IN1 and IN2 must have had the signal status 0 (safety door completely opened) and subsequently signal status 1 (safety door closed).

Warning!

The parameterization of the variables OPEN_NEC=0 is only permitted, if an automatic restart of the respective process is excluded otherwise.

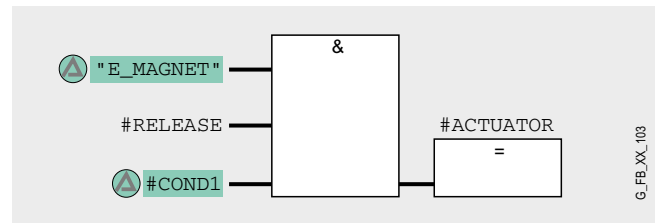
At the output DIAG a non-failsafe information on occurred errors is provided for service purposes. You can read it out via HMI systems or if necessary evaluate them in your standard user program.

Note

The safety program does not allow accessing the output DIAG!

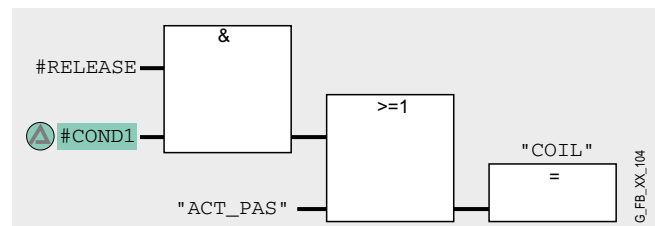
FB "COORDINATION" (FB1, DB1)

After processing the FB 217, processing is continued in FB 1: Network 2



The machine must only start at valid enable from FB 217 (#RELEASE="1") and the start request ("COND1"="1") from the standard user program. Additionally the tumbler (E_MAGNET) must be monitored (see "Network 3" below). The "machine" stops by a failure locking.

Network 3



The safety door locks ("COIL"="1"), if

- the machine is active or
- a movement of the machine (slowing down movement) has been detected.

Only in case of locked door (COIL="1") E_MAGNET will be "1". E_MAGNET="1" is necessary for a start of the "machine" (see "Network 2"). The locking will be active with the start signal. The start will be active (ACTUATOR="1") one program cycle later as COIL="1".

FC "REINTEGRATION" (FC2)

Network 4 of FB1 calls the FC2, where in case of a passivation of F-DI or F-DO the reintegration will be implemented. For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

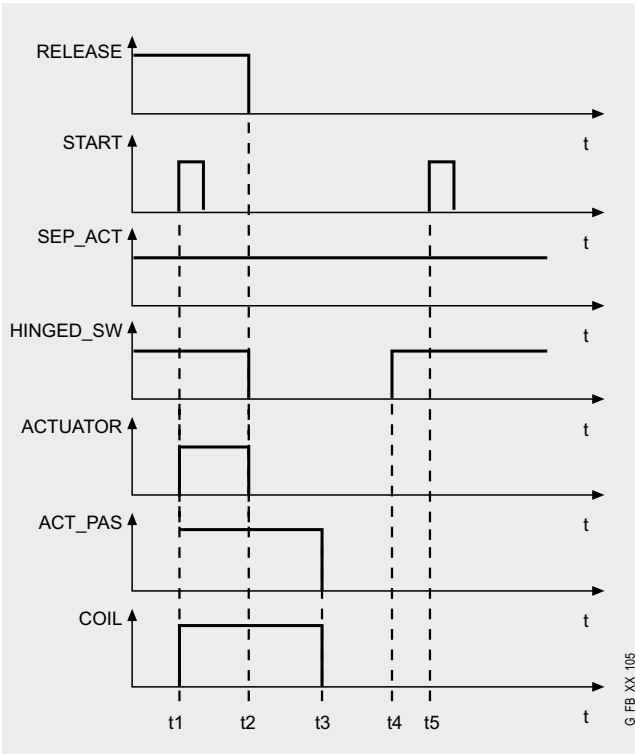
Operating instructions

No.	Instruction	Result/Note
1	Plug the actuator into the safety position switch.	Safety door is closed (safety position switch and hinge switch deliver "1" signal)
2	Check the position of the hinge switch.	
3	Press the START button	"Machine" starts (here: indicator light goes on)
4	Press the and hold the ACT_PAS button	Simulation of machine movement:
5	Press the STOP button	Indicator light goes off, however, safety door cannot be opened (if still pressing down ACT_PAS).
6	Release ACT_PAS	Simulated machine stoppage. Safety door can be opened (actuator outside positioning switch and hinge switch turned).
7	Repeat no. 1 to 4	–
8	Turn the hinge switch up to the "0" signal.	Enable signal is reset and machine stops.
9	Release hinge switch and ACT_POS button.	–
10	Press the START button	"Machine" does not start! Safety door must first be opened completely for the enable signal to return to "1".

Timing diagram

The timing diagram below (explanation is provided after the diagram) illustrates the following case:

While the hazardous machine is active, the door is opened (by force); during this process, the actuator breaks off the door and gets stuck in the safety position switch.



Time	t1	t2	t3	t4	t5
Bit					
RELEASE	Enable given	Enable reset			Stays reset
START	Start request				Start request
SEP_ACT	Door closed	Door open, however actuator breaks and stays in the position switch		Door closed	For enable, the door must be completely opened (error uncovered)
HINGED_SW		Door open,			
ACTUATOR	"Machine" rotates	Machine stops			No start of the "Machine"
ACT_PAS		Slowing down movement	"Machine" in STOP		
COIL	Door locked		Door unlocked		

Alternative

In case of the principle of interlock by magnetic force used here, the safety door remains locked as long as voltage is applied to the magnet in the safety position switch.

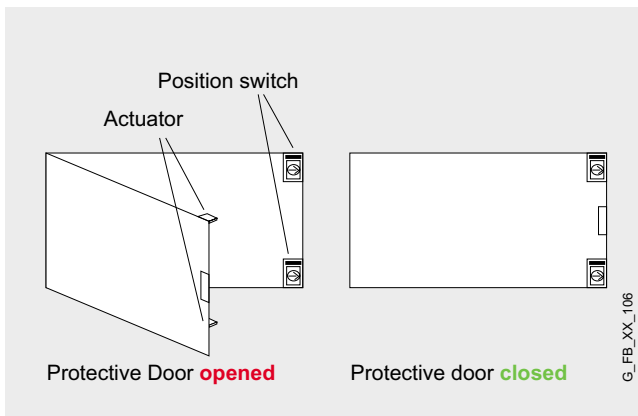
An alternative is the principle according to which the safety door remains closed due to spring force. The voltage applied to the magnet of the safety position switch must drop to zero to keep the door interlocked. This principle is described in the Safety Integrated Functional Example No. AS-FE-I-002-V10-EN.

Safety Door without Guard Locking in Category 4 acc. to EN 954-1

Automation Function

Description of the functionality

In general, two types of safety doors can be used. In case of the type **with guard locking**, the door is held in a position switch during the potential hazard. In case of hazardous machine motions with short braking times, position switches **without tumbler** are often used. The example introduced here shows how the requirements of Safety Category 4 can be met with the latter variant according to **EN 954 : 1996**.



The requirements of Safety Category 4 are met due to use of 2 SIGUARD position switches (or a magnetic switch) with separate actuators (redundancy for mechanical parts). The position switch is installed form fit at the closing edge on the fixed part, the actuator is installed at the moving door.

The position switch features positive-opening contacts which are directly connected to the failsafe digital input module of the ET 2005 I/O system. The commands acquired that way are evaluated in the safety program of the S7-CPU. The safety program of the S7-CPU ensures that:

- prior to each start, acknowledgement is necessary if the application has been stopped by opening the safety door
- if only one position switch indicates an open safety door, it must be completely opened prior to a restart (open/close safety door, acknowledge, start)
- the application can only be started if the safety door is closed
- the application stops if the safety door is opened during operation or as soon as a contact of the position switch responds

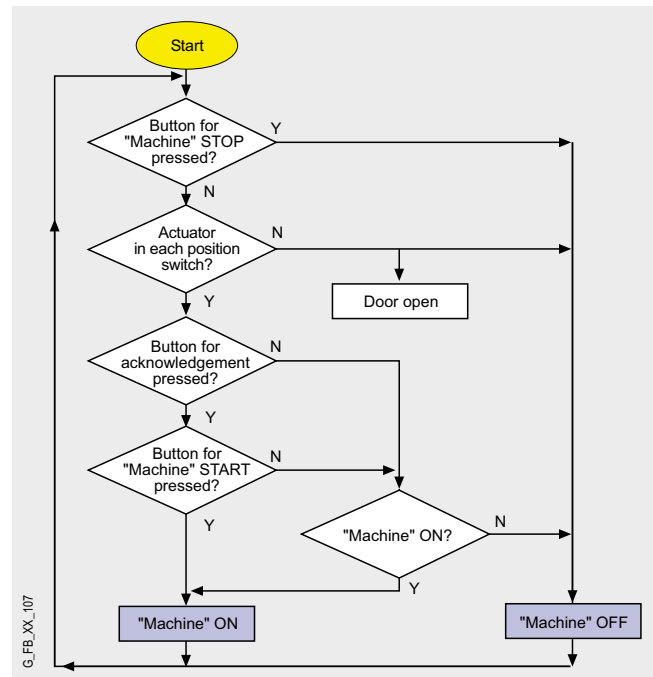
In this example, the hazardous machine is simulated by an indicator light which is connected to a failsafe digital output module of the ET 2005 I/O system. In this document, the designation "machine" refers to this indicator light.

Warning!

When using different actuators, the feedback circuits have to be integrated and evaluated by the user. You find more information about the readback signals in the Safety Functional Example no. AS-FE-I-007-V10-EN.

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet: <http://support.automation.siemens.com/WW/view/en/19138505>

The diagram below illustrates the conditions for a start or a stop of the "machine".



Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the failsafe program with STEP 7 engineering tools.
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	1	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Optional: Indicator light incl. incandescent lamp	yellow	3SB3217-6AA30	1	
Position switch	metal-enclosed	3SE2120-6XX	2	
Actuator	–	3SX3197	2	
Push button	green, 1NO	3SB3801-0DA3	2	
Push button	red, 1NC	3SB3801-0DB3	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

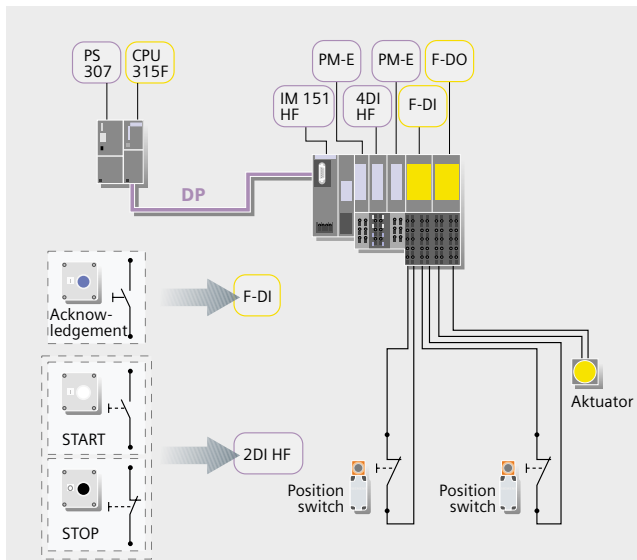
Warning!

In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.

The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example AS-FE-I-007-V10-EN provides a detailed description of "Read back".

An overview of the hardware structure

The arrangement to implement the safety door consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave. The yellow indicator light can be replaced by actuators in accordance with their requirements. Below, the wiring of conventional modules is shown only partly to provide greater clarity.



Note

The "high feature" electronic modules can also be replaced by standard modules.

Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

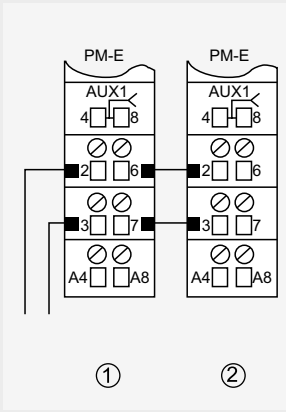
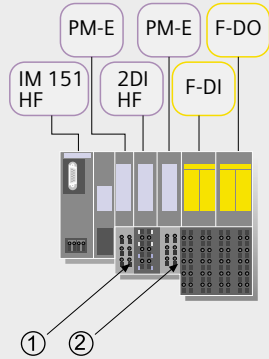
Hardware component	Einzustellende Adress	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note

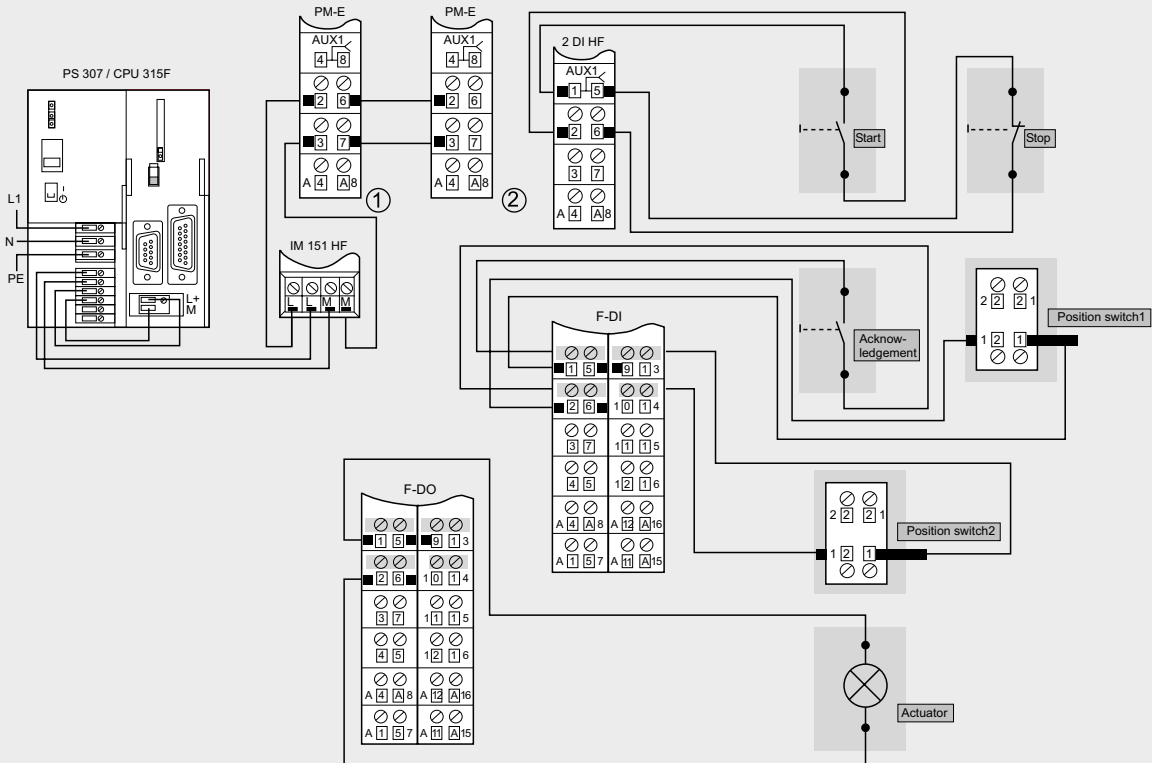
The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



G_FB_XX_108



G_FB_XX_109

Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	START	"0"	–
2	Push button (NC)	E 0.1	STOP	"1"	–
3	Position switch	E 2.0	SW1	"1"	"1" signal, if actuator in the position switch
4	Push button (NO)	E 2.1	ACK	"0"	Acknowledgement
5	Position switch	E 2.4	SW2	"1"	"1" signal, if actuator in the position switch
6	Indicator light (yellow)	A 8.0	ACTUATOR	"0"	Simulates "machine"

Testing inputs and outputs

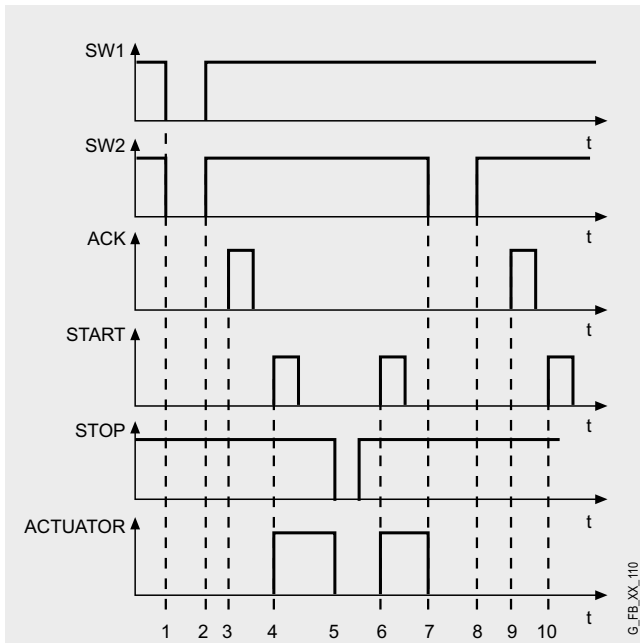
Requirements: The inputs and outputs have the default values specified under "Inputs/outputs used".

No.	Instruction	A8.0	Note
1	Pull both actuators from the position switches	"0"	Open the safety door Necessary prior to the first start.
2	Plug both actuators into the position switch.	"0"	Close safety door
3	Press the push button E2.1 and release it	"0"	Acknowledge
4	Press the push button E0.0 and release it	"1"	"Machine" start
5	Press the push button E0.1 and release it	"0"	"Machine" stop
6	Press the push button E0.0 and release it	"1"	"Machine" start
7	Pull one actuator from the position switch	"0"	Error case: Door open, an actuator breaks and gets stuck in the position switch

No.	Instruction	A8.0	Note
8	Plug the actuator back into the position switch	"0"	Close safety door
9	Press the push button E2.1 and release it	"0"	Acknowledgement obligatory after opening the safety door
10	Press the push button E0.0 and release it	"0"	Start not possible, only...
11	Repeat no. 1 to 4	"1"	... after completely opening and closing the safety door and subsequent acknowledgement.
12	Press the push button E0.1 and release it	"0"	"Machine" stop

Timing diagram

As an illustration, points 1 to 10 from the preceding table are illustrated in the following time diagram. The time axis contains numbers 1 to 10, which refer to the numbers in the table.



Important hardware component settings

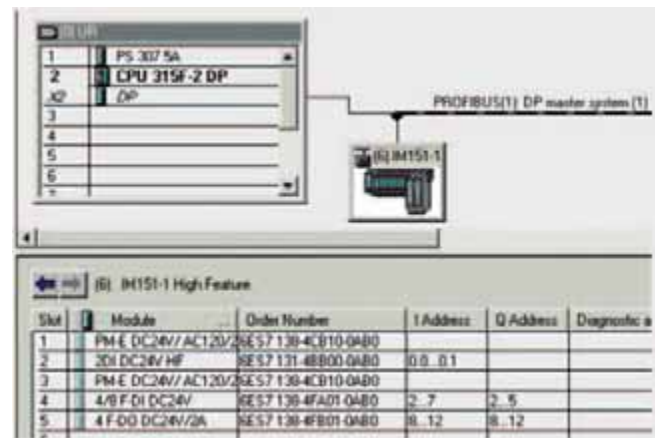
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



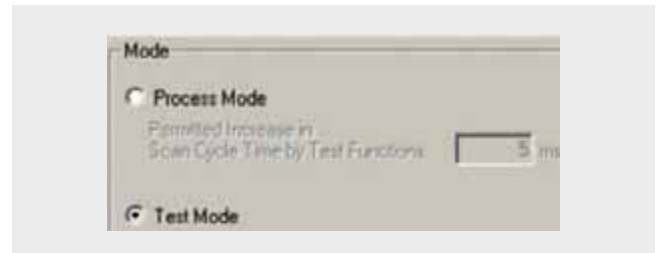
Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



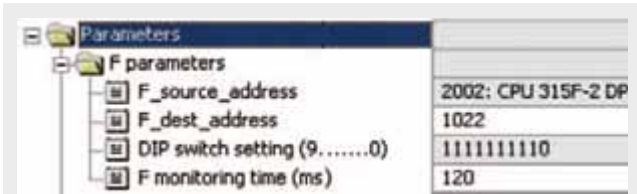
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").

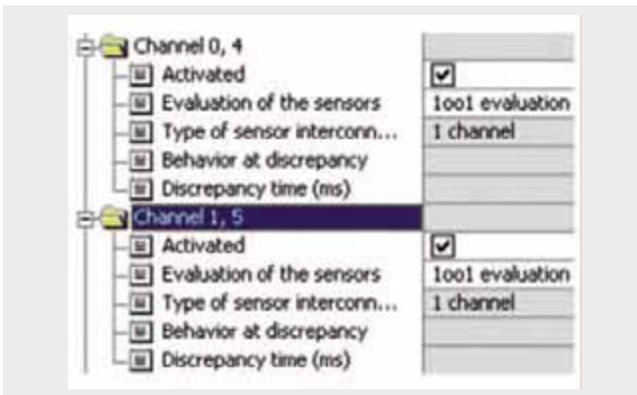


DIL switch settings:

This value has to be set on the module (F-DI).

F monitoring time:

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Also in the "Parameter" tab.

The two position switches are transferred to the channels 0 and 4 as single-channel sensors.

The button for acknowledgement is assigned to channel 1 as single channel sensor.

All other channels: Deactivate

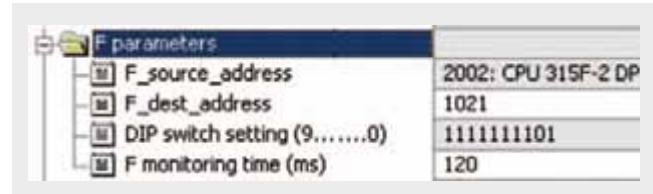
Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 37,4	approx. 0,1 k	approx. 37,3 k
Main memory	approx. 28,1	approx. 0,04 k	approx. 28,1 k

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

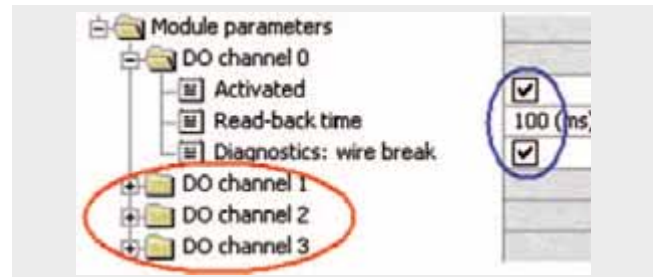


DIL switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Activate used channels, deactivate channels which are not used.

The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 44,6 k	approx. 1,1 k	approx. 43,5 k
Main memory	approx. 32,4 k	approx. 0,4 k	approx. 32,0 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	9 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the described emergency stop functionality.

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

Password

In all cases, the passwords used for the safety-relevant part is „**siemens**“.

Use of the STEP 7 Project

The STEP 7 project shows the possibility of a safety door locking without guard locking in safety category 4. In this example, the hazardous machine is simulated by an indicator light. The conditions necessary for the actuators to reach safety category 4 (e.g. read back of actuator signals) are not considered in this example.

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21331363>

To call the corresponding project file, open the "as_fe_i_004_v10_code_sdoor.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory. For downloading the project into the F-CPU please proceed as follows:

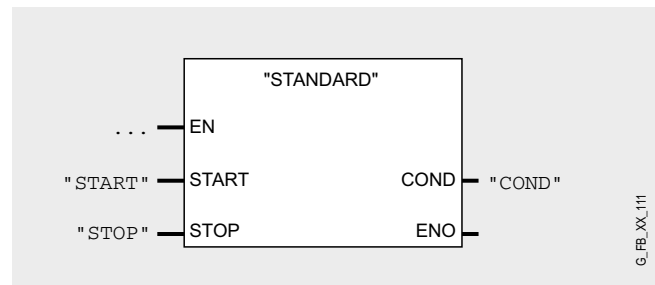
- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container
- Menu "Options" -> Edit safety program.
- Click the "Download" button

The sample code with the given configurations enables the following:

- An application (here: Machine simulated by indicator lights) can only be started if the safety door is closed.
- Opening the safety door during operation of the machine stops the application
- After each opening, the safety must be acknowledged prior to a restart.
- If an actuator breaks off during opening the safety door and gets stuck in the position switch, this error will be certainly recognized.

Program procedure

The (non-failsafe) FC "STANDARD" (FC 3) is called from OB 1 (see following figure).



Parameter	Adress	Explanation
START	E 0.1	Push button (NO) for the start requirement.
STOP	E 0.1	Button (NC) for the stop requirement.
COND	M 90.0	Information for the safety program

The information of the memory bit "COND" is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

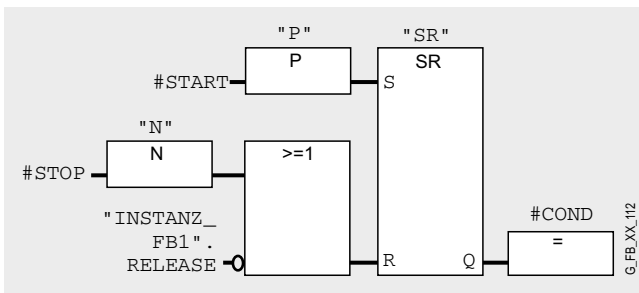
When reading data, which may be changed by the standard user program or an operation control and monitoring system during running of an F runtime group, from the standard user program (memory bits or PAE of standard I/O), in the safety program, it is necessary to use separate memory bits (here COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been implemented. Generally, however, the following applies:

Note

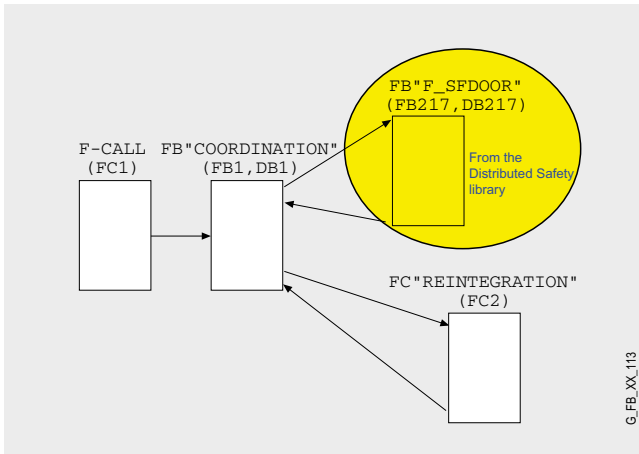
If the above section is not observed the F CPU may go to STOP mode.

FC "STANDARD" (FC3)



"INSTANZ_FB1".RELEASE is a bit from the instance data block (DB 1) of the FB 1, which is processed in the safety program. The static variable "RELEASE" is set or reset. Here in FC 3 the standard user program will read this information, as the machine must only be operated with "RELEASE"="1".

The failsafe program has the following program sequence:

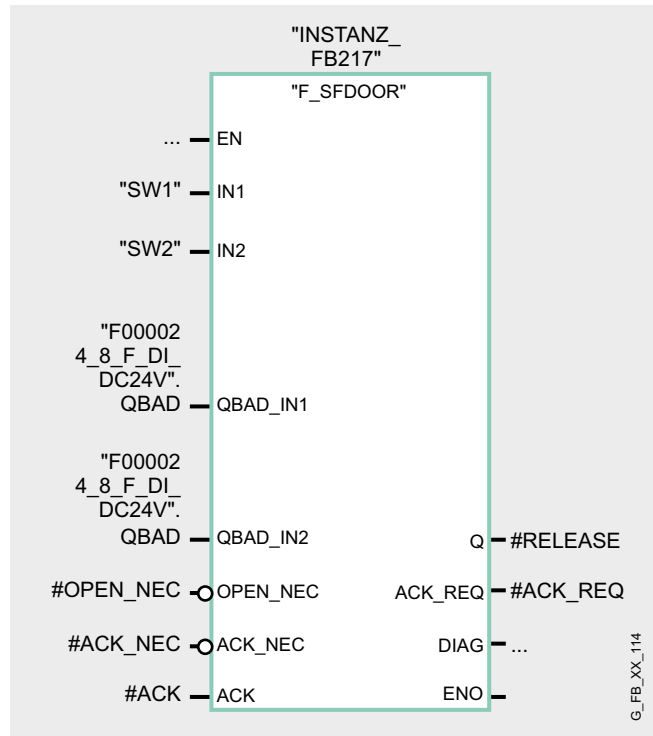


F-CALL (FC 1)

F-CALL (FC 1) is the F runtime group and is called from the cyclic interrupt OB (OB 35). F-CALL calls the F program block (here the FB 1).

FB "F_SFDOOR" (FB 217, DB 217)

FB "COORDINATION" (FB1, DB1) is the first to call the FB "F_SFDOOR" (FB217, DB217). FB 217 is a certified block from the library of distributed safety, which from version 5.3 on is available for safety door monitoring.



The enable signal Q (#RELEASE) decides whether the actuator is switched on/off. Enable is given at #RELEASE="1".

The inputs of the position switch "SW1" and "SW2" are allocated to the inputs IN1 and IN2 of the FB 217. As soon as one of the two inputs IN1 and IN2 has the signal status "0", it is interpreted as opening the safety door. The enable signal is thereby reset to '0'.

The enable signal can only be reset to 1 if:

- prior to closing the door both inputs IN1 and IN2 have the signal status 0 (safety door completely opened). This uncovers the error of a broken actuator still in the position switch despite of an opened door
- subsequently both inputs IN1 and IN2 take on signal status 1 (safety door closed)
- an acknowledgement is given

The acknowledgement for the enable is given at the input ACK_NEC depending on the parameters:

- For ACK_NEC = 0 an automatic acknowledgement is given.
- For enable at ACK_NEC = 1 you must acknowledge ACK at the input by means of a rising edge (**as implemented in this example**).

Note

The acknowledgement signal is in this example read via a failsafe input module (F-DI). For safety door applications this becomes necessary if the hazardous area is accessible. For a non-accessible hazardous area, the acknowledge signal can also be read via a standard input module.

In order for the F application block to recognize whether the inputs IN1 and IN2 are only "0" due to a passivation of the respective F-periphery, you must supply the inputs QBAD_IN1 and QBAD_IN2 with the variable QBAD of the respective F periphery DB. This prevents for example that for a passivation of the F-periphery the safety door must be completely opened prior to acknowledgement.

Warning!

Should you change the example in that ACK_NEC=0 is set for the parameterization of the FB 217, an automatic restart of the respective process must be excluded some other way.

The F-application module supports the requirements according to EN954-1 and EN 1088.

After restarting the F system, the enable signal Q is reset to "0". The acknowledgement for the enable is given at the input OPEN_NEC and ACK_NEC depending on the parameters:

- For OPEN_NEC = 0 an automatic acknowledge is given **independent** of ACK_NEC, as soon as both inputs IN1 and IN2 have the signal status 1 for the first time after reintegration of the respective F periphery (safety door is closed).
- For OPEN_NEC = 1 or if at least on of both inputs IN1 and IN2 have the signal status "0" even after reintegration of the respective periphery, an automatic acknowledgement is given depending on ACK_NEC, or the enable requires acknowledging ACK at the input by means of a rising edge. Prior to acknowledgement both inputs IN1 and IN2 must have had the signal status 0 (safety door completely opened) and subsequently signal status 1 (safety door closed). **In this example this variant has not been activated.**

Warning!

Should you change the example in that OPEN_NEC=0 is set for the parameterization of the FB 217, an automatic restart of the respective process must be excluded some other way.

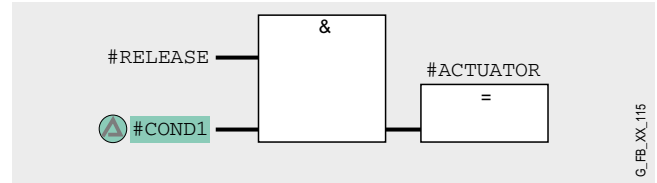
At the output DIAG a non-failsafe information on occurred errors is provided for servicing purposes. You can read it out via HMI systems or if necessary evaluate them in your standard user program.

Note

The safety program does not allow accessing the output DIAG!

FB "COORDINATION" (FB1, DB1)

After processing the FB 217, processing is continued in FB 1:



The machine must only start at valid enable from FB 217 (#RELEASE="1") and the start request ("COND1"="1") from the standard user program.

FC "REINTEGRATION" (FC2)

Network 3 of FB1 calls the FC2, where in case of a passivation of F-DI or F-DO the reintegration will be implemented. For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

The table below will help you during operation.

No.	Instruction	A 8.0	Result/Note
1	Pull both actuators from the position switches	"0"	Open the safety door Necessary prior to the first start.
2	Plug both actuators into the position switch.	"0"	Close safety door
3	Press the push button E2.1 and release it	"0"	Acknowledge
4	Press the push button E0.0 and release it	"1"	"Machine" start
5	Press the push button E0.1 and release it	"0"	"Machine" stop
Now number 4 and 5 can be performed continuously without having to acknowledge. Acknowledgement will become necessary if the safety door has been opened once.			
6	Press the push button E0.0 and release it	"1"	"Machine" start
7	Pull one actuator from the position switch	"0"	Error case: Door open, an actuator breaks and gets stuck in the position switch
8	Plug the actuator back into the position switch	"0"	Close safety door
9	Press the push button E2.1 and release it	"0"	Acknowledgement obligatory after opening the safety door
10	Press the push button E0.0 and release it	"0"	Start not possible, only...
11	Repeat no. 1 to 4	"1"	... after completely opening and closing the safety door and subsequent acknowledgement.
12	Disconnect a connection between indicator light and F-DO.	"0"	Wire break will be recognized and F-DO be passivated.
13	Re-connect the connection between indicator light and F-DO.	"0"	The reintegration of the F-DO starts automatically. It may take several minutes.
After reintegration, the actuator is automatically set to "1" (unless safety door has not been opened). Please note above warning note under the heading FC "Reintegration" (FC2) .			
14	Press the push button E0.1 and release it	"0"	"Machine" stop

Note

In the case of the "machine" simulated by the yellow indicator light, it is assumed that no hazardous slowing down emanates from the "machine" after a stop request by the user (or after opening the safety door during operation).

Alternative

In case hazardous slowing down emanates from the machine, it has to be made sure that the safety door can only be opened after the slowing down no longer constitutes a hazard. In this case, e.g. safety position switches with locked engagement are suitable. The Safety Integrated Functional examples 2 „Safety Door with Spring-Loaded Engagement“ and 3 „Safety Door with Magnetic Engagement“ describe the use of such a switch in order to meet the requirements of Safety Category 4 according to EN 954-1.

Light Curtain in Category 4 with Muting Function acc. to EN 954-1

Automation Function

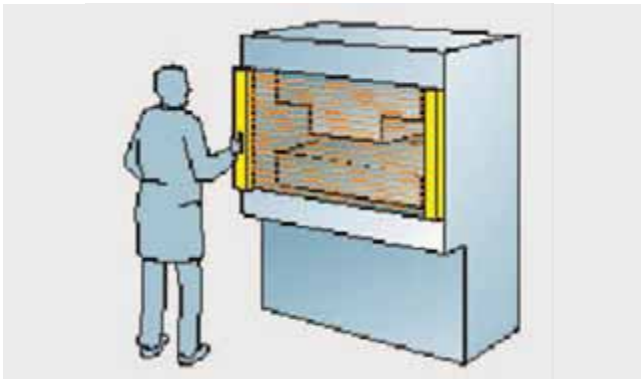
Description of the functionality

Light curtain

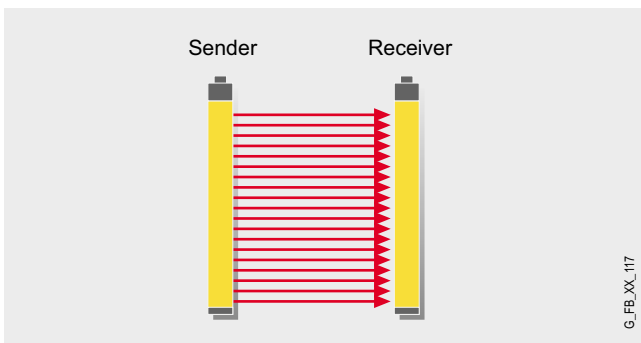
SIGUARD light curtains 3RG7844 meet the requirements of Safety Category 4 according to **IEC 61496-1 : 2004** and **EN 61496-1 : 2004**. The relevant machine safety regulations apply for the application, particularly:

- machinery directive **98/37/EC** and
- work equipment directive **89/655/EEC**

The SIGUARD light curtain used here is mainly used in vertical arrangement of the danger spot protection (see figure). With the physical resolution of 30 millimeters, hand/arm are safely detected in a range from 0.8 to 18 meters.



SIGUARD light curtains 3RG7844 consist of a transmitter and a receiver (see figure).



Starting with the first beam (= synchronization beam), the transmitter quickly pulses beam after beam. The receiver detects the specially formed pulse packets of the send beams and successively opens the linked receive elements with the same rhythm. This ensures that a protection field is created between transmitter and receiver. Transmitter and receiver are synchronized optically.

Light curtains can only realize their protective effect, if they are installed with an adequate safety margin. The formulas used to calculate the safety margin depend on the type of protection. Mounting situations and calculation formulas are available in the standard **EN 999** ("The positioning of protective equipment in respect of approach speeds of parts of the human body"). The formula for the required distance to reflecting areas complies with the European Standard for "Active Opto-Electronic Protective Devices" **prEN IEC 61496-2 : 1997**. The transmitter and receiver type used in this example provides a 12-pin Hirschmann connector (see figure).



The Hirschmann connector uses the following pins:

Transmitter

Pin	Input / output	Connected to	Note
1	Input	+24 V DC	Supply
2	Input	0 V DC	
3	Output	Pin 4	No internal jumper set in factory
4	Input	Pin 3	

Receiver

Pin	Input / output	Connected to	Note
1	Input	+24 V DC	Supply
2	Input	0 V DC	
3	Output	F-DI	OSSD1
4	Output	F-DI	OSSD2

OSSD1 and OSSD2 are the safety-relevant switching outputs (Output Signal Switching Devices). They are placed on the F-DI and polled by the F CPU using a 1oo2 evaluation. "0" signal means: Light curtain is interrupted. The F program causes the stop of the hazardous machine.

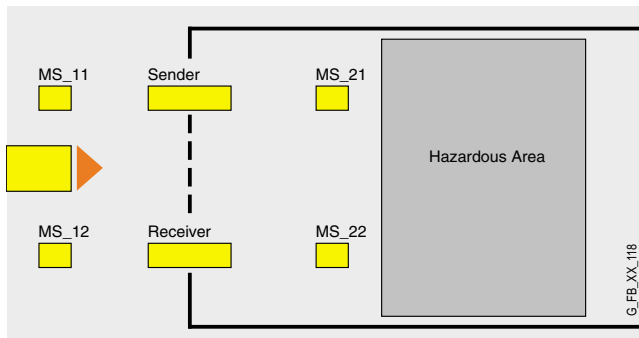
Warning!

In this example, the hazardous machine is simulated by an indicator light. When using other actuators than this indicator light, safe switching-off of the loads including signal feedback is to be supplemented.

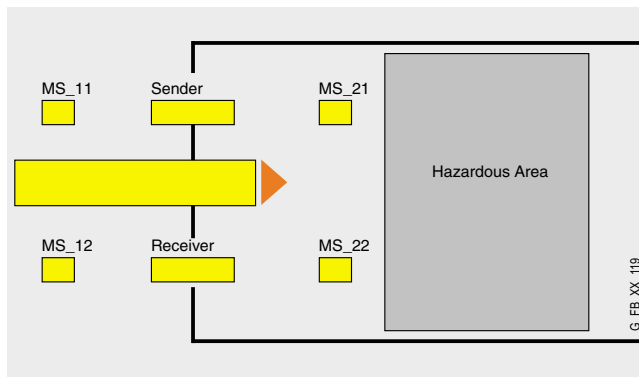
For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet: <http://support.automation.siemens.com/WW/view/en/19138505>

Muting

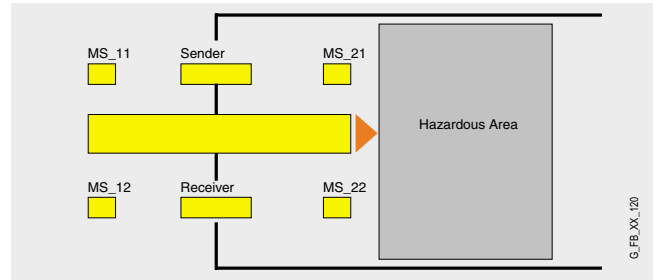
In this example we show parallel muting. Muting is an intended suppression of the protective function. This is e.g. required during transporting the material into the danger zone. Muting is triggered by muting sensors. In this example, FB189 (F_MUTING) is called in the F program (FB 1, DB 1). Among other things, FB189 as input parameter has the signals of the four muting sensors (MS_11...MS_22) as well as three parameterizable times (DISCTIM1, DISCTIM2; TIME_MAX).



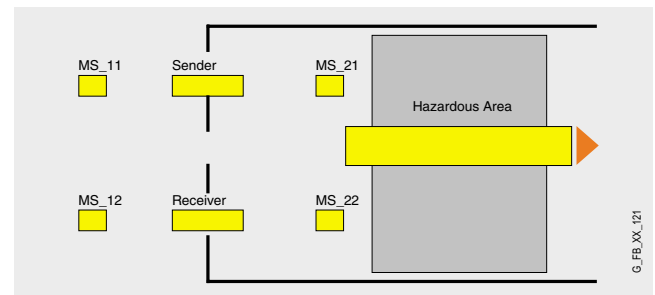
If the muting sensors MS_11 and MS_12 are activated by the product within the time DISCTIM1, the muting mode is activated.



The muting mode remains active as long as MS_11 and MS_12 are activated by the product. The product may pass the light curtain without causing a stop of the machine.



Before the muting sensors MS_11 and MS_12 switch inactive, the muting sensors MS_21 and MS_22 must have been activated within the time DISCTIM2. This ensures that muting mode remains active.

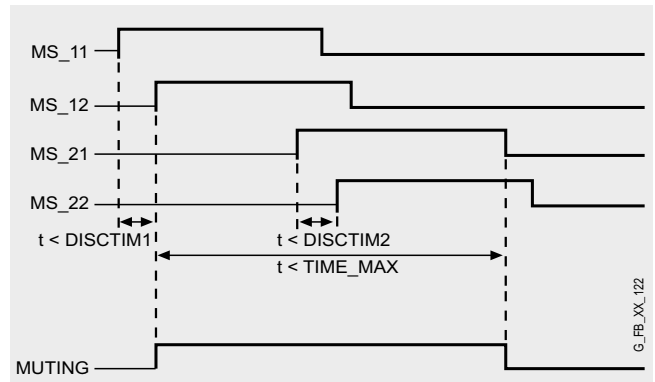


The muting mode is terminated, if one of the muting sensors MS_21 or MS_22 is switched inactive by the product. The maximum time for the muting mode to be active is TIME_MAX.

Note

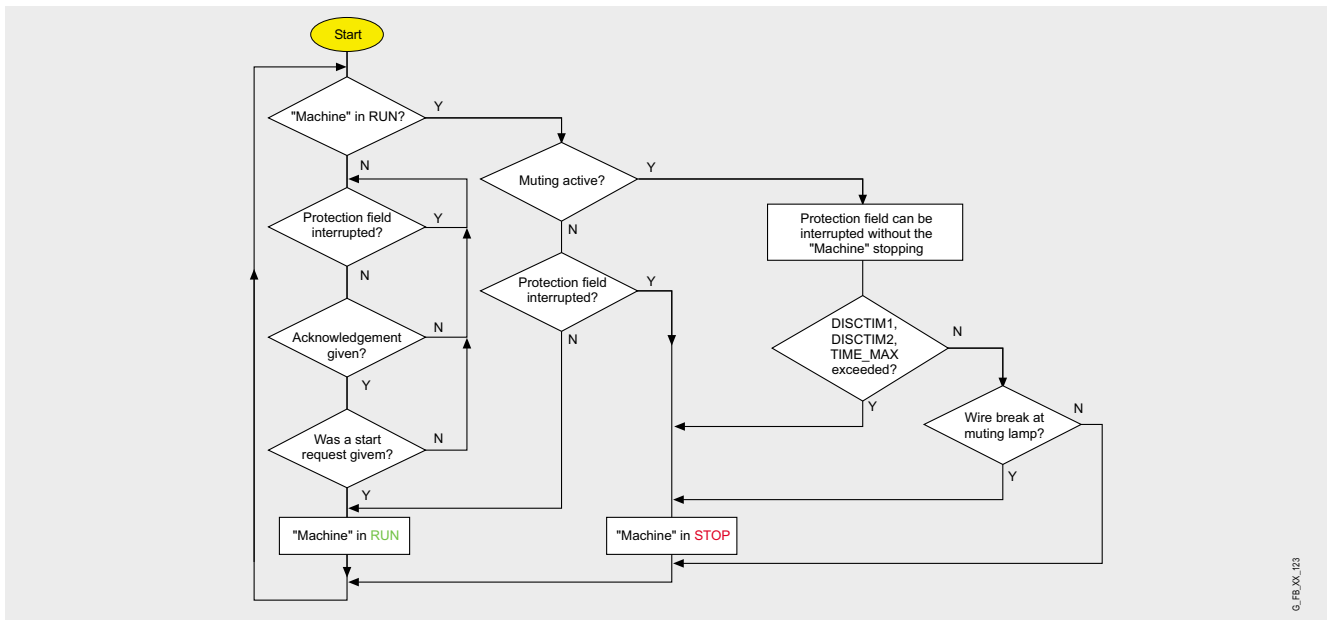
Muting mode also becomes active if the muting sensors MS_21 and MS_22 respond first.

Active muting operation is indicated by white indicator lights. In this example, one indicator light is used to display the muting mode. The diagram below illustrates the relations during muting mode with regard to time.



Flow chart

The flow chart below shows the relation between hazardous "machine", protection field and muting mode.



G.FB.XX.133

Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the failsafe program with STEP 7 engineering tools.
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU
- The output signals of the light curtain (OSSD1 and OSSD2 of the receiver) can be directly transferred to the failsafe I/O modules (F-DI).
- Use of prefabricated (and certified) failsafe blocks from the Distributed Safety library to implement the muting mode.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	2	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	3	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	Siemens AG
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	3	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Indicator light incl. incandescent lamp	white	3SB3217-6AA60	1	
Optional: Indicator light incl. incandescent lamp	yellow	3SB3217-6AA30	1	
Optical proximity switch (as muting sensor)	Diffuse sensor (type K80)	3RG7200-6CC00	4	
SIGUARD light curtain Cat. 4	Standard TRANSMITTER resolution 30 mm	3RG7844-2SD03-0SS0	1	
SIGUARD light curtain Cat. 4	Standard RECEIVER resolution 30 mm	3RG7844-2SD03-0SS1	1	
Hirschmann contact box	incl. crimp contacts, even	3RG7848-2DA	2	
Push button	green, 1NO	3SB3801-0DA3	2	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case

changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

Warning!

In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.

The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example AS-FE-I-007-V10-EN provides a detailed description of "Read back".

An overview of the hardware structure

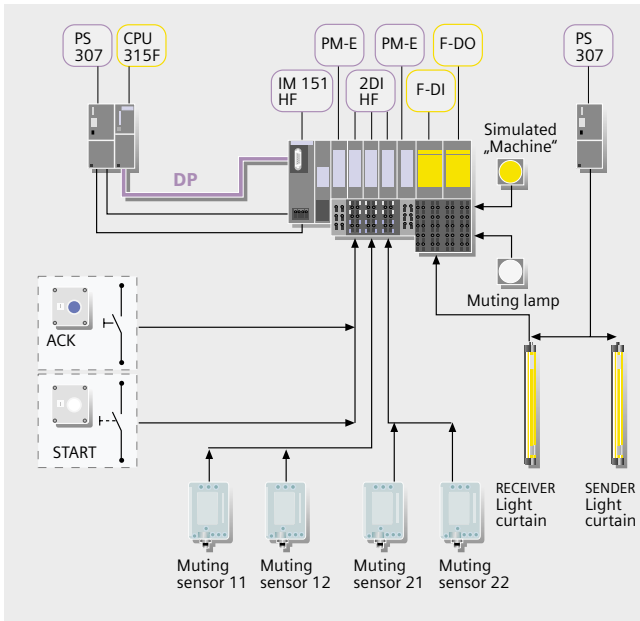
The arrangement to implement the light curtain with muting function consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave. The yellow indicator light, which can be used optionally, simulates the hazardous "machine", the white indicator light indicates active muting.

Note

Except for the connected safety components, the Power supply (for the light curtain) must not supply any additional parts of the machine with power. Both power supplies require the same ground.

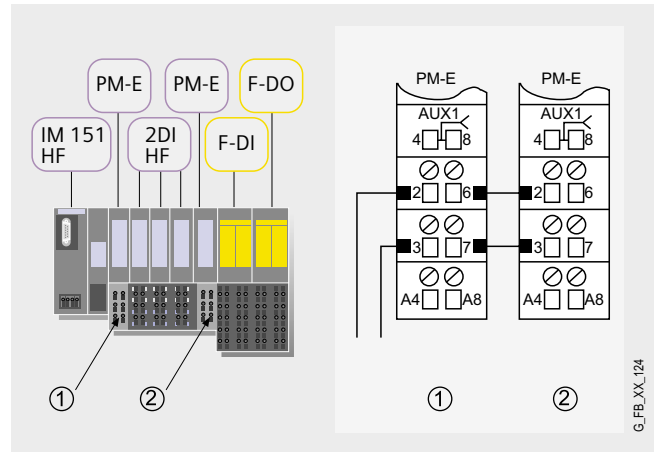
Note

A 4DI electronic module can also be used instead of two 2DI electronic modules. The "high feature" electronic modules can also be replaced by standard modules.



Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



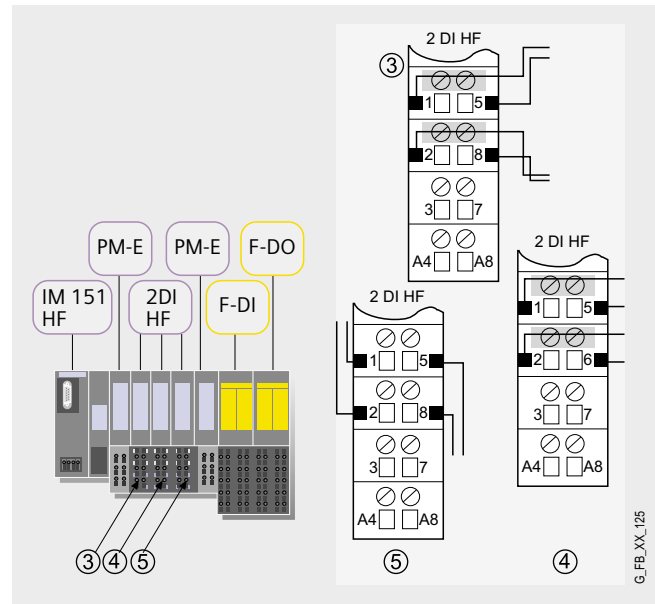
Wiring of the hardware components

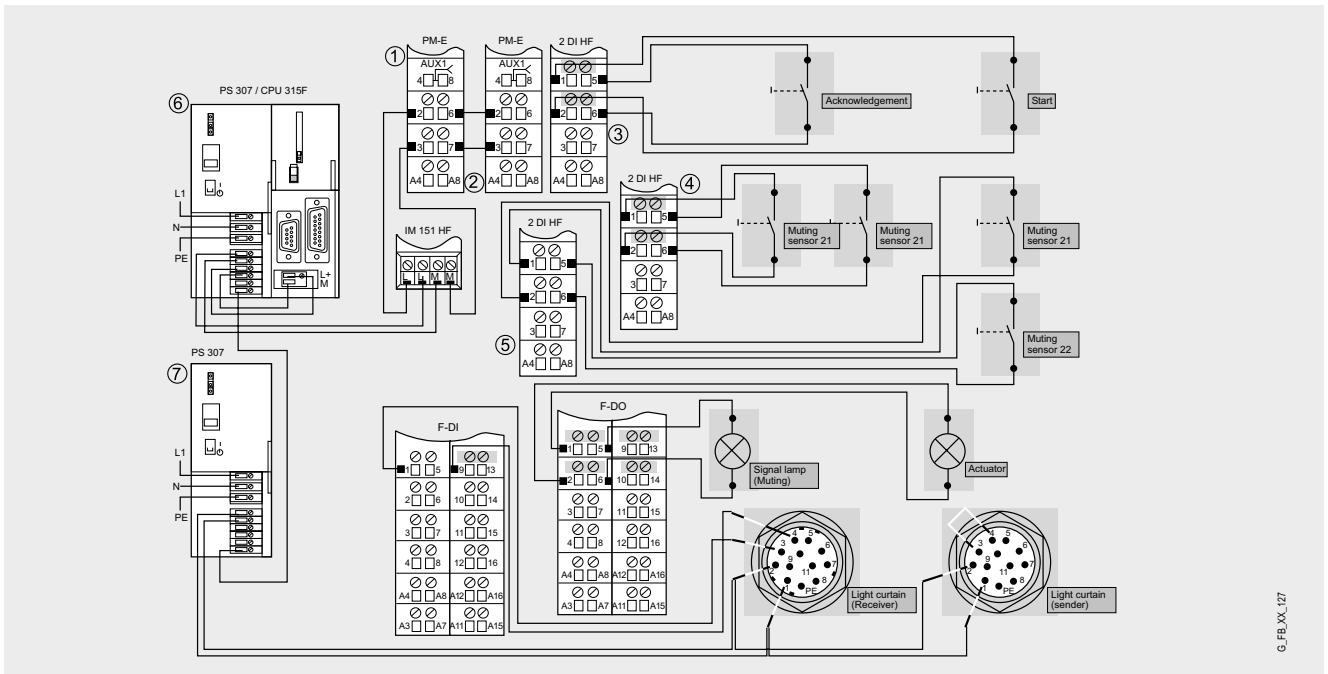
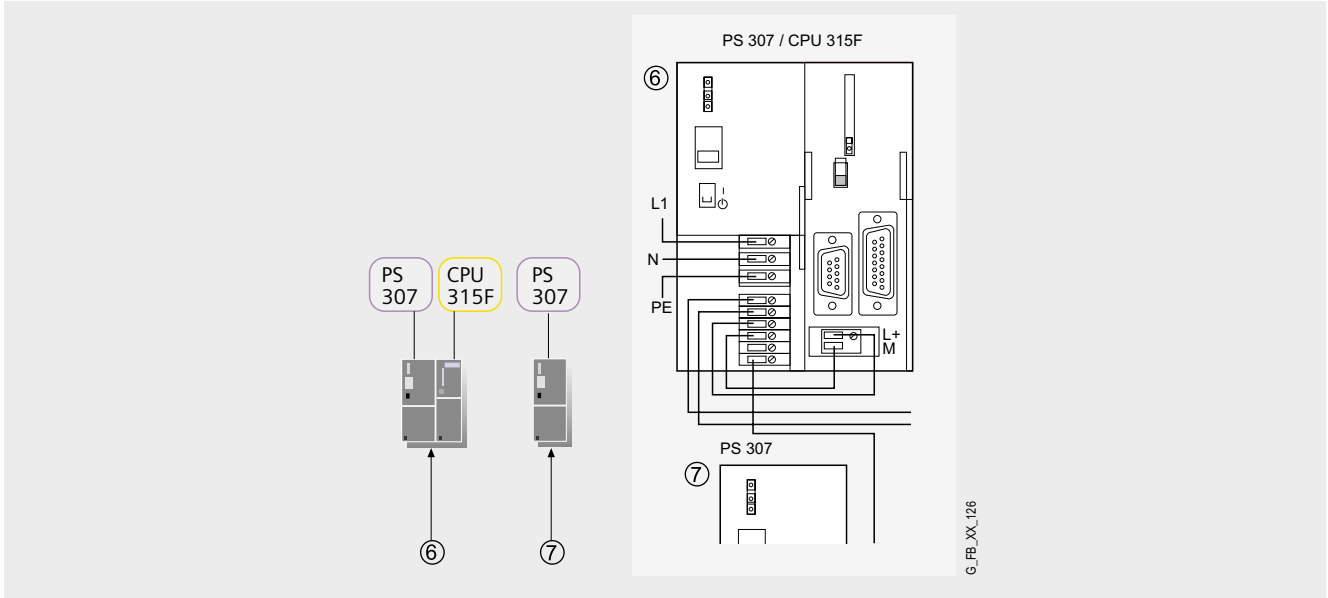
Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111100	

Note

The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.





Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Note

The ground of the two power supplies (PS) used has to be identical.

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	START	"0"	–
2	Push button (NO)	E 0.1	ACK	"0"	–
3	Optical proximity switch	E 1.0	MS_11	"0"	Muting sensors "1": sensor detects material
4	Optical proximity switch	E 1.1	MS_12	"0"	
5	Optical proximity switch	E 2.0	MS_21	"0"	
6	Optical proximity switch	E 2.1	MS_22	"0"	
7	Receiver light curtain	E 4.0	OSSD	"1"	"1" signal in case of free protection field
8	Indicator light (yellow)	A 10.0	ACTUATOR	"0"	Simulated machine
9	Indicator light (white)	A 10.1	MLAMP	"0"	Muting lamp

Testing inputs and outputs

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

Note

The times DISCTIM1 and TIME_MAX mentioned in the following table are parameterized in FB 1 of the program code.

No.	Instruction	Response		Note
		A 10.0	A 10.1	
1	Press the push button E 0.1 and release it.	"0"	"0"	Acknowledgement
2	Press the push button E 0.0 and release it.	"1"	"0"	Start of the "machine"
3	Interrupt the protection field	"0"	"0"	OSSD="0"
4	Repeat No. 1 and 2	"1"	"0"	Start of the "machine"
5	Set E 1.0 = "1"	"1"	"0"	Muting sensor 11 triggers

No.	Instruction	Response		Note
		A 10.0	A 10.1	
6	Set E 1.1 = "1" (this action has to be performed within DISCTIM1)	"1"	"1"	Start muting mode Protection field not active!
7	Interrupt the protection field	"1"	"1"	–
8	Wait until TIME_MAX has elapsed	"0"	"0"	Muting not yet completed and $t > \text{TIME_MAX}$

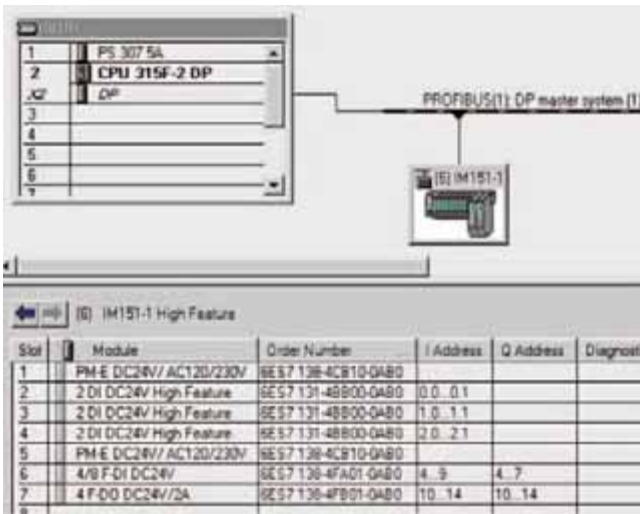
Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!
 The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of safety functions.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

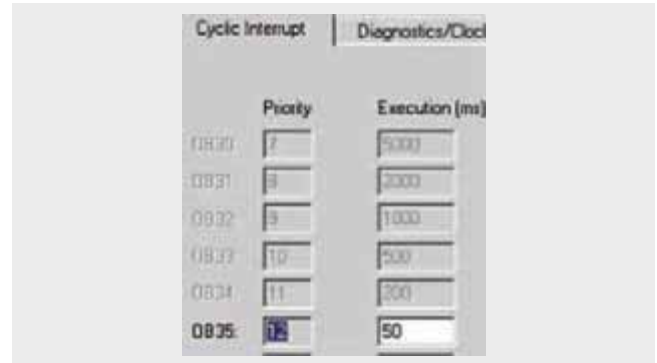
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



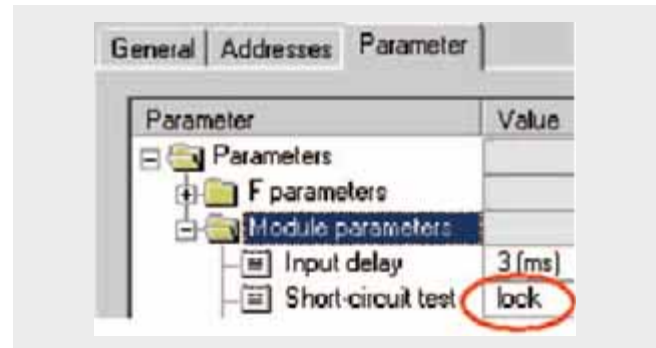
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

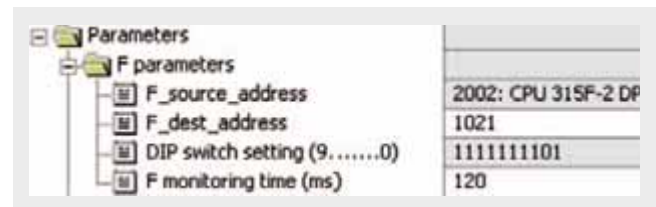
During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



With external sensor supply, the requirements of Cat. 4 according to EN 954-1 can be met by using intelligent sensors which independently monitor the wiring with regard to short-circuit and wire break. For this application case, the short-circuit test has to be deactivated in the F-DI.

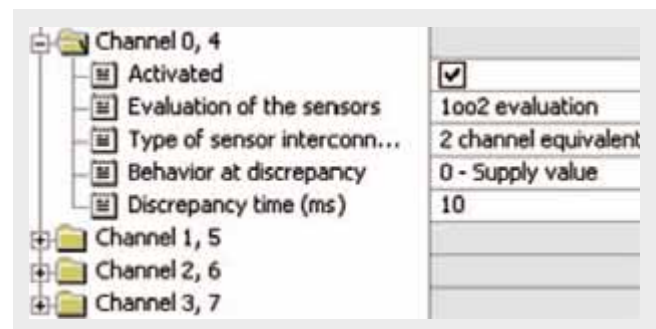


DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



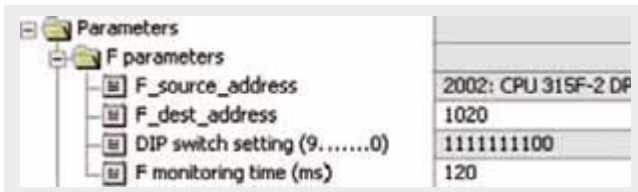
Also in the "Parameter" tab.

The OSSD outputs of the light curtain are evaluated in a 1oo2 evaluation.

All other channels: Deactivate

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").



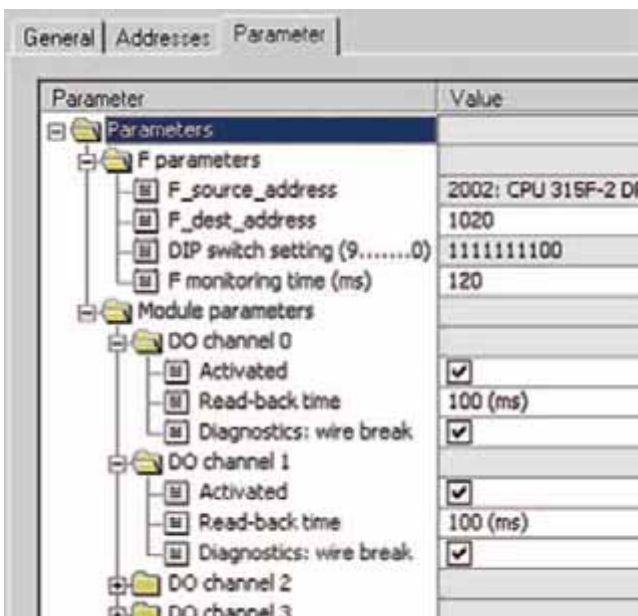
Parameter	Value
F_source_address	2002: CPU 315F-2 DP
F_dest_address	1020
DIP switch setting (9.....0)	1111111100
F monitoring time (ms)	120

DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Parameter	Value
F_source_address	2002: CPU 315F-2 DP
F_dest_address	1020
DIP switch setting (9.....0)	1111111100
F monitoring time (ms)	120
Module parameters	
DO channel 0	
Activated	<input checked="" type="checkbox"/>
Read-back time	100 (ms)
Diagnostics: wire break	<input checked="" type="checkbox"/>
DO channel 1	
Activated	<input checked="" type="checkbox"/>
Read-back time	100 (ms)
Diagnostics: wire break	<input checked="" type="checkbox"/>
DO channel 2	
DO channel 3	

Channel 0:

Actuator connection (in this case: Indicator light)

Channel 1:

Muting lamp

All other channels: deactivate

The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,1	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 48,0 k	approx. 1,0 k	approx. 47,0 k
Main memory	approx. 35,1	approx. 0,4 k	approx. 34,7 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	10 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

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

Password

In all cases, the passwords used for the safety-relevant part is „Siemens“.

Use of the STEP 7 Project

The STEP 7 project indicates the possibility of operating light curtain of safety category 4 according to EN 954-1 by means of a failsafe S7-CPU. In this example, the hazardous machine is simulated by an indicator light. The conditions necessary for the actuators to reach safety category 4 (e.g. read back of actuator signals) are not considered in this example.

After setting up and commissioning the functionality introduced here, the indicator lights used provide the following information:

Illuminated indicator lights	Explanation
Yellow	Hazardous "machine" running (simulates the actuator).
White	Muting mode

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21331201>

To call the corresponding project file, open the "as_fe_i_005_v10_code_lcurtain.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

For downloading the project into the F-CPU please proceed as follows:

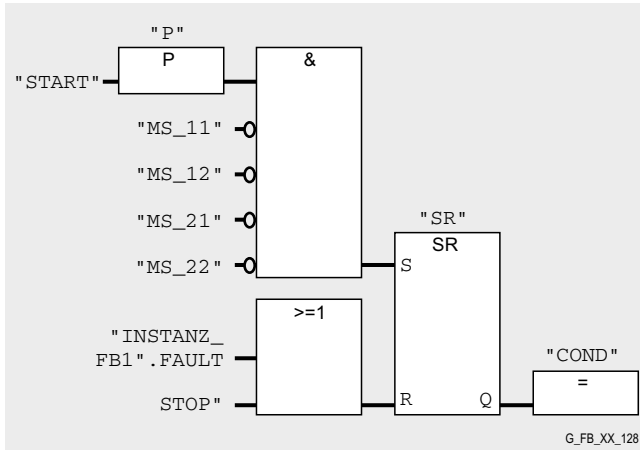
- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container
- Menu "Options" -> Edit safety program
- Click the "Download" button

The sample code with the given configurations enables the following:

- Connection of a SIGUARD light curtain 3RG7844 to the failsafe I/O modules of a failsafe SIMATIC S7-CPU for danger spot protection.
- Muting mode

Program procedure

OB 1 defines the start conditions for the hazardous machine (here simulated by an indicator light):



G_FB_XX_128

Parameter	Adress	Explanation
START	E 0.0 (NO)	Start request
MS_11	E 1.0	Optical proximity switch (as muting sensor) Any type of sensor can be used which need not be failsafe.
MS_12	E 1.1	Optical proximity switch (as muting sensor) Any type of sensor can be used which need not be failsafe.
MS_21	E 2.0	Convention: At the "1" signal the object is recognized.
MS_22	E 2.1	Convention: At the "1" signal the object is recognized.
INSTANZ_FB1 . FAULT	DB1.DBX4.2	This bit causes a start of the "machine" to only be possible after previous acknowledgement. The signal status of this bit is defined in the safety program (FB 1) and filed in its respective instance DB (DB1, byte 4, bit 2)
STOP	M 92.3	Dummy bit In this example, no operational stopping has been implemented. If you wish to extend the example accordingly, the memory bit can be replaced by the respective sensor signal.
COND	M 92.0	Sets or resets the machine (in FB 1 of the safety program).

A start in this example shall only be possible if workpieces are out of the monitored area of the light curtain (MS_11...MS_22="0").

The information of the memory bit "COND" is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

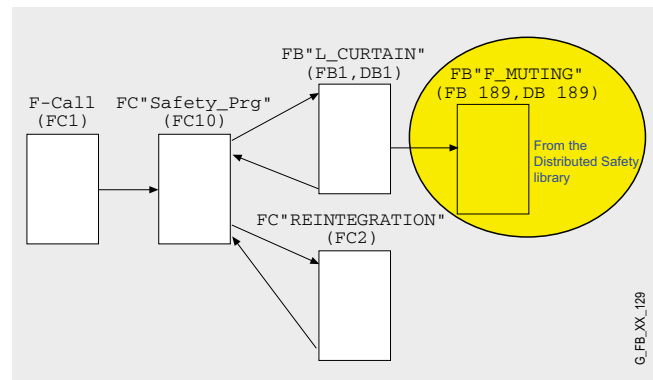
When reading data, which may be changed by the standard user program or an operation control and monitoring system during running of an F runtime group, from the standard user program (memory bits or PAE of standard I/O), in the safety program, it is necessary to use separate memory bits (here COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been implemented. Generally, however, the following applies:

Note

If the above section is not observed the F CPU may go to STOP mode.

The failsafe program has the following program sequence:



F-CALL (FC1)

F-CALL (FC 1) is the F runtime group and is called from the cyclic interrupt OB (OB 35). F-CALL calls the F-programme block (here the FC 10).

FC "Safety_Prg" (FC 10)

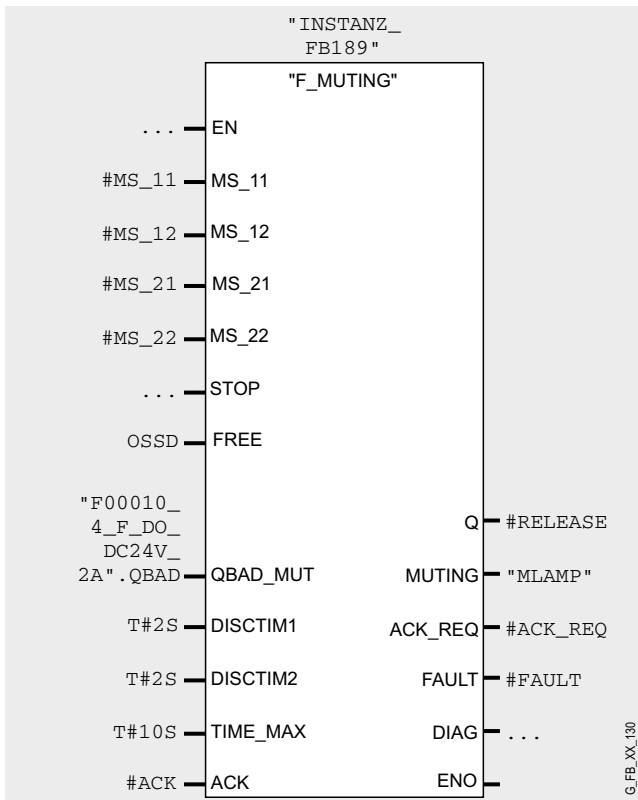
FC 10 ensures the modular setup of the safety program.

FB "L_CURTAIN" (FB 1, DB 1)

FB 1 has two functions:

1. Call of FB "F_MUTING" (FB 189, DB 189) from the Distributed Safety library (network 1).
2. Switching the "machine" (here simulated by an indicator light) on and off (network 2).

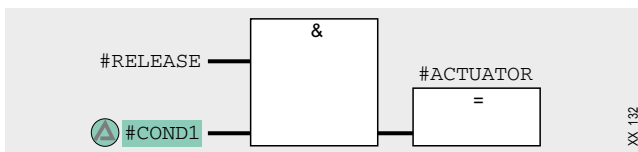
Network 1



If the light curtain for example has been interrupted, a restart of the "machine" (here simulated by an indicator light) requires acknowledgement. This requirement is indicated by the output parameter ACK_REQ="1" of FB 189.

In OB 1 the static variable #EN_FAULT is read from the instance DB of FB 1 and connected so that a start is only possible if acknowledged in FB 1.

Network 2

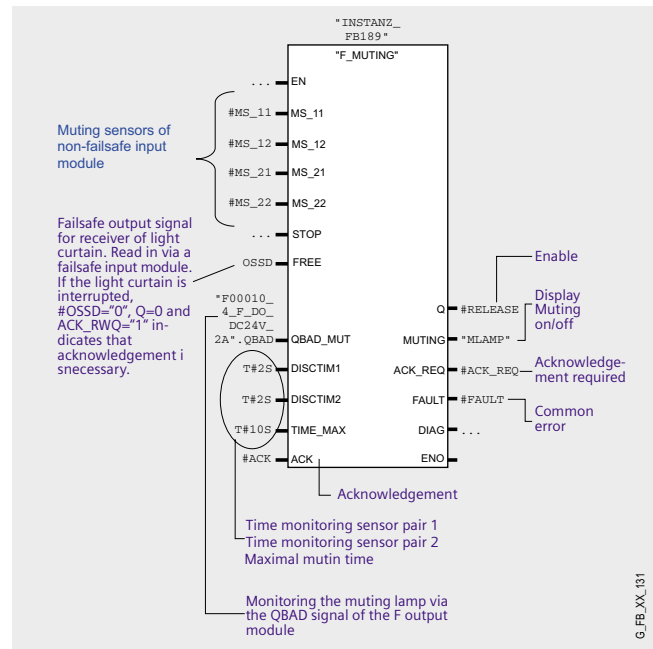


After successful acknowledgement, an enable (#RELEASE="1") is given by FB 189. A standard requirement in OB 1 makes "COND1"="1" and the "machine" is switched on (#ACTUATOR="1").

If the light curtain, for example, is interrupted, the enable is reset by FB 189 and the "machine" is switched off.

FB "F_MUTING" (FB 189, DB 189)

FB 189 is a certified block from the Distributed Safety library.



FC "REINTEGRATION" (FC 2)

Network 2 of FB 10 calls the FC2, where in case of a passivation of F-DI or F-DO the reintegration will be implemented. For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

The table below will help you during operation.

Operating instructions 1: Interrupting light curtain

No.	Instruction	Result/Note
1	Press the acknowledgement push button ACK	Required before starting the "machine". The 4 muting sensors must be on "0" signal.
2	Press the start push button START	"Machine" running (simulated by yellow indicator lights).
3	Interrupt the light curtain	Yellow indicator light goes off ("machine" stops).

Operating instructions 2: Muting

Note

During performing the following actions, please make sure that the discrepancy times DISCTIM1 and DISCTIM2 as well as the maximum muting time TIME_MAX are not exceeded. The allocation of the time values is available in the F program (FB 1, network 1 when calling FB189).

No.	Instruction	Result/Note
1	Press the acknowledgement push button ACK.	Required before starting the "machine". The 4 muting sensors must be on "0" signal.
2	Press the start push button START.	"Machine" running (simulated by yellow indicator light).
3	Switch the muting push button MS_11 and keep it on "1" signal.	Muting sensor 1 of sensor pair 1 triggers.
4	Switch the muting push button MS_12 and keep it on "1" signal.	Muting sensor 2 of sensor pair 1 triggers. The white muting lamp indicates active muting function. Interrupting the light curtain does not cause a stop of the "machine".
5	Switch the muting push button MS_21 and keep it on "1" signal.	Muting sensor 1 of sensor pair 2 triggers.
6	Switch the muting push button MS_22 and keep it on "1" signal.	Muting sensor 2 of sensor pair 2 triggers.
7	Switch the muting push button MS_11 back to "0" signal.	Muting sensor 1 of sensor pair 1 is released by the work piece.
8	Switch the muting push button MS_12 back to "0" signal.	Muting sensor 2 of sensor pair 1 is released by the work piece.

No.	Instruction	Result/Note
9	Switch the muting push button MS_21 back to "0" signal.	Muting sensor 1 of sensor pair 2 is released by the work piece. Muting is no longer active -> The white muting lamp goes off.
10	Switch the muting push button MS_22 back to "0" signal.	Muting sensor 2 of sensor pair 2 is released by the work piece.

Operating instructions 3: Wire break of the muting lamp

No.	Instruction	Result/Note
1	Press the acknowledgement push button ACK.	Required before starting the "machine". The 4 muting sensors must be on "0" signal.
2	Press the start push button START.	Required before starting the "machine". The 4 push buttons (NC) for muting have to be on "0" signal.
3	Switch the muting push button MS_11 and keep it on "1" signal.	Muting sensor 1 of sensor pair 1 triggers.
4	Switch the muting push button MS_12 and keep it on "1" signal.	Muting sensor 2 of sensor pair 1 triggers. The white muting lamp indicates active muting function. Interrupting the light curtain does not cause a stop of the "machine".
5	Disconnect the connection of the muting lamp from the F-DO.	Wire break: "Machine" is switched off.

Two-Hand Control Panel with Integrated Emergency Stop in Category 4 acc. to EN 954-1

Automation Function

Description of the functionality

Use and version of the two-hand control panel

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

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

The SIGUARD two-hand control panels 3SB38 6 are designed in accordance with the requirements of Category 4 according to **EN 954-1: 1996**. The standard equipment of all control panels features two operator push buttons and one emergency stop mushroom-head pushbutton.



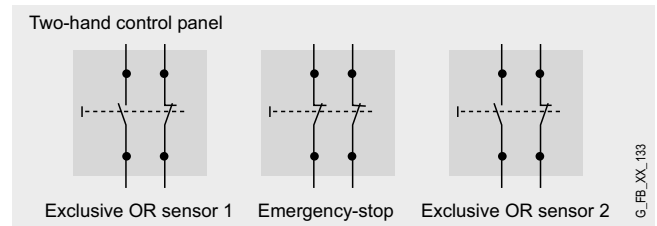
Standards

The relevant standards for the two-hand control panel are listed below:

Standard	Content
DIN 24980 (EN 574)	Safety of machinery - Two-hand control devices
EN 418	Safety of machinery - Emergency stop equipment
EN 999: 1998	Approach speeds
EN ISO 12100-1: 2003	Safety of machinery - General principles of design
EN 954-1: 1996	Safety of machinery - Safety-related parts of control systems
EN 60204-1: 1997	Safety of machinery - Electrical equipment of machines
EN 60947-5-1: 1991	Low-voltage switching devices - Positive opening operation

Function

A characteristic feature of the two-hand control is the fact that both hands are fixed. The desired actions can only be started if both push buttons of the two-hand control are pressed. Each of the two push buttons is an exclusive OR sensor (make contact and break contact).



Make contact and break contact of the exclusive OR sensor have to switch within a **discrepancy time** when operated. The length of this discrepancy time is **parameterized** in the hardware configuration of STEP 7 (max. 500 ms according EN 574).

Aside from the discrepancy time monitoring between make contact and break contact of an exclusive OR sensor, the switching times between exclusive OR sensor 1 and 2 are monitored. This discrepancy time monitoring is **parameterized** at the F-application block in the safety program of STEP 7.

Actuator used

This document describes the following example: When pressing both exclusive OR sensors a "machine" starts which is active for 4 seconds. After that period of time (or if at least one of the exclusive OR sensors is released) the machine automatically shuts down. A restart is only possible by a release of both exclusive OR sensors and again pressing. In this example, instead of a real machine an indicator light is used for simulation. The designation "machine" refers to this indicator light.

Warning!

In this example the hazardous machine is simulated by an indicator light. When using other actuators than this indicator light, safe switching-off of the loads including signal feedback is to be supplemented.

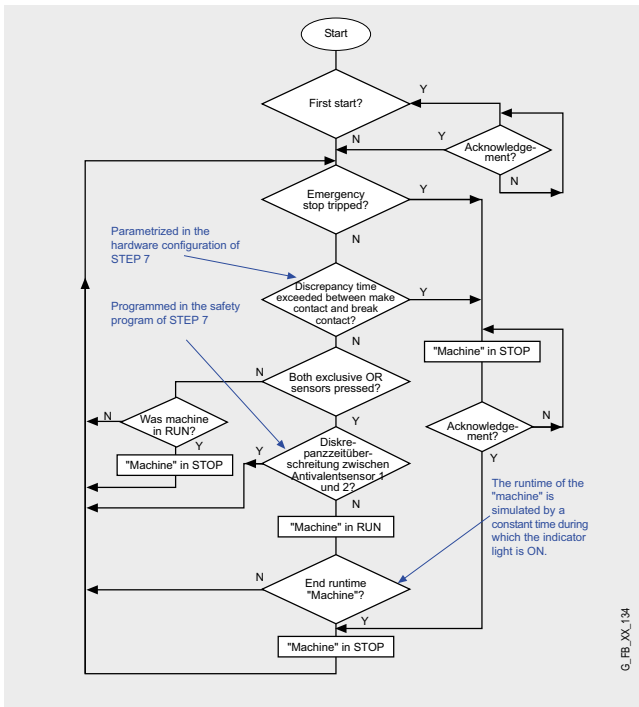
Use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3, for the calculation of the max. reaction time of your F system. This file is available on the internet: <http://support.automation.siemens.com/WWW/view/en/19138505>

Emergency stop

Pressing the emergency stop push button resets the indicator light (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.

Flowchart

The flowchart below once again illustrates the relations.

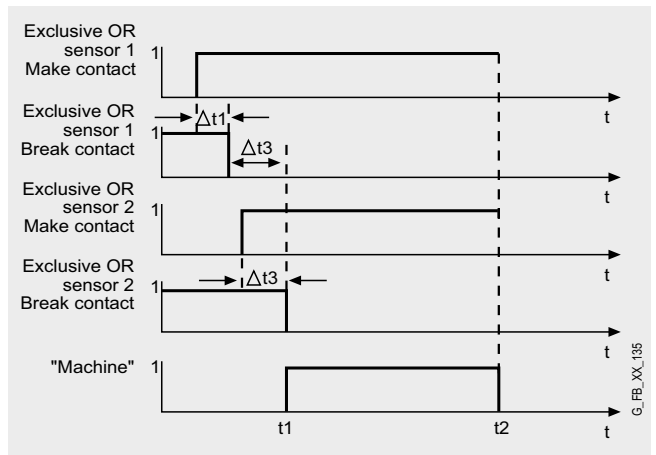


Time sequence

Die in der nachfolgenden Tabelle genannten Zeiten werden im weiteren in einem Zeitdiagramm gezeigt.

Time	Explanation	Note
$\Delta t1$	Discrepancy time between make contact and break contact at exclusive OR sensor 1	Parameterized in the hardware configuration of STEP 7.
$\Delta t2$	Discrepancy time between make contact and break contact at exclusive OR sensor 2	
$\Delta t3$	Discrepancy time between exclusive OR sensor 1 and 2	Programmed in the failsafe F program of STEP 7.
t1	Start of the "machine"	Simulated by indicator light.

Time	Explanation	Note
t2	Stop of the "machine"	Possible reasons: <ul style="list-style-type: none"> End of "machine time" At least one exclusive OR sensor was released Emergency stop was actuated Passivation of the failsafe input module of ET 200S (F-DI)



Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the failsafe program with STEP 7 engineering tools.
- Only one CPU is required since failsafe and standard program parts run on a coexistent basis in the CPU.
- Use of prefabricated (and certified) failsafe blocks from the Distributed Safety library.
- Design of the two-hand control with integrated control devices including emergency stop.
- Additional control devices can be mounted.
- All relevant standards are complied with.
- The metal version of the two-hand control is also suitable for harsh industrial conditions.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface modules for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	1	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Indicator light including incandescent lamp	yellow	3SB3217-6AA30	1	
Push button	green, 1NO	3SB3801-0DA3	1	
SIGUARD two-hand control panel	Plastic version	3SB3863-1BB	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

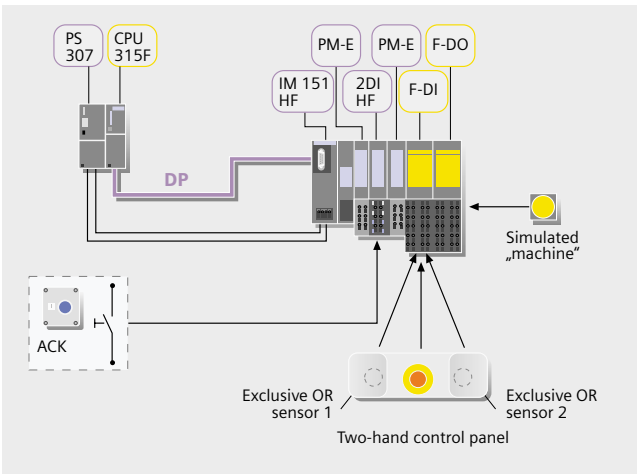
Setup and Wiring

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

Warning!
 In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator. Read back is **not** implemented in this example.
 The actuator in this example is an indicator light simulating a machine. If other actuators are used, read back has to be ensured by the user. The Safety Integrated Functional Example No. 7 „Integration of the Readback Signal in an Application of Category 4 acc. to EN 954-1“ provides a detailed description of "Read back".

An overview of the hardware structure

The arrangement to use a two-hand control panel consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave. The indicator light simulates the hazardous "machine".



Note
 The "high feature" electronic modules can also be replaced by standard modules.

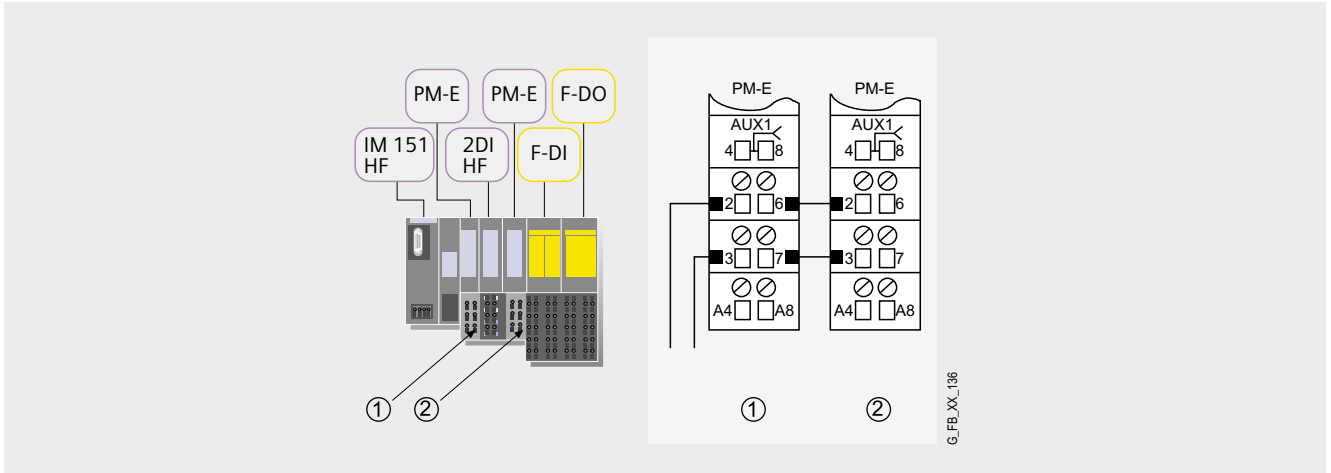
Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

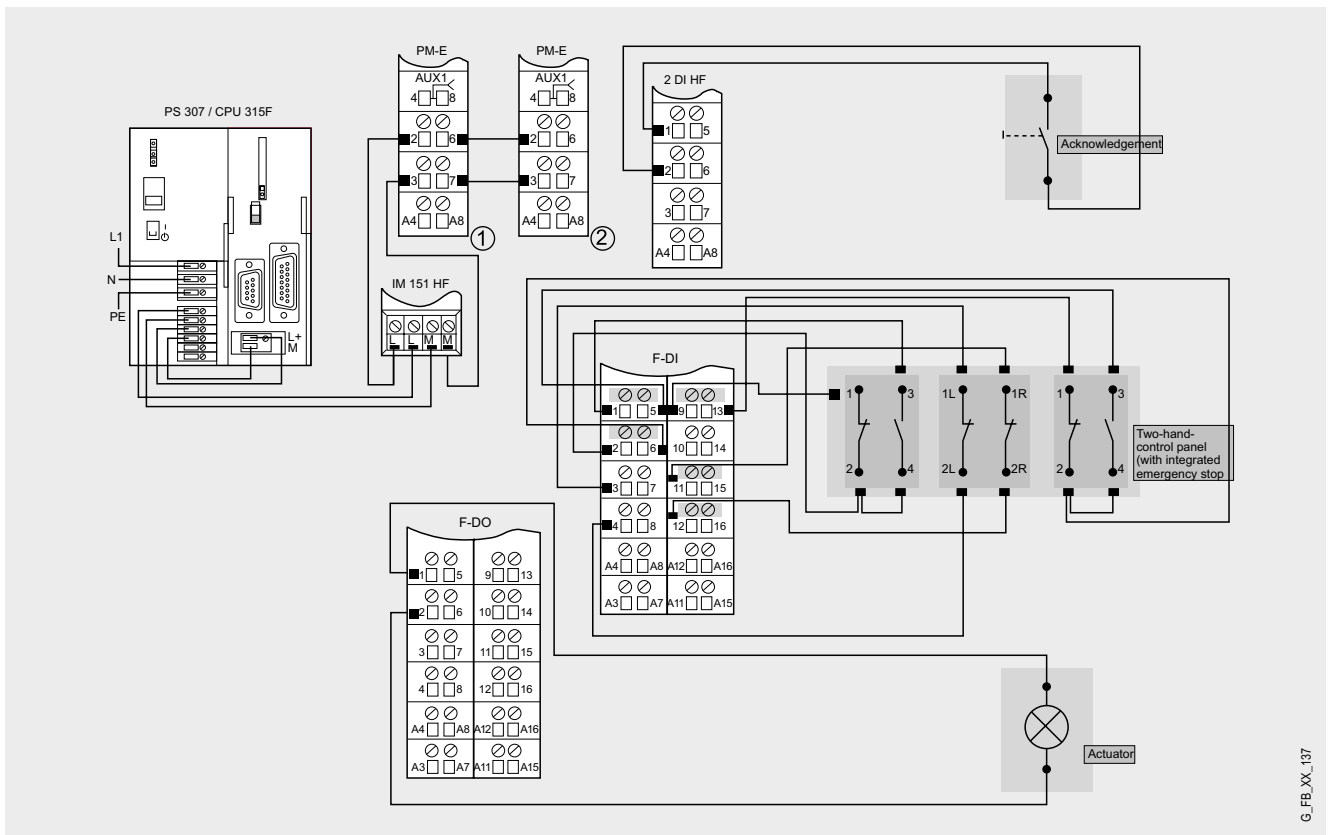
Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIP switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note
 The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note
 The wiring of the hardware is illustrated below. In the following table the hardware components which occur several times are numbered to ensure that they can be clearly assigned in the subsequent wiring diagram.



G_FB_XX_136



G_FB_XX_137

Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

The following point is taken into account in the wiring: 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) is activated, both contacts of the exclusive OR sensor have to be supplied with voltage via the internal sensor supply VS1.

As soon as a discrepancy between the signals of the two affected input channels is detected, the value "0" is made available to the safety program in the F CPU (parameterized in the hardware configuration of STEP 7).

Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

No.	Hardware component	Address	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	ACK	"0"	Acknowledgement
2	Push button 1 two-hand control panel (NO/NC)	E 0.1	HAND1	"0"	The make contact is evaluated
3	Push button 2 two-hand control panel (NO/NC)	E 1.1	HAND2	"0"	The make contact is evaluated
4	Emergency stop on two-hand control panel (NC/NC)	E 1.2	ESTP	"1"	–
5	Indicator light (yellow)	A 7.0	LAMP	"0"	Simulates hazardous machine

Testing inputs and outputs

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

No.	Instruction	Response A 7.0	Note
1	Press the push button E 0.0 and release it.	"0"	Acknowledgement (the negative edge is evaluated)
2	Press and simultaneously keep pressed the push buttons E 1.0 and E 1.1.	"1"	"Machine" active
3	Wait 4 seconds	"1" -> "0"	Simulated machine time
4	Release the push buttons E 1.0 and E 1.1	"0"	New start is possible
5	Press and simultaneously keep pressed the push buttons E 1.0 and E 1.1 and release one (or both of them) after approximately 1s.	"1" -> "0"	"Machine" starts and shutdown.

An acknowledgement is required

- when the "machine" is started for the first time
- after unlocking the emergency stop
- after reintegration (module was passivated) of the failsafe input module (F-DI) of the ET 200

Important hardware component settings

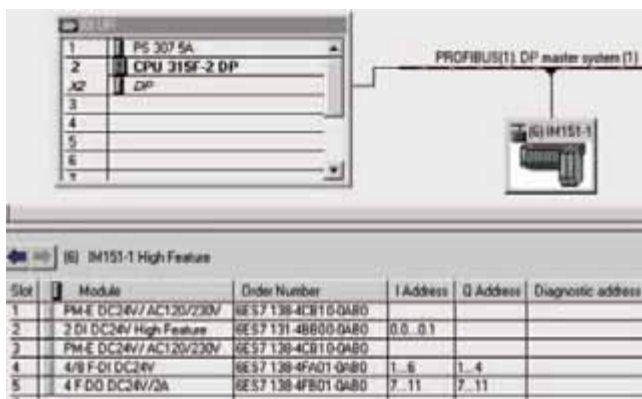
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes of the settings may cause a loss of the safety functions.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

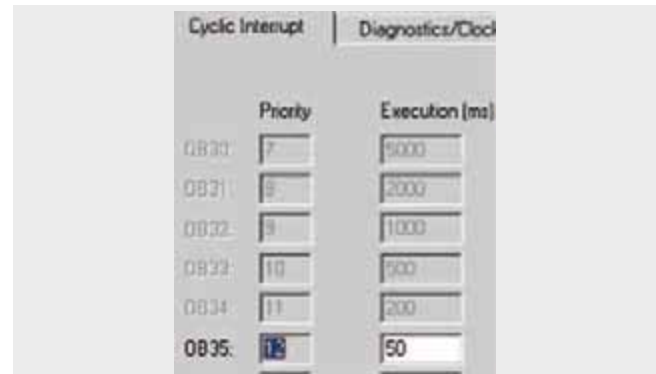
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



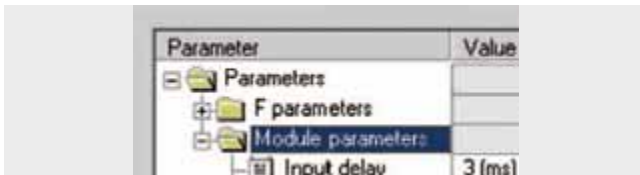
Set mode: "Test Mode"

During **Process Mode** the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

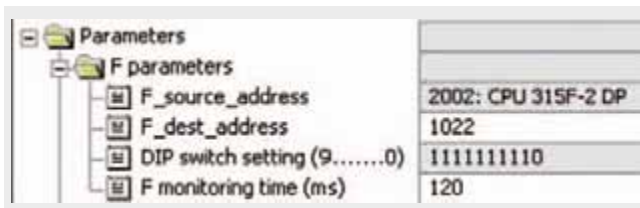
During **Test Mode** all test functions can be used without restrictions via PG/PC, which can also cause larger extensions of the cycle time. Important: During test mode of the CPU you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



The two-channel push buttons are supplied with power via the module. Category 4 is reached due to the fact that a cross-circuit detection is possible. This requires that the short circuit test is activated.

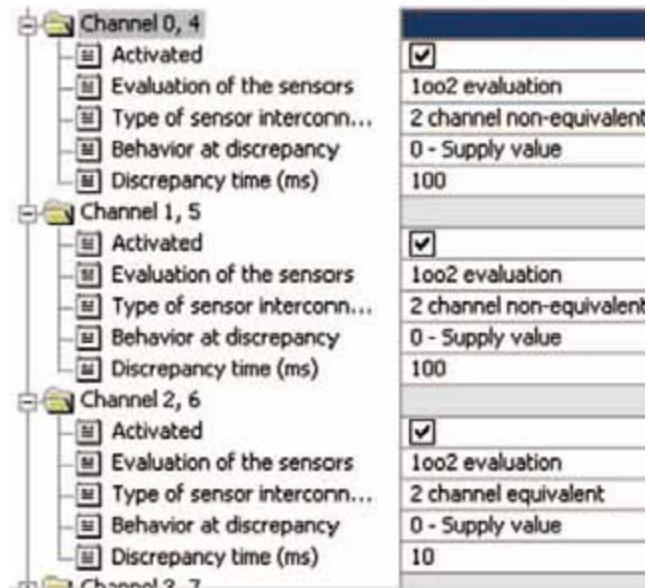


DIL switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Also in the "Parameter" tab.

During 1002 evaluation only the first-mentioned channel (0, 1, 2) is used in each case, the channels 4, 5, 6 cannot be accessed.

Channel 0, 4 and channel 1, 5

Exclusive OR sensor of the two-hand control panel: The discrepancy time between make contact and break contact of an exclusive OR sensor can be defined here.

Channel 2, 6

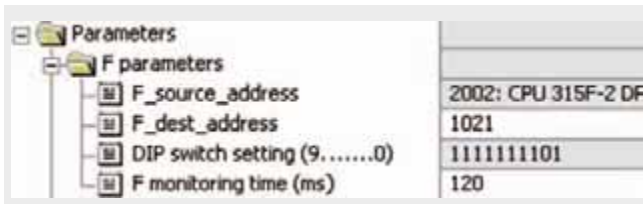
Emergency stop

All other channels (3, 7)

deactivate

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").



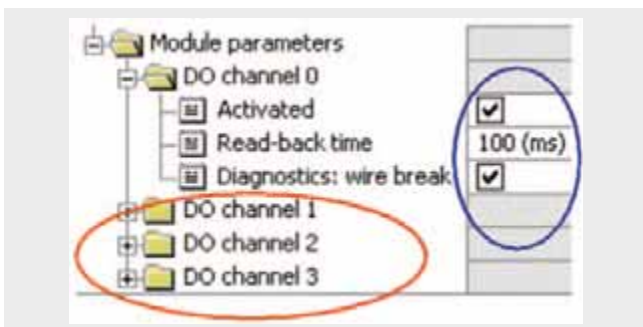
Parameter	Value
F_source_address	2002: CPU 315F-2 DF
F_dest_address	1021
DIP switch setting (9.....0)	1111111101
F monitoring time (ms)	120

DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Module parameters	Value
DO channel 0	Activated <input type="checkbox"/>
Read-back time	100 (ms)
Diagnostics: wire break	<input checked="" type="checkbox"/>
DO channel 1	Activated <input checked="" type="checkbox"/>
DO channel 2	Activated <input type="checkbox"/>
DO channel 3	Activated <input type="checkbox"/>

Activate used channels, deactivate channels which are not used.

The read-back time defines the duration of the switch-off process for the respective channel. If the respective channel switches high capacity loads the read-back time should be set sufficiently. We recommend to set the read-back time as small as possible by trying, however large enough to ensure that the output channel is not passivated.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5 k	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2 k	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 48,0 k	approx. 0,9 k	approx. 47,1 k
Main memory	approx. 34,8	approx. 0,3 k	approx. 34,5 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	11 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

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

Password

In all cases, the passwords used for the safety-relevant part is „**siemens**“.

Use of the STEP 7 Project

With the two-hand control panel a "machine" is started, which is simulated by an indicator light in this example. As long as the two push buttons of the two-hand control panel remain pressed, the "machine" "runs" (indicator light is on). As soon as one push button is released or if the simulated "machine time" has elapsed, the "machine" stops (indicator light goes off). Furthermore, the "machine" stops if the failsafe input/output modules of the ET 200S is passivated and if the emergency stop push button integrated in the two-hand control panel is actuated.

The conditions necessary for the actuators to meet the requirements of Safety Category 4 (e.g. read back of the actuator signals) are not described in this example.

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21331100>

To call the corresponding project file, open the "as_fe_i_006_v10_code_2hand.zip" file offered as separate download (on the HTML page) and extract it into a user-defined directory.

To download the project to the F CPU please proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" folder
- Menu "Options" -> Edit safety program
- Click the "Download" button

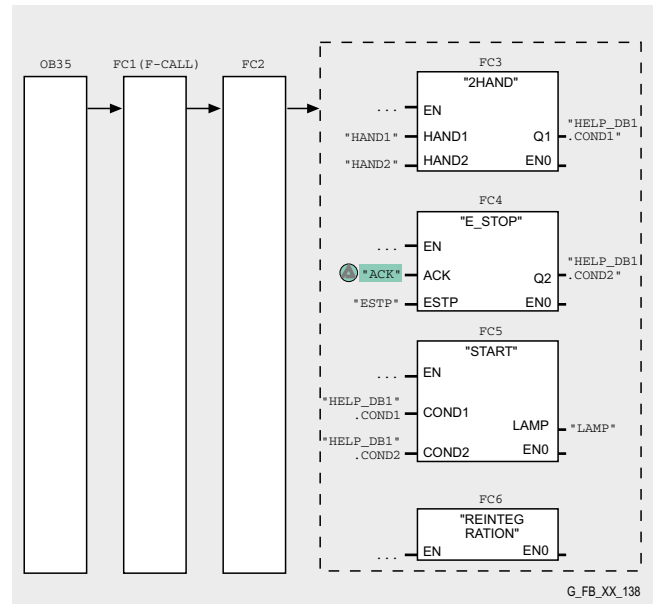
The sample code with the given configurations enables the following:

- Connecting a SIGUARD two-hand control panel with integrated emergency stop to the failsafe I/O modules (F-DI/F-DO) and evaluation using a failsafe SIMATIC S7-CPU

Program procedure

The standard user program only consists of a call of FC "F-CALL" in the cyclic interrupt OB (OB 35). The only nonsafety-related signal (acknowledgement signal) is evaluated directly in the safety program.

The failsafe program has the following program sequence:



F-CALL (FC1)

F-CALL (FC1) is the F runtime group and is called from the cyclic interrupt OB (OB35). F-CALL calls the F-programme block (here the FC 2).

FC "2H_and_ESTP" (FC 2)

FC 2 ensures the modular setup of the safety program. The "two-hand control" functionality is basically implemented in the function blocks FC3, FC4 and FC5, FC6 called by FC2.

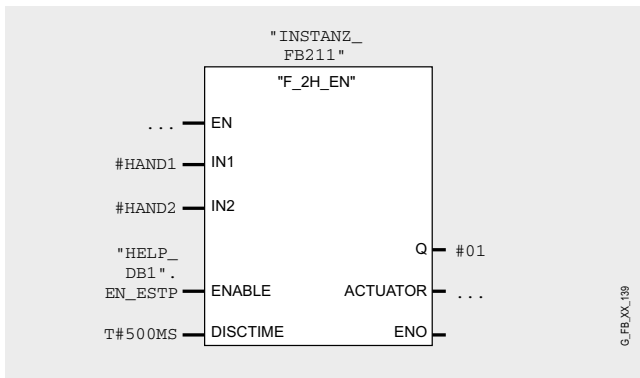
Block	Task
FC "2Hand" (FC 3)	Evaluation of the status of the two exclusive OR sensors of the two-hand control panel.
FC "E_STOP" (FC 4)	Evaluation of the status of the emergency stop mushroom-head push button integrated in the two-hand control panel.
FC "START" (FC 5)	Evaluation of the information from FC3 and FC4 to start the "machine".
FC "REINTEGRATION" (FC 6)	Reintegration after passivation of F-DI or F-DO.

FC "2Hand" (FC 3)

Input parameter	Assignment	Function
HAND1	Exclusive OR sensor of the two-hand control panel	Starting the "machine". To start the machine both exclusive OR sensors must be pressed simultaneously and have to remain pressed during the entire "machine time".
HAND2		

Output parameter	Assignment	Function
HELP_DB1.CO ND1	Bit from F-DB	Storing the result for later evaluation in FC5

For realisation of the "two-hand control", FC 3 calls the FB "F_2H_EN" (FB 211, DB 211). FB 211 is a certified block from the Distributed Safety library.



In #HAND1 and #HAND2 the make contacts are polled by the exclusive OR sensors of the two-hand control panel.

Both exclusive OR sensors have to be pressed within a time. This time is indicated on the DISCTIME parameter of FB "F_2H_EN" (FB 211). The maximum permissible value which can be parameterized is 500 ms according to EN 574).

Only with "1"-signal at ENABLE, Q can be set. The bit "HELP_DB1".EN_ESTP is the the emergency stop signal (see FC 4): "HELP_DB1".EN_ESTP will be set, if the emergency stop button is unlocked **and** acknowledged. Consider the following scenario:

- Both exclusive OR sensors are pressed and will be pressed all along
- The emergency stop is pressed
- The emergency stop is unlocked
- An acknowledgement is done

Even though both exclusive OR sensors have been pressed during those 4 steps, the "machine" will not turn on (a release of the both exclusive OR sensors is necessary).

FC "E_STOP" (FC 4)

Input parameter	Assignment	Function
ACK	Push button (NO)	An acknowledgement prior to the start of the "machine" is required in the following cases: <ul style="list-style-type: none"> ■ First start ■ After unlocking the emergency stop ■ After the F-DI has come from passivation (reintegration) The ACK signal is received by a standard DI. The signals which are not failsafe are indicated in color in the F program.
ACK		
ESTP	Emergency stop push button (NC/NC)	Interruption of the "machine activity"

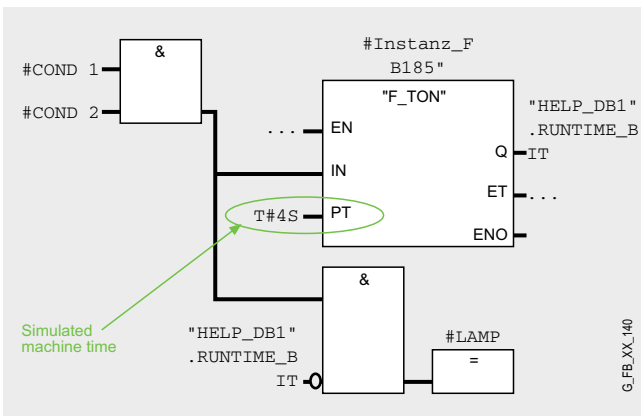
Output parameter	Assignment	Function
HELP_DB1.COND2	Bit from F-DB	Storing the result for later evaluation in FC5

FC "START" (FC 5)

Input parameter	Assignment	Function
HELP_DB1.COND1	Bit from F-DB	Condition for the start of the "machine" from FC3
HELP_DB1.COND2		Condition for the start of the "machine" from FC4
Output parameter	Assignment	Function
LAMP	Indicator light connected to the F-DO	Simulates the "machine" to be started by the two-hand control.

To start and operate the "machine" (indicator light ON), HELP_DB1.COND1 and HELP_DB1.COND2 each have to be on "1" signal. The "machine" runs for 4 seconds with the default setting (LAMP="1"). Subsequently the "machine" stops (LAMP="0"). In order to restart the machine it is necessary to release the push buttons of the two-hand control once before restarting.

The machine time is simulated with FB "F_TON" (FB185). FB "F_TON" (FB185) is a certified block from the Distributed Safety library.



Note

The bits from DB "HELP_DB1" (DB1) mentioned here and used in the STEP 7 program are only used for buffering.

FC "REINTEGRATION" (FC 6)

Network 4 of FC 2 calls FC 6 where the reintegration is implemented in case of a passivation of F-DI or F-DO. For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example the reintegration of passivated modules takes place automatically. Only use the automatic reintegration for your applications if it does not cause hazards.

A passivation is indicated by an illuminated LED "SF" on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

Prerequisite:

- Hardware configuration and safety program are in the S7-CPU
- Emergency stop unlocked
- No passivation of F-DI/F-DO

No.	Instruction	Result/Note
1	Press the acknowledgement push button and release it.	Necessary prior to the first start.
2	Simultaneously press the exclusive OR sensors of the two-hand control and keep them pressed	Start of the "machine" (indicator light goes on)
3	Wait 4 seconds	Simulated machine time. After 4 seconds the "machine" goes off (indicator light goes off).
4	Release the exclusive OR sensor	You can continue with no. 2.

Note

An acknowledgement is required after an actuated emergency stop, discrepancy time exceeding of an exclusive OR sensor or prior to starting the "machine" for the first time.

Integration of the Readback Signal in an Application of Category 4 acc. to EN 954-1

Automation Function

Description of the functionality

What is "read back"?

The part of a circuit in which read back is implemented is referred to as feedback circuit. In this circuit the status of the contactor auxiliary contacts are evaluated; it is required to use positively driven 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.

Read back is thus used for monitoring the load to prevent a reactivation in case of a fault. This also applies to the use of valves and it is already required from Safety Category 2.

Functional example

In the functional example described here a motor is started and stopped. Using this example it will be shown

- how the feedback circuit is integrated in the circuit design and
- how it is evaluated using STEP 7

According to the machinery directive each machine has to be equipped with one or several emergency stop control devices. This is the reason why an emergency stop functionality is integrated in this example; however, this functionality is not described in detail. Explanations on the subject emergency stop are available in "Safety Integrated Functional Example" 1.

Safety Category 4

In order to meet the requirements of Safety Category 4 it is obligatory to read back the process signal to the actuator. This example complies with the requirements of Safety Category 4.

Reaction times

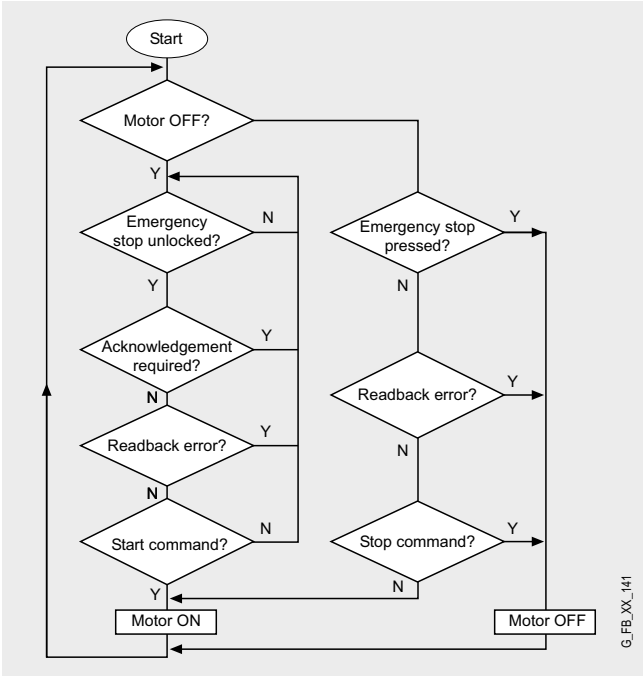
Use the Excel file, which is available for S7 Distributed Safety V 5.3, for the calculation of the max. reaction time of your F system. This file is available on the internet:

<http://support.automation.siemens.com/WW/view/en/19138505>

Flowchart

The flowchart shown below illustrates the function process of the example. The acknowledgement in the flowchart is required

- prior to starting the motor for the first time
- prior to a start after activating the emergency stop
- after reintegration (end of a passivation) of the failsafe input module of the ET 200S



Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. Dieser Vorteil kommt um so mehr zum Tragen, je mehr Sicherheitsfunktionen realisiert werden
- Programming the failsafe program with STEP 7 engineering tools
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	3	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	3	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Emergency stop	Push button, 1NC	3SB3801-ODG3	1	
Contact (for Emergency stop)	1NC, screw-type connection	3SB3420-0C	1	
Push button	green, 1NO	3SB3801-0DA3	2	
Push button	red, 1NC	3SB3801-0DB3	1	
Contact	AC-3, 3KW/400V, 1NC, DC 24V,	3RT1015-2BB42	2	
Excess voltage limiter for plugging onto contactor	RC element AC 24...48V, DC 24...70V	3RT1916-1CB00	2	
Motor	Low-voltage motor 0.12kW	1LA7060-4AB10	1	
Circuit breaker for motor protection	0.35...0.5A	3RV1011-0FA1	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Warning!

Always check whether contactors and circuit breakers are suitable for the used motor with regard to the performance data. Furthermore, ensure safe operation on the net by using appropriate fuses.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

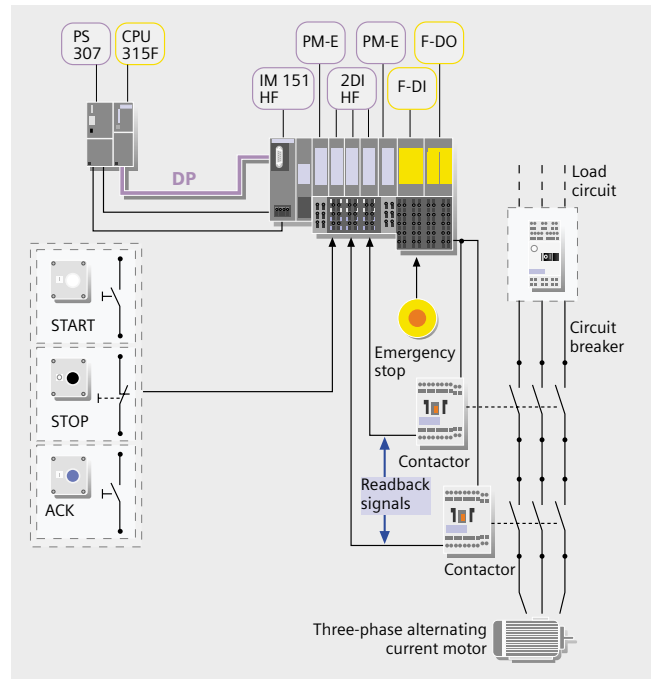
Note
In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator.

An overview of the hardware structure

Overall arrangement

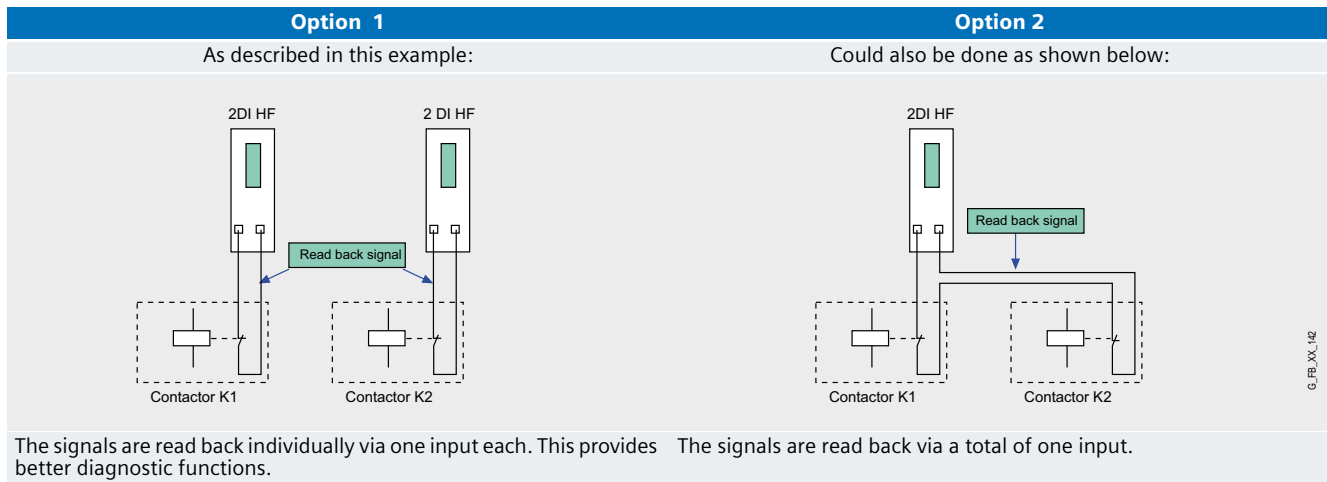
The arrangement used to demonstrate the signal feedback consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave.

Note
One 4DI electronic module can be used instead of two 2DI electronic modules. The "high feature" electronic modules can also be replaced by standard modules.



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** input channel of the ET 200S. There are 2 options:



Note
The reason that two input modules are shown under "Option 1" is due to the division of the signals in the respective example program. In general, the two required inputs can also be located on **one** input module.

Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

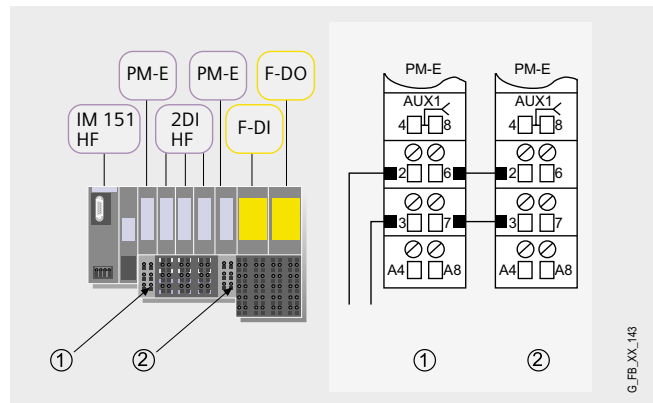
Hardware component	Einzustellende Address	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFI-safe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFI-safe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIP switch) on the side of the module corresponds to the PROFI-safe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note

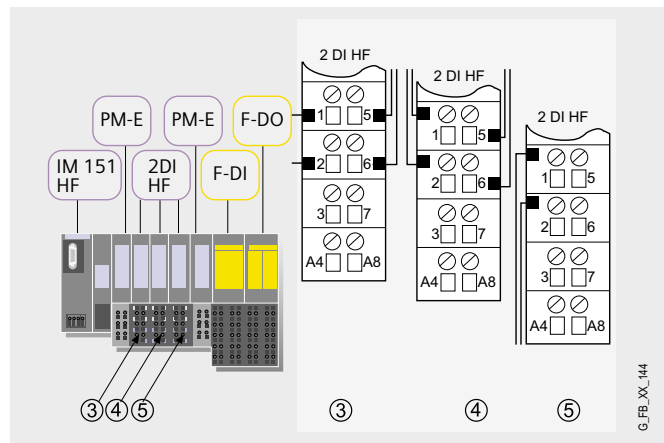
The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

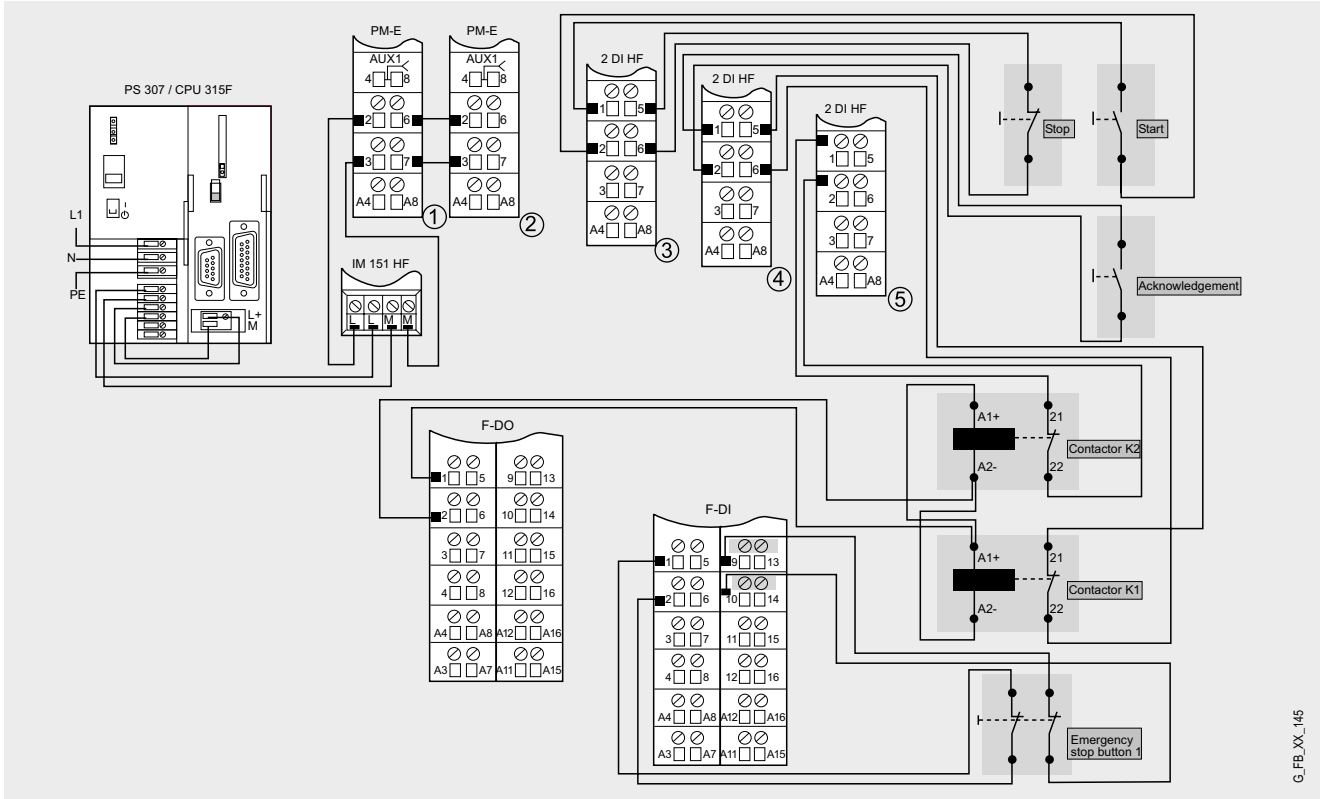
The wiring of the hardware is illustrated below. In the following table the hardware components which occur several times are numbered to ensure that they can be clearly assigned in the subsequent wiring diagram.



G_FB_XX_143



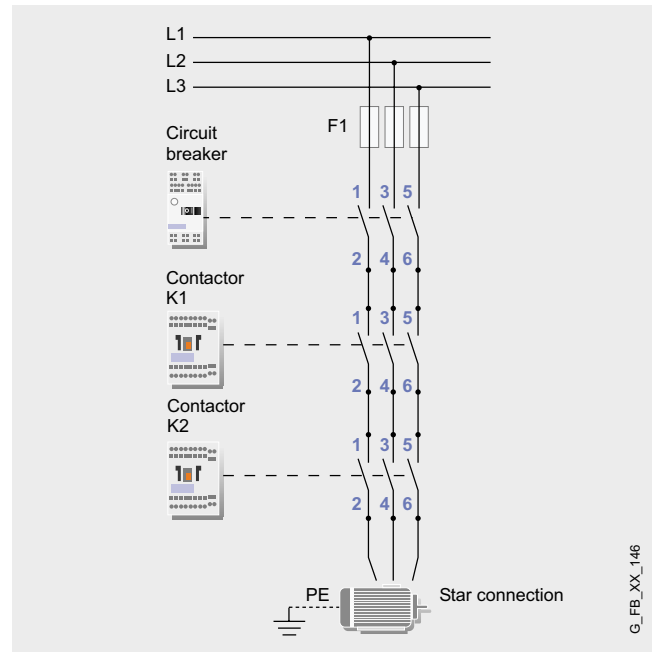
G_FB_XX_144



G_FB_XX_145

The load circuit looks as follows:

Note
A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project to the CPU 315F-2DP.



G_FB_XX_146

Function test

After wiring the hardware components you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project).

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	START	"0"	Start request
2	Push button (NC)	E 0.1	STOP	"1"	Stop request
3	Push button (NO)	E 1.0	ACK	"0"	Acknowledgement
4	Contactorauxiliary contact (NC)	E 1.1	K1_HELP	"1"	Readback signal
5	Contactorauxiliary contact (NC)	E 2.0	K2_HELP	"1"	
6	Emergency stop push button	E 3.0	ESTP	"1"	–
7	Magnet coil contactor	A 9.0	K1_K2	"0"	–

Testing inputs and outputs

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

Warning!

The instructions listed in the table below should first be performed without activated load circuit.

No.	Instruction	A 9.0	Response K1	K2	Motor	Note
1	Press the push button E 1.0 and release it.	"0"	not activated		AUS	Acknowledgement
2	Press the push button E 0.0 and release it.	"1"	activated		AN	Start request
3	Press the push button E 0.1 and release it.	"0"	not activated		AUS	Stop request
4	Repeat no. 2.	"1"	activated		AN	Start request
5	Press the emergency stop (E 3.0).	"0"	not activated		AUS	Activate emergency stop
6	Unlock the emergency stop.		not activated			–
7	Repeat no. 1 and 2.	"1"	activated		AN	Acknowledgement and start request
8	Press the push button E 0.1 and release it.	"0"	not activated		AUS	Stop request

An acknowledgement is required

- when starting for the first time
- after unlocking the emergency stop
- after reintegration (module was passivated) of the failsafe input module (F-DI) of the ET 200S
- after exceeding the read-back time in the feedback circuit monitoring

Important hardware component settings

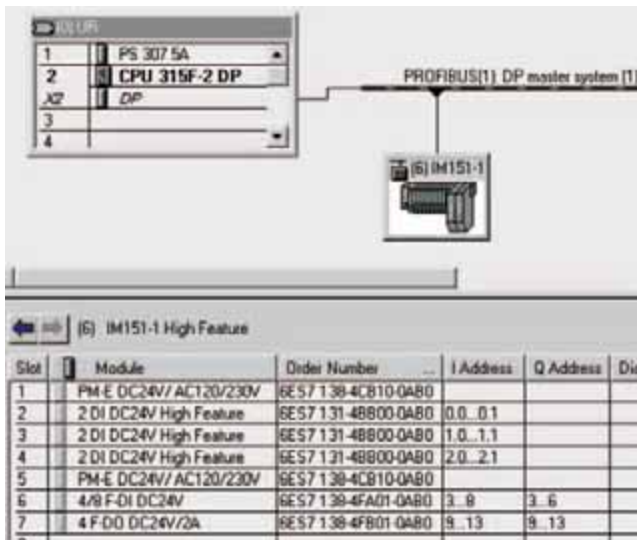
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements) but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

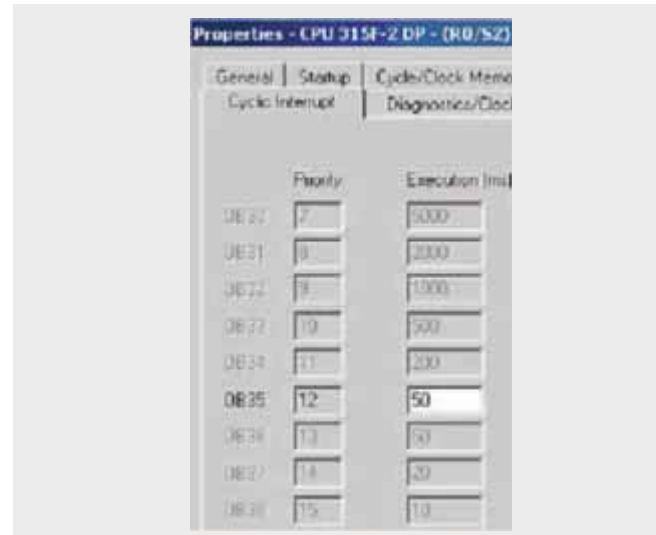
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



Set mode: "Test Mode"

During **Process Mode** the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode** all test functions can be used without restrictions via PG/PC, which can also cause larger extensions of the cycle time. Important: During test mode of the CPU you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").

Parameter	Value
Parameters	
F parameters	
Module parameters	
Input delay	3 (ms)
Short-circuit test	cyclic

The two-channel emergency stop push button is supplied with power via the module. Category 4 is reached due to the fact that a cross-circuit detection is possible. This requires that the short circuit test is activated.

Parameter	Value
Parameters	
F parameters	
F_source_address	2002: CPU 315F-2 DP
F_dest_address	1022
DIP switch setting (9,.....0)	1111111110
F monitoring time (ms)	120

DIL switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

Parameter	Value
Channel 0, 4	
Activated	<input checked="" type="checkbox"/>
Evaluation of the sensors	1oo2 evaluation
Type of sensor interconn...	2 channel equivalen
Behavior at discrepancy	0 - Supply value
Discrepancy time (ms)	10
Channel 1, 5	
Channel 2, 6	
Channel 3, 7	

Also in the "Parameter" tab.

Channel 0, 4

The two break contacts of the emergency stop push button are polled in a 1oo2 evaluation.

All other channels deactivate

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

Parameters	
F parameters	
F_source_address	2002: CPU 315F-2 DP
F_dest_address	1021
DIP switch setting (9.....0)	1111111101
F monitoring time (ms)	120

DIP switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

Module parameters	
DO channel 0	
Activated	<input checked="" type="checkbox"/>
Read-back time	100 (ms)
Diagnostics: wire break	<input checked="" type="checkbox"/>
DO channel 1	
DO channel 2	
DO channel 3	

Activate the used channel 0, deactivate channels (1, 2, 3) which are not used.

The output of channel 0 provides the pick-up/drop-out of the contactor coils of K1 and K2.

The read-back time defines the duration of the switch-off process for the respective channel. If the respective channel switches high capacity loads the read-back time should be set sufficiently. We recommend to set the read-back time as small as possible by trying, however large enough to ensure that the output channel is not passivated.

Settings for the readback signals

Slot	Module	Order Number	I Address
1	PME DC24V/AC120/230V	6ES7 130-4CB10-0AB0	
2	2 DI DC24V High Feature	6ES7 131-4B800-0AB0	0.0..0.1
3	2 DI DC24V High Feature	6ES7 131-4B800-0AB0	1.0..1.1
4	2 DI DC24V High Feature	6ES7 131-4B800-0AB0	2.0..2.1
5	PME DC24V/AC120/230V	6ES7 130-4CB10-0AB0	
6	4/8 FDI DC24V	6ES7 131-4B800-0AB0	
7	4 F-DO DC24V/2A	6ES7 131-4B800-0AB0	
I Address Symbols - 2 DI DC24V High Feature			
8		Address	Symbol
9		E 2.0	K2_HELP
10		E 2.1	

The readback signals ("K2_HELP" is shown in the screenshot) are read in via a standard input module of the ET 200S; they don't have to be read via a failsafe input module.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5 k	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2 k	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 46,3 k	approx. 1,0 k	approx. 45,3 k
Main memory	approx. 33,4 k	approx. 0,4 k	approx. 33,0 k

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	8 ms	Calculation with the Cotia table. Page 180 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code in which readback is demonstrated.

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

Password

In all cases, the passwords used for the safety-relevant part is „**siemens**“.

Use of the STEP 7 Project

A three-phase asynchronous motor is started via a push button (NO) and stopped via a push button (NC). In case of emergency the motor can also be stopped via an emergency stop push button.

This functionality is used as a framework to show how the signals are read back from the actuator and evaluated within the STEP 7 program.

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21331098>

To call the corresponding project file open the "f07_readback_v10.zip" file offered as separate download (on the HTML page) and extract it into a user-defined directory.

To download the project to the F CPU please proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" folder
- Menu "Options" -> Edit safety program
- Click the "Download" button

The sample code with the given configurations enables the following:

- Starting and stopping a three-phase asynchronous motor considering the signals read back from the actuator.
- Emergency stop for shutdown in case of a fault.

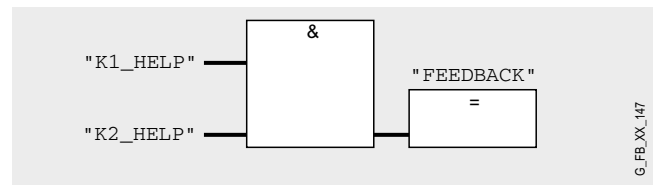
Note

The focus of this functional example is to demonstrate how the readback signal is connected to the hardware and how it is evaluated using software (STEP 7). Running the motor is a means to an end. The emergency stop functionality is used for safety reasons if the example is reproduced.

Program procedure

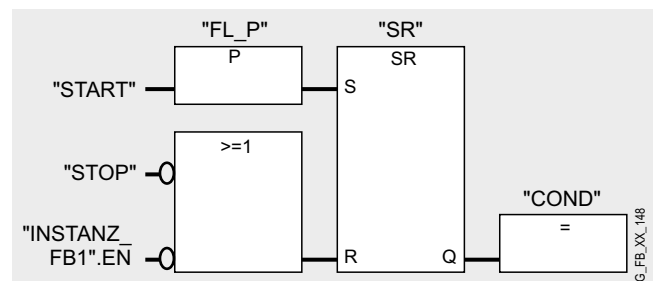
The standard user program basically consists of two networks in OB1:

Network 1



The auxiliary contacts of K1 and K2 are evaluated under the memory bit FEEDBACK in the safety program.

Network 2



The switch-on condition COND="1" is only possible if the R input of the flip-flop is on "0" signal (if "1" signal at S and R input the reset function is predominant in this flip-flop).

INSTANZ_FB1.EN characterizes the signal state of a flip-flop in the safety program (used as static variable in the safety program). As long as a necessary acknowledgement has not been transmitted in the safety program this bit remains on "0" and it cannot be started.

The information of the flag "COND" is read as flag COND1 in the safety program. This assignment takes place in the cyclic interrupt OB 35 for the following reason:

Note

The reason below also applies to the memory bit FEEDBACK from network 1.

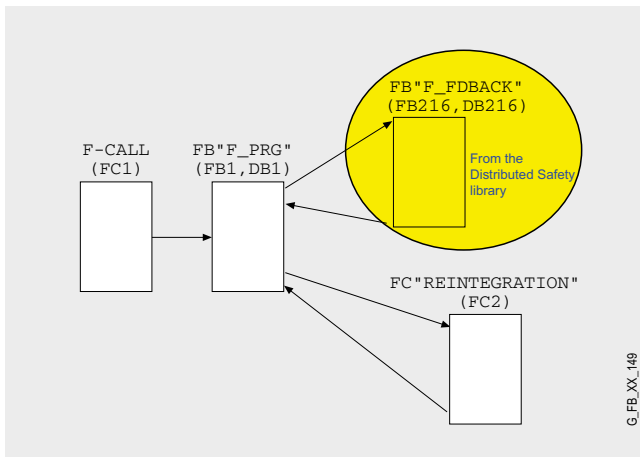
If you want to read data from the standard user program (flags or PII of standard I/O) in the safety program (here: COND), which can be changed by the standard user program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate flags (here: COND1). Data from the standard user program have to be written to these flags immediately before calling the F run-time group. Only these flags may then be accessed in the safety program.

This has already been implemented in this example. In general, however, the following applies

Note

If the above section is not observed the F CPU may go to STOP mode.

The failsafe program has the following program sequence:



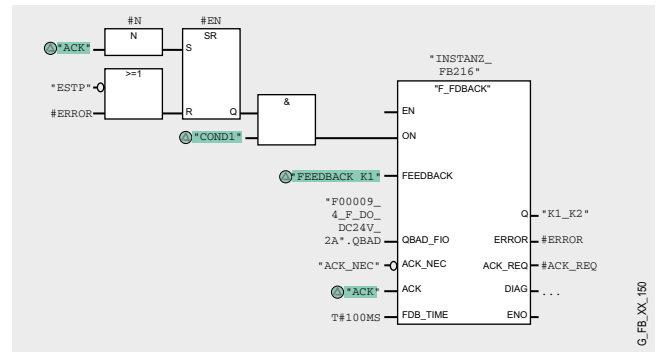
F-CALL (FC1)

The obligatory F-CALL (FC 1) is called from the cyclic interrupt OB (OB 35). This OB calls the F runtime group (here FB 1).

FB "F_PRG" (FB 1, DB 1) und FB "F_FDBACK" (FB 216, DB 216)

Network 1

FB "F_PRG" (FB1, DB1) first calls FB "F_FDBACK" (FB216, DB216). FB 216 is a certified block from the Distributed Safety library; this block is available from version 5.3.



The acknowledgement signal ACK is responsible for the acknowledgement after activating and unlocking the emergency stop as well as after exceeding the feedback time FDB_TIME (on FB 1). The latter is indicated by #ERROR="1".

The status of the flip-flop is stored in the static variable #EN and read as switch-on condition in OB 1.

"1" signal on the formal parameter ACK_NEC indicates that a manual acknowledgement is required to set release (formal parameter Q). The bit #ACK_NEC is a static variable with initial value "0".

Output Q is set to 1 as soon as input ON = 1. It is required that readback input FEEDBACK = 1 and no readback error must be stored.

A readback error ERROR = 1 is detected if the signal state of the readback input FEEDBACK (to output Q) does not follow the signal state of the input ON within the maximum tolerable readback time FDB_TIME. K1_K2 is the bit from the F-output module, which sets the contactors K1 and K2.

To ensure that no readback error is detected and that no acknowledgement is required in a passivation of failsafe the I/O modules controlled by output Q you have to supply the input QBAD_FIO with the variable QBAD of the corresponding failsafe I/O module DB.

Note

Before inserting the F application block F_FDBACK, you have to copy the F application block F_TOF from the block container F-Application Blocks\Blocks of the F library Distributed Safety (V1) into the block container of your S7 program if it is not available in this container (has already been done in this example project).

Warning!

When using the F application block F_FDBACK it is required that the F application block F_TOF has the number FB 186 and that the number is not changed!

Network 2**FC "REINTEGRATION" (FC 2)**

Network 2 of FB 1 calls FC 2 where the reintegration is implemented in case of a passivation of F-DI or F-DO.

Warning!

In this example, the reintegration of passivated modules takes place automatically. Only use the automatic reintegration for your applications if it does not cause hazards.

A passivation is indicated by an illuminated LED "SF" on the module. The reintegration of an F module may take approx. one minute.

Example

Contactor K1 welds during shutdown. In the S7 program this process is detected as follows:

No.	Function	Comment
1	The memory bit "FEEDBACK" does not go to "1" after shutting down so that the auxiliary contacts of K1 and K2 are on different signals.	OB 1, network 1
2	At the input FEEDBACK of FB 216 in the safety program this signal does now not follow (within the parameterizable read-back time FDB_TIME) the signal of the status of the input ON.	FB 216, call in FB 1
3	The error bit ERROR is set at FB216.	
4	ACK_REQ="1" is only displayed after eliminating the welding of the contactor, which indicates that the error has been corrected and that an acknowledgement can be made.	
5	After the acknowledgement ERROR is reset and a restart can be performed.	

Operating instructions

Prerequisite:

- Hardware configuration of STEP 7 and safety program are in the S7-CPU
- Emergency stop unlocked
- No passivation of the F-DI/F-DO

Warning!

The instructions listed in the table below should first be performed without activated load circuit.

Motor ON/OFF

No.	Instruction	Result/Note
1	Press the acknowledgement push button and release it.	Necessary before starting the motor for the first time.
2	Press the push button for start request and release it.	Contactors K1 and K2 are activated; due to this the motor starts
3	Press the push button for stop request and release it.	Contactors K1 and K2 drop out; due to this the motor stops

Emergency stop

No.	Instruction	Result/Note
1	If the motor is started for the first time: Press the acknowledgement push button If not: No. 2	An acknowledgement is required before starting the motor for the first time.
2	Press the push button for start request and release it.	Contactors K1 and K2 are activated; due to this the motor starts
3	Press the emergency stop push button.	Contactors K1 and K2 drop out: The motor stops
4	Unlock the emergency stop push button	–
5	Press the push button for start request and release it.	Contactors K1 and K2 are not activated, the motor does not start. Starting the motor is only possible after an acknowledgement.

Welding of a contactor

No.	Instruction	Result/Note
1	If the motor is started for the first time: Press the acknowledgement push button If not: No. 2	An acknowledgement is required before starting the motor for the first time.
2	Press the push button for start request and release it.	Contactors K1 and K2 are activated; due to this the motor starts
3	Press the STOP push button and keep the coil of contactor K1 or K2 activated.	Simulated welding of the contactor.
4	Press the push button for start request and release it.	F output for K1 and K2 is not switched.

Safety Shutdown in the Stop Categories 0 and 1 in Safety Category 4 according to EN 954-1

Automation Function

Description of the functionality

Classification

Three Stop Categories (Stop Category 0, 1 and 2) are defined for the safety shutdown of machines. The Stop Category has to be defined on the basis of the risk assessment of the machine. The standards and regulations are listed in DIN EN 60204-1: 1998.

Stop Category 0

Stopping by immediate shutdown of the energy supply to the machine actuators. This stopping is an uncontrolled stop. Each machine has to be equipped with a stop function of Stop Category 0. The stop of Category 0 must have priority. In this example the shutdown complies with Safety Category 4.

Stop Category 1

Controlled stop during which the energy supply to the machine actuators is maintained to enable the stopping. The energy supply is only interrupted when the stop is reached. In this example the shutdown complies with Safety Category 4.

Stop Category 2

Controlled stop during which the energy supply to the machine actuators is maintained.

Functional example

In this example, safety shutdown in the Stop Categories 0 and 1 is shown. The DS asynchronous motor is hereby switched on and off via a MICROMASTER frequency converter. Apart from the operational stop, the motor can be fail-safe stopped as follows:

Stop Category 0

An NC button simulates a safety door contact. If the safety door is opened during operation ("0" signal of the button) the drive is immediately electrically isolated from the line supply

Stop Category 1

Stop Category 1 is used for an emergency stop. The motor is brought to a standstill. After a parameterized time (after which the motor must be safely in standstill) the motor is taken off the grid.

In addition the conditions listed below apply to the emergency stop:

- Precedence over all other functions and operations
- Resetting may not start a restart (acknowledgement required)

Note

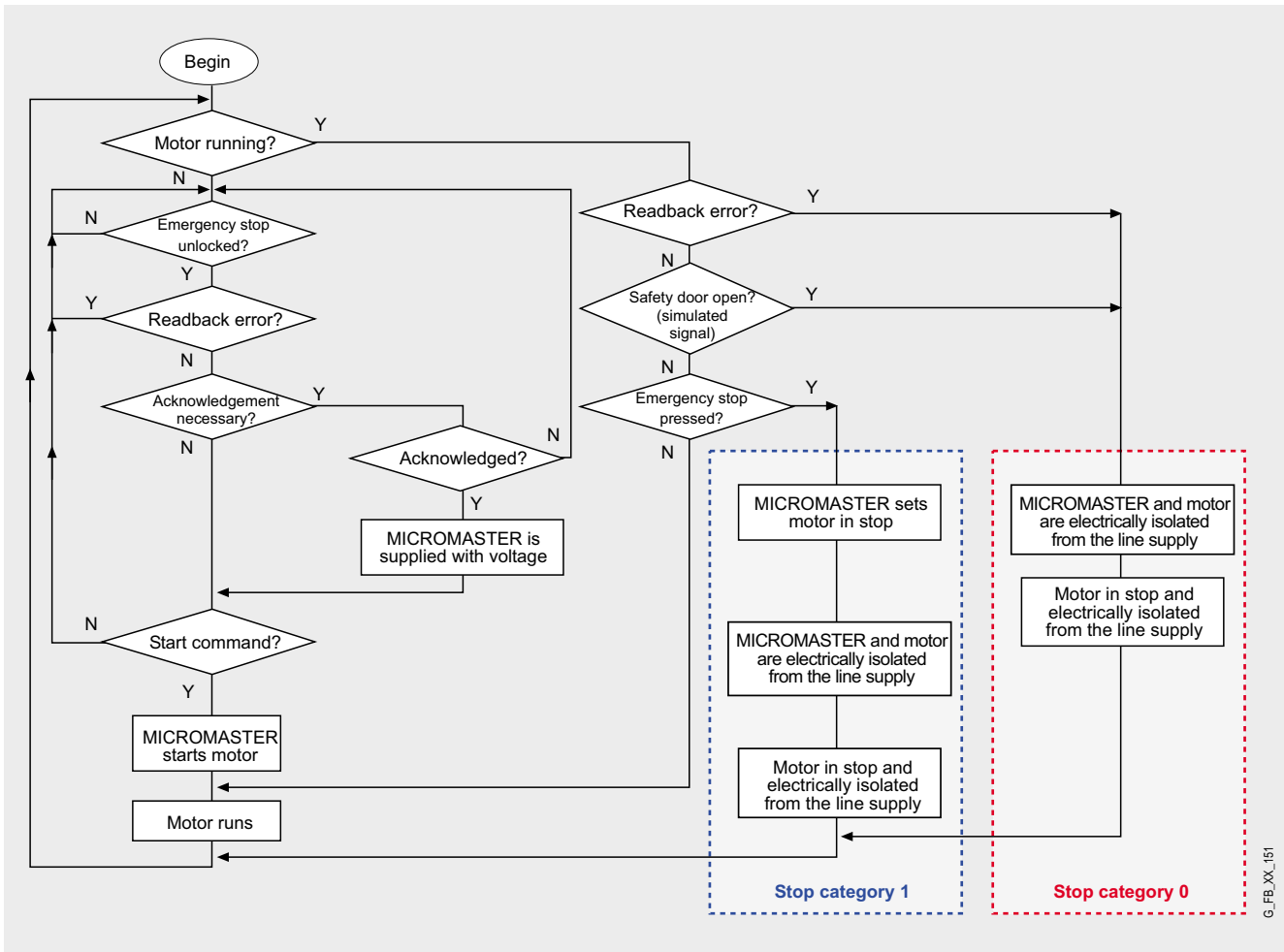
In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. Should you wish to not use the motor holding break, please change the parameterization of the MICROMASTERS.

Reaction times

Use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3, for the calculation of the max. reaction time of your F system. This file is available on the internet: <http://support.automation.siemens.com/WW/view/en/19138505>

Flowchart

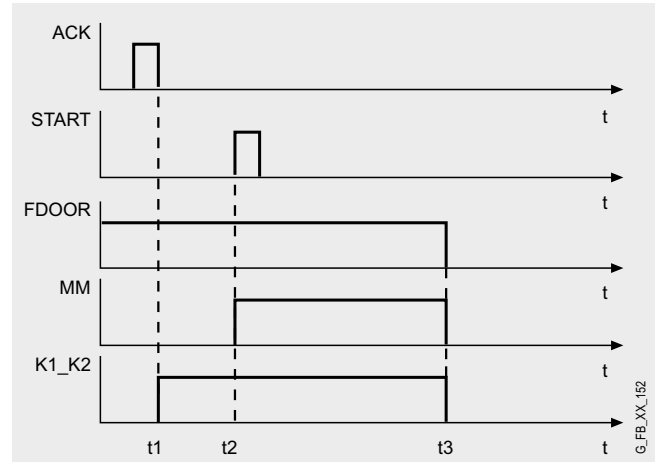
The following flow chart shows the correlation (for a better overview, operational stoppage is not displayed here):



Time sequence for Stop Category 0

The times listed in the following table are also shown in a timing diagram below. The names of the signals correspond to the ones of the S7 program code.

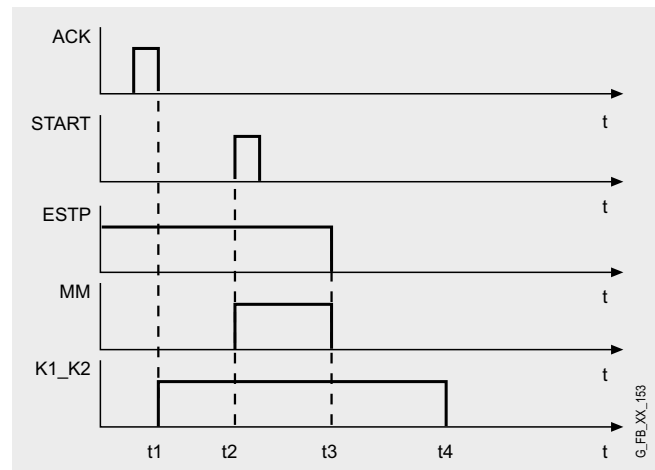
Time	Explanation
t1	With the acknowledge signal (negative edge) the contactors K1 and K2 are activated and supply the MICROMASTER with power. This switches the MICROMASTER on.
t2	With the start signal (positive edge) the output MM of the standard output module "1" signal switches to the MICROMASTER. This starts the motor according to a ramp parameterized in the MICROMASTER.
t3	During operation the safety door is opened (FDOOR="0"). The safety door signal is in this example simulated by an (NC) button. The contactors K1 and K2 drop out and electrically isolate MICROMASTER and motor from the line supply; output MM is reset in the program.



Time sequence for Stop Category 1

The times listed in the following table are also shown in a timing diagram below. The names of the signals correspond to the ones of the S7 program code.

Time	Explanation
t1	With the acknowledge signal (negative edge) the contactors K1 and K2 are activated and supply the MICROMASTER with power. This switches the MICROMASTER on.
t2	With the start signal (positive edge) the output MM of the standard output module "1" signal switches to the MICROMASTER. This starts the motor according to a ramp parameterized in the MICROMASTER.
t3	After activating the emergency stop (ESTP="0") the output MM of the standard output module is reset. This puts MICROMASTER motor to stop.
t4-t3	After this time the motor must be in standstill. This time is specified in the safety program as input parameter at a certified function block from the distributed Safety library.
t4	At motor standstill (parameterized time has elapsed) the contactors K1 and K2 drop out. This isolates the drive from the supply.



Operational stop

If in this example, the (NC) button for the operational stop is pressed, the following procedure has been prepared:

The motor is brought to a standstill by the MICROMASTER. Contactor K1 and K2 continue to supply the MICROMASTER with power. A motor restart is possible without previous acknowledgement.

Advantages/customer benefits

- 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 STEP 7 engineering tools.
- Only one CPU is required, since fail-safe and standard program parts run on a coexistent basis in the CPU
- Use of prefabricated (and certified) fail-safe blocks from the Distributed Safety library.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG, A&D
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 KByte	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V HF	6ES7131-4BB00-0AB0	3	
Electronic module for ET 200S	2DO HF DC24V HF	6ES7 132-4BB00-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	4	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Emergency stop	Push button, 1NC	3SB3801-0DG3	1	
Contact (for Emergency stop)	1NC, screw-type connection	3SB3420-0C	1	
Push button	Green, 1NO	3SB3801-0DA3	2	
Push button	Red, 1NC	3SB3801-0DB3	2	
Contact	AC-3, 3KW/400V, 1NC, DC 24V	3RT1015-2BB42	2	
Contact	AC-3, 3KW/400V, 1NO, DC 24V	3RT1015-2BB41	1	
Excess voltage limiter for plugging onto contactor	RC element AC 24...48V, DC 24...70V	3RT1916-1CB00	3	
Circuit breaker for motor protection	0.35...0.5A	3RV1011-1JA20	1	
Frequency inverter	MICROMASTER 410	6SE6410-2BB13-7AA0	1	
Operator panel for the frequency inverter	MM410 Operator Panel	6SE6400-0SP00-0AA0	1	
Motor	Low-voltage motor 0.18kW	1LA7063-4AB10-Z +Option 26	1	

Note

In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the following hardware components are not necessary: Contactor with auxiliary contact (NO), 1 excess voltage limiter for plugging onto the contactor, option 26 at the motor.

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

Regarding the use of MICROMASTER 410, please consider the following safety note:

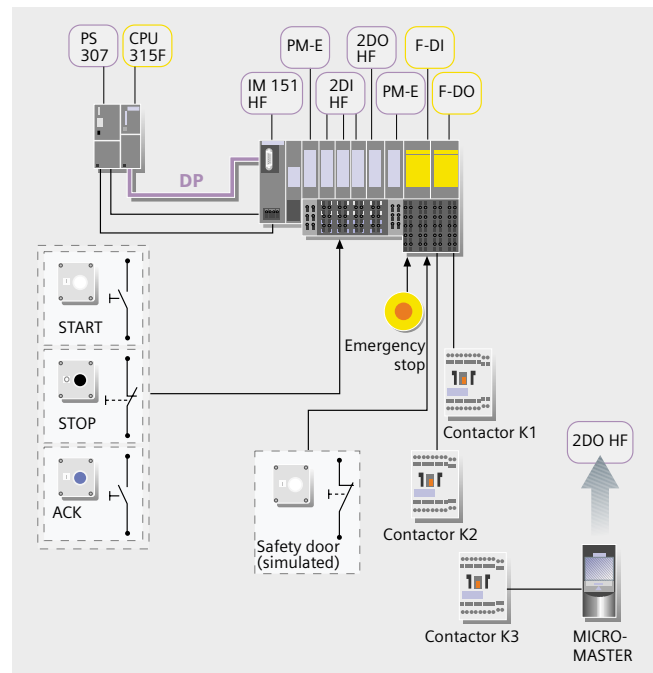
Warning!

- The MICROMASTER carries hazardous voltages and controls potentially dangerous rotating mechanical parts. Non-compliance with warnings or failure to follow the instructions contained in the MICROMASTER manual can result in loss of life, severe personal injury, or serious damage to property.
- Only adequately qualified personnel may work at this equipment. It is required that this personnel is informed in detail on and familiar with all safety notices, installation, operation and maintenance procedures listed in the MICROMASTER manual. Proper and safe operation of the equipment requires proper handling, installation, operation and maintenance.
- Risk of electric shock. The DC link capacitors remain charged for 5 minutes after power has been removed. **It is thus not permissible to open the equipment until 5 minutes after the power has been removed.**
- Children and not authorized persons must be prevented from accessing or approaching the equipment!
- The equipment may only be used for the purpose specified by the manufacturer. Unauthorized modifications and the use of spare parts and accessories which are not sold or recommended by the manufacturer of the equipment can cause fires, electric shocks and injuries.

Overview of the hardware configuration

The arrangement for shutdown in the Stop Categories 0 and 1 consists of a PROFIBUS configuration. A fail-safe S7-CPU is used as DP master, an ET 200S as DP slave.

Overview control circuit



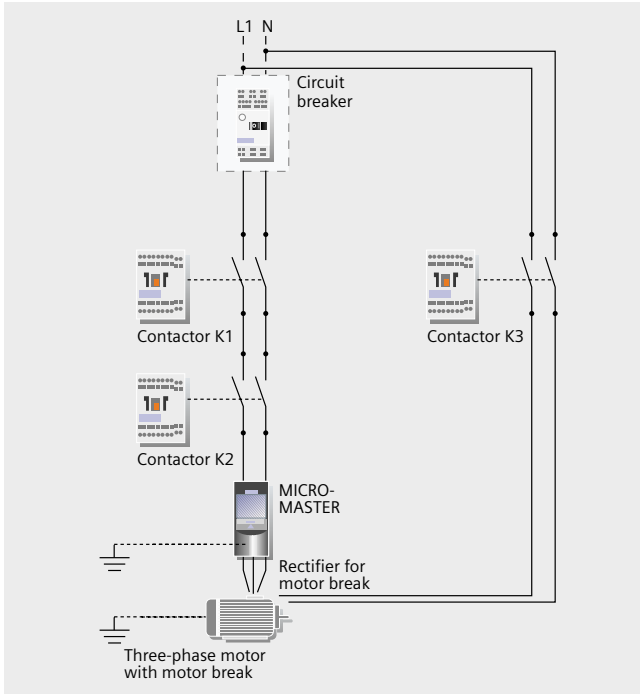
Note

In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the contactor K3 is not necessary.

Note

One 4DI electronic module can be used instead of two 2DI electronic modules. The "high feature" electronic modules can also be replaced by standard modules.

Overview load circuit



Note

In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the contactor K3 is not necessary:

Parameterization of the MICROMASTER 410

The parameterization of MICROMASTER 410 is described in the respective instruction manual. To provide better understanding, some points are emphasized in this document:

- Input of the parameters
- Parameters used

Input of the parameters



The inverter parameters can be accessed with the operator panel (OP). Below, it is shown how to set the parameter "Function of digital input 1" (P0701). All other parameters can be set identically.

At this point, the procedure during parameterization is described; the parameters are explained under "Parameters used".

Requirements: The MICROMASTER is supplied with voltage.

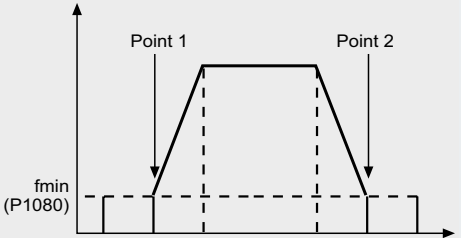
No.	Drücken Sie...	Note	Display
1		... to be able to access the parameters.	
2		... until P0701 is displayed.	
3		... to display the parameter value level.	
4		.. to receive the required value (here: 1)	
5		... to confirm and save the value.	

Note

Alternatively, the MICROMASTER can also be parameterized with the "STARTER" software by Siemens, which can be downloaded on the Internet (link on page 273) free of charge.

Parameters used

Below, some characteristic parameters are shown which were used for this example (with the motor used).

Parameter No.	Parameter name	Value to be set	Note/Explanation
P0700	Selection of command source	2 (connecting terminal plate)	There different options of starting or stopping the motor using the MICROMASTER, e.g. via the keyboard on the OP. In this example, the commands for starting/stopping the motor come from the standard output module (2DO HF) of the ET 200S and are transferred to the terminal connecting plate of the MICROMASTER.
P0701	Function of digital input 1	1 (ON/OFF1)	The commands for starting/stopping are acquired by digital input 1 on the MICROMASTER. If "1": Motor starts (ON) If "0": Motor stops (OFF1)
P0731	Function of digital output 1	52.C (motor holding brake (MHB) active)	Motor holding brake active (see also P1215)
P0971	Transfer data from RAM to EEPROM	1 Start RAM -> EEPROM	All values are transferred from RAM to EEPROM.
P1120	Startup time	6	Time value in seconds required by the motor to accelerate from stop to the highest motor frequency.
P1121	Ramp-down time	6	Time value in seconds required by the motor for delaying the maximum motor frequency until stop.
P1215	Holding break enable	1: Motor holding brake enabled	By the value 52.C in P0731, a relay is switched at the points 1 and 2 to control the brake. The relay is located at the terminals 11 and 12 of the MICROMASTER. 

Note

The parameters are stored in the "as_fe_i_008_v10_code_pstopcat.zip" file. The "STARTER" software by Siemens is required to use this file. Page 273 provides information on where to download this software.

Warning!

Please note that the parameters stored in the file "as_fe_i_008_v10_code_pstopcat.zip" refer to the motor with holding break used by us for testing. If you use a different motor, the parameters have to be adapted for the MICROMASTER.

For safety reasons, the motor with the prepared parameters does not accelerate to maximum speed.

Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

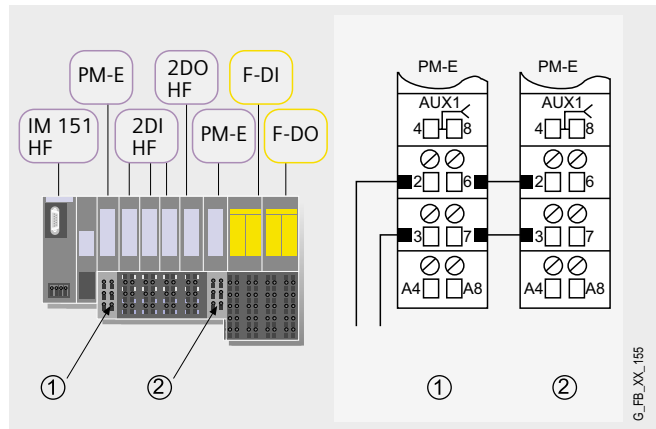
Hardware component	Einzustellende Address	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFSafe addresses are automatically assigned during configuring the fail-safe modules in STEP 7. The PROFSafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFSafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note

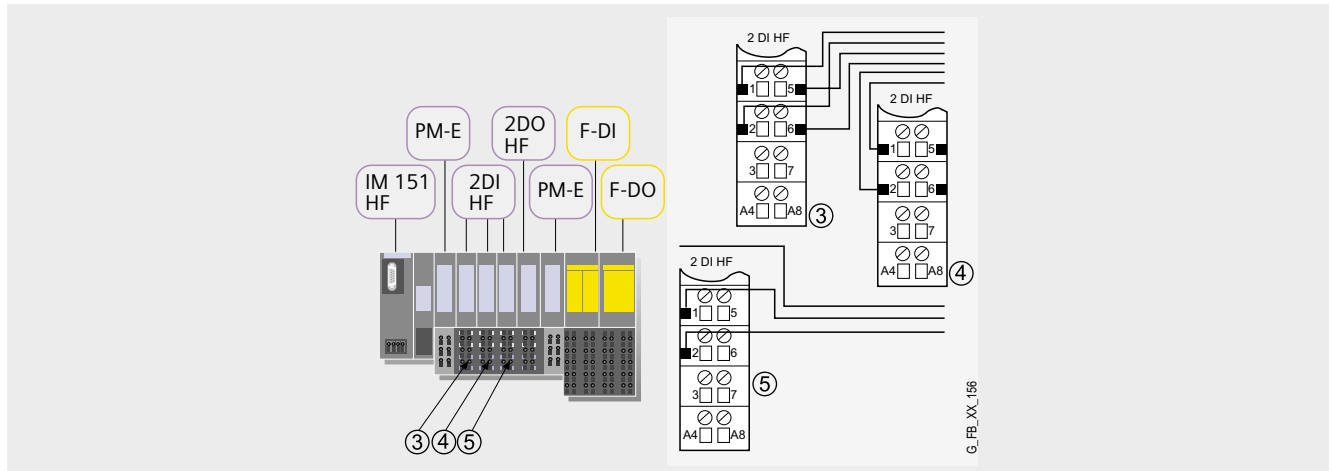
The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



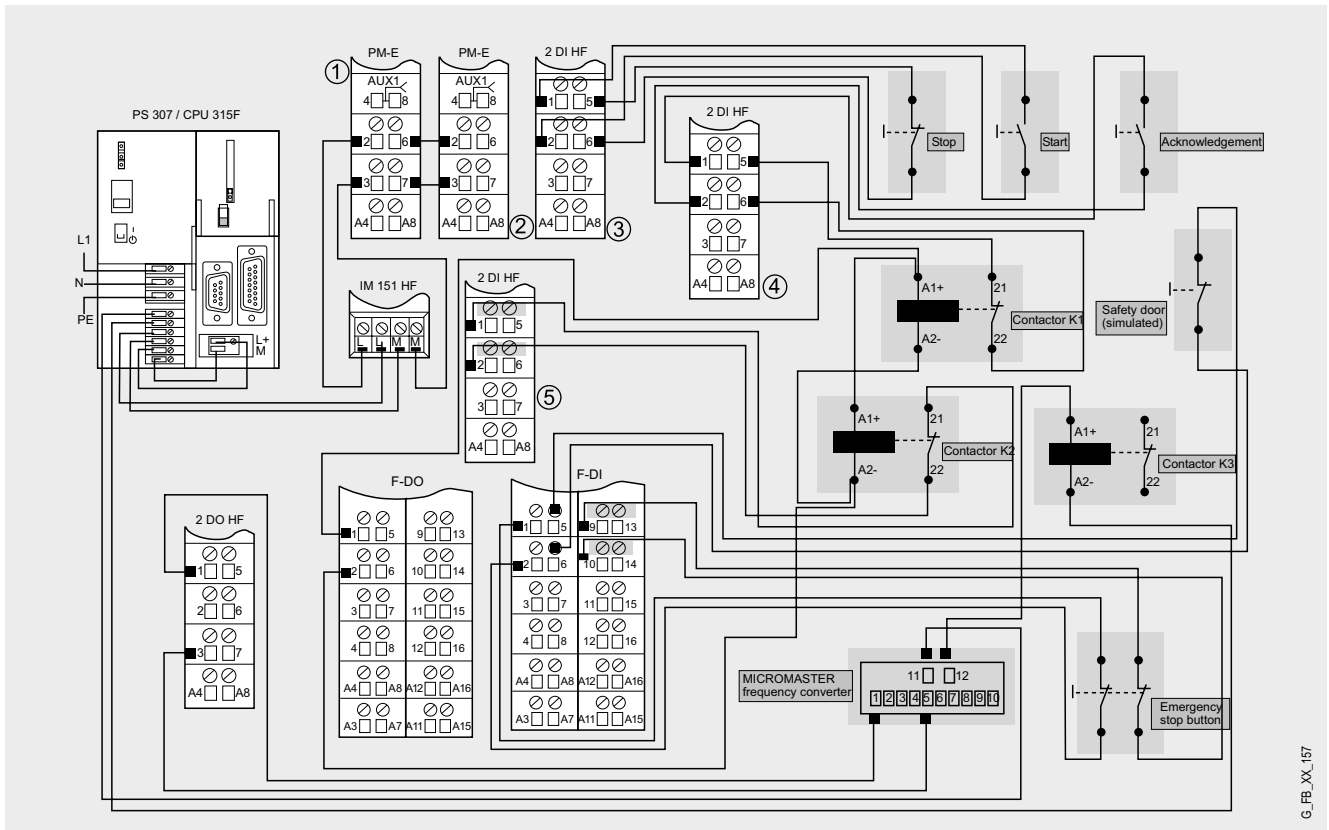
G_FB_XX_155



G_FB_XX_156

Note

In this example we used a motor holding brake (see following page). The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the contactor K3 is not necessary.



G_FB_XX_157

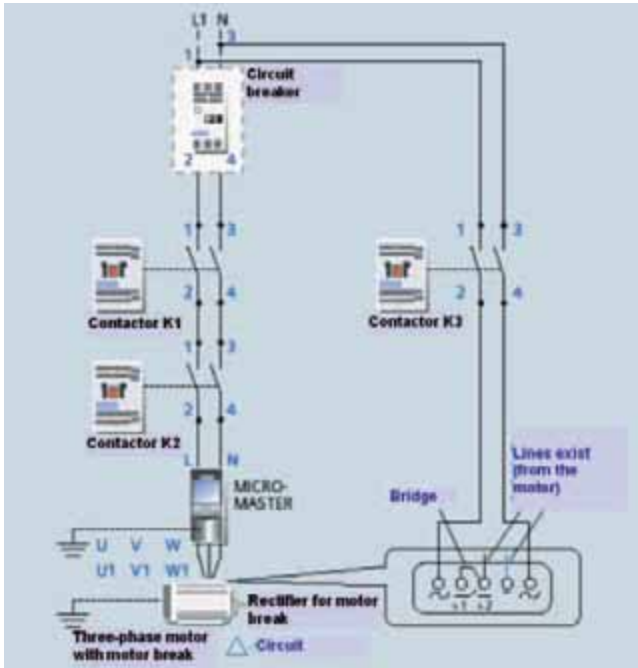
Warning!

The MICROMASTER has to be grounded.

Note

A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

The load circuit looks as follows:



Contactor K3 is responsible for the power supply of the rectifier for the motor brake.

Note

Please note that, in this example, contactor K3 - unlike K1 and K2 - features a make contact. If you do not want to use the motor holding brake, the contactor K3 is not necessary.

Function test

The inputs and outputs used can be checked with regard to their functionality, if

- the hardware components are wired
- the S7 project was loaded to the F CPU
- the MICROMASTER was supplied with the respective parameters.

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	START	"0"	Start request
2	Push button (NC)	E 0.1	STOP	"1"	Operational stop
3	Push button (NO)	E 1.0	ACK	"0"	Acknowledgement
4	Push button (NC)	E 3.1	FDOOR	"1"	Simulated safety door contact
5	Contactorauxiliary contact (NC)	E 1.1	K1_HELP	"1"	Contactorauxiliary contact K1
6	Contactorauxiliary contact (NC)	E 2.0	K2_HELP	"1"	Contactorauxiliary contact K2
7	Emergency stop push button (NC)	E 3.0	ESTP	"1"	Emergency stop
8	Micromaster	A 0.0	MM	"0"	Control MICROMASTER
9	Magnet coil contactor	A 9.0	K1_K2	"0"	From A 9.0 to K1 and K2

Testing inputs and outputs

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

No.	Instruction	A 9.0	Response MICROMASTER	Motor
1	Press the push button E 1.0 and release it.	"1"	Supplied with voltage via K1 and K2	In stop
2	Press the push button E 0.0 and release it.	"1"	ON	Accelerates
3	Wait until the motor has accelerated.	"1"	ON	Runs
4	Press the emergency stop push button E 3.0	"0" (delayed)	After stopping the motor, K1 and K2 drop out and the MICROMASTER is electrically isolated from the line supply (stop category 1).	Decelerates to stop
5	Unlock the emergency stop button and repeat no 1 to 3.	"1"	Supplied with voltage via K1 and K2	Accelerates
6	Press the push button E 3.1 and release it.	"0"	By drop-out of K1 and K2, MICROMASTER and motor are electrically isolated from the line supply immediately (stop category 0).	

Note

After an emergency stop, a signal from the simulated safety door, and an initial start an acknowledgement is required before restarting.

Important hardware component settings

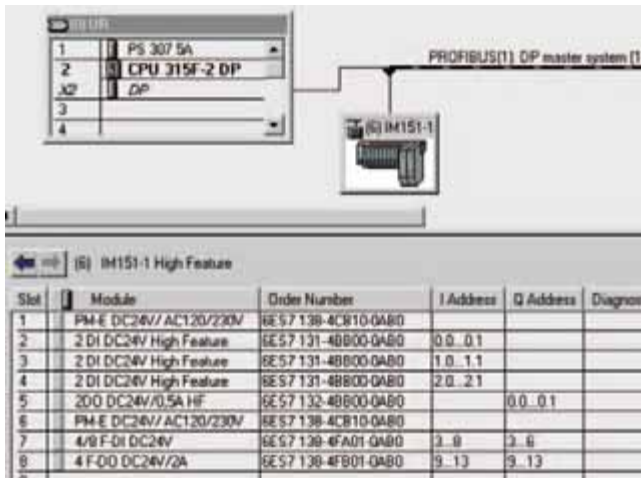
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!

The settings shown below contribute to meet the requirements of Safety Category 4 in Stop Category 0. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

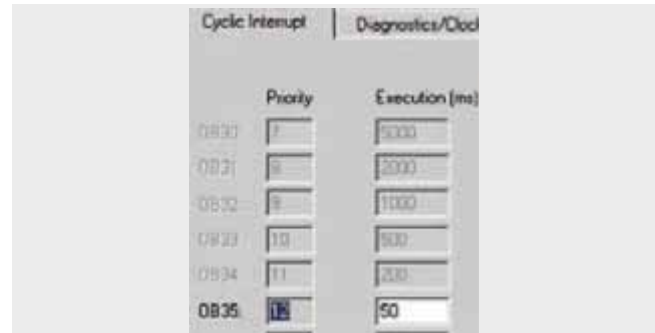
Overview picture



The PROFIBUS address at IM 151HF is set using DIP switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



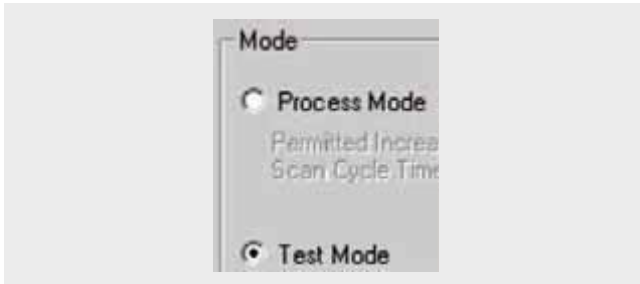
Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



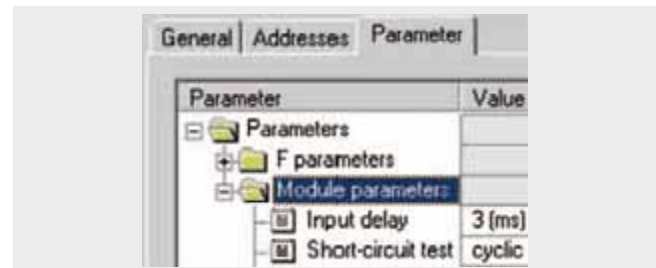
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the fail-safe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



The two-channel emergency stop push button is supplied with power via the module. Category 4 is reached due to the fact that a cross-circuit detection is possible. This requires that the short circuit test is activated.

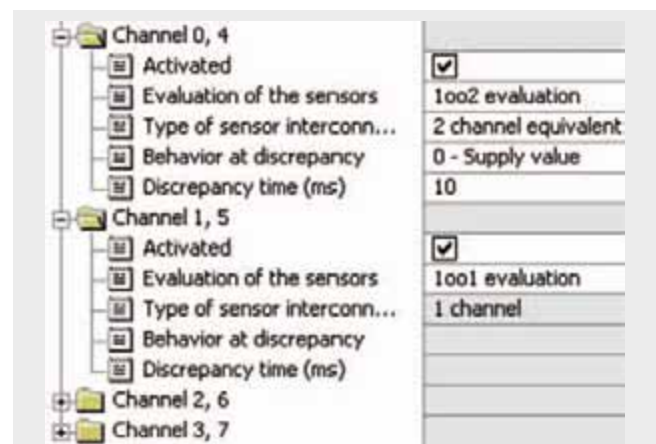


DIP switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Also in the "Parameter" tab.

A two-channel connection of the emergency stop push button to channel 0 is performed. At channel 1 the simulated safety contact NC is read in.

All other channels are to be deactivated.

Warning!

Monitoring a safety door of safety category 4 is performed with two sensors (see Safety Function Examples no. 2, 3 and 4). The connected single button simulates only one signal, which is assigned to a safety door for better clarity.

Settings of the fail-safe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

Parameter	Value
F_source_address	2002: CPU 31SF-2 DF
F_dest_address	1021
DIP switch setting (9.....0)	1111111101
F monitoring time (ms)	120

DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

Parameter	Value
DO channel 0	
Activated	<input checked="" type="checkbox"/>
Read-back time	100 (ms)
Diagnostics: wire break	<input checked="" type="checkbox"/>
DO channel 1	
DO channel 2	
DO channel 3	

Activate used channel 0 for the switching of the line contactors K1 und K2, deactivate channels which are not used.

The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Basic Performance Data**Load and main memory (without program code)**

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 37,5 k	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2 k	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 47,1 k	approx. 1,0 k	approx. 46,1 k
Main memory	approx. 31,5 k	approx. 0,4 k	approx. 31,1 k

Cycle time

Total cycle time (typical)	approx. 4 ms	Standard and safety program
Max. runtime of the safety program	7 ms	Calculation with the Cotia table. Page 259 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

The sample code is always assigned to the **components used** in the functional examples 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.

Password

In all cases, the passwords used for the safety-relevant part is „siemens“.

Use of the STEP 7 Project

Using a MICROMASTER, a motor can be started via a push button (NO). There are two options of stopping the motor:

1. Operational via a button NC.
2. fail-safe via (NC) button, simulating a safety door contact (stop category 0)
3. fail-safe via an emergency stop button in stop category 1

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21331097>

To call the corresponding project file, open the "as_fe_i_008_v10_code_cstopcat.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

For downloading the project into the F-CPU please proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container.
- Menu "Options" -> Edit safety program
- Click the "Download" button

The sample code with the given configurations enables the following:

- A motor is turned off via a push button (NC) simulating a safety door contact according to Stop Category 0.
- A motor is turned off via an emergency stop push button (NC/NC) according to Stop Category 1

Note

If you want to use the parameter settings used by us for the MICROMASTER ("as_fe_i_008_v10_code_pstopcat.zip"), you need the Siemens software "STARTER", which you can download free of charge via the internet. The link is listed below.

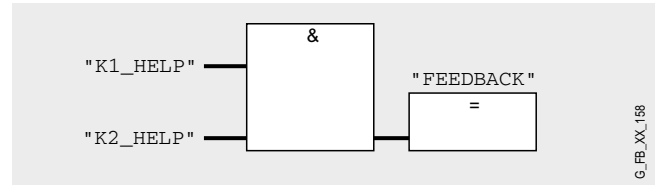
Link: www.siemens.de/automation/service&support

Subsequently click the "Download" link and enter "Starter" as keyword.

Older projects (*.mcp) can be converted into a current project and further edited. Select the Starter project in the displayed window and confirm by clicking OK. The project is converted and possible errors are displayed in the detail display.

Program procedure

The standard user program consists of two networks of OB 1:
Network 1



The memory bit "FEEDBACK" evaluates the readback signals of the contactors K1 and K2. "FEEDBACK" is used as input parameter of FB "F_FDBACK" in the safety program. FB "F_FDBACK" is a certified block from the Distributed Safety library for the monitoring of the readback signals.

The information of the memory bit FEEDBACK is read as memory bit FEEDBACK1 in the safety program. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

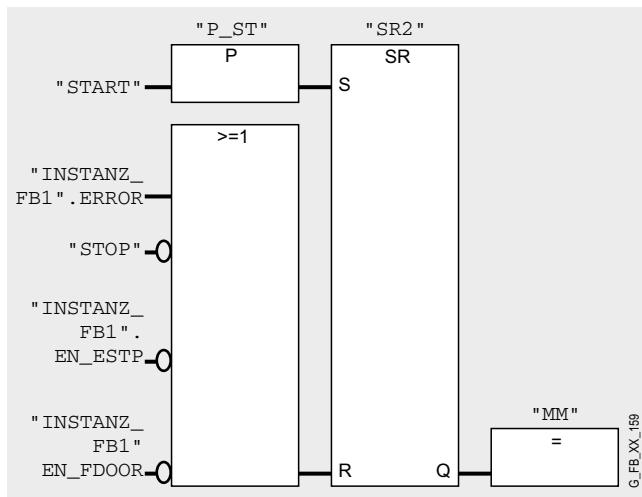
If you want to read data from the standard user program (flags or PII of standard I/O) in the safety program (here: FEEDBACK), which can be changed by the standard user program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate flags (here: FEEDBACK1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been realized. Generally, however, the following applies:

Note

If the above section is not observed the F-CPU may go to STOP mode.

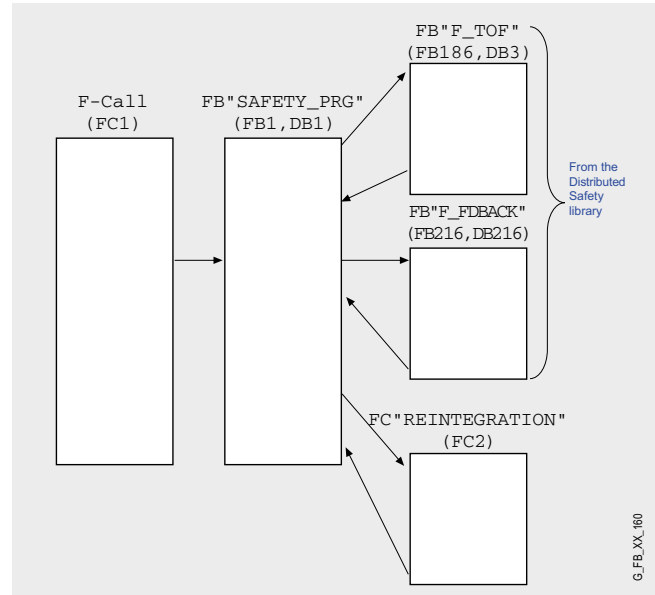
Network 2



In network 2 the signal for operational starting (START) and the stopping (Stop) are given. The output of the standard output module MM is set/reset. This output is connected with the MICROMASTER. With MM="1" the MICROMASTER receives the request of starting up the motor; with MM="0" the MICROMASTER sets the motor to standstill.

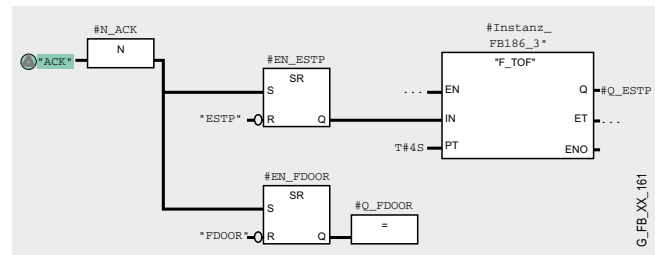
As long as there is a "1" signal at the R input of the flip-flop, MM="0" remains true, even if the start button is pressed, as the reset function at this flip-flop type has priority.

The fail-safe program has the following program sequence:



FB "Safety_PRG" (FB 1, DB 1)

Network 1



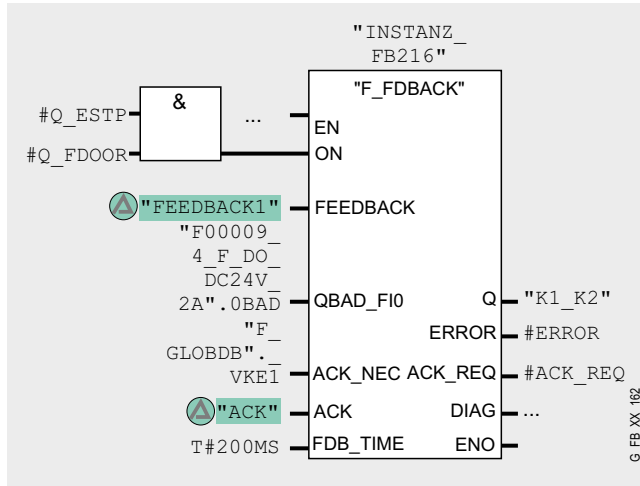
At an acknowledgement (negative edge of ACK) both #Q_ESTP and #Q_FDOOR remain "1" (precondition: emergency stop button unlocked and simulated safety door contact FDOOR="1"). In network 2 the contactors K1 and K2 are activated and supply the MICROMASTER with power.

If the safety door is opened during operation (simulated with FDOOR), then FDOOR becomes 0" and Q_FDOOR="0", which in network 2 causes an immediate drop-out of contactor K1 and K2. The drive is immediately isolated from the supply (stop category 0).

If the emergency stop button is pressed during running operation (ESTP="0"), #Q_ESTP is reset after the time parameterized at PT has elapsed. This time must be set so that after it has elapsed, the motor is in standstill. Only then is the drive isolated from the supply in network 2 (stop category 1).

Network 2

FB "Safety_PRG" (FB1, DB1) calls FB "F_FDBACK" (FB216, DB216). FB 216 is a certified block from the Distributed Safety library; this block is available from version 5.3.



Note

Before inserting the F application block F_FDBACK you have to copy the F application block F_TOF from the block container F-Application Blocks\Blocks of the F library Distributed Safety (V1) into the block container of your S7 program, if it is not available in this container (has already been done in this example project).

Warning!

When using the F application block F_FDBACK it is required that the F application block F_TOF has the number FB 186 and that the number is not changed!

The acknowledgement signal ACK is responsible for the acknowledgement after exceeding the feedback time FDB_TIME (at FB 216).

Output Q is set to 1 as soon as input ON = 1. It is required that readback input FEEDBACK = 1 and no readback error must be stored. In this example, this causes contactor K1 and K2 to pick up, which supplies the MICROMASTER with power.

A readback error ERROR = 1 is detected if the signal state of the readback input FEEDBACK (to output Q) does not follow the signal state of the input ON within the maximum tolerable readback FDB_TIME time.

To ensure that no readback error is detected and that no acknowledgement is required in a passivation of the fail-safe I/O modules controlled by output Q you have to supply the input QBAD_FIO with the variable QBAD of the corresponding fail-safe I/O module DB.

F_GLOBDB.VKE1 applies a "1" signal at the input ACK_NEC. This requires acknowledgement at the input ACK in case of an error (ERROR="1").

Note

The F-Global-DB (F_GLOBDB) provides the variables "VKE0" or "VKE1". This can be used in the safety program for supplying parameters at block calls if the Boolean constants "0" and "1" are required.

Network 3

FC "REINTEGRATION" (FC 2)

Network 3 of FB 1 calls FC 2 where the reintegration is realized in case of a passivation of F-DI or F-DO. For R-DO, a REINT memory bit has been prepared, which reintegrates the module with a positive edge.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

Prerequisite:

- Hardware configuration and safety program are in the S7-CPU
- Emergency stop unlocked
- No passivation of the F-DI/F-DO

The tables below demonstrate the function principle:

No.	Instruction	Result/Note
1	Press the acknowledgement push button (NO) and release it.	Necessary prior to the first start. Contactor K1 and K2 pick up and supply the MICROMASTER with power.
2	Press the start push button (NO) and release it.	The output MM of the digital output module is set. The MICROMASTER receives the signal for starting the motor. The MICROMASTER starts the motor up according to its parameterization.
3	Press the button (NC) which simulates the safety door contact and release it.	Contactors K1 and K2 drop out: MICROMASTER and motor are isolated from the supply (stop category 0).
4	Repeat No. 1 and 2	–
5	Press the emergency stop push button.	The output MM of the digital output module is reset. The MICROMASTER receives the signal for stopping the motor. The MICROMASTER brings the motor to standstill according to its parameterization. Contactors K1 and K2 drop out and isolate the drive from the supply.

Note

After an emergency stop, a signal from the simulated safety door, and an initial start acknowledgement is required before restarting.

Alternative

The Distributed Safety library offers a Stop Category function block FB "F_ESTOP1" (FB 215). With this block you can realize an emergency stop in the Stop Categories 0 and 1.

Single and Group Shutdown of Actuators in Safety Category 4 acc. to EN 954-1

Automation Function

Description of the functionality

Single and group shutdown

When using several actuators within a system, the following behavior is often required: It is to be possible to safely power an individual actuator down (independent of the other actuators). Additionally it should be possible to safely switch off all actuators together.

Functional example

This example shows single and group shutdown of actuators. Two three-phase asynchronous motors which can be started independently of one another are used. An emergency stop button is assigned to each motor for safe stopping (single shutdown). Furthermore, there is an emergency stop button which safely stops all motors (group shutdown).

Operational stopping of motors has **not** been included in this example.

Allocation contactors - motors

Group 1 consists of the motor M1 which is switched via the contactors K1 and K2.

Group 2 consists of the motor M2 which is switched via the contactors K3 and K4.

If a readback error is detected in a group, this group is stopped. Safe operational start and stop of the other group is still possible.

Safety Category

The actuator shutdown via failsafe outputs of the ET 200S shown here complies with Safety Category 4 according to **EN 954-1: 1996**.

Reaction times

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet:

<http://support.automation.siemens.com/WW/view/en/19138505>

Failsafe input and output modules

One failsafe input and output module of the ET 200S switching the following variables is used in each case:

Failsafe...	Signals
Input module (F-DI)	Emergency stop button for group 1 Emergency stop button for group 2 Emergency stop button for both groups
Output module (F-DO)	Switches all contactors (K1, K2, K3, K4).

Standard input modules

The standard input modules read the signals listed below for each group:

- Start request
- Acknowledgement
- Readback signals of the contactors

In addition, an acknowledgement signal exists with which an acknowledgement can be transmitted for all groups.

Acknowledgement

An acknowledgement is required

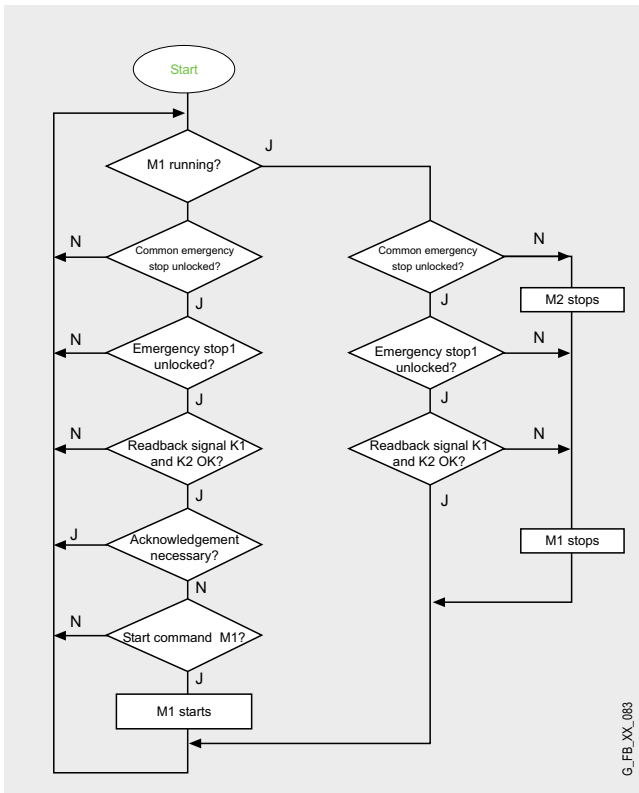
- prior to the first start
- after a readback error (acknowledgement with the acknowledgement push button assigned to the group or the acknowledgement push button applying to all groups)
- after activating an emergency stop push button after this push button was unlocked manually (acknowledgement either individually for each group with the assigned acknowledgement push button or with the acknowledgement push button applying to all groups)
- after the reintegration of the passivated F-DI

Recognizing a welding

A readback error occurs, for example, when a contacts welds. This error is revealed in the program code by the use of a certified block from the Distributed Safety block library. Starting the application is only possible if the error was corrected and if an acknowledgement was transmitted.

Flowchart

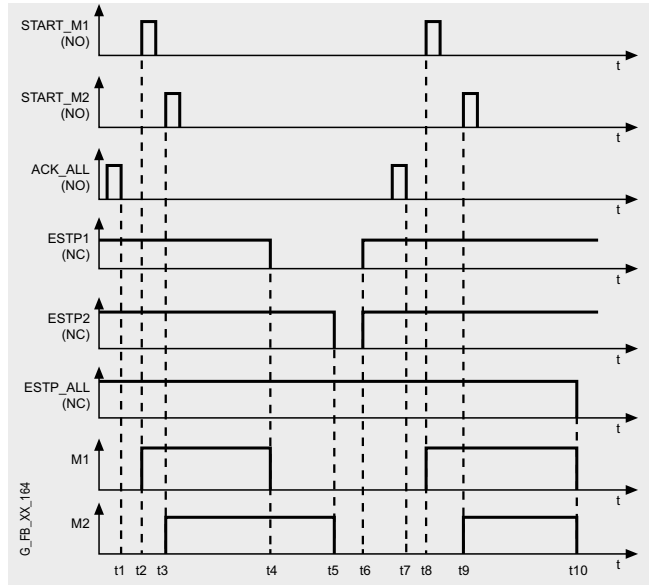
The following flow chart shows the functionality at the example of group 1 (motor M1) and the group shutdown. The same procedure applies to group 2 (motor M2); only M1 and M2 need to be exchanged and K1, K2 be replaced with K3, K4.



Time sequence for single/group shutdown

To illustrate the process, the time sequence during a single and a group shutdown is shown below. The names at the ordinates correspond to the names in the program code.

Designation	Explanation
START_M1	Start command for motor 1 (group 1).
START_M2	Start command for motor 2 (group 2).
ACK_ALL	Acknowledgement for all groups
ESTP1	Emergency stop for motor M1 (group 1)
ESTP2	Emergency stop for motor M2 (group 2)
ESTP_ALL	Emergency stop for all groups
M1	Motor 1 (group 1)
M2	Motor 2 (group 2)



Time	Explanation
t1	An acknowledgement is required before starting for the first time.
t2	Start command for motor M1. Motor M1 starts.
t3	Start command for motor M2. Motor M2 starts.
t4	Emergency stop triggered for group 1 Motor M1 stops.
t5	Emergency stop triggered for group 2 Motor M2 stops.
t6	Unlocking both pressed emergency stop buttons.
t7	Acknowledgement is necessary prior to every restart.
t8	Start command for motor M1. Motor M1 starts.
t9	Start command for motor M2. Motor M2 starts.
t10	Emergency stop, applying to all groups, is activated and switches all groups off.

Note

Apart from the acknowledge button applying to all groups, each group as a respective acknowledge button (not displayed in the above time sequence).

Advantages/customer benefits

- Wiring reduced to a minimum due to use of failsafe S7-CPU and distributed I/O. Dieser Vorteil kommt um so mehr zum Tragen, je mehr Sicherheitsfunktionen realisiert werden.
- Programming the failsafe program with STEP 7 engineering tools.
- Only one CPU is required, since failsafe and standard program parts run on a coexistent basis in the CPU
- Use of prefabricated (and certified) failsafe blocks from the Distributed Safety library.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 KByte	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24...48V AC24...230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	4	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	4	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Emergency stop	Push button, 1NC	3SB3801-ODG3	3	
Contact (for Emergency stop)	1NC, screw-type connection	3SB3420-0C	3	
Push button	green, 1NO	3SB3801-0DA3	5	
Contact	AC-3, 3KW/400V, 1NC, DC 24V	3RT1015-2BB42	4	
Excess voltage limiter for plugging onto contactor	RC element AC 24...48V, DC 24...70V	3RT1916-1CB00	4	
Circuit breaker for motor protection	0.35...0.5A	3RV1011-0FA1	2	
Motor	Low-voltage motor 0.12kW	1LA7060-4AB10	2	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

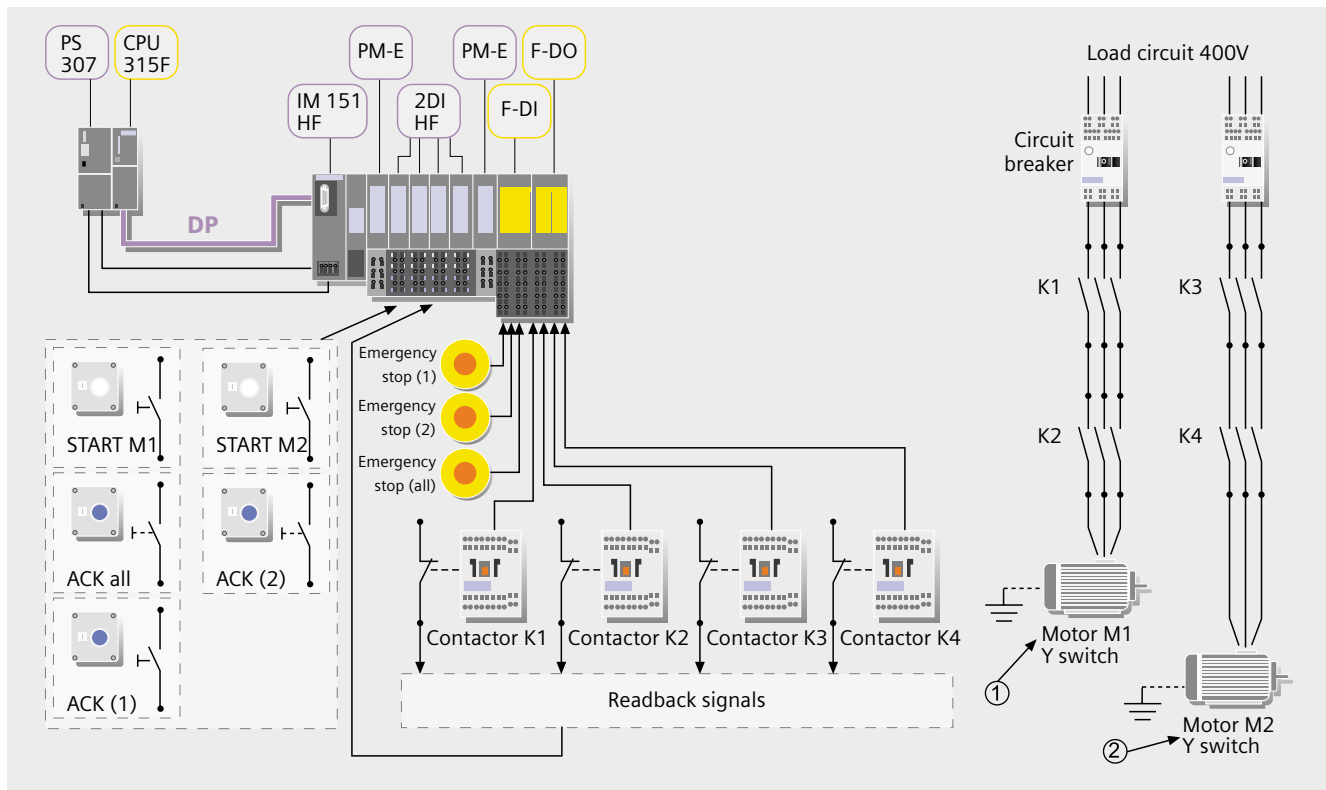
In order to set up and wire the functional example, it is absolutely necessary to consider the following note:

An overview of the hardware structure

The arrangement for single or group shutdown consists of a PROFIBUS configuration. A failsafe S7-CPU is used as DP master, an ET 200S as DP slave.

Note

In order to meet the requirements of Safety Category 4, it is obligatory to read back the process signal to the actuator.



Note

One 4DI electronic module can be used instead of two 2DI electronic modules. The "high feature" electronic modules can also be replaced by standard modules.

Wiring of the hardware components

Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

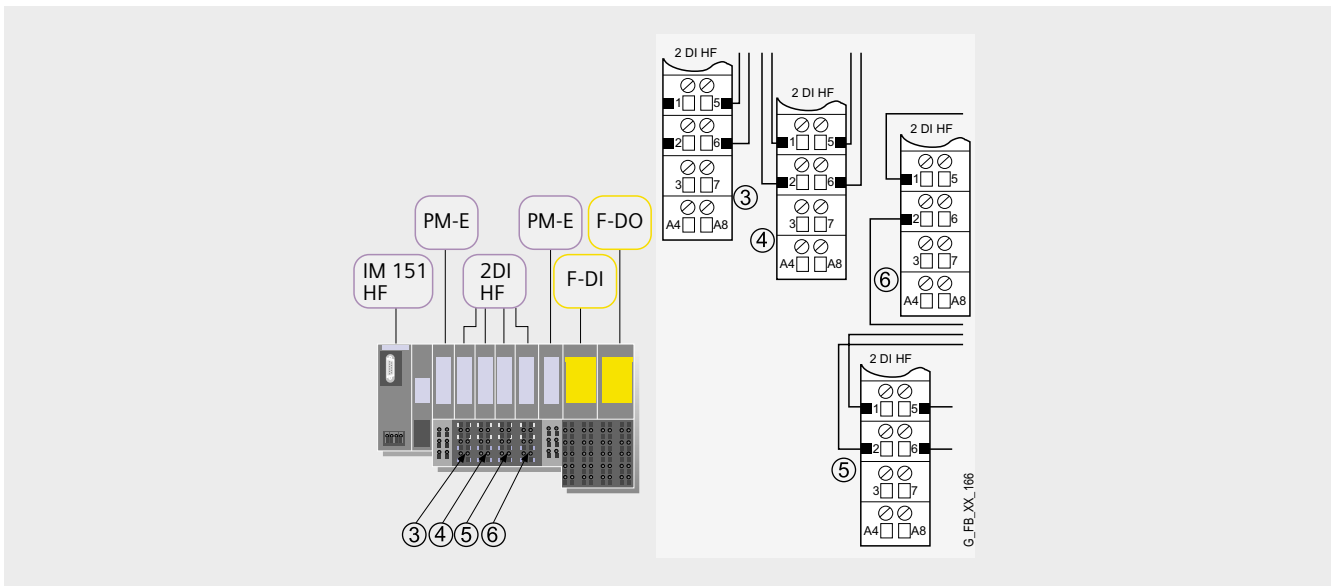
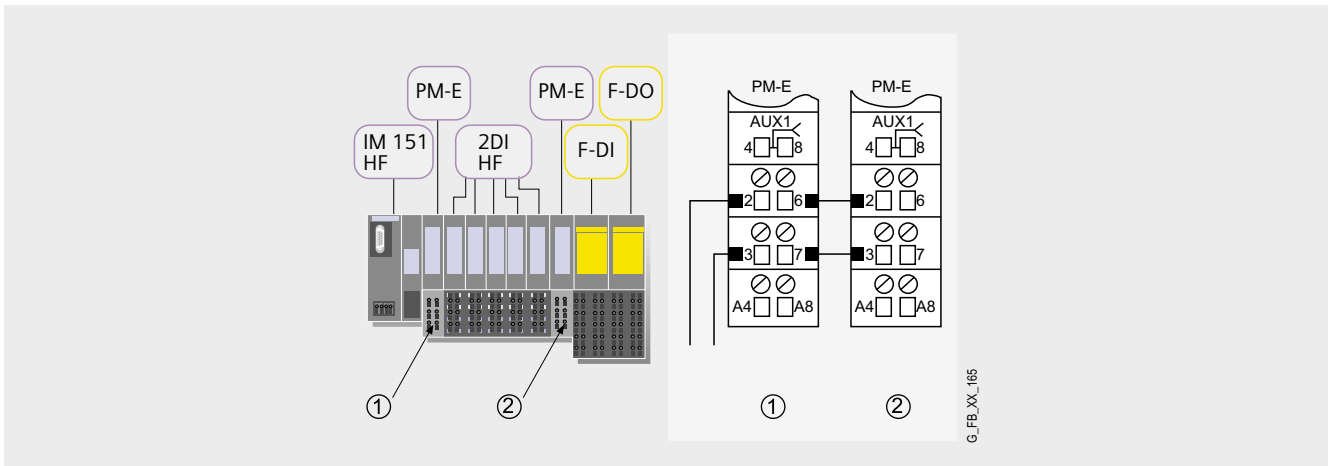
Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

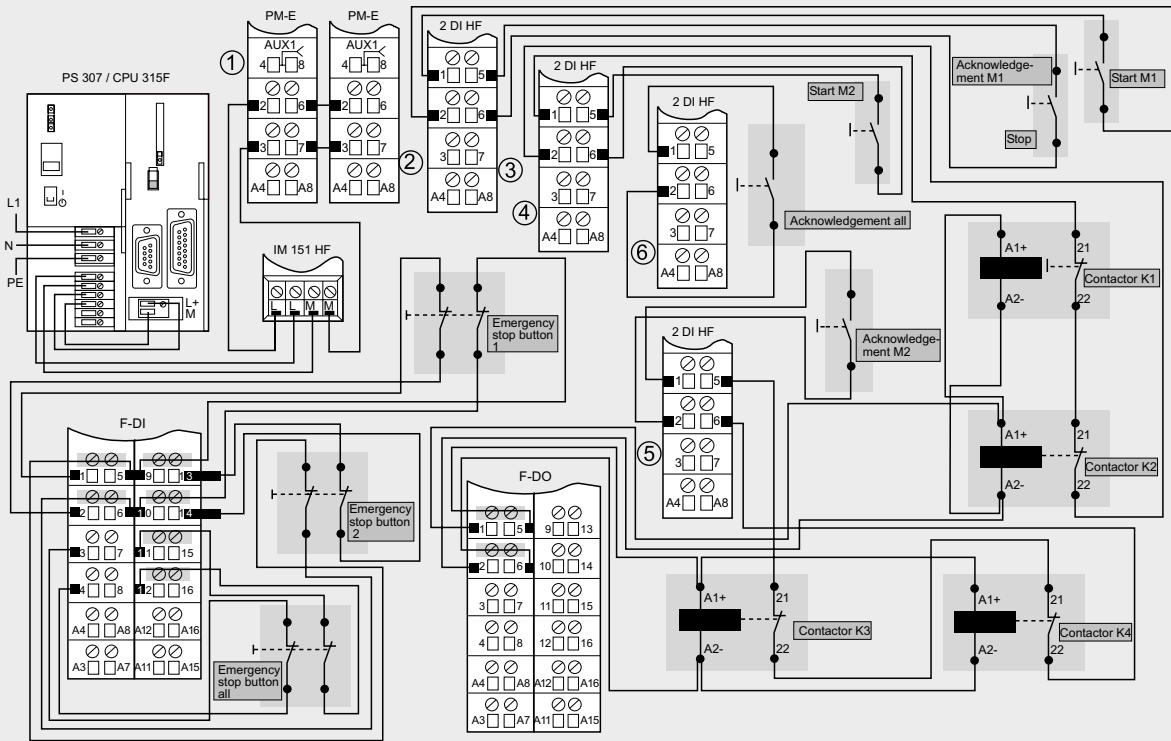
Note

The DP interface of the CPU 315F must be connected with the DP interface of the IM 151 HF.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.



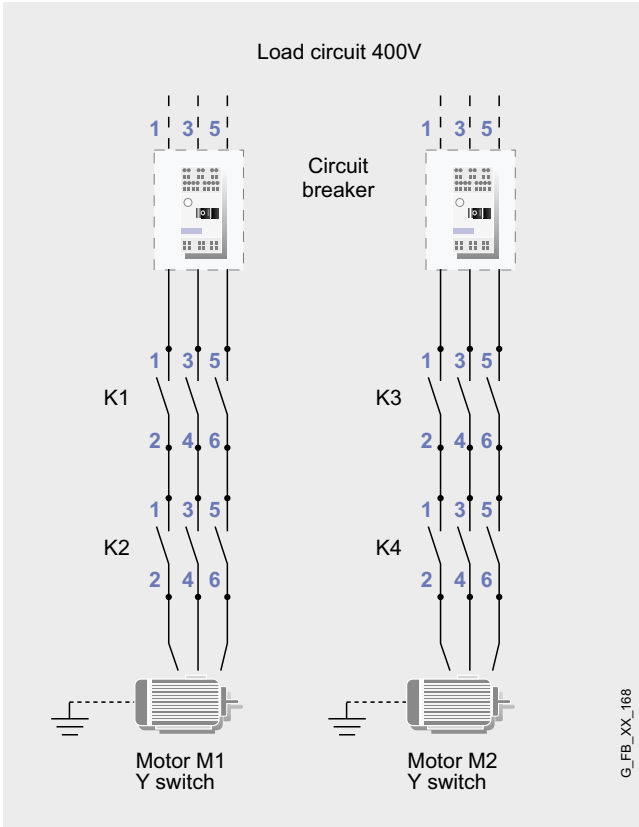


G_FB_XX_167

Note

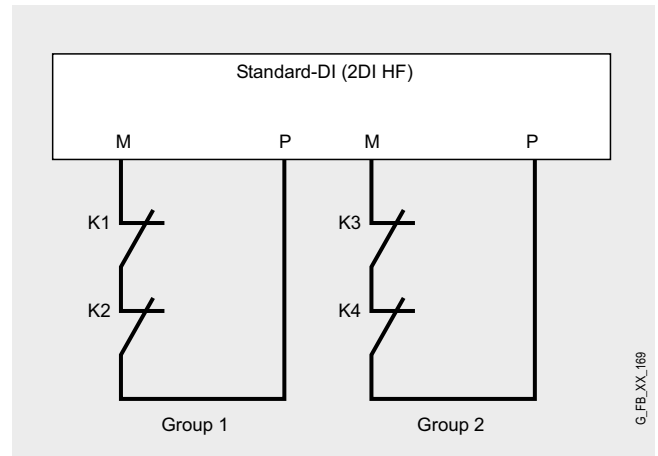
A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project to the CPU 315F-2DP.

The terminal markings of the load circuit are as follows:

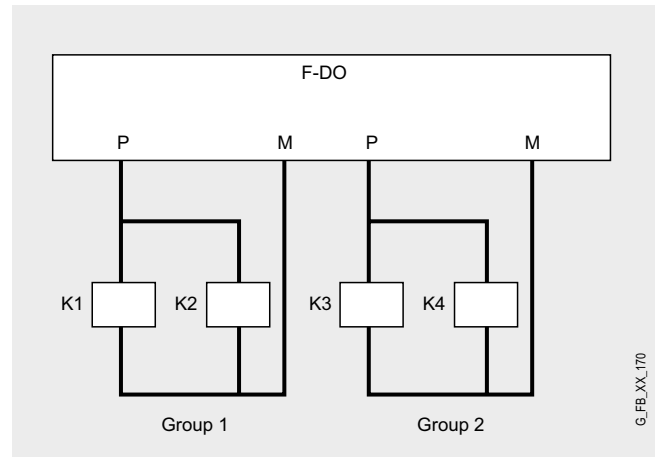


The interconnection of the contactor auxiliary contacts and the control of the contactor coils is shown once again to provide greater clarity (it is also shown in the wiring diagram).

Contactor auxiliary contacts:



Control of the contactor coils:



Function test

The inputs and outputs used can be checked with regard to their functionality, if

- the hardware components are wired
- the S7 project was loaded to the F CPU

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Emergency stop push button (NC / NC)	E 0.0	ESTP1	"1"	Emergency stop for group 1
2	Emergency stop push button (NC / NC)	E 0.1	ESTP2	"1"	Emergency stop for group 2
3	Emergency stop push button (NC / NC)	E 0.2	ESTP_ALL	"1"	Emergency stop for all groups
4	Push button (NO)	E 6.0	START_M1	"0"	Start requirement group 1
5	Push button (NO)	E 6.1	ACK_M1	"0"	Acknowledgement for group 1
6	Contacteur auxiliary contact (NC)	E 7.0	K12_HELP	"1"	Readback signal (group 1)
7	Push button (NO)	E 7.1	START_M2	"0"	Start requirement group 2
8	Push button (NO)	E 8.0	ACK_M2	"0"	Acknowledgement for group 2
9	Contacteur auxiliary contact (NC)	E 8.1	K34_HELP	"1"	Readback signal (group 2)
10	Push button (NO)	E 9.0	ACK_ALL	"0"	Acknowledgement signal for groups 1 and 2
11	Magnet coil contactor	A16.0	M1	"0"	For motor M1 (group 1, connection to F-DO)
12	Magnet coil contactor	A16.1	M2	"0"	For motor M2 (group 2, connection to F-DO)

Testing inputs and outputs

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

Note

You can also test the instructions listed in the table below without connected main circuit.

No.	Instruction	M1	M2	Note
1	Press the push button E 9.0 and release it.	"0"	"0"	Acknowledgement required prior to first start. Instead of E 10.0, you can also press the two push buttons E 6.1 and E 8.0.
2	Press the push button E 6.0 and release it.	"1"	"0"	Start request for motor M1.
3	Press the push button E 7.1 and release it.	"1"	"1"	Start request for motor M2.
4	Press the emergency stop push button E 0.0	"0"	"1"	Single shutdown group 1
5	Press the emergency stop push button E 0.1	"0"	"0"	Single shutdown group 2
6	Unlock the pressed emergency stop buttons.	"0"	"0"	–
7	Repeat no. 1 to 3	"1"	"1"	Start request for motor M1 and M2.
8	Press the emergency stop push button E 0.2	"0"	"0"	Group shutdown

Note

After an emergency stop (and when starting for the first time), an acknowledgement is required before a restart.

Important hardware component settings

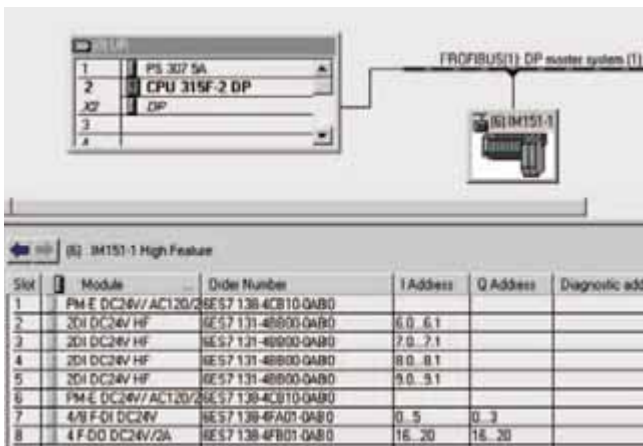
Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!!

The settings shown below contribute to meet the requirements of Safety Category 4. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

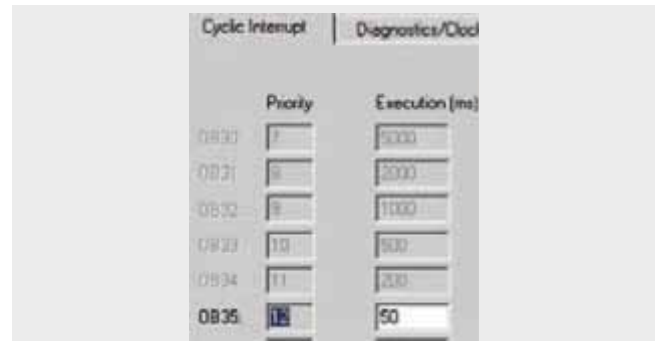
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture")..



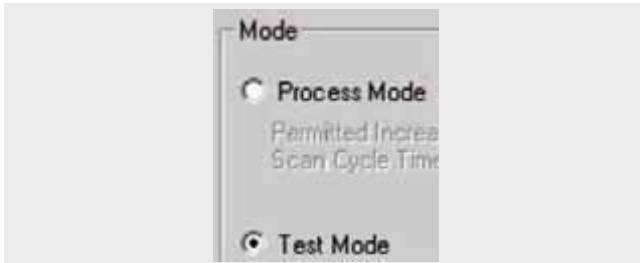
Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

Password used here: siemens



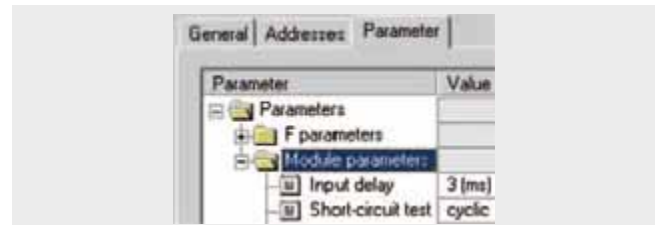
Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of the failsafe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



The two-channel emergency stop push button for shutdown of the group is supplied with power via the module. Category 4 is reached due to the fact that a cross-circuit detection is possible. This requires that the short circuit test is activated.

Parameter	Value
F_source_address	2002: CPU 315F-2 DP
F_dest_address	1022
DIP switch setting (9.....0)	111111110
F monitoring time (ms)	120

DIP switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

Channel	Activated	Evaluation of the sensors	Type of sensor interconn...	Behavior at discrepancy	Discrepancy time (ms)
Channel 0, 4	<input checked="" type="checkbox"/>	1oo2 evaluation	2 channel equivalent	0 - Supply value	10
Channel 1, 5	<input checked="" type="checkbox"/>	1oo2 evaluation	2 channel equivalent	0 - Supply value	10
Channel 2, 6	<input checked="" type="checkbox"/>	1oo2 evaluation	2 channel equivalent	0 - Supply value	10
Channel 3, 7	<input type="checkbox"/>				

Also in the "Parameter" tab.

For the 1oo2 evaluation, only the respective initially mentioned channel (0,1,2) is used for addressing.

Channel 0: Emergency stop for group 1

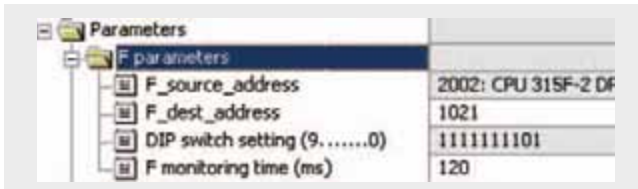
Channel 1: Emergency stop for group 2

Channel 3: Emergency stop applying to all groups

Channel 4: deactivated

Settings of the failsafe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

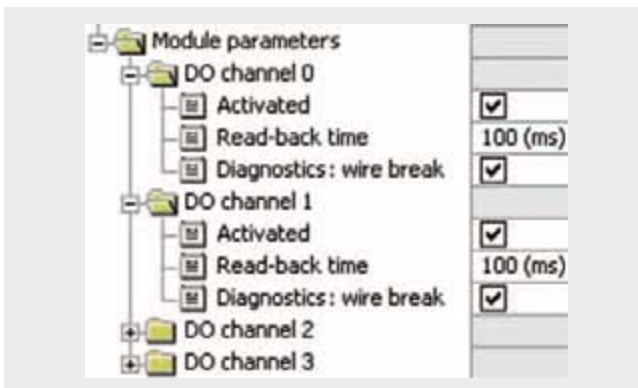


DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Channels which are not used (channel 2 and 3): Deactivate Channel 0: For switching the contactors K1 and K2 (group 1 with motor M1).

Channel 1: For switching the contactors K3 and K4 (group 2 with motor M2).

The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 37,5 k	approx. 0,2 k	approx. 37,3 k
Main memory	approx. 28,2 k	approx. 0,09 k	approx. 28,1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (failsafe)
Load memory	approx. 47,7 k	approx. 1,0 k	approx. 46,7
Main memory	approx. 34,7	approx. 0,4 k	approx. 34,2

Cycle time

Total cycle time (typical value)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	8 ms	Calculation with the Cotia table. Page 277 specifies where to find it.

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

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

Password

In all cases, the passwords used for the safety-relevant part is „siemens“.

Use of the STEP 7 Project

Two three-phase asynchronous motors can be started independently of one another with separate push buttons (NO). The motors are either safely stopped:

1. individually (respectively one emergency stop button assigned to one group) or
2. as group shutdown. An emergency stop button exists that switches off all groups (stopping all motors).

Download

The download is available via the following link:
<http://support.automation.siemens.com/WW/view/en/21330890>

To call the corresponding project file, open the "as_fe_i_009_v10_code_singlegroup.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

For downloading the project into the F-CPU please proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container
- Menu "Options" -> Edit safety program
- Click the "Download" button

The sample code with the given configurations enables the following:

- Independent starting of two motors M1 (group 1) and M2 (group 2).
- Safe shutdown of individual groups (motor M1 and/or M2)
- Group shutdown for both motors (M1 and M2)

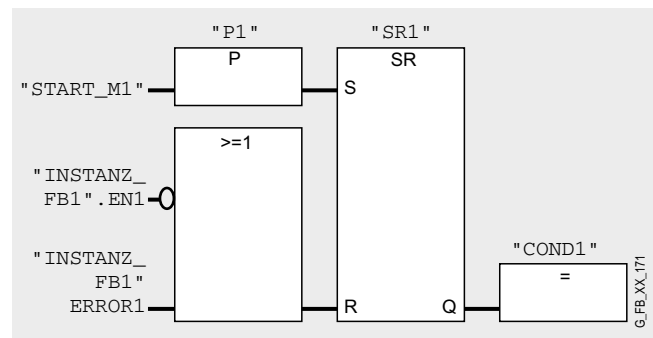
Note

Operational stopping has not been prepared in this example.

Program procedure

The standard user program consists of two networks of OB 1.

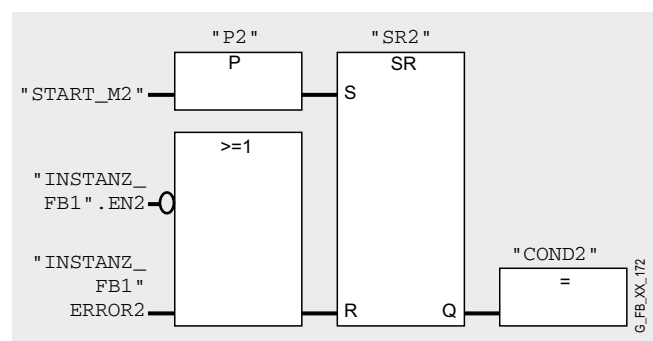
Network 1



The signal for operational starting (START_M1) for group 1 consisting of motor M1 is given in network 1.

The "INSTANZ_FB1".... ensures that the motor cannot be started with an acknowledgement transmitted in the safety program. As long as on of these bits is "0", COND1= "0" remains true also if the start button is pressed, since the reset function has priority in this flip-flop type.

Network 2



Basically the above information on network 1 applies to group 2 with motor M2.

The information of the flags "COND1" and "COND2" from the networks 1 and 2 is read in the safety program as flag COND1_F or COND2_F. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

If you want to read data from the standard user program (flags or PII of standard I/O) in the safety program (here: COND1 or

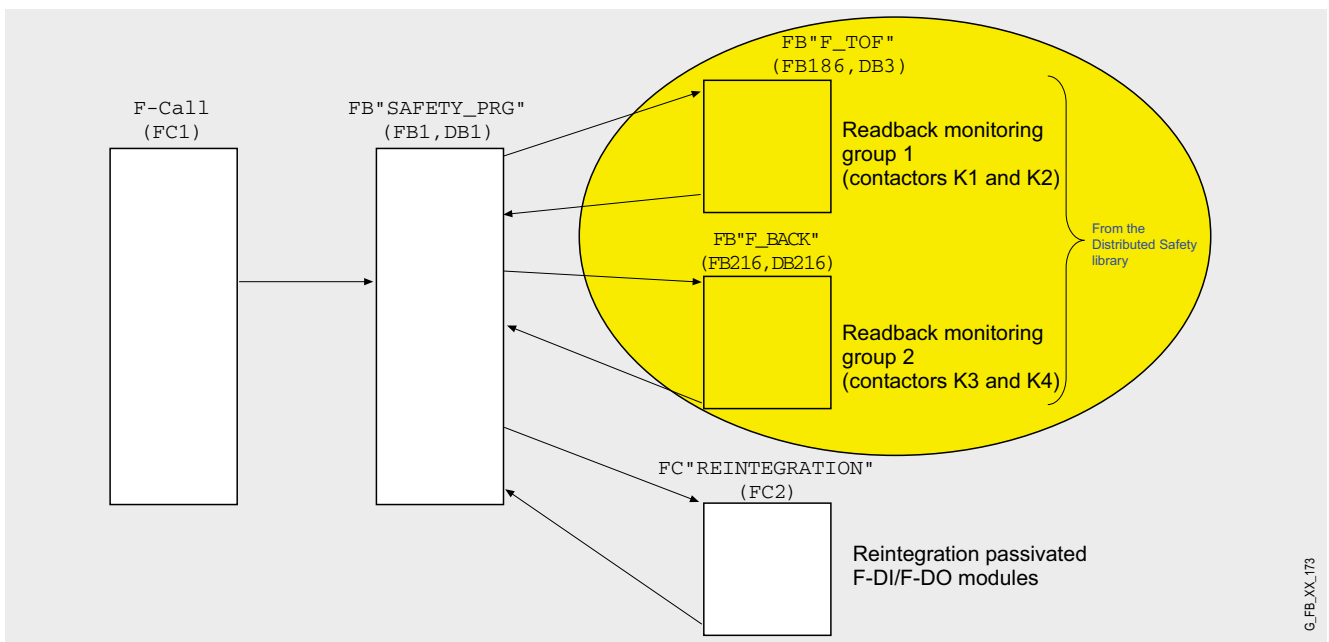
COND2), which can be changed by the standard user program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate flags (here: COND1_F or COND2_F). Data from the standard user program have to be written to these flags immediately before calling the F run-time group. Only these flags may then be accessed in the safety program.

In this example it has already been implemented. Generally, however, the following applies:

Note

If the above section is not observed the F CPU may go to STOP mode.

The failsafe program has the following structure:

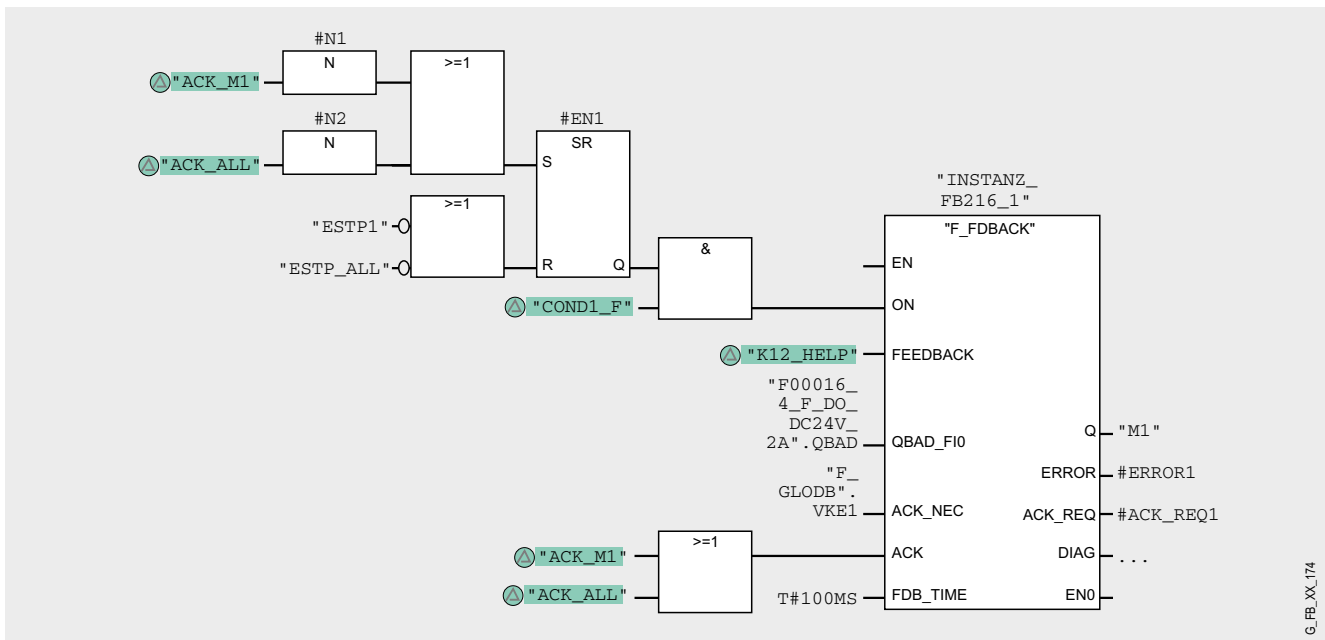


FB "F_PRG" (FB 1, DB 1)

Network 1

This network is assigned to group 1 with motor M1.

FB "Safety_PRG" (FB1, DB1) first calls FB "F_FDBACK" (FB216, DB216). FB 216 is a certified block from the Distributed Safety library; this block is available from version 5.3.



If the emergency stop for group 1 (ESTP1) or the emergency stop button (ESTP_ALL) applying to all groups is pressed, then ON="0" which makes Q="0". With Q="0" the contactors K1 and K2 drop out (actual parameter M1).

For a start (Q="1") it is required that readback input FEEDBACK = 1 and no readback error must be stored. A readback error ERROR = 1 is detected if the signal state of the readback input FEEDBACK (to output Q) does not follow the signal state of the input ON within the maximum tolerable readback FDB_TIME time.

The status of the flip-flop is stored in the static variable #EN1 and read as switch-on condition in OB 1.

To ensure that no readback error is detected and that no acknowledgement is required in a passivation of the failsafe I/O modules controlled by output Q you have to supply the input QBAD_FIO with the variable QBAD of the corresponding failsafe I/O module DB.

F_GLOBDB.VKE1 applies a "1" signal at the input ACK_NEC. This requires acknowledgement at the input ACK in case of an error (ERROR="1").

Note

The F-Global-DB (F_GLOBDB) provides the variables "VKE0" or "VKE1". This can be used in the safety program for supplying parameters at block calls if the Boolean constants "0" and "1" are required.

Please consider the following notes on using the FB "F_FDBACK":

Note

Before inserting the F application block F_FDBACK you have to copy the F application block F_TOF from the block container F-Application Blocks\Blocks of the F library Distributed Safety (V1) into the block container of your S7 program, if it is not available in this container (has already been done in this example project).

Warning!

When using the F application block F_FDBACK it is required that the F application block F_TOF has the number FB 186 and that the number is not changed!

Network 2

This network is assigned to group 2 with motor M2.

The structure of the program is identical to network 1. The statements on network 1 thus also apply to network 2.

Network 3

FC „REINTEGRATION“ (FC 2)

Network 3 of FB 1 calls FC 2 where the reintegration is implemented in case of a passivation of F-DI or F-DO. For R-DO, a RE-INT memory bit has been prepared, which reintegrates the module with a positive edge.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Use the automatic reintegration for your application only if it will not cause any hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions

Prerequisite:

- Hardware configuration and safety program are in the S7-CPU
- All emergency stop buttons are unlocked
- No passivation of the F-DI/F-DO

The tables below demonstrate the function principle:

No.	Instruction	Result/Note
1	Press the acknowledgement push button E 9.0 (NO) and release it.	Acknowledgement (here with the acknowledgement signal ACK_ALL applying to all groups) is required prior to the first start and after activating the emergency stop. Transmitting the acknowledgement signal for individual groups is also possible (push buttons E 6.1 or E 8.0).
2	Press the push button E 6.0 (NO) and release it.	If all conditions for a start of group 1 are met, the contactors K1 and K2 switch motor M1.
3	Press the push button E 7.1 (NO) and release it.	If all conditions for a start of group 2 are met, the contactors K3 and K4 switch motor M2.
4	Press the emergency stop push button E0.0.	The contactors K1 and K2 drop out, due to this motor M1 of group 1 is shut down.
5	Press the push button E 0.1 and release it.	Contactors K3 and K4 drop out, due to this motor M2 of group 2 is shut down.
6	Unlock the emergency stop button and repeat no 1 to 3.	Motors M1 and M2 start.
7	Press the emergency stop push button E 0.2	K1 to K4 drop out and shut down groups 1 and 2 (with their motors M1 and M2).

Note

An acknowledgement is required after an actuated emergency stop or prior to the first start.

Distributed application of laserscanner LS4-4 in Category 3 according to EN 954-1

Ex. No.

10

Automation Function

Description of the functionality

Application areas

The SIGUARD laser scanner LS4 is mainly used in order to provide safe operation. At a predominantly horizontal alignment, the presence of persons within the detection zone is continuously monitored. When using LS4, access to the hazardous location must only be possible through the detection zone. A safe distance must be kept between detection zone and hazardous location. The distance is calculated according to the formulas in the specific machine related European C standards or in the general B1 standard EN 999: 1998.

Picture of the LS4 laser scanner



Function principle of the LS4 laser scanner

The LS4 is an area scanner. It sends very short laser pulses and measures the time until the pulse hits an object, as well as its remission (diffuse reflection of a beam by a non-reflecting surface) to the receiver in the LS4. The device uses this time to calculate the distance between object and LS4. The sensor unit within the LS4 rotates and sends/receives a laser pulse after respectively 0.36° . A circular sector of up to 190° is scanned in the center of which the LS4 is located.

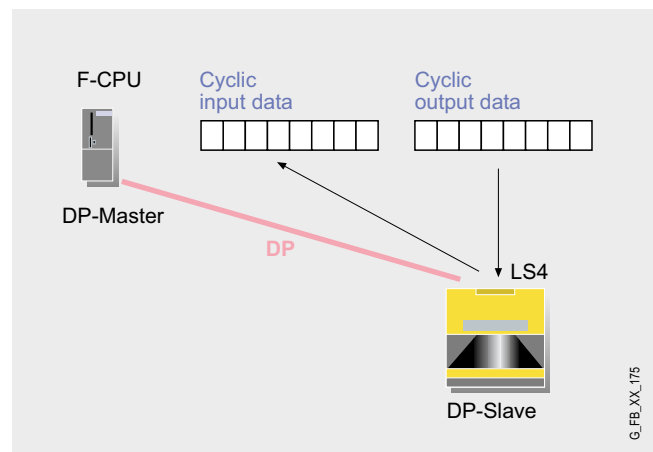
Distributed application

In the "PROFIBUS" variant, the LS4 can be operated as safe bus component together with non-safe standard components at the same bus (PROFIBUS DP). This is enabled by PROFIsafe, a functional expansion of PROFIBUS DP. For the user this makes no difference: You connect the LS4 in the same way to the PROFIBUS in which you are used to it from other DP slaves.

Communication between fail-safe S7-CPU and the LS4

fail-safe S7-CPU (F-CPU) and LS4 laser scanner communicate via PROFIBUS. Hereby the LS4 of the S7-CPU provides cyclic input data of 1 byte length. The LS4 in return expects from the S7-CPU cyclic output data of 1 byte length. These input and output data can only be processed or evaluated in user program and fail-safe STEP 7 program.

Cyclic input and output data



The name input and output data refer to the view of the DP master:

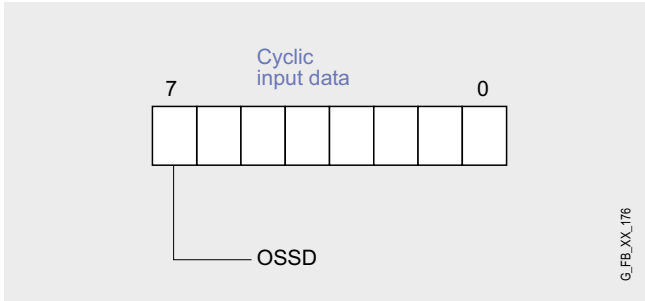
- Input data are read from the DP master, hence are output data from the LS4.
- Output data are written by the DP master, hence are control signals for the LS4.

The integration of the cyclic input and output data into the program code can seed in the delivered S7 example project.

Bits of the cyclic input data

Only one bit (Bit 7), which is useful for understanding the complete functionality, is discussed here.

The bit OSSD (Bit 7) describes the fail-safe output signals of the LS4. In case of a detection zone violation, this bit changes from "1" to "0", which in fail-safe programs causes the actuator to be switched off.



Warning!
Bits 0 to 6 must not be used for safety relevant decisions. The fail-safe S7-CPU only has to evaluate bit 7 in order to enable the successive actuator if necessary.

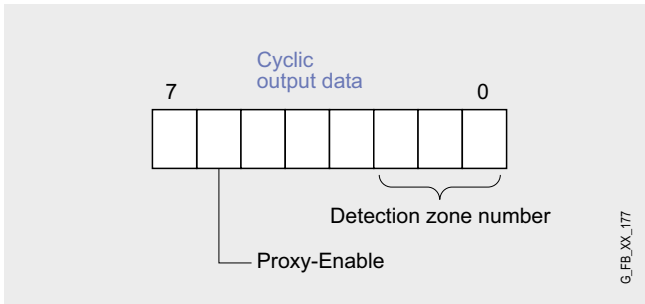
Bits of the cyclic output data

Only individual bits, which are useful for understanding the complete functionality, are discussed here. **Proxy-Enable (Bit 6):**

Setting this bit is important for switching between the detection zones (further information on detection zones available at the bottom of this page).

Detection zone number (bits 0, 1, 2):

A detection / warning zone pair in LS4 is selected with this bit.



Detection and warning zones

When using the LS4 you define detection and warning zones. A detection zone (SF) and a warning zone (WF) always form a **zone pair**. All in all, only 4 zone pairs can be defined, whereas only **one** zone pair must be active at a time. Detection zone numbers (bits 0, 1 and 2 of the cyclic output data) define the zone pair (1, 2, 3 or 4) to be active. **The Proxy-Enable bit of the cyclic output data must be "0"**.

The detection and warning zones are defined with the LS4Soft software. The PROFIsafe adapter enables correct time behavior when switching the zone pairs.

A violation of detection and warning zones is indicated by

- LEDs at the LS4 and by
- the bits of the cyclic input data

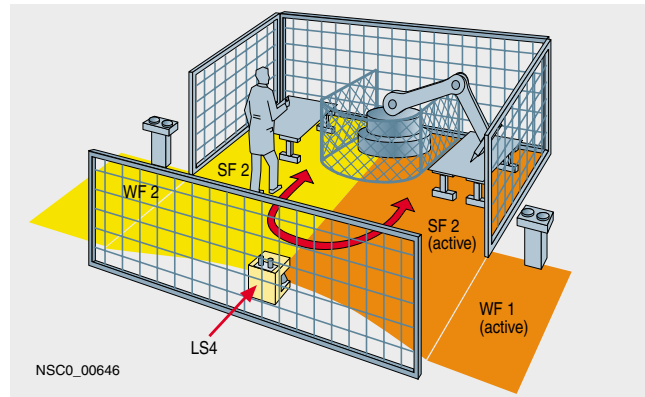
Violation of warning zones are not evaluated in the STEP 7 example program. A violation of the detection zone turns the OSSD bit of the cyclic input data to "0", which changes the actuator used in this example to the fail-safe status.

Example for an active zone pair

The robotic cell displayed below consists of two zone pairs:

Zone pair 1 (SF1, WF1): This zone is active, intrusion into SF1 stops the roboter.

Zone pair 2 (SF2, WF2): At the displayed point in time, the specified detection and warning zone 2 may be entered.



Example project

The STEP 7 project used as an example in this document consists of

- a fail-safe S7-CPU (DP-Master),
- the LS4 laser scanner for PROFIBUS (DP-Slave) as well as
- standard and fail-safe input and output modules of ET 200S (DP-Slave)

In this example, the actuator is simulated by an indicator light. It is switched on and off via a fail-safe output (F-FO or the ET 200S). If the detection zone of the LS4 is violated while the output (indicator light ON) is switched (active), the indicator light is automatically switched off. Restarting is only possible in case of previous acknowledgement.

The status of the sensors defines the detection zone numbers (bits 0-2 of the cyclic output data). This defines which detection and warning zone is active. Possible activation in this example:

- zone pair detection zone 1 and warning zone 1 or
- zone pair detection zone 2 and warning zone 2

If you want to expand the example in such a way as to work with three or (maximum) four zone pairs, you can use the already prepared program sequences (further information given on page 311).

The sensors for switching the detection zones are directed to a fail-safe input module of the ET 200S. In case of a failure at this input module, switching between the detection zones is not possible anymore. This error is detected and sets the fail-safe output module into fail-safe mode (indicator light is switched off).

Reaction times

For calculating the max. reaction time of your F-system please use the Excel file (Cotia table), which is available for S7 Distributed Safety V 5.3. This file is available on the internet:

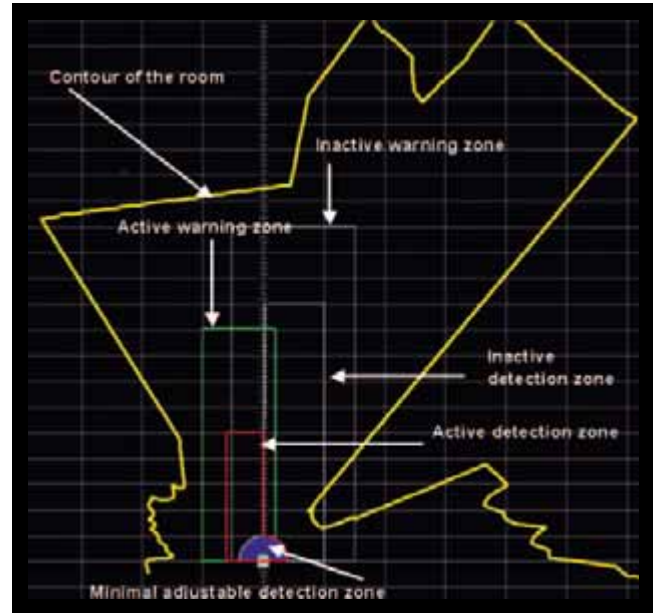
<http://support.automation.siemens.com/WW/view/en/19138505>

Prepared detection and warning zones

Apart from the STEP 7 project, both prepared zone pairs (SF1-WF1, SF2-WF2) are also available as a separate download file. Chapter 4 describes how to load these configuration data into the LS4. The prepared zone pairs are illustrated below for a first impression of the parameterization software LS4Soft.

Note

The contours of the detection and warning zones used in the example project are rectangles. The software LS4Soft also offers the possibility of parameterizing other contours (e.g. semi circles) as zone delimiters.



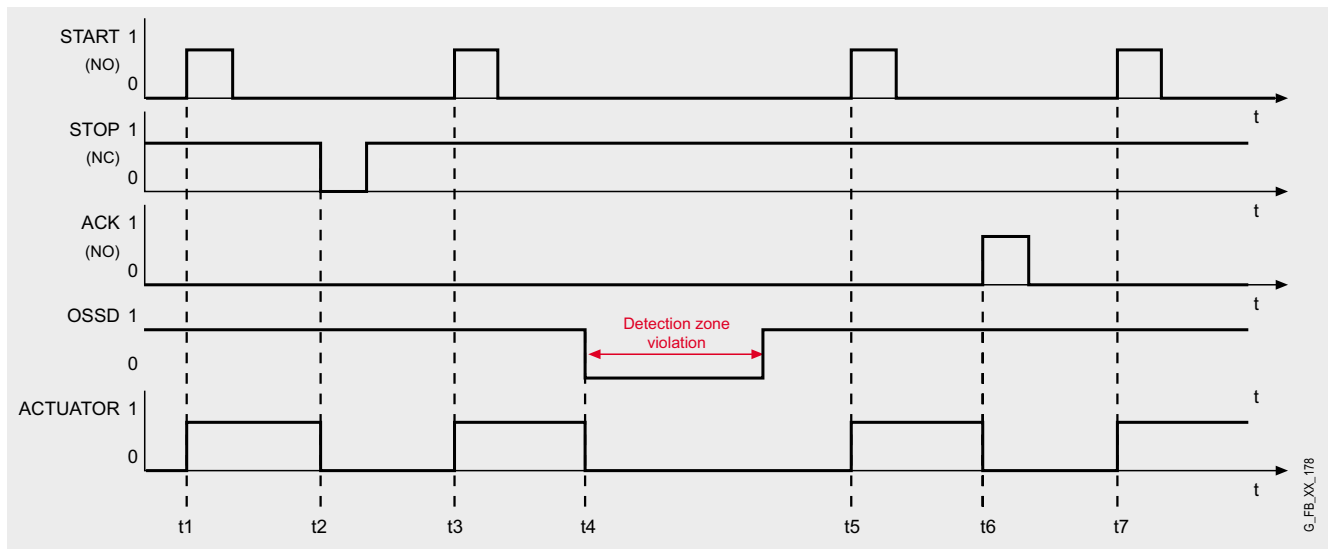
Time sequence

For a better understanding, the time sequence of the parameters used in the sample project is displayed in this section. The name of the parameters corresponds to the symbols in the STEP 7 project.

Variable	Input / output	Note/Explanation
START	Input (NO)	Start command for switching the actuator on.
STOP	Input (NC)	Stop command for switching the actuator off.
ACK	Input (NO)	Acknowledgement signal
OSSD	Cyclic input date	Bit which reads the fail-safe S7-CPU of the LS4 via PROFIBUS. A signal change from "1" to "0" indicates a detection zone violation.
ACTUATOR	Output	fail-safe output with indicator light connected to it.

An explanation of the times is given in the diagram below:

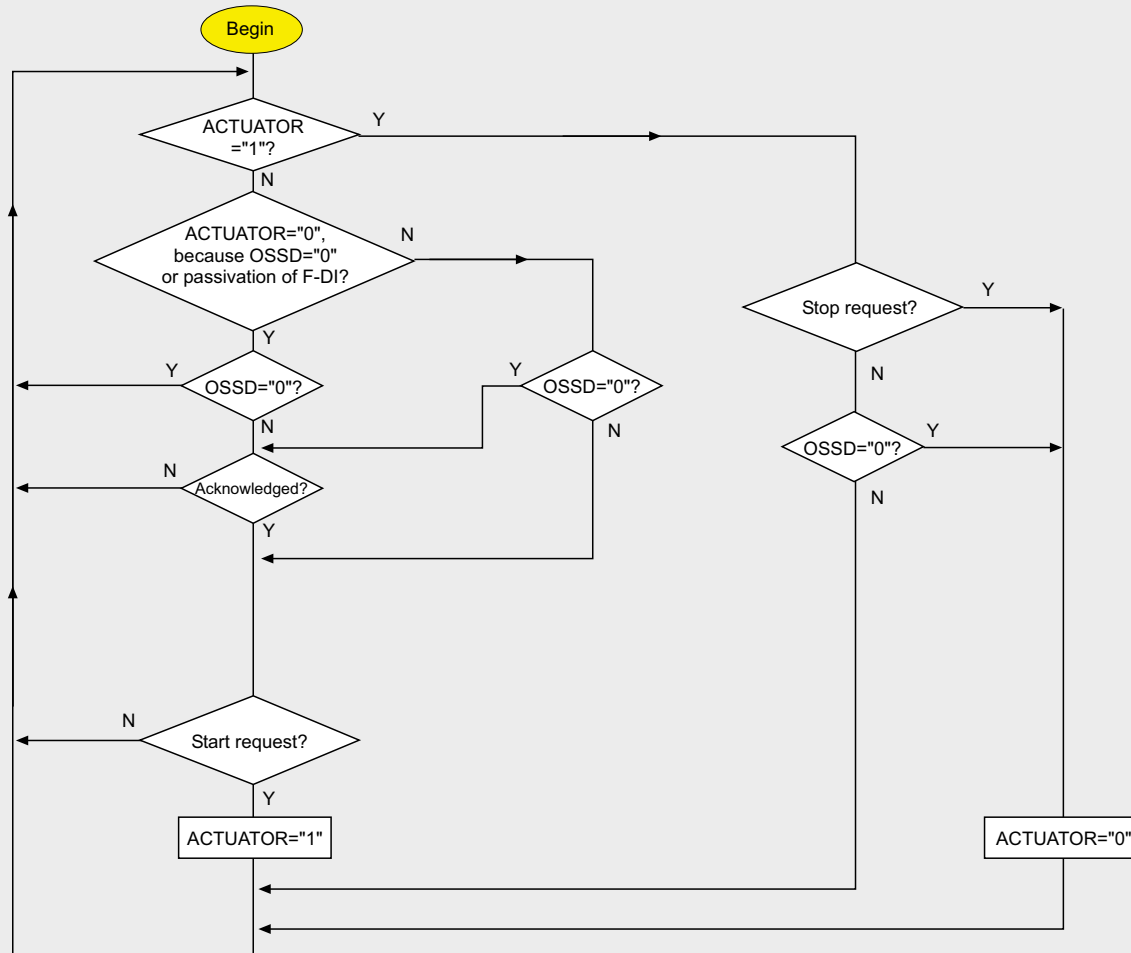
Time	Explanation
t1	Switching the actuator on: Indicator light goes on (ACTUATOR="1").
t2	Switching the actuator off: Indicator light goes on (ACTUATOR="0").
t3	Switching the actuator on: Indicator light goes on (ACTUATOR="1").
t4	LS4 recognizes a violation of the active detection zone (OSSD="0") . Then...
t5	...a restart does not cause the indicator light to be switched on, but...
t6	...it must first be acknowledged. Only then...
t7	...does a renewed start request cause the indicator light to be switched on.



Note
Requirement for the above time sequence is an adjusted, active zone pair.

Flow chart

The flowchart below once again illustrates the relations.



In this example, an indicator simulates an actuator in order to demonstrate the functionality of the laser scanner. When replacing the indicator light with an other actuator, you have to evaluate the read back signals (see also example no. 7)

G_FB_XX_179

Standards for the application of area scanners

The relevant regulations of machine safety in Europe apply for the application of LS4 PROFIBUS are scanners:

- machinery directive 98/37/EC and
- work equipment directive 89/655/EEC

Standards on PROFIsafe

Relevant standards are:

- IEC 61508
- EN954-1: 1996

Safety Category

The SIGUARD laser scanner LS4-4 corresponds to safety category 3 of EN954-1: 1996. The example on hand complies with the requirements of Safety Category 3.

Advantages/customer benefits

- Four freely programmable detection zone pairs
- Detection zone switching with any sensors without additional evaluation device
- Expanded measuring range of 190°
- Low current intake (approx. 300 mA)
- Simple connection to PROFIBUS-DP
- Comfortable operator software LS4Soft
- 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 STEP 7 engineering tools.
- Only one CPU is required, since fail-safe and standard program parts run on a coexistent basis in the CPU
- Use of prefabricated (and certified) fail-safe blocks from the Distributed Safety library.

Required components

Hardware components

Component	Type	MRPD / Ordering data	Qty	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG, A&D
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 KByte	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA00-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	2DI HF DC24V	6ES7131-4BB00-0AB0	2	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA01-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB01-0AB0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E15S24-A1	6ES7193-4CA20-0AA0	2	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Profile rail	482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length: 483 mm	6ES5710-8MA11	1	
Push button	Green, 1NO	3SB3801-0DA3	3	
Push button	Red, 1NC	3SB3801-0DB3	1	
Position switch	Overtravel plunger, 1S+1Ö	3SE2200-1C	2	
Indicator light with lamp	Yellow	3SB3217-6AA30	1	
SIGUARD laser scanner	LS4-4 for PROFIBUS	3SF7834-6PB00	1	
Optical PC adapter cable	–	3RG7838-1DC	1	
PROFIBUS M12 connecting plug	Pin insert (5 ea)	6GK1905-0EA00	1	
PROFIBUS M12 connecting plug	Connector insert (5 ea)	6GK1905-0EB00	1	
PROFIBUS M12 connecting plug	(5 ea)	6GK1905-0EC00	1	

Note

The functionality was tested with the hardware components listed. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

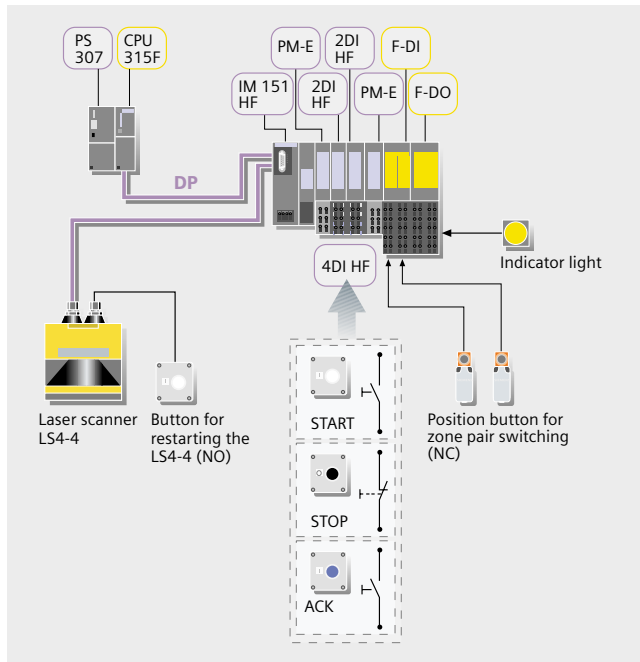
Configuration software/tools

Component	Type	MRPD / Ordering data	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	
LS4Soft	V1.08	Delivered with the LS4	1	

Setup and Wiring

Overview of the hardware configuration

Like the ET 200S, the laser scanner LS4-4 is operated at PROFIBUS DP as a DP slave. A fail-safe S7-CPU is thereby used as DP master.



Warning!
 In this example, the actuator is simulated by an indicator light. For reaching safety category 3, the actuator must be read back via two channels (using two contactors).

Note
 One 4DI electronic module can be used instead of both 2DI electronic modules. The "high feature" electronic modules can also be replaced by standard modules.

Wiring of the hardware components

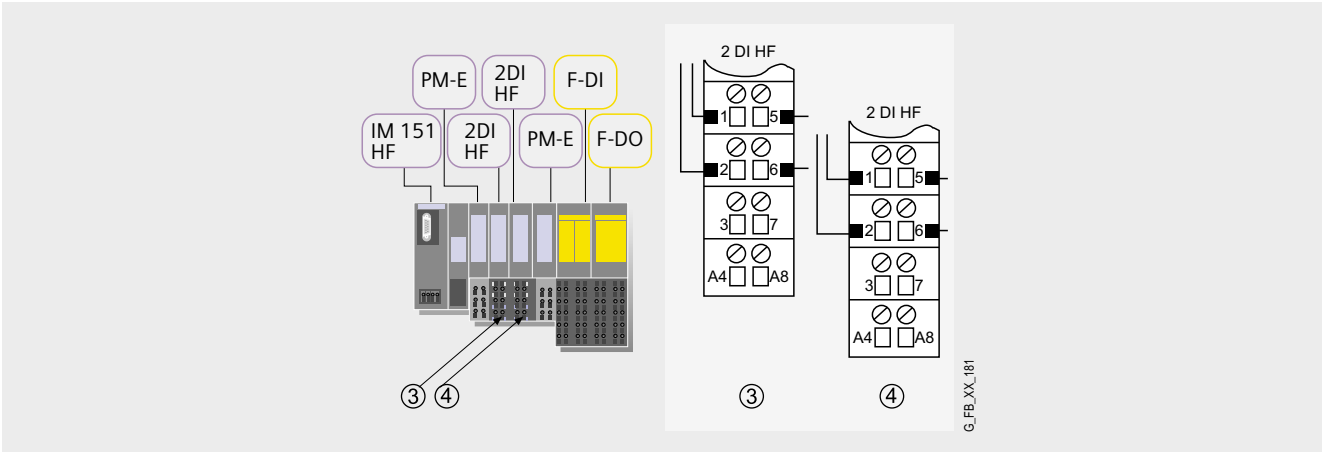
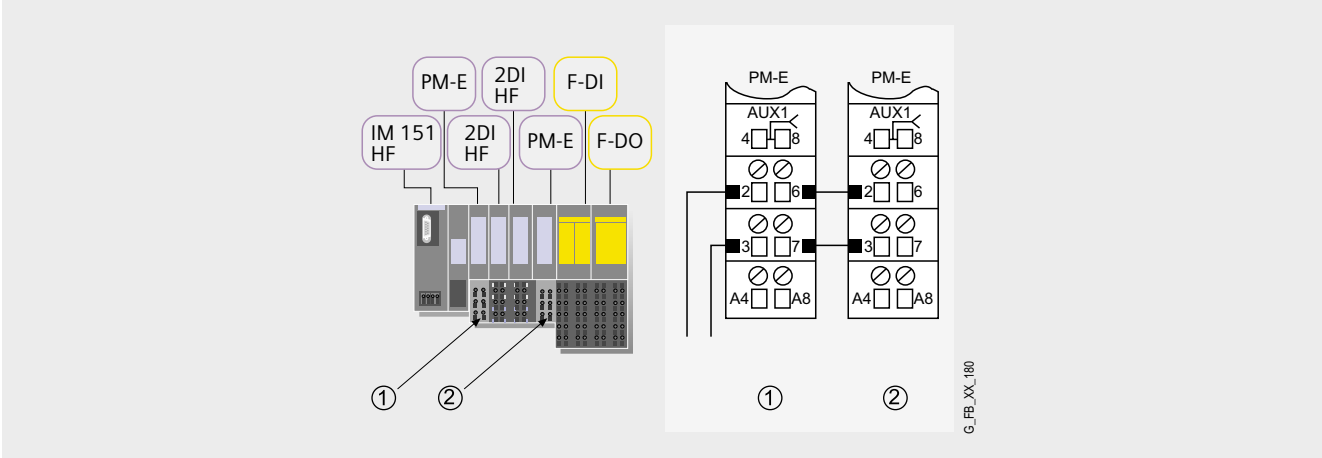
Requirements: The power supplies are supplied with 230V AC. First check the addresses set at the hardware components listed below:

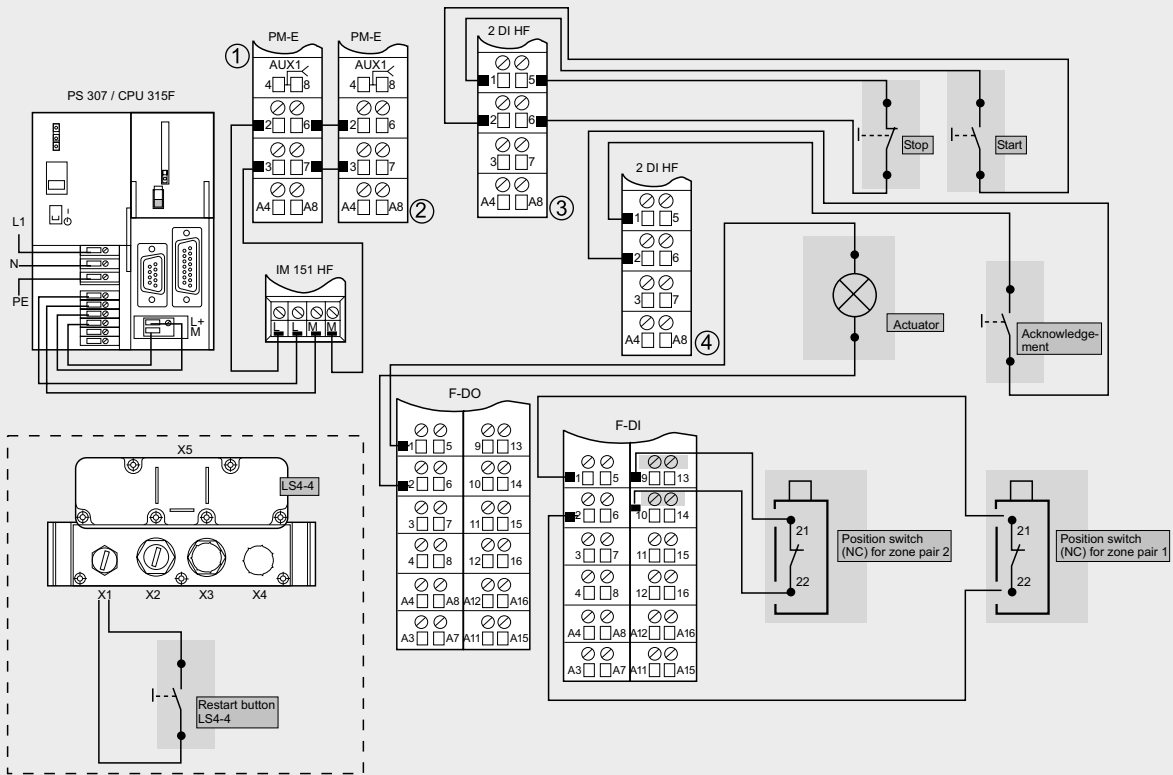
Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed
Laserscanner LS4-4	4 (PROFIBUS address)	Default setting, can be changed
F-DI	Switch position: 111111110	The PROFIsafe addresses are automatically assigned during configuring the fail-safe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 111111101	

Note
 The laser is not illustrated in the figure below. Its connections are discussed separately later on.

Note
 The DP interface of the CPU 315F must be connected with the respective DP interface of the IM 151 HF.

Note
 The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.





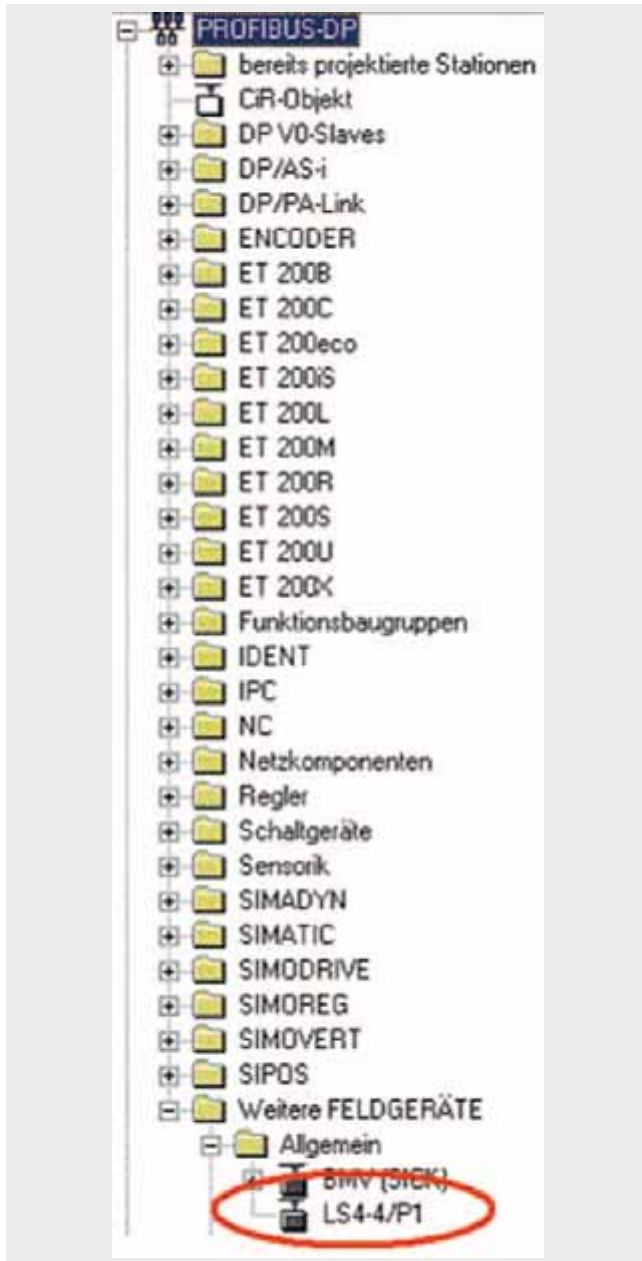
G_FE_XX_182

Note

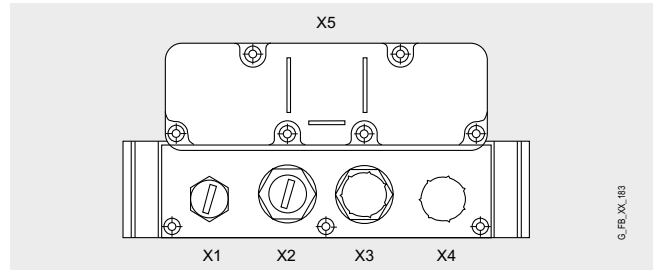
A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the S7 project into the CPU 315F-2DP.

Connection of the LS4

Integrating the LS4 into the PROFIBUS network requires the GSD file of the LS4. It is delivered with the LS4. Install the GSD into the hardware configuration of STEP 7 (Menu Options -> Install new GSD). Subsequently, the LS4 is available in the hardware catalog (within the hardware configuration of STEP 7, see following figure).

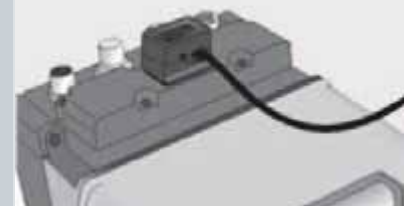


Externally, the LS4 has five male/female connectors (X1, X2,...,X5).



Connect these male/female connectors as follows:

Male/female connector	Function	Note/Explanation
X1	Restart button	Here you connect a push button (NO) (considered in chapter 3 in the table "Hardware components"). This button has two functions: <ul style="list-style-type: none"> Unlocking the scanner-internal starting/restarting lockout, if it has been activated. In this example it has not been activated. However, a restarting lockout has been realized in the fail-safe S7-program. Error acknowledgement, if the LS4 is in failure mode.
X2	PROFIBUS output	If the LS4 is the last device at the PROFIBUS, a standards compliant terminating resistor should be connected (this was the case in our test run).
X3	PROFIBUS input	–
X4	Power supply	Pin 1: +24V DC Pin 3: 0V DC
X5	Optical PC interface (also referred to as PC adapter)	Connected to the COM interface of the PG/PC on which the programming software LS4Soft has been installed.

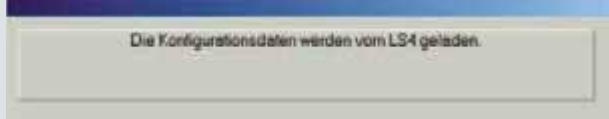


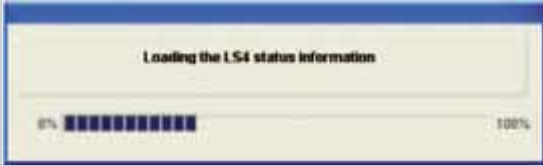
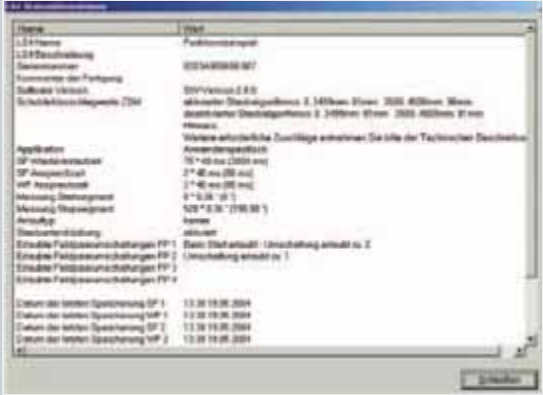


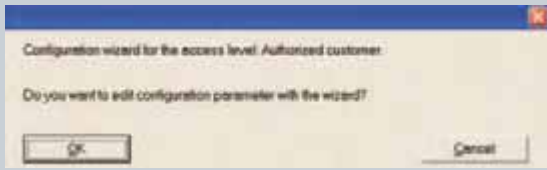

Note

The cable outlet of the PC adapter at LS4 must point in the direction of the detection zone. The PC adapter should only be connected in the installation phase or for control purposes.

Configuration and diagnosis software LS4Soft

The following example illustrates how to load the example file as_fe_i_010_v10_code_plscanner.ls to the LS4 using LS4Soft. The sample file is available as separate download (like as the respective STEP 7 project).

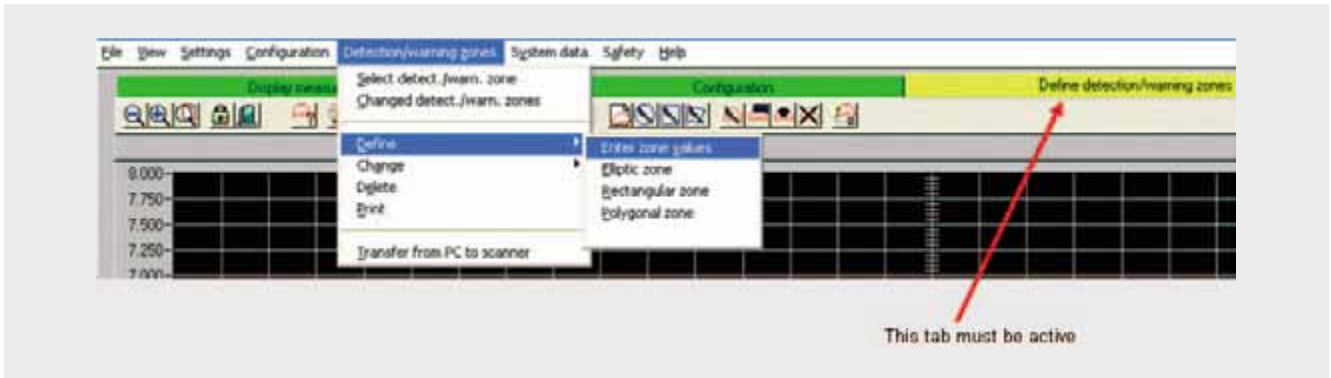
No.	Instruction	Note
1	Install the LS4Soft software on your PG/PC.	–
2	Switch on the LS4.	–
3	Start LS4Soft.	–
4	Connect the COM interface of your PG/PC with the LS4 via the PC adapter.	The configuration data currently located on the LS4 are now loaded. 
5	Register as "authorized customer" and enter the required password LS4SIG.	A query that no individual password has been specified appears.  
6	Wait until the LS4 has determined the status information.	– 
7	Click "Close".	– 

No.	Instruction	Note
8	Click "Cancel". 	No new configuration shall be generated, but the example file as_fe_i_010_v10_code_plscanner.ls be used.
9	Verify whether the "Display of measurement values" is active.	The currently active zone pairs and contours appear.
10	Activate the "LS4 configuration" tab via mouse click and select LS4 configuration -> Load configuration data from file and transfer to LS4 system from the menu 	–
11	Now search the example file as_fe_i_010_v10_code_plscanner.ls and follow the further instructions	–

Note
Ensure the COM interface is set correctly. The COM interface settings are available in the menu Settings -> PC configuration -> Interface

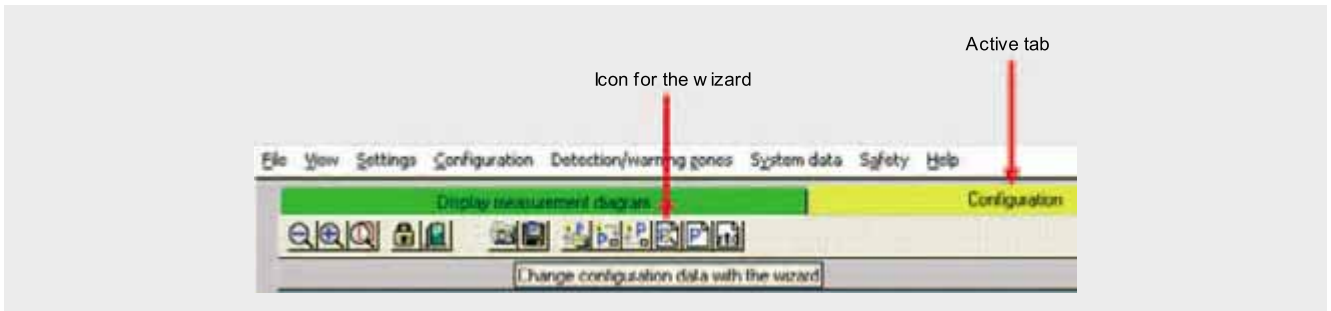
Changing detection and warning zones

If you wish to change detection and warning zones, mouse-click the "Definition of detection zone/warning fields" tab. Set the detection or warning zone to be edited, and select detection zone/warning fields->Define->Enter detection zone/warning field from the menu.



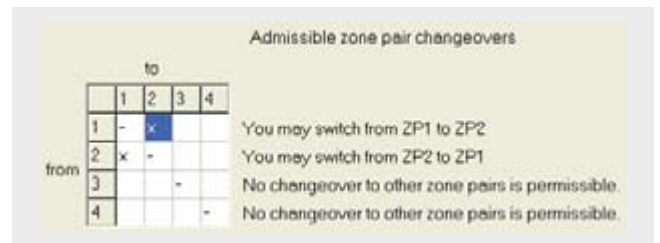
Working with the wizard

A helpful wizard for time efficient scanner configuration exists for the access "authorized customer" layer. The wizard can be called up as illustrated below.



Amongst other things, the wizard enables you to set the zone pairs to be enabled when starting the LS4. In the prepared example this is zone pair 1 (detection zone 1 and warning zone 1).

The wizard can also be used to specify which zone pairs can be switched. In the prepared example, it may be switched from zone pair 1 to 2 and from zone pair 2 to 1. Zone pairs 3 and 4 have not been prepared in this example.



Function test

After wiring the hardware components, you can check the inputs and outputs used with regard to their functionality (after downloading the S7 project and transferring the as_fe_i_010_v10_code_plscanner.ls file).

Inputs/outputs used

No.	Hardware component	Adress	Symbol	Signal (default value)	Note
1	Push button (NO)	E 0.0	START	"0"	Switches the indicator light ON
2	Push button (NC)	E 0.1	STOP	"1"	Switches the indicator light OFF
3	Push button (NO)	E 1.0	ACK	"0"	Acknowledgement
4	Position switch (NC)	E 2.0	SEN_FIELD1	"1"	Defining which zone pair is active.
5	Position switch (NC)	E 2.4	SEN_FIELD2	"1"	
6	Indicator light	A 8.0	ACTUATOR	"0"	Actuator (In this case: Indicator light)

Testing inputs and outputs

Requirements:

- The inputs and outputs have the default values specified under "Inputs/outputs used".
- The STEP 7 sample project is loaded
- The LS4 has been switched on and has loaded the example project as_fe_i_010_v10_code_plscanner.ls.
- No objects are currently in the detection zone of the LS4

No.	Instruction	Response! 8.0	Note
1	Keep E 2.0 on "0" signal	"0"	Activating zone pair 1 (detection zone 1 and warning zone 1)
2	Keep E 2.4 on "1" signal	"0"	
3	Press the push button E 1.0 and release it.	"0"	Acknowledgement necessary at initial start.
4	Press the push button E 0.0 and release it.	"1"	Start request
5	Press the push button E 0.1 and release it.	"0"	Stop request
6	Press the push button E 0.0 and release it.	"1"	No acknowledgement required for Start
7	Place an object into the detection zone of LS4	"0"	Violation of the detection zone
8	Remove the object from the detection zone of LS4	"0"	–
9	Press the push button E 0.0 and release it.	"0"	Acknowledgement necessary prior to the start.
10	Press the push button E 1.0 and release it.	"0"	Acknowledgement
11	Press the push button E 0.0 and release it.	"1"	Start possible again

Testing the LEDs at LS4

The LS4 indicates its current status via five LEDs:

LED	Color	Function/Meaning	Pictogram
1	Green	Sensor function is active, active detection zone is free	
2	Yellow	Warning zone occupied	
3	Red	OSSD outputs switched off	
4	Green	OSSD outputs switched on	
5	Yellow	■ Permanent light: Restarting lockout	
		■ Slowly blinking (1): Warning message (ca. 0.25 Hz)	
		■ Blinking fast (((1))): Failure message (ca. 4 Hz)	

Perform the following actions:

Instruction	Response				
Ensure, that objects are located neither in the warning zone, nor in the detection zone	ON	OFF	OFF	ON	OFF
Place an object into the warning zone of LS4	ON	ON	OFF	ON	OFF
Place an object into the detection zone of LS4	OFF	ON	ON	OFF	OFF

Note

In order to remove a failure message of the LS4-4, the error must be removed and the "1" signal be applied to the LS4-4 for 0.5 - 3 s using the restart button.

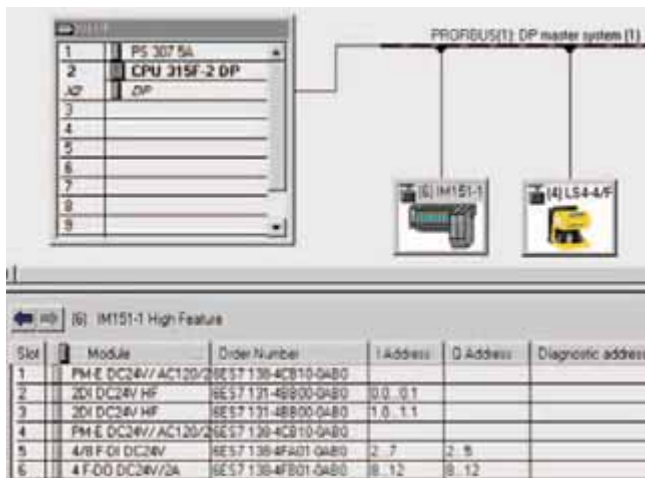
Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Warning!
 The settings shown below contribute to meet the requirements of Safety Category 3. Changes at the settings may cause loss of safety functions.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

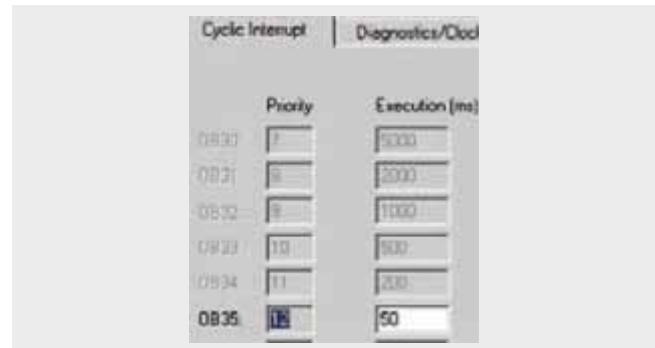
Overview picture



The PROFIBUS address at IM 151HF is set using DIP-switches.

Settings of the CPU 315F-2DP

The settings are displayed after double-clicking "CPU 315F-2 DP" (see "Overview picture").



Default value: 100 ms. It has to be observed that the F monitoring time must be larger than the call time of OB 35.



Available in the "Protection" tab.

A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.

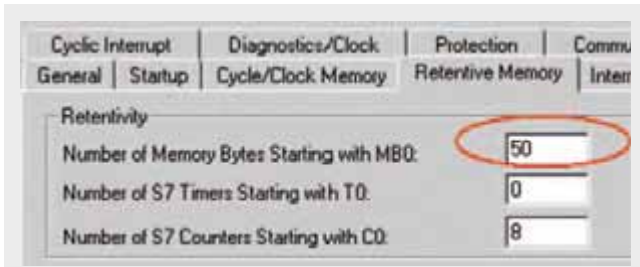
Password used here: siemens



Set mode: "Test Mode"

During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.

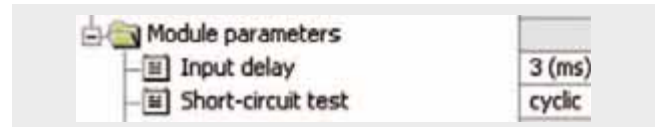
During **Test Mode** all test functions can be used without restrictions via PG/PC, which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.



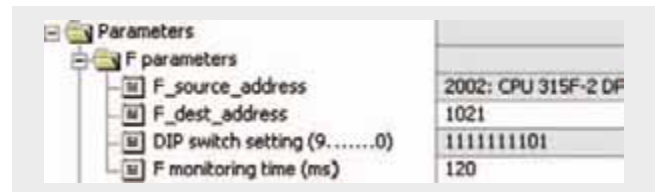
A function block "FB LS4" is provided with the LS4, which in this example is not used (this FB is briefly referred to in the sample code). Should you wish to use the "FB LS4" for adjusting the example program to your requirements, you must ensure to reserve a **retentive** memory area of **at least 36 bytes**.

Settings of the fail-safe F-DI

The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").



Activate the short circuit test.

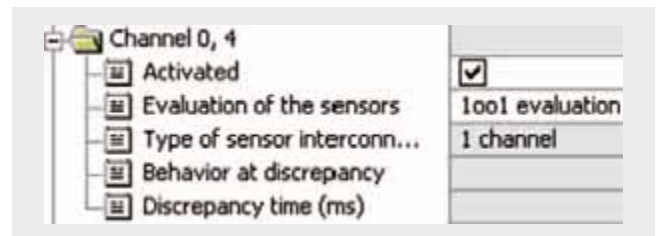


DIP switch settings

This value has to be set on the module (F-DI).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

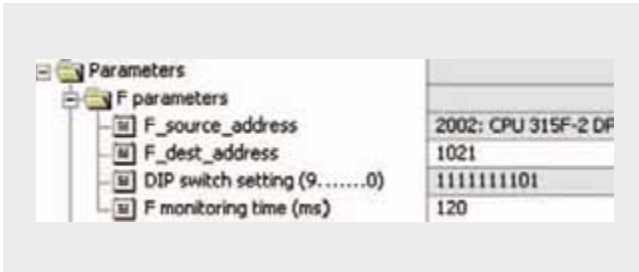


Also in the "Parameter" tab.

The sensors, which define which zone pair must be active, are integrated as fail-safe. In this example, two position switches are connected at channels 0 and 4. The remaining channels are deactivated.

Settings of the fail-safe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

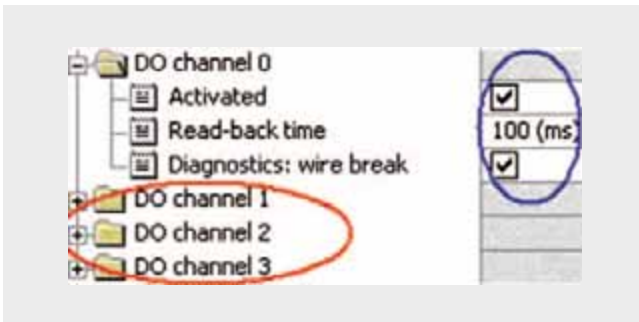


DIL switch settings

This value has to be set on the module (F-DO).

F monitoring time

It has to be observed that the F monitoring time must be larger than the call time of OB 35.

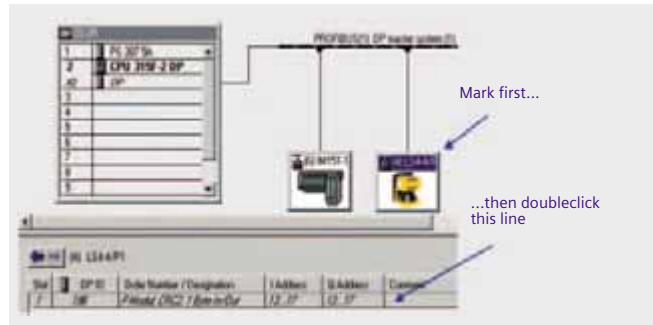


Activate used channels, deactivate channels which are not used. The indicator light ACTUATOR has been connected to channel 0.

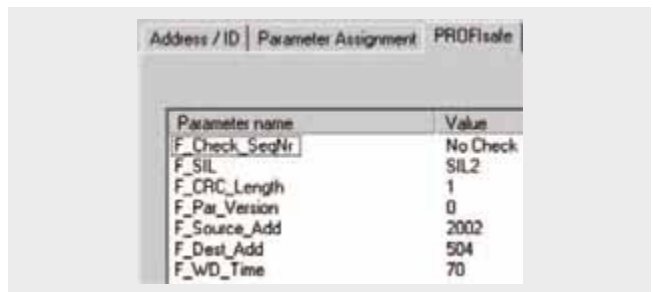
The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.

Settings of the LS4

Select the LS4 and then double-click the line which appears (see following figure):



Click the PROFIsafe tab.



F_Dest_Add:

This value always results from the PROPIBUS address (here: 4) plus 500

F_WD_Time:

The default value of 10 ms is usually too small. A valid current safety frame must be received from the F-CPU within the watchdog time period. Otherwise, the DP standard slave goes to the safe state. The selected watchdog time should be long enough to tolerate frame delays in communication, but also short enough for your process to run without interference.

Basic Performance Data

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 37.5 k	approx. 0.2 k	approx. 37.3 k
Main memory	approx. 28.2 k	approx. 0.09 k	approx. 28.1 k

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 97.8 k	approx. 48.9 k	approx. 48.9 k
Main memory	approx. 79.6 k	approx. 44.9 k	approx. 34.7 k

Cycle time

Total cycle time (typical value)	approx. 8 ms	Standard and safety program
Max. runtime of the safety program	14 ms	Calculation with the Cotia table. Page 294 specifies where to find it.

Performance data of the LS4

- 4 user programmable contactors up to 4 m
- 4 user programmable warning zones up to 15 m
- Monitored radius up to 190°
- Low power consumption 300 mA
- Weight 2 kg

Sample Code

Preliminary Remarks

Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

The sample code is always assigned to the **components used** in the functional examples 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.

Password

In all cases, the passwords used for the safety-relevant part is „siemens“.

Use of the STEP 7 project

The STEP 7 project enables you to safely monitor the connection with the laser scanner LS4. If the LS4 recognizes a safety zone violation, the fail-safe S7-CPU switches the output channel at the actuator (here: indicator light) safely off.

Download the STEP 7 project

To call the corresponding project file, open the "as_fe_i_010_v10_code_clsscanner.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

For downloading the project into the F-CPU please proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager.
- Select the "Blocks" container.
- Menu "Options" -> Edit safety program.
- Click the "Download" button.

The sample code with the given configurations enables the following:

- Connecting a laser scanner to a fail-safe S7-CPU via PROFIBUS DP
- Switching between two prepared zone pairs (SZ1/WZ1 and SZ2/WZ2)

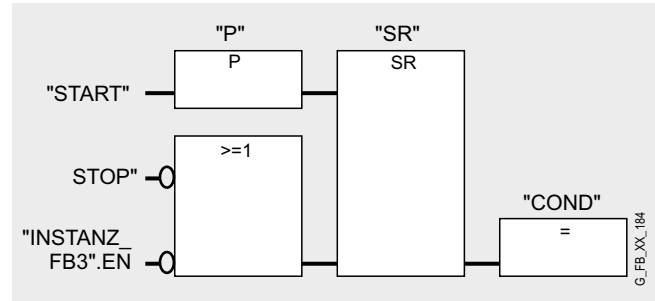
Download of the LS4Soft project

For parameterizing the LS4 project, please load the sample project as_fe_i_010_v10_code_plscanner.ls to the LS4 (instructions are available on page 302 under „Configuration and diagnosis software LS4Soft“), which is also available as separate download (on the HTM-page)

Program procedure

The standard user program consists mainly of three networks of **OB 1**:

Network 1



The signal for an operational start (START) and stop (STOP) request for the actuator (here simulated by an indicator light) is given in network 1.

The "INSTANZ_FB3" bit includes the status of an SR flip-flop in the safety program (FB3, NW1) and in this case prevents the starting of the actuator (here simulated by an indicator light) with an acknowledgement transmitted in the safety program. As long as "INSTANZ_FB3".EN="0", COND= "0" remains, also if the start push button is pressed since the reset function has priority in this flip-flop type.

The information of the memory bit "COND" from network 1 is read as memory bit COND1 in the safety program. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

If you want to read data from the standard user program (memory bits or PII of standard I/O) in the safety program (here: COND), which can be changed by the standard user program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate memory bits (here: COND1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

In this example it has already been realized. Generally, however, the following applies:

Note

If the above section is not observed the F CPU may go to STOP mode.

Network 2

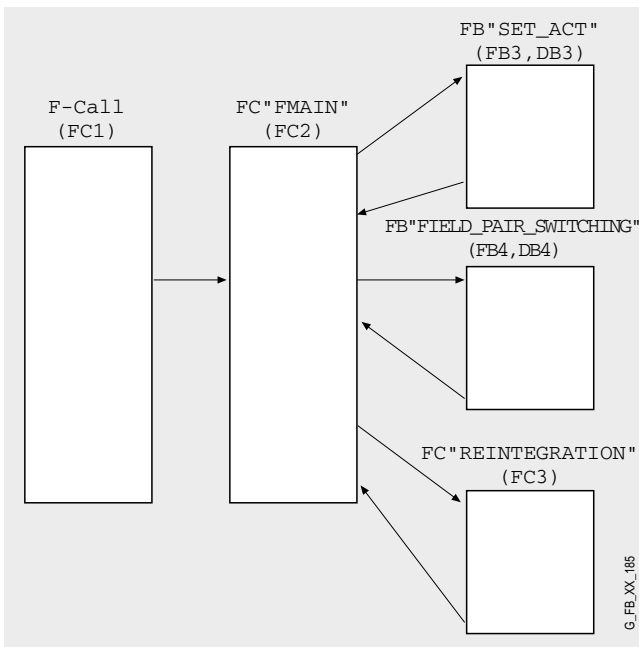
In OB 1 the "Proxy-Enable" bit (Bit 6 of the cyclic output data) is reset as the default value "0".

Network 3

Additionally contained in OB 1 is the "FB LS4", which, however, is not processed. It only serves as preparation it is to be used. Please note: Before calling the "FB LS4" the "Proxy-Enable" bit must be permanently set to "1".

The "FB LS4" enables automatic parameterization when exchanging the LS4.

The fail-safe program has the following structure:

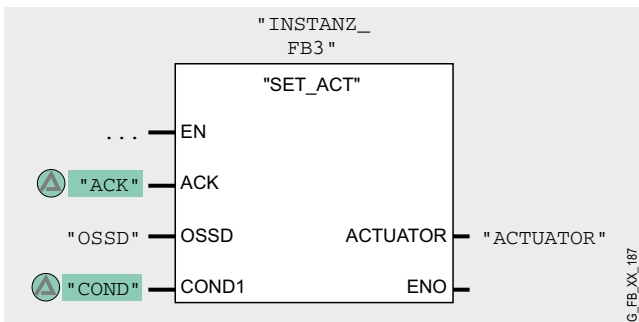


FC "FMAIN" (FC 2)

The calls of the F-blocks are coordinated from here.

Network 1

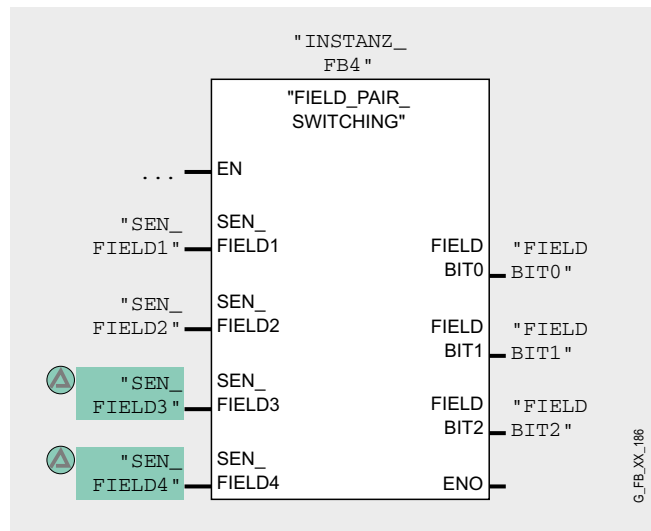
FB 3, DB 3 is called here:



Parameter	Note
ACK	Acknowledgement signal
OSSD	Safety-relevant output of LS4.
COND1	Starting condition defined in OB 1 (or OB 35).
ACTUATOR	Indicator light

Network 2

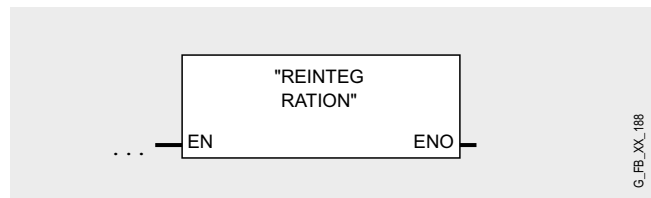
FB 4, DB 4 is called here:



Inputs: Position switches which define which zone pair is active. The inputs "SEN_FIELD3" and "SEN_FIELD4" are not used in this example and are therefore assigned with memory bits as dummies.

Outputs: Detection zone number (bit 0 to 2) of the cyclic output data.

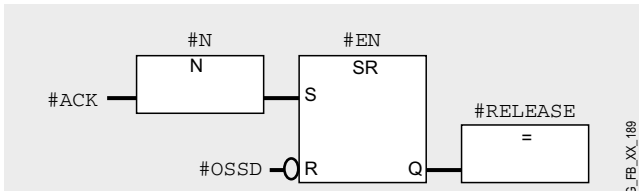
Network 3



Here the FC 3 is called for reintegration of passivated modules (F-DI / F-DO) and the LS4.

FB "SET_ACT" (FB 3, DB 3)

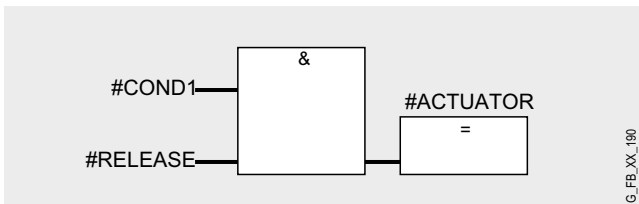
Network 1



The status of the SR flip-flop (#EN) is evaluated in OB 1 as a precondition for a start command. In case of a detection zone violation OSSD becomes "0" and resets the SR flip-flop as well as the #RELEASE (used in network 2).

Note
For this type of flip-flop it is reset if the S input and the R input are controlled with a "1" signal (resetting has priority).

Network 2



The actuator (here simulated by an indicator light) only becomes active if

- the start condition could be transmitted (see OB 1 or OB 35) and
- an enable was given (see previous network 1)

FB "FIELD_PAIR_SWITCHING" (FB 4)

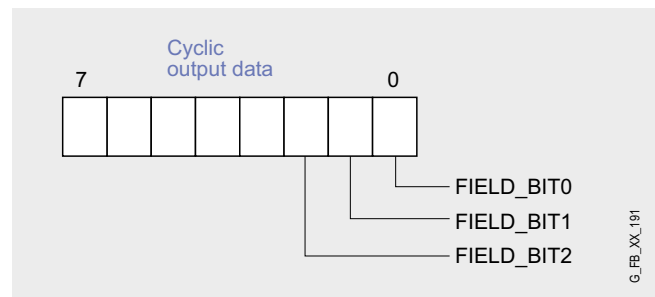
The following table describes the parameters.

Parameter	Input / output	Convention
SEN_FIELD1	Position switch (NC)	"1": Switch not activated
SEN_FIELD2	Position switch (NC)	"1": Switch not activated
SEN_FIELD3	Memory bit	Dummy
SEN_FIELD4	Memory bit	Dummy
FIELD_BIT0	Bits of the cyclic output data	–
FIELD_BIT1		
FIELD_BIT2		

A maximum of four zone pairs (one zone pair consists of a safety and a warning zone) can be actively switched. However, only one zone pair must be active at any time. In this example zone pair 1 or 2 can be active. Zone pair 3 and 4 are not

ready. If you also wish to use these zone pairs, replace the memory bits (in this example the dummies) by sensors (e.g. further position switches). These zone pairs 3 and/or 4 must previously have been configured with the LS4Soft software. In the prepared example, it can be switched from zone pair 1 to 2 and from zone pair 2 to 1. Which zone pair is now active depends on bits 0, 1, 2 of the cyclic output data (parameter "FIELD_BIT0", "FIELD_BIT1", "FIELD_BIT2").

Note
When switching the zone pairs, the PC adapter must not be connected (PC adapter must not be connected at the LS4).

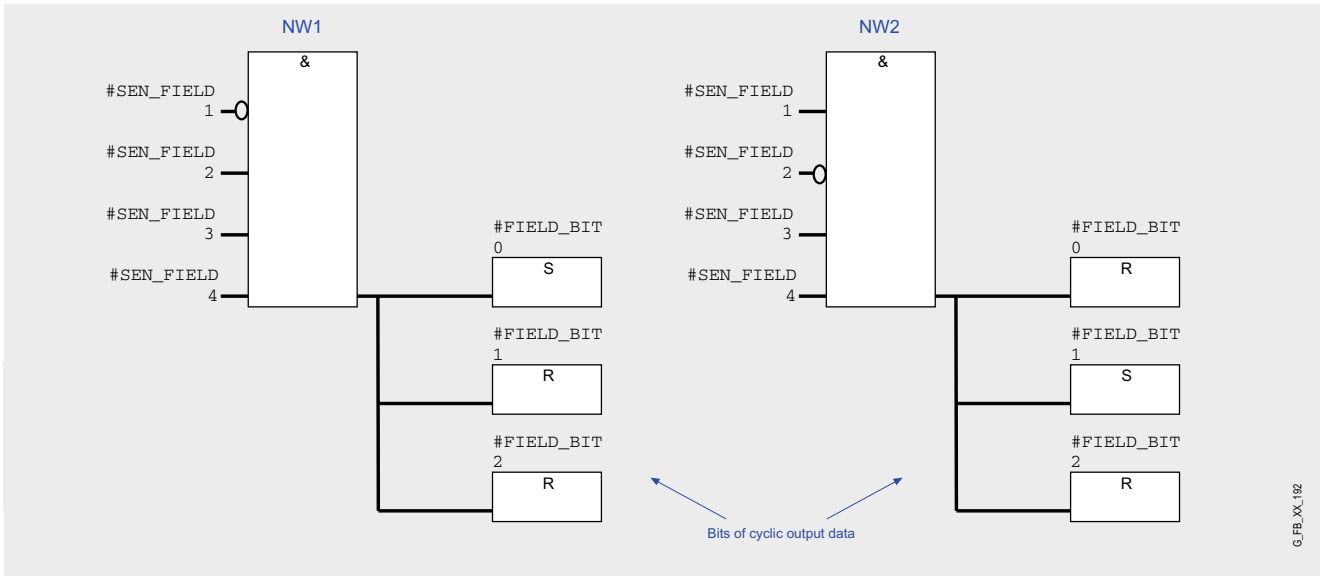


The following assignments apply:

FIELD_BIT2	FIELD_BIT1	FIELD_BIT0	Active zone pair	Note
0	0	1	1	–
0	1	0	2	–
0	1	1	3	Not realized in the example
1	0	0	4	

The statuses of these three bits are determined by the status of the position switches (SEN_FIELD1 and SEN_FIELD2). The realization in the program code is displayed below.

Network 1 and Network 2



Network 3 and Network 4

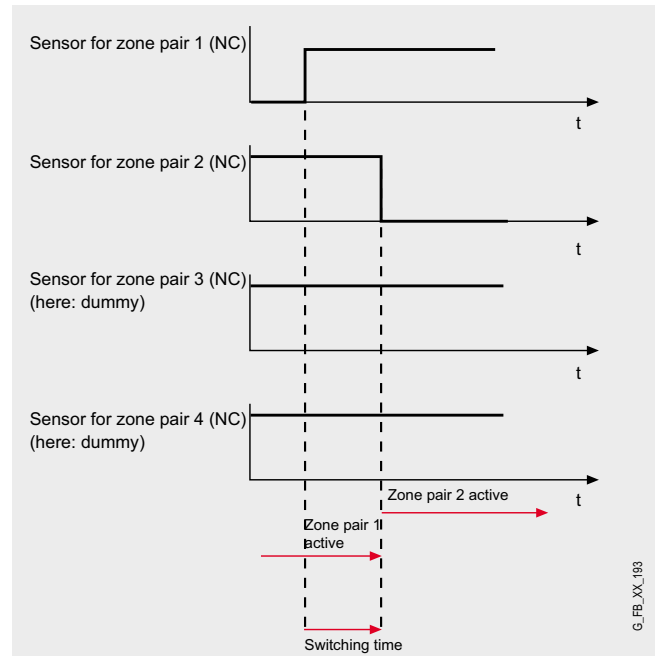
In these networks the zone pairs 3 and 4 can be switched active. To do this change the flags (dummies) against their sensors (input parameter in FC2) and parameterize the zone pairs in LS4-4 with the LS4Soft software. In this example only zone pair 1 and 2 are considered.

Note

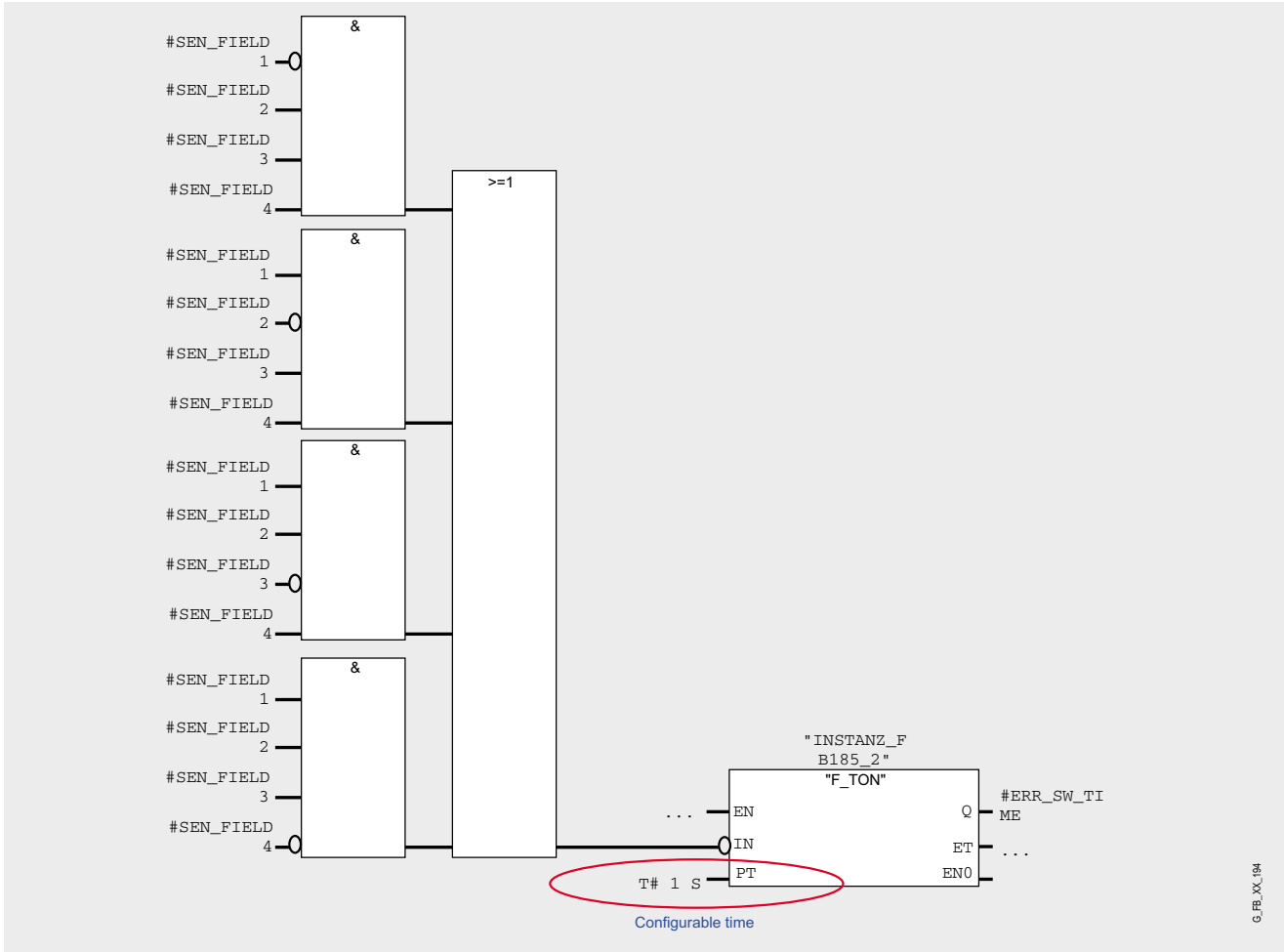
The memory bits (dummies) are default in OB 100.

Network 5 and Network 6

In this example a zone pair always becomes active when the respective sensor (here NC) switches (i.e. is on "0" signal) **AND** the other sensor (NC) or the dummy bits are on "1" signal. During switching (e.g. from zone pair 1 to zone pair 2) this condition is not true for a certain duration of time. **During this time the last set zone pair remains active!**

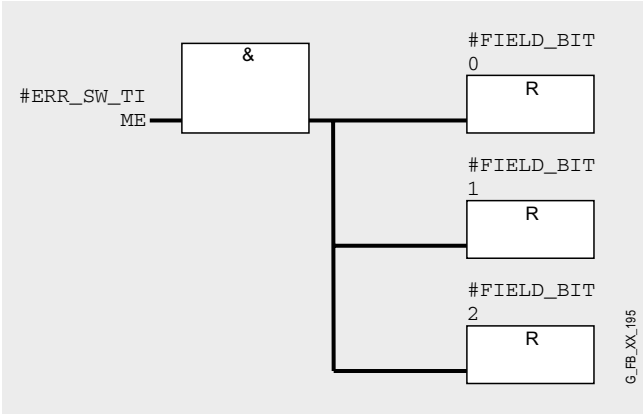


This condition can (depending on the application) be a possible hazard (e.g. if the sensor does not react) In this example the status is recorded and compared with a parameterized time. If this condition continues to be true after this time has elapsed, this will be interpreted as an error and the #ERR_SW_TIME bit will be set (see following figure).



Warning!
 The time to be parameterized at the parameter PT depends on the application and can be changed. Generally, however, it should be as small as possible. For times larger than 1 sec additional safety measures should be considered.

For a set #ERR_SW_TIME bit, the bits 0, 1 and 2 of the cyclic output data (determine which detection zone is active) are then reset. At the LS4-4, in return, this bit combination causes the OSSD bit to be reset. In this example, resetting the OSSD bit causes the indicator light to be switched off (see FB 3 NW 1 and 2).



FC "REINTEGRATION" (FC 3)

The reintegration applies for

- the LS4 (network 1)
- the F-DO
- the F-DI

For the F-DO a memory bit REINT is prepared. With a positive flank of REINT the F-DO will be reintegrated.

Warning!

In this example, the reintegration of passivated modules occurs automatically. Only use the automatic reintegration for your applications if it does not cause hazards.

A passivation is indicated via LED "SF" lighting up on the module. The reintegration of an F module may take approx. one minute.

Operating instructions**Prerequisites:**

- Hardware configuration of STEP 7 as well as the fail-safe and user program are located in the S7-CPU
- No objects are currently in the detection zone of the LS4
- Zone pair 1 has been set (via positioning switch)
- The PC adapter has not been connected
- LS4 has been parameterized
- Zone pair 1 is active

No.	Instruction	Result/Note
1	Press the acknowledgement button ACK (E 1.0)	Necessary prior to the first start.
2	Press the start button START (E 0.0)	Indicator light goes ON
3	Place an object into the detection zone	OSSD bit of LS4 becomes "0" -> Indicator light goes OFF
4	Press the acknowledgement button ACK (E 1.0)	Necessary in case of error (here: detection zone interrupted)
5	Press the START button (E 0.0)	Indicator light goes ON
6	Now use the position switches to switch from zone pair 1 to zone pair 2: FIELD_BIT0="0", FIELD_BIT1="1"	Zone pair 2 is now active. Switching must be performed within the time parameterized within FB4, NW5.

Passivation and Reintegration of F-I/O considering as example the ET 200S

Automation Function

Scope of validity of the functional example

The functional example applies for the following framework conditions:

Hardware:

- CPU 315F-2 DP, with PROFIsafe I/O modules ET 200S

Software:

- STEP 7 V5.3 + SP3
- S7 Distributed Safety V5.4, and S7 F Configuration Pack V5.4 + SP1

Functionality of the functional example

Task

The fail-safe system "S7 Distributed Safety" enables realizing safety functions at machines. Proper functioning of the "S7 Distributed Safety" system is necessary as human health depends on it and it avoids damage to machines.

In case of an error, the "S7 Distributed Safety" system must behave so that the machine remains fail-safe or will be turned fail-safe. An error at the F-I/O-module for example (e.g. wire break at actuator or sensor) turns the affected F-I/O-module fail-safe, i.e. it is "passivated".

This functional example demonstrates "passivation" and "reintegration" of fail-safe I/O modules in the "S7 Distributed Safety" system.

Solution

A concrete example from practice illustrates the behavior of "S7 Distributed Safety" in case of errors at the F-I/O-module:

- Passivation channels due to wire-break at an F DO.
Manual reintegration after error has been removed.
- Passivation entire module due to wire-break at an F DI.
Automatic reintegration after error has been removed.
- Passivation of the F-I/O-module due to disconnecting F-CPU and distributed station.
Reintegration after error has been removed.

Apart from the practical application, the functional example provides extensive background knowledge on the topic of "passivation" and "reintegration".

Note

In this functional example, the combination of type of passivation (channels, entire module), type of F-module (F-DO, F-DI), and type of reintegration (manual, automatic) is exemplary. Other combinations can also be realized.

Advantage / Customer benefits

The "passivation" and "reintegration" functions of "S7 Distributed Safety" have the following function:

- Errors at the F-I/O-module are turned fail-safe.
- F-modules can be passivated entirely or by channels.
- If an F-module passivates, passivation of further F-modules can be "forced".
- After the error has been removed, the reintegration occurs only after acknowledgement by the user. In cases where an automatic startup of the plant is not possible, reintegration can also occur automatically.

Required Components

In this chapter you find an overview of hardware and software components required for the functional example.

Hardware components

Component	Type	MLFB / Order information	No.	Manufacturer
Power supply	PS307 5A	6ES73071EA00-0AA0	1	Siemens AG
S7-CPU, can be used for safety applications	CPU 315F-2DP	6ES7315-6FF01-0AB0	1	
Micro Memory Card	MMC 512 kB	6ES7953-8LJ10-0AA0	1	
Interface module for ET 200S	IM 151 High Feature	6ES7151-1BA01-0AB0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Electronic module for ET 200S	4 DI, DC 24V, Standard	6ES7131-4BD01-0AA0	1	
Electronic module for ET 200S	4 DO, DC 24V/0,5A, Standard	6ES7132-4BD01-0AA0	1	
Electronic module for ET 200S	4/8 F-DI, DC 24V, PROFI-safe	6ES7138-4FA02-0AB0	1	
Electronic module for ET 200S	4 F-DO, DC24V/2A, PROFI-safe	6ES7138-4FB02-0AB0	1	
Terminal module for ET 200S	TM-P15C22-01	6ES7193-4CE10-0AA0	2	
Terminal module for ET 200S	TM-E15C23-01	6ES7193-4CB10-0AA0	2	
Terminal module for ET 200S	TM-E30C44-01	6ES7193-4CG30-0AA0	2	
S7-300, mounting rail	Length 482.6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail for ET 200S	35 mm, length: 483 mm	6ES5710-8MA11	1	
Indicator light including incandescent lamp	Yellow	3SB3217-6AA30	2	
Indicator light including incandescent lamp	Green	3SB3217-6AA40	1	
Indicator light including incandescent lamp	White	3SB3217-6AA60	2	
Push button	Green, 1NO	3SB3801-0DA3	3	
Emergency stop	Push button, 2NC	3SB3801-0DG3	1	

Note

The functionality was tested with the listed hardware components. Similar products not included in the above list can also be used. Please note that in such a case changes in the sample code (e.g. setting different addresses) may become necessary.

Software components

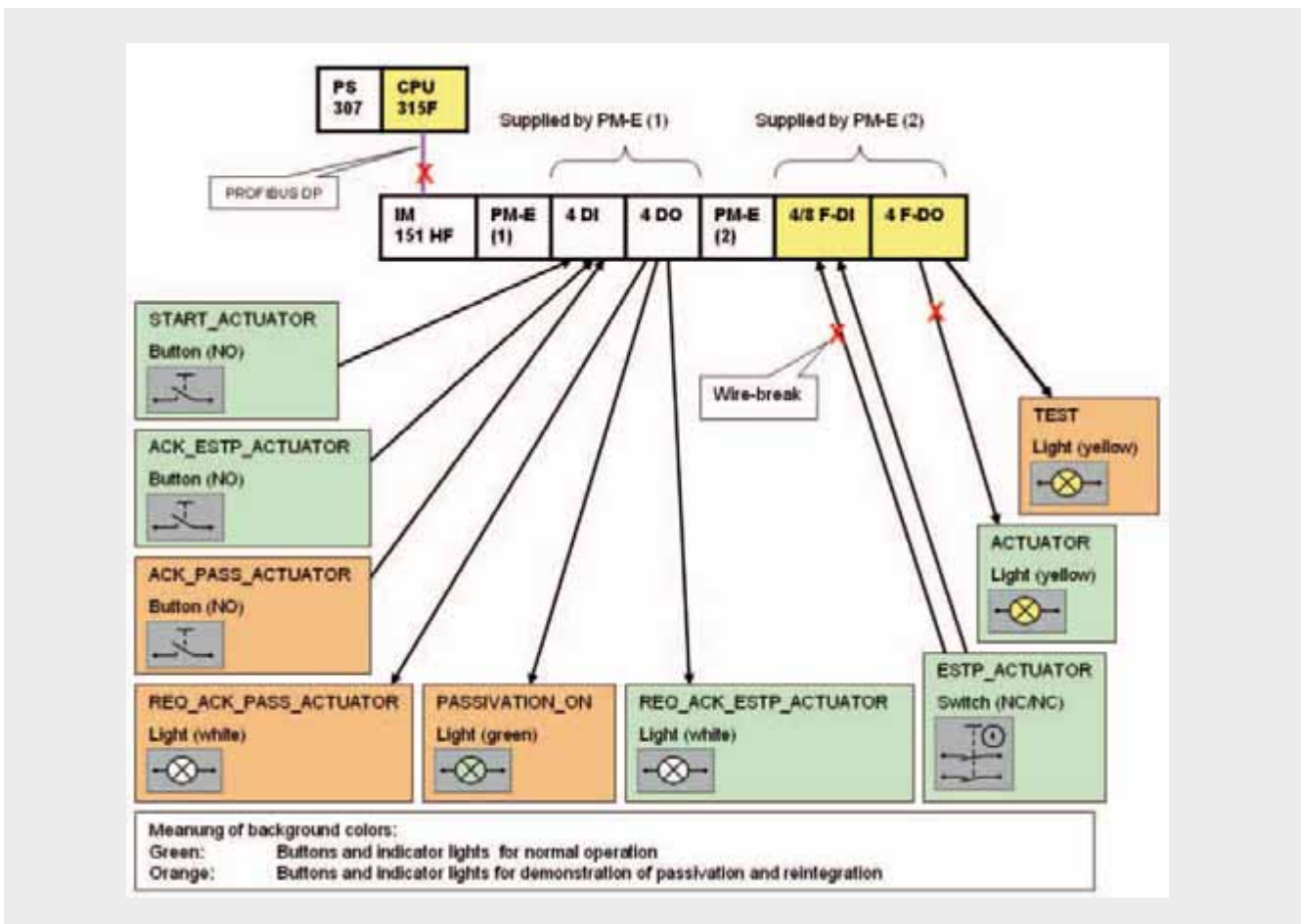
Component	Type	MLFB / Order information	No.	Manufacturer
STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1	Siemens AG
S7 Distributed Safety	V5.4	6ES7833-1FC02-0YA5	1	
S7 F Configuration Pack	V5.4 + SP1	-	1	

Setup and Wiring

This chapter describes hardware setup and wiring of the functional example.

Overview of hardware configuration

The arrangement used to demonstrate passivation and re-integration consists of a PROFIBUS configuration. A fail-safe S7-CPU is used as DP master, an ET 200S as DP slave. Passivation is triggered by means of disconnections (simulated wire-break) at F-DI, F-DO or DP interface.



Wiring of hardware components

This chapter contains information on the setup of hardware components. It contains the required address settings and the wiring plan.

Address settings

The following addresses must be set at the DIL-switches of the hardware components.

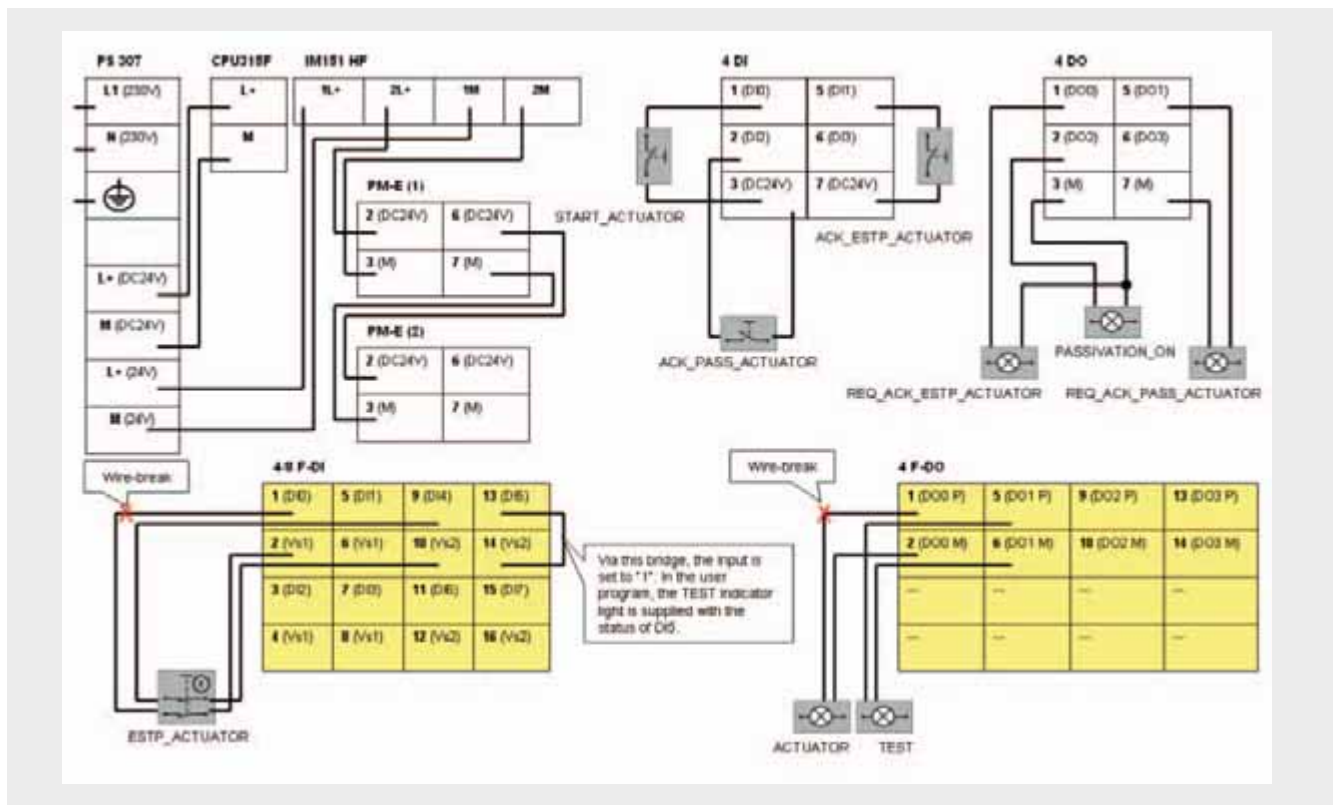
Hardware component	Address to be set at the DIL switch	Note
IM 151 HIGHFEATURE	3 (PROFIBUS address)	You can change the PROFIBUS address.
4/8 F-DI	0011001000 (PROFIsafe address)	The PROFIsafe addresses are automatically assigned when configuring the fail-safe modules in STEP 7.
4 F-DO	0011000111 (PROFIsafe address)	Please ensure that the setting at the address switch of the F-I/O-module (DIP switch) on the module side corresponds to the PROFIsafe address in the hardware configuration of STEP7.

Wiring plan

Please wire the hardware components according to the wiring plan (following figure).

Please include the following **additional** wiring settings:

- Power supply "PS 307" with 230V AC
- Connect the DP interface of the CPU 315F-2 DP with the DP interface of the IM 151 HF.



Overview of inputs and outputs

Overview of connected push buttons:

No.	HW component (type)	Address	Symbolic address	Default	Function
1	Push button (NO)	E 0.0	START_ACTUATOR	"0"	This button switches on the ACTUATOR indicator light .
2	Push button (NO)	E 0.1	ACK_ESTP_ACTUATOR	"0"	This button acknowledges the emergency stop circuit.
3	Push button(NO)	E 0.2	ACK_PASS_ACTUATOR	"0"	This button acknowledges the manual reintegration of the ACTUATOR indicator light.
4	Emergency stop push button at F-DI (NC/NC)	E 1.0	ESTP_ACTUATOR	"1"	This button switches off the ACTUATOR indicator light .

Overview of connected indicator light:

No.	HW component (color)	Address	Symbolic address	After startup	Meaning
5	Indicator light (white)	A 0.0	REQ_ACK_ESTP_ACTUATOR	"1"	The switched on indicator light indicates, that the emergency stop circuit requires acknowledgement.
6	Indicator light (white)	A 0.1	REQ_ACK_PASS_ACTUATOR	"0"	The switched on indicator light indicates, that acknowledgement for manual reintegration of the ACTUATOR indicator light is necessary.
7	Indicator light (green)	A 0.2	PASSIVATION_ON	"0"	The switched on indicator light indicates the current passivation.
8	Indicator light at F DO (yellow)	A 7.0	ACTUATOR	"0"	The indicator light simulates the "hazardous loads". The switched on indicator light indicates the "hazardous loads" being switched on
9	Indicator light at F DO (yellow)	A 7.1	TEST	"1"	The indicator light is only used to demonstrate the passivation of the entire module. The indicator light has no other function. Normally, TEST is always switched on. TEST is only switched off if F-DI is passivated.

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Function test

After wiring the hardware components and loading the STEP 7 project into the S7-CPU (see page 327), please test the inputs (buttons) and the outputs (indicator lights) for correct functioning.

Note
A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the STEP7 project to the CPU 315F-2DP.

Please perform the steps of the table below successively. For each step check whether the indicator light is switched on or off.

No.	Action	Indicator light (*2)				
		A	B	C	D	E (*3)
1	Mode switch of the S7-CPU: Switch from STOP to RUN (startup)	0 (*1)	0	1	0	1
2	Press: ACK_ESTP_ACTUATOR	0	0	0	0	1
3	Press: START_ACTUATOR	0	0	0	1	1
4	Press: ESTP_ACTUATOR	0	0	0	0	1
5	Press: ESTP_ACTUATOR	0	0	1	0	1
6	Press: ACK_ESTP_ACTUATOR	0	0	0	0	1

Explanations on the table:

(*1): The PASSIVATION_ON indicator light briefly lights up in step 1, as during startup the F-I/O-modules are passivated shortly.

(*2): Switched on indicators are marked with "1". To recognize more clearly which bits change during a mode transition, they are shaded in gray: If a bit is shaded gray, it has changed compared with its previous state.

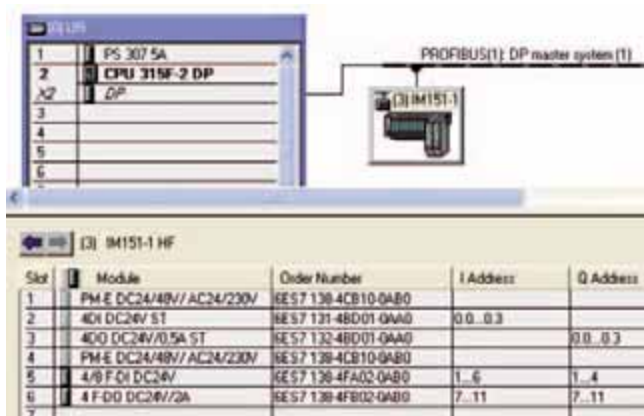
(*3): One channel of F-DI is constantly set to "1". In the user program this channel is read in, and it is output at the TEST indicator light.

Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown for your information. In the STEP 7 project (sample code, see page 327) of the functional example on hand, these settings have already been made.

Changes at the settings are possible (e.g. due to individual requirements). Should you implement the changes (e.g. add an additional module), the sample code has to be adapted accordingly.

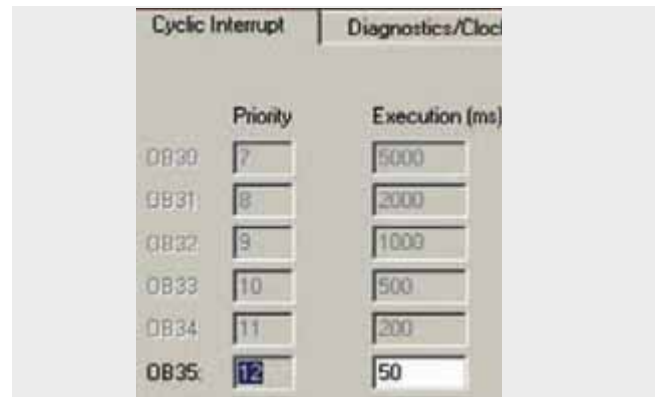
Overview of the configuration



The PROFIBUS address is set at the IM 151 HF component via DIP switches. In this functional example the address 3.

Setting the CPU 315F 2 DP

You reach the input dialog in the HW configuration of STEP 7 by double-clicking "CPU 315F-2 DP".



"Cyclic Interrupts" tab:

The call time of OB35 is configured with "50ms".

Important:

The monitoring time of the F-I/O-modules must be larger than the call time of OB35.

Please use the Cotia table for selecting the monitoring time ("min. F monitoring time" sheet). At page 326 you find the link to the Cotia table.



"Protection" tab:

A "Password" must be allocated in order to be able to set the parameter "CPU contains safety program". It is only in this case that all required F blocks for safe operation of the F-I/O-modules are generated during the compilation of the STEP 7 hardware configuration.

Password used this functional example: siemens



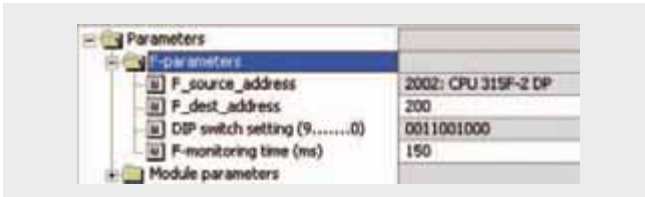
"Protection" tab:

Mode used here is "Test Mode":
The Mode field is not relevant for safety operation.

Settings of the F-DI

You reach the input dialog in the HW configuration of STEP 7 by double-clicking "4/8 F-DI DC24V" (see Figure „Overview of the configuration“).

All input screens are available in the "Parameter" tab.



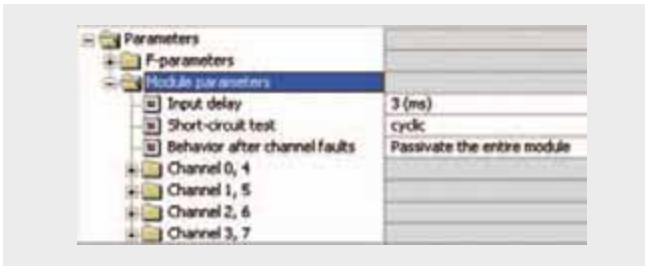
"DIP switch setting (9...0)":

The displayed value must be set at the F-DI.

"F-monitoring time (ms)":

"150 ms"

Important: The F-monitoring time must be larger than the call time of OB35. Please use the Cotia table for selecting the monitoring time ("min. F-monitoring time" sheet). At page 326 you find the link to the Cotia table.



"Short-circuit test":

"cyclic"

The two channel emergency stop button contains the power supply via the module.

"Behavior after channel faults":

"Passivate the entire module"

"Channel 0.4":

"activate"

The two break contacts of the emergency stop push button are polled with a 1oo2 evaluation.

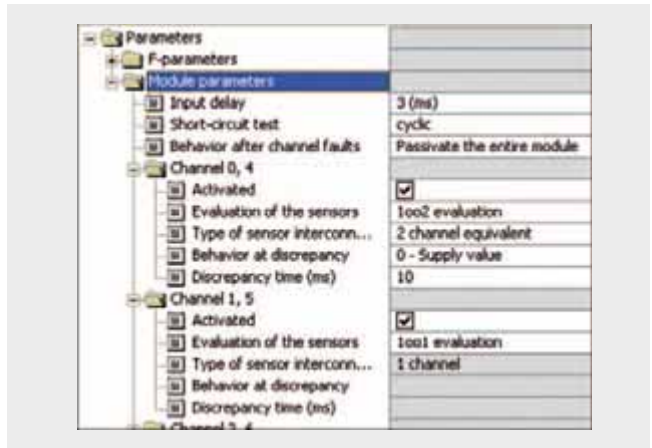
"Channel 1.5":

"activate"

"1" is read at channel 1. This directly controls the TEST indicator light.

Unused channels:

"deactivate"



"Channel 0.4":

"Evaluation of the sensors":

"1oo2 evaluation"

"Type of sensor interconnection":

"2 channel equivalent"

"Behavior of discrepancy":

"0-Supply value"

"Discrepancy time (ms)":

"10 ms"

"Channel 1.5":

"Evaluation of the sensors":

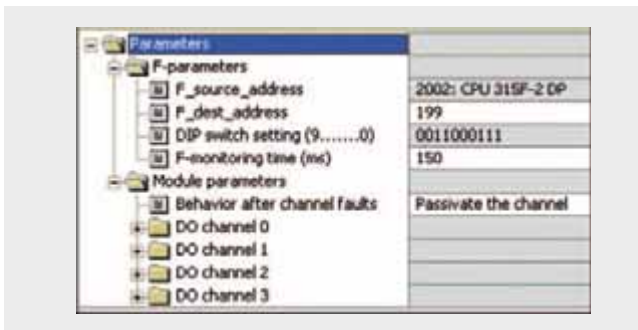
"1oo1 evaluation"

"Type of sensor interconnection":

"1 channel"

Settings of the F-DO

You reach the input dialog in the HW configuration of STEP 7 by double-clicking "4 F-DO DC24V/2A" (see Figure „Overview of the configuration“). All input screens are available in the "Parameter" tab.



"DIP switch setting (9...0)":

The displayed value must be set at the F-DO.

"F-monitoring time (ms)":

"150 ms"

Important: The F-monitoring time must be larger than the call time of OB35. Please use the Cotia table for selecting the monitoring time ("min. F-monitoring time" sheet). In chapter 5 you find the link to the Cotia table.

"Behavior after channel faults":

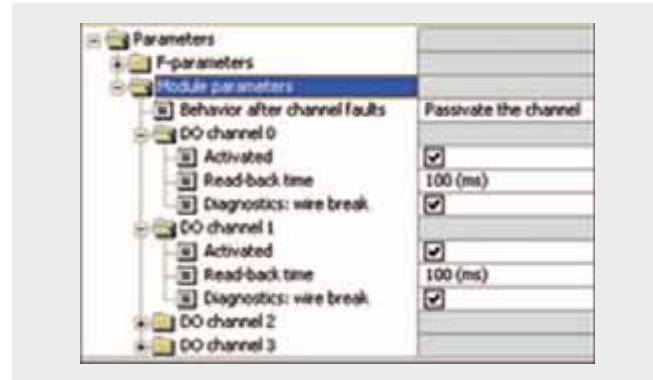
"Passivate the channel"

"Channel 0" and "Channel 1":

"activate"

Unused channels:

"deactivate"



"Channel 0" and "Channel 1":

"Read-back time":

"100 ms"

The read-back time defines the duration of the switch-off procedure for the channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large.

We recommend specific tests for selecting the readback time settings so that the following criteria are met:

As small as possible, however, large enough so that the output channel is not passivated.

"Diagnostics: wire break: "activated"

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Basic Performance Data

Load memory and main memory

	Total	Standard blocks	F blocks (fail-safe)
Load Memory	56.5 KByte	1.2 KByte	55.3 KByte
Main Memory	39.1 KByte	0.5 KByte	38.6 KByte

Determining the memory parameters:

- Open STEP 7 project of the functional example in the SIMATIC Manager
- Determine load memory and main memory for all blocks in the block container

Runtimes

	Time		Note
Total cycle time (standard program and safety program)	minimum	1ms	Read from S7-CPU
	maximum	12ms	
Maximum runtime safety program		13ms	Calculated with Cotia table

Determining the total cycle time:

- Load STEP 7 project into S7-CPU, set S7-CPU to run, and operate the functional example.
- Read the measured cycle time in the "Module Information CPU / Scan Cycle Time" tab

Determine max. runtime of the safety program:

- The value is calculated with the Cotia table for "S7 Distributed Safety" V5.4.

This file is available on the internet:

<http://support.automation.siemens.com/ww/view/en/21627074>

Sample Code

In this chapter you learn how to download the sample code, which functions are realized, how the STEP 7 program is structured and how the functions are operated.

The functional example consists of the documentation on hand and a respective STEP 7 project, the "sample code". Using the sample code and the setup described in chapter 4, you can reproduce the functions described here. For further problems you can use the sample code as a basis.

Download sample code

The sample code is available on the HTML-page of this functional example as a ZIP-file. In order to use the sample code, please proceed as follows:

Load sample code on PC/PG

- Load ZIP-file into any directory on the PC/PG.
Name of the ZIP-file:
22304119_as_fe_i_011_v10_code_pass.zip
- Open the SIMATIC Manager
- Dearchive the ZIP-file into a STEP 7 project

Load STEP7 project to F-CPU

- Activate the "Blocks" folder in the SIMATIC Manager
- Load the hardware configuration into F-CPU
- Select "Edit safety program" in the "Options" menu
- Press "Download" in the "Safety Program" window
- Press "Yes" in the "Cycle program download" window
- Enter password "siemens" in the "Set Permission for the Safety Program" window and press "OK"
- Press "Close" in the "Safety Program" window

Note

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

Functions realized in the sample code

In the sample code, a "hazardous load" is simulated via an indicator light. The indicator light can be switched on via a button and be switched off via an emergency stop button.

For demonstrating the passivation and reintegration of F-I/O-modules, four scenarios have been realized in the sample code. The following table gives an initial overview. An overview of all states and mode transitions is available at page 334.

Scenario	Description
Normal operation	In "normal operation" no F-module has been passivated. An output is switched at an F-DO via a push button. This output can be switched off via an emergency stop button connected at an F-DI.
Manual reintegration	During wire-break at the F-DO only the affected channel of the F-DO is passivated. After repairing the wire break and acknowledgement by the user via a button, the channel is reintegrated.
Automatic reintegration	During wire-break at the F-DI, the entire F-DI is passivated. After repairing the wire-break, the F-DI is automatically reintegrated.
F-communication errors	The connection between F-CPU and the decentralized station is interrupted. Thereafter, the entire F-I/O is passivated. After restoring the connection and acknowledgement by the user via a button, the entire F-I/O is reintegrated.

In the following chapters, the above scenarios are described in greater detail. For clarification, in the "Overview hardware configuration" view the respectively affected buttons and indicator lights are marked by a thick frame.

Scenario: Normal operation

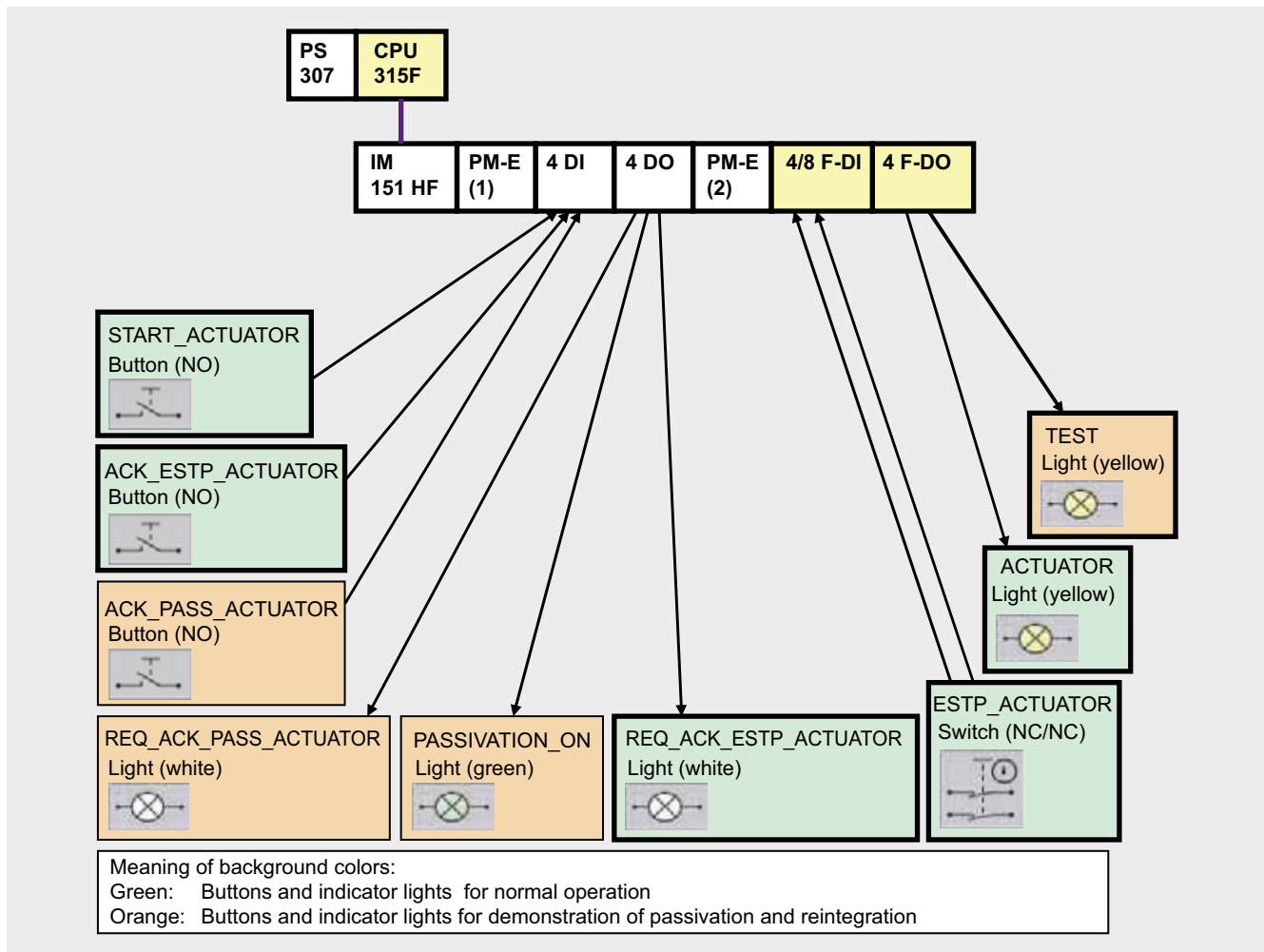
The ACTUATOR indicator light is switched on if the START_ACTUATOR button is pressed and the ESTP_ACTUATOR emergency stop button is not activated.

The TEST indicator light is always switched on. It is controlled with "1" via the input of the F-DI constant.

Pressing the ESTP_ACTUATOR emergency stop button switches the ACTUATOR indicator light off.

After unlocking the ESTP_ACTUATOR emergency stop button and acknowledgement via the ACK_ESTP_ACTUATOR button, the ACTUATOR indicator light can be switched on again via the START_ACTUATOR button.

Overview for hardware setup



Scenario: Manual reintegration

Disconnecting the F-DO and the switched on ACTUATOR indicator light (simulated wire-break) a channel error, hence passivation, is triggered. The PASSIVATION_ON indicator light is switched on.

The F-DO is configured with "Passivate channels", therefore not the entire F-DO is passivated, but only the affected channel. This is made clear by the fact that the TEST indicator light remains switched on.

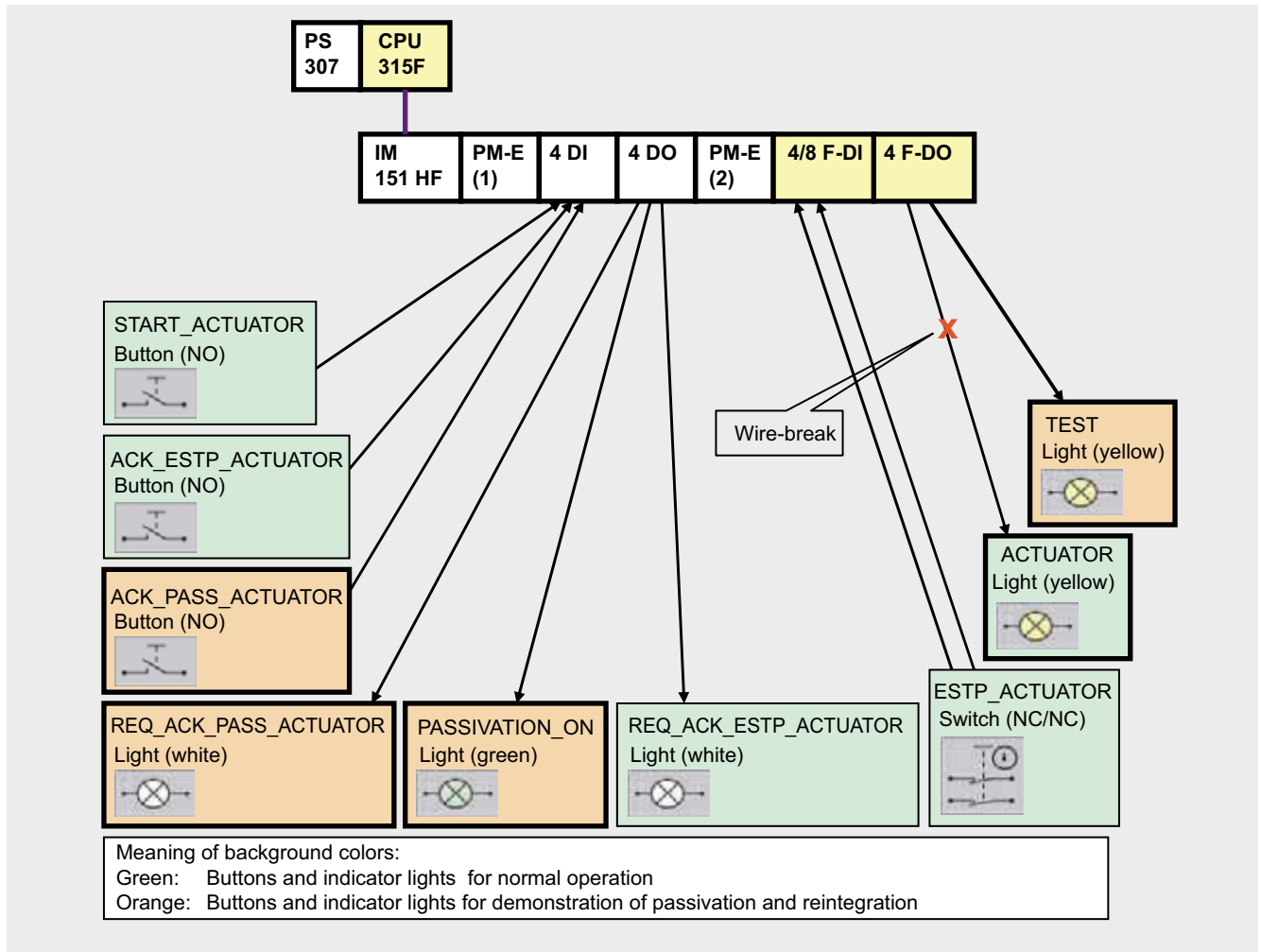
After restoring the connection, the channel remains passivated, the ACTUATOR indicator light remains switched off.

An acknowledgement is requested from the user by switching on the REQ_ACK_PASS_ACTUATOR indicator light.

After the user has acknowledged via the ACK_PASS_ACTUATOR button, the passivation of the channel is cancelled. The channel however remains switched off.

The ACTUATOR indicator light is only switched on again after the user has additionally acknowledged START_ACTUATOR button.

Overview for hardware setup



Scenario: Automatic reintegration

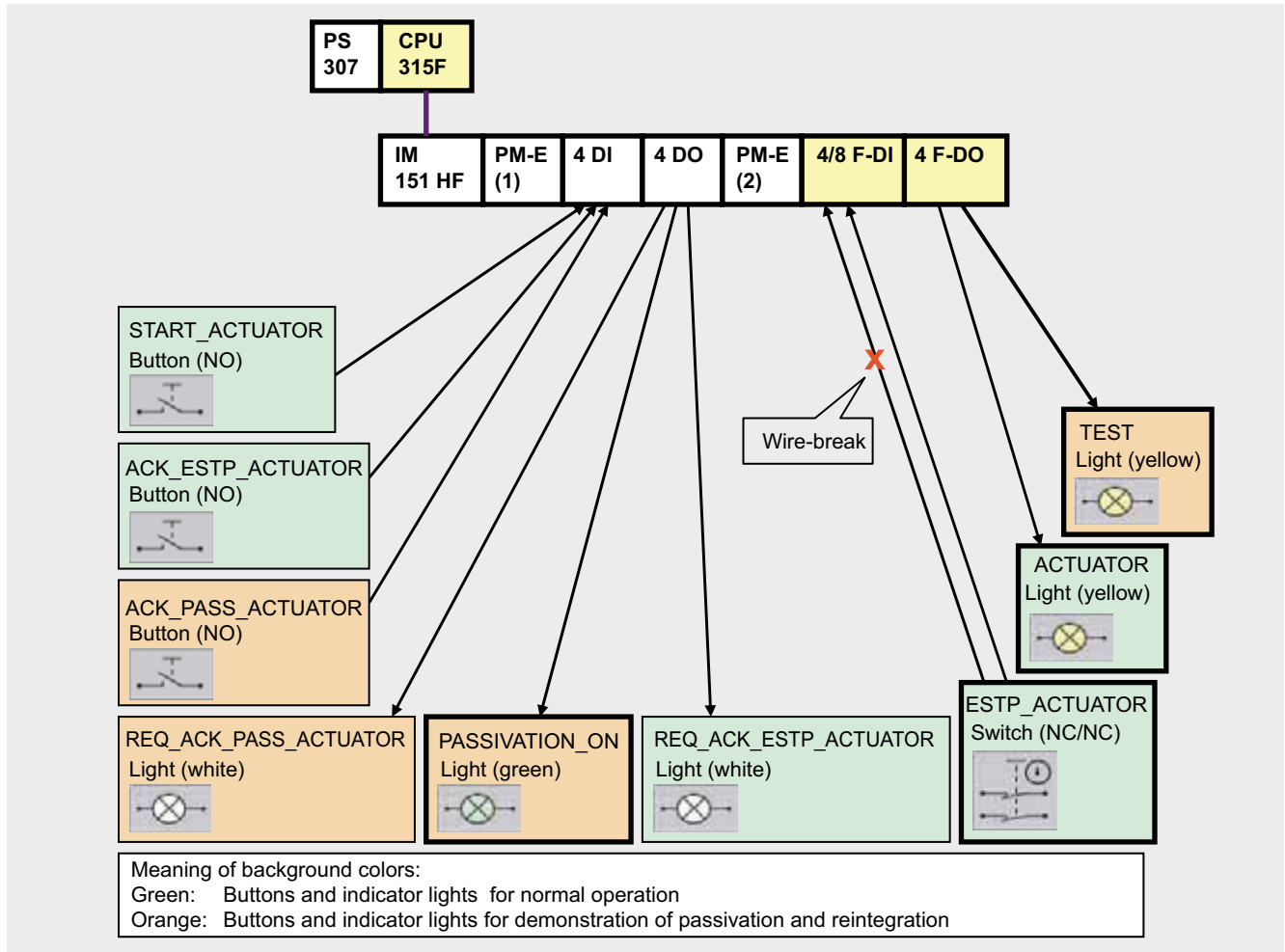
Disconnecting an F-DI and the ESTP_ACTUATOR emergency stop button, a channel error, hence passivation, is triggered. The PASSIVATION_ON indicator light is switched on, the ACTUATOR indicator light is switched off. The F-DI is configured with "Passivate the entire module", which is why the entire F-DI is passivated. This is made clear by the fact that the TEST¹⁾ indicator light is switched off.

After restoring the connection, the module is automatically reintegrated, the TEST indicator light is switched on.

After acknowledging the user via the ACK_ESTP_ACTUATOR button, the ACTUATOR indicator light can be switched on via the START_ACTUATOR button.

Warning!
Automatic reintegration is only permitted if an automatic startup of the plant is not possible after the error has been removed.

Overview for hardware setup



1) TEST indicator light is controlled with "1" via the input of the F-DI. Due to passivation of the entire module, the safety program now reads "0" at the input instead of "1".

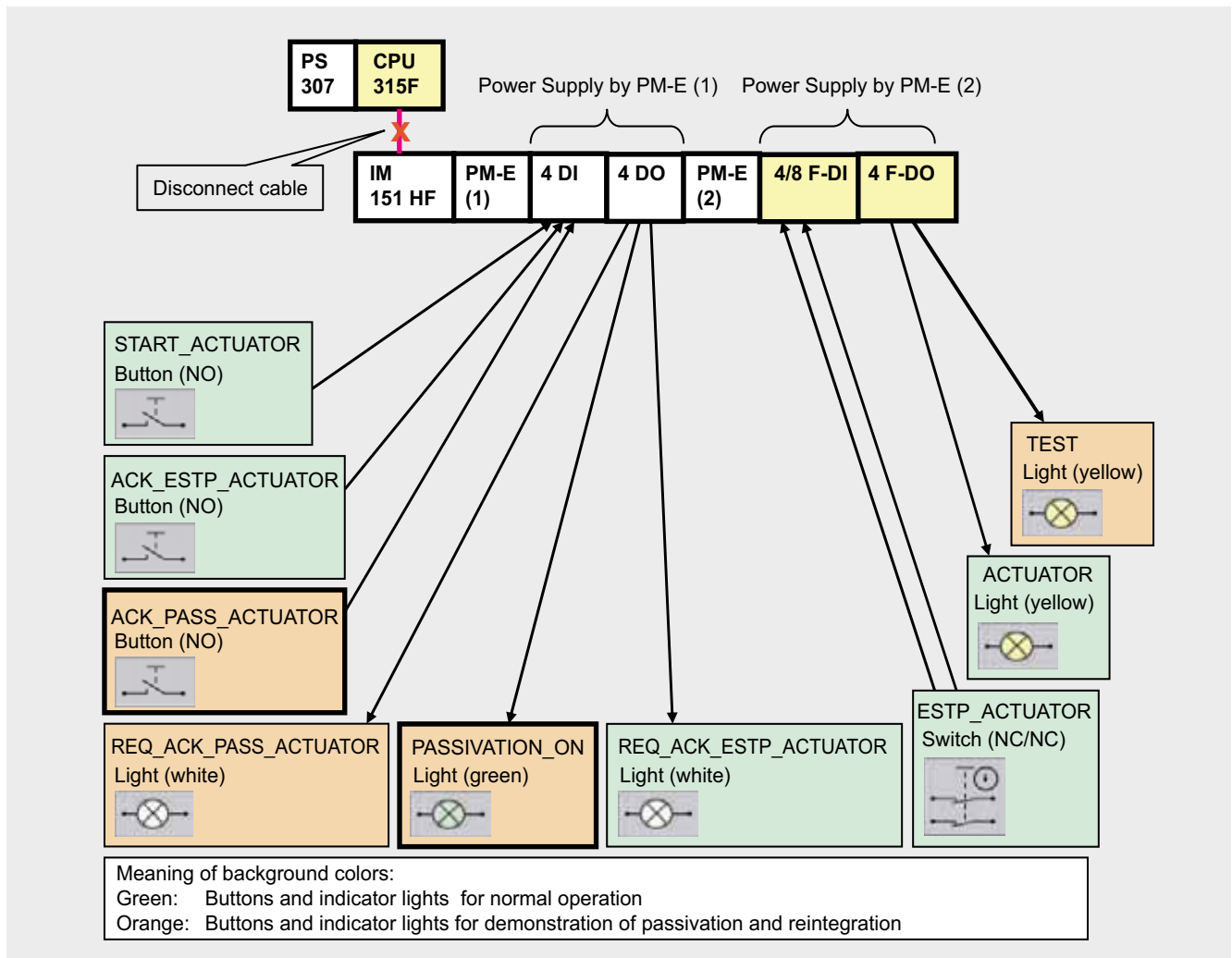
Scenario: F-communication error

Disconnecting the F-CPU and the decentralized station (unplugging the PROFIBUS DP cable) causes passivation of the entire F-I/O-modules in the distributed station.

After restoring the connection (plugging the PROFIBUS DP cable back in) the F-I/O-modules remain passivated. The switched on PASSIVATION_ON indicator light indicates this.

If the user acknowledges via ACK_PASS_ACTUATOR, the F-I/O is reintegrated.

Overview for hardware setup



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Overview of the scenarios:

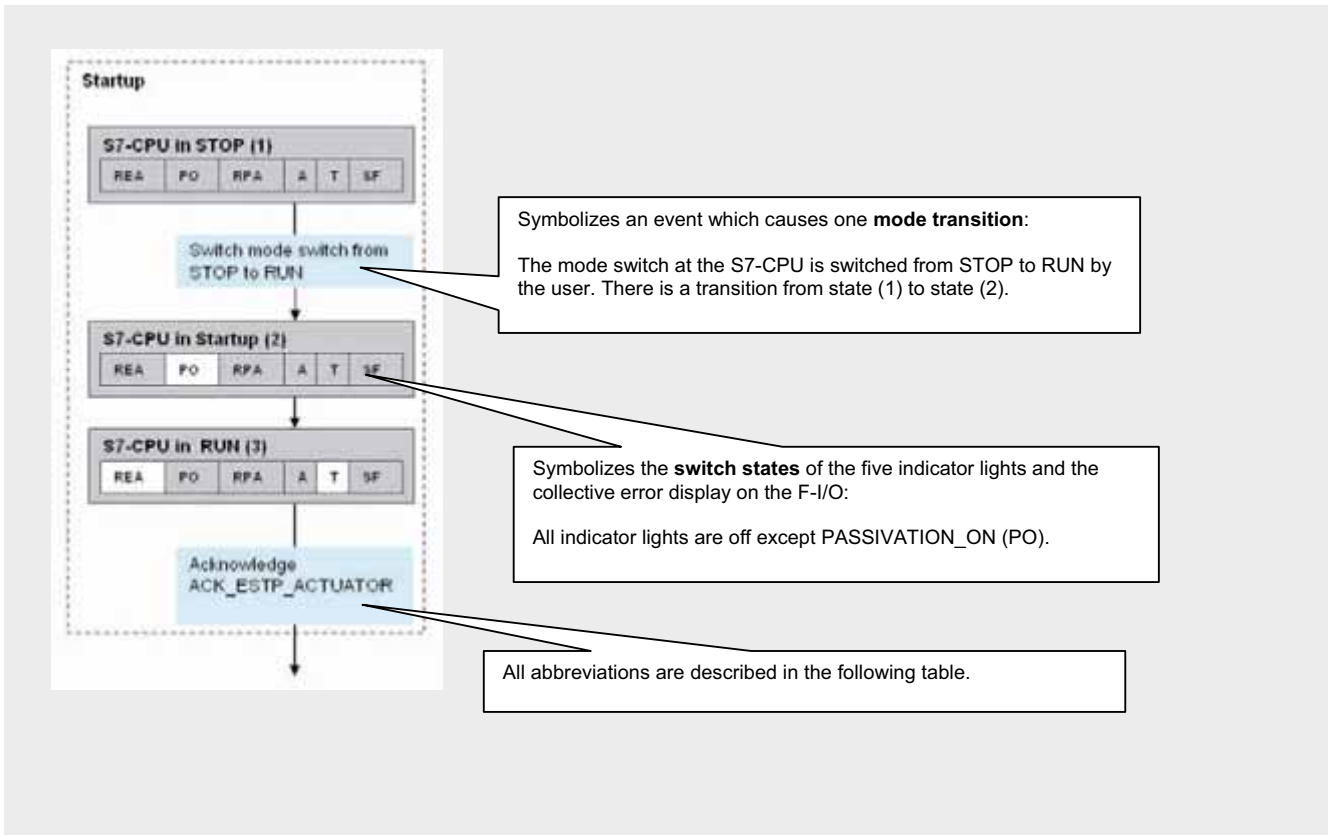
At page 334 indicates the states and mode transitions of the sample code following scenarios:

- Startup
- Normal operation
- Manual reintegration
- Automatic reintegration

The following figure shows you:

- What effect pressing the button has?
- When do which indicator lights come on?

The following figure explains the used representation method, using the example of the "Startup" scenario.



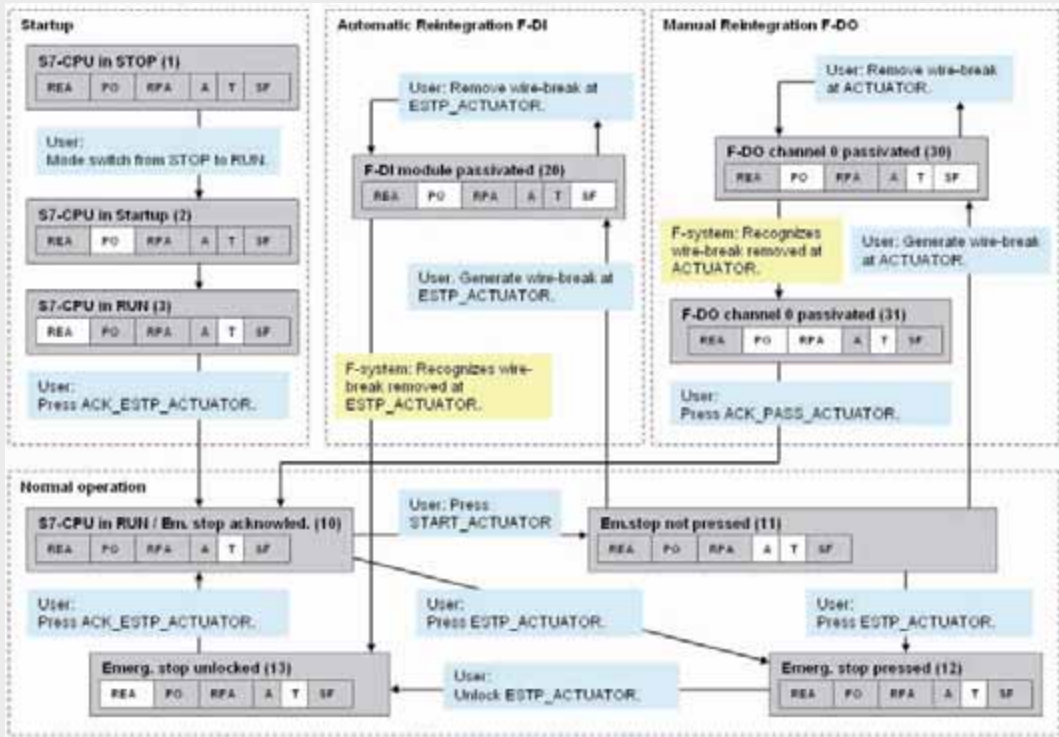
Overview of buttons and indicator lights

Symbol	Abbreviations	HW component	Function
START_ACTUATOR	---	Button	Switch on ACTUATOR indicator light
ACK_ESTP_ACTUATOR	---	Button	Acknowledge ACTUATOR emergency stop actuator
ACK_PASS_ACTUATOR	---	Button	Acknowledge ACTUATOR passivation
ESTP_ACTUATOR	---	Emergency stop push button at F-DI	ACTUATOR emergency stop
REQ_ACK_ESTP_ACTUATOR	REA	Indicator light	Acknowledge ACTUATOR emergency stop requirement
REQ_ACK_PASS_ACTUATOR	RPA	Indicator light	Acknowledge ACTUATOR passivation requirement
PASSIVATION_ON	PO	Indicator light	Passivation exists
ACTUATOR	A	Indicator light at F-DO	Simulation of "hazardous load"
TEST	T	Indicator light at F-DO	Only switched off if F-DI passivated.
---	SF	LED on F-module	Collective error display

Meaning of background colors

Section	Color	Meaning
Mode transitions / actions	light blue	Action by user
	light yellow	Action by F-system
Overview of indicator light:	white	Indicator light is switched on
	gray	Indicator light is switched off

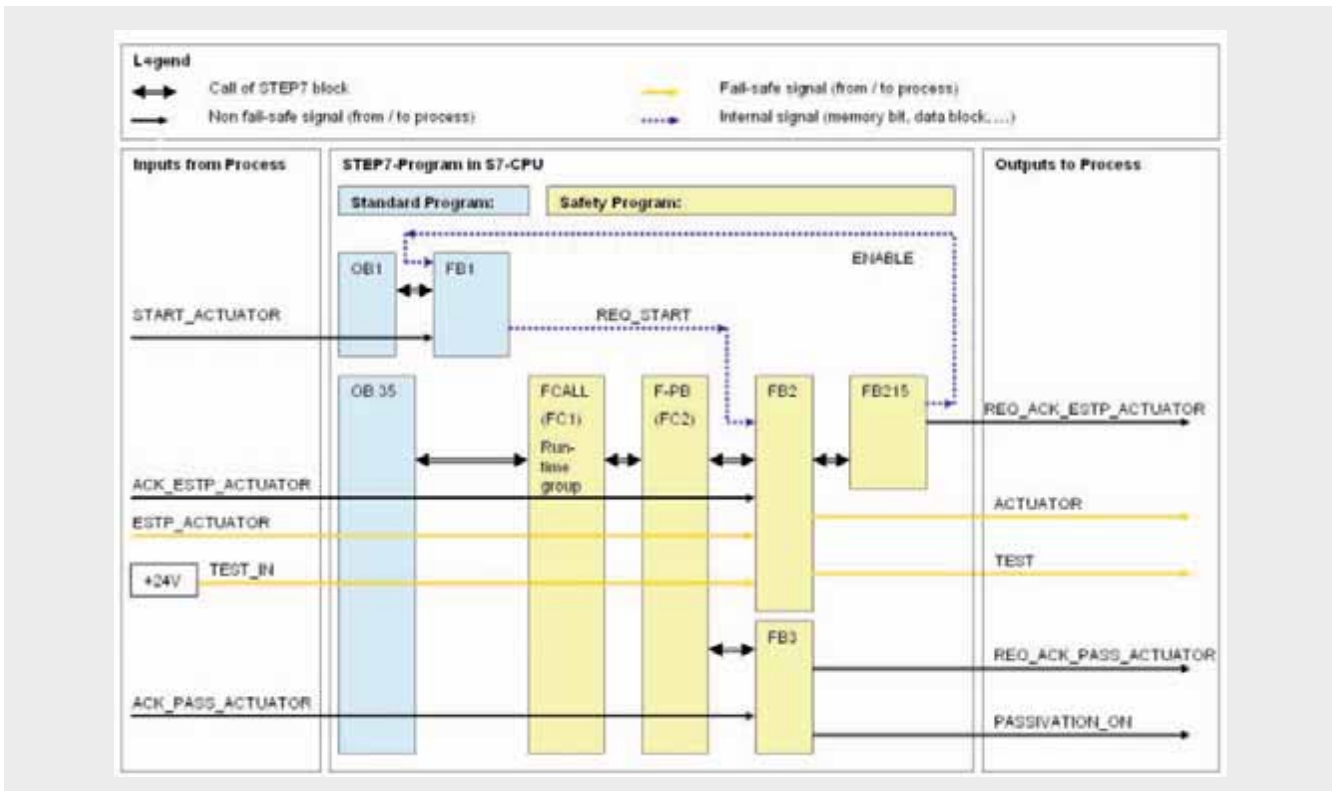
Overview of states and mode transitions of the sample code



Explanations for the STEP 7 program

Interaction of STEP 7 blocks

The following figure displays the interaction between the STEP 7 blocks and the connection to the process I/O. The description of the process signals is available at page 321.



Program	Block	Name	Tasks
Standard program	OB1	---	Cyclic program: Call of FB1 (START)
	OB35	---	Periodic call of F-runtime group (FCALL)
	FB1	START	Operational switching: Generating the start requirement (REQ_START)
Safety program	FCALL	FCALL	F run-time group (FCALL)
	F-PB	COORDINATION	F-program block: Calls FB2 and FB3
	FB2	MODE	Call FB215 (F_ESTOP1): Controlling ACTUATOR and TEST
	FB3	REINTEGRATION	Display passivation, automatic F-DI reintegration, manual F-DI and F-DO reintegration,
	FB215	F_ESTOP1	F-block from Distributed Safety library: "Emergency stop up to stop category 1" Creating ENABLE for emergency stop circuit

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Description: F-I/O-module data blocks

Function and design of the F-blocks:

- See page 349

The following F-I/O-module data blocks are used in the sample code:

- DB819: F-I/O-module data block of F-DI
- DB820: F-I/O-module data block of F-DO

Description: OB1

Function of the standard block:

- Cyclic call of FB1 (START)

Parameter of the standard block:

- None

Description: OB35

Function of the standard block:

- Periodic call of F-runtime group (FCALL): The safety program is called every 50 msec.

Parameter of the standard block:

- None

Description: FB1, DB2 (START)

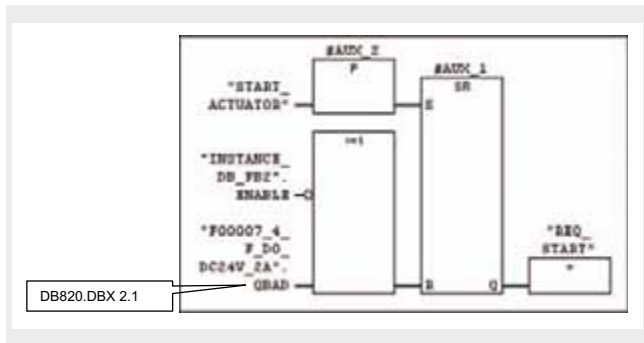
Function of the standard block:

- Operational switching: Generating the standard requirement REQ_START for the ACTUATOR indicator light.

Parameter of the standard block:

- None

FB1 / Network 1



Overview of the signals of the network:

Signal	Source / Target	Meaning
START_ACTUATOR	From process (button)	Start button for ACTUATOR
INSTANCE_DB_FB2.ENABLE	From F-block FB215	Enable from emergency-stop circuit
F00007_4_F_DO_DC24V_2A.QBAD	From F-I/O-module data block of F-DO	Display, whether F-DO has been passivated
REQ_START	To F-block FB2	Start request for ACTUATOR

Description of the network function:

The standard requirement REQ_START for the ACTUATOR indicator light is generated if the following conditions are true at the same time (AND):

- The START_ACTUATOR start button was pressed
- The ENABLE from the emergency-stop circuit (FB215) exists
- The F-DO is not passivated

The start requirement REQ_START is evaluated in the F-block FB2. FB215 is a block from the Distributed Safety library.

Description: FCALL

Function of the F-block:

- F run-time group: Call of safety program

Parameter of the F-block:

- None

Description: F-PB (COORDINATION)

Function of the F-block:

- Call of F-block FB2
- Call of F-block FB3

Parameter of the F-block:

- None

Description: FB2, DB3 (MODE)

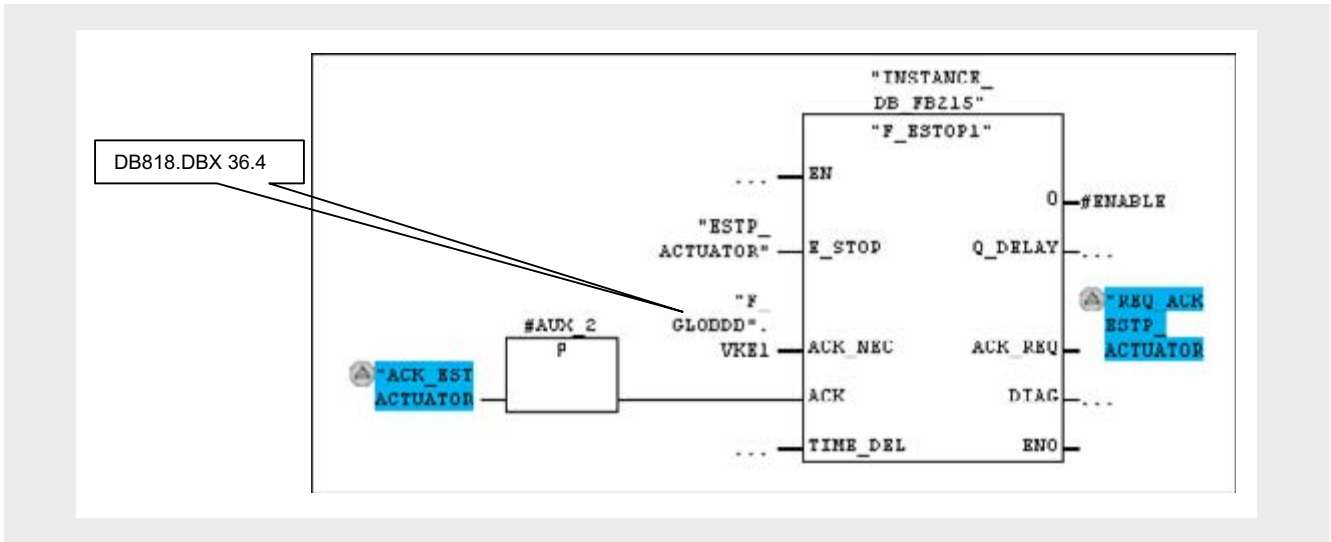
Function of the F-block:

- Realizing the emergency stop functionality for the ACTUATOR indicator light
- Controlling both indicator lights, ACTUATOR and TEST

Parameter of the F-block:

- None

FB2 / Network 1



Overview of the signals of the networks:

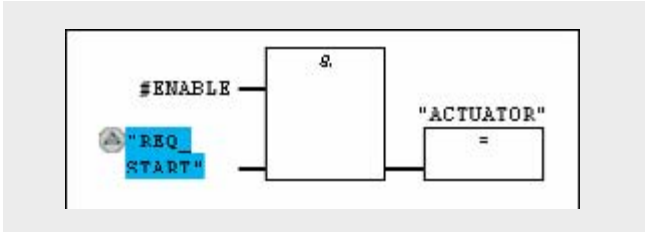
Signal	Source / Target	Meaning
ACK_ESTP_ACTUATOR	From process (button)	Acknowledgement for emergency-stop circuit
ESTP_ACTUATOR	From process (button)	Emergency-stop button
F_GLOBDB.VKE1	From F-Global-DB	Result of logic operation "1"
ENABLE	To FB1 (standard block)	Enable for emergency-stop circuit
REQ_ACK_ESTP_ACTUATOR	To process (indicator light)	Acknowledgement for emergency-stop circuit requirement

The F-Global-data block (F_GLOBDB) is a fail-safe data block, which contains all global data of the safety program as well as additional information for the F-system. Amongst other things, VKE0 and VKE1 provided there.

Description of the network function:

Here the emergency stop functionality for the ACTUATOR indicator light is realized. The FB215 is called for this. FB215 is an F-block from the Distributed Safety library.

FB2 / Network 2



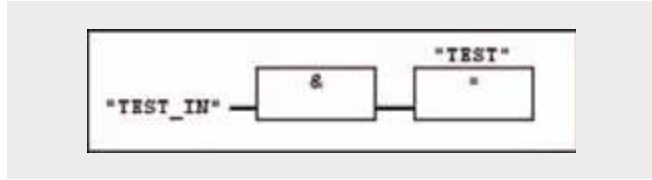
Overview of the signals of the network

Signal	Source / Target	Meaning
ENABLE	From network 1	Enable from emergency-stop circuit
REQ_START	From FB1 (standard block)	Start requirement for ACTUATOR
ACTUATOR	To process (indicator light)	Representative for a "hazardous load".

Description of the network function:

The ACTUATOR load is switched on if the ENABLE from the emergency-stop circuit is pending and the start requirement REQ_START is given.

FB2 / Network 3



Overview of the signals of the network

Signal	Source / Target	Meaning
TEST_IN	From process („1“)	Signal from F-DI "1" is constantly set at F-DI.
TEST	To process (indicator light)	Only for demonstration, no other function.

Description of the network function:

TEST is used to demonstrate passivation of the entire module. When there is no passivation, TEST is always switched on, as TEST_IN at the F DI is constantly supplied with "1".

The TEST indicator light is only switched off if F-DI is passivated.

Description: FB3, DB4 (REINTEGRATION)

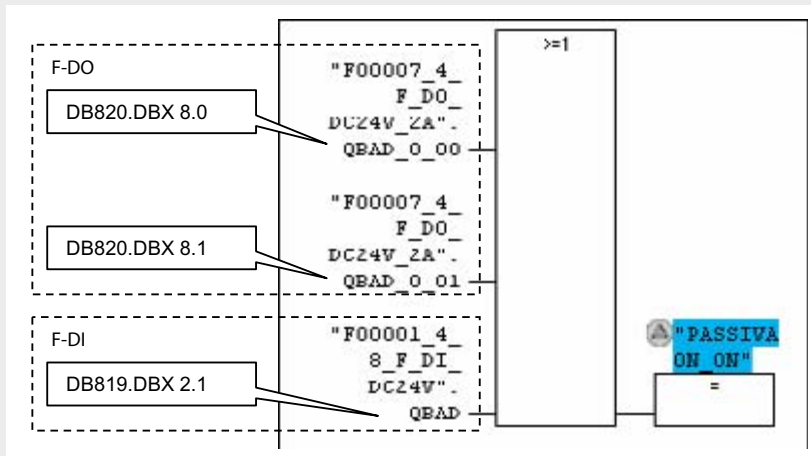
Function of the F-block:

- Display of passivation at the PASSIVATION_ON indicator light
- Automatic reintegration of the F-DI
- Manual reintegration of F-DI/F-DO

Parameter of the F-block:

- None

FB3 / Network 1



Overview of the signals of the network:

Signal	Source / Target	Meaning
F00007_4_F_DO_DC24V_2A.QBAD_0_00	From F-I/O-module data block of F-DO	If "1": channel F-DO is passivated
F00007_4_F_DO_DC24V_2A.QBAD_0_01		If "1": channel 1 of F-DO is passivated
F00001_4_8_F_DI_DC24V.QBAD	From F-I/O-module data block of F-DI	If "1": At least one channel of the F-DI is passivated.
PASSIVATION_ON	To process (indicator light)	If "1": At least one channel of F-DI and/or F-DO is passivated.

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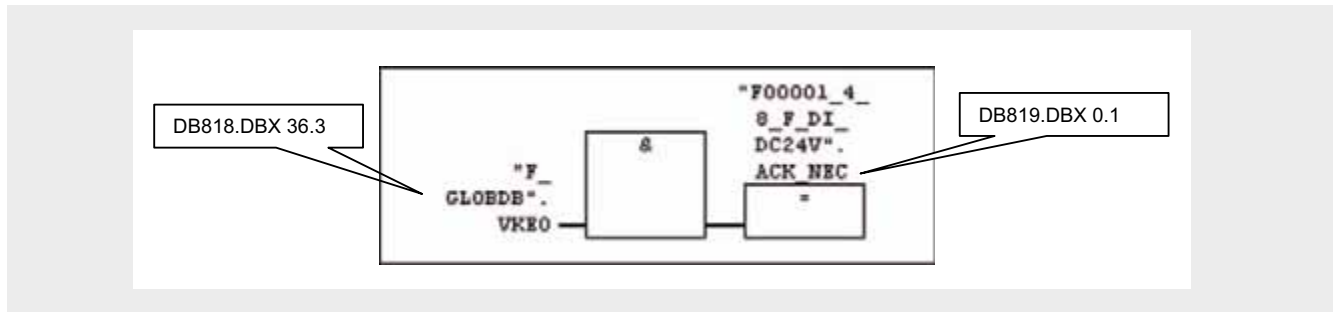
Description of the network function:

The PASSIVATION_ON indicator light indicates that at least one channel of F DO and/or F-DI is passivated. Basically, there are two different methods to test whether at least one channel of a module is passivated:

Method	Advantage
1 Polling all channels of the F-module: <ul style="list-style-type: none"> for F-DI: via the "QBAD_I_xx" variables for F-DO: via the "QBAD_O_xx" variables 	The passivated channels can be identified individually.
2 Polling the entire F-module: <ul style="list-style-type: none"> via the "QBAD" variable. 	Polling only possible once.

In the sample code both methods are used for demonstration purposes. "Method 2" can also be used here to detect whether the F-DO is passivated.

FB3 / Network 2



Overview of the signals of the network:

Signal	Source / Target	Meaning
F_GLOBDB.VKE0	From F-Global-DB	Result of logic operation "0"
F00001_4_8_F_DI_DC24V.ACK_NEC	To F-I/O-module data block of F-DI	F-DI is automatically reintegrated

The F-Global data block (F_GLOBDB) is a fail-safe data block which contains all global data of the safety program as well as additional information for the F-system.

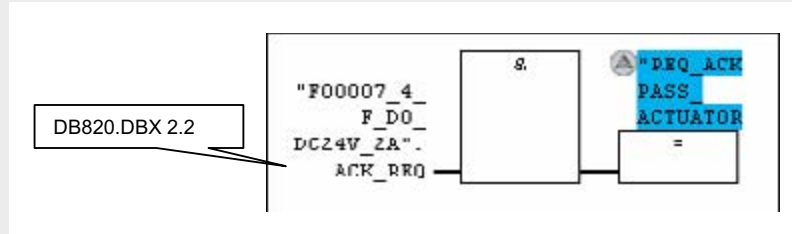
Amongst other things, VKE0 and VKE1 provided there.

Description of the network function:

Channel or module errors at the F-DI cause passivation of the F-DI at the entire module. After removing the error, the F-DI is automatically reintegrated.

Warning
Automatic reintegration is only permitted if an automatic startup of the plant is not possible after the error has been removed.

FB3 / Netzwerk 3



Overview of the signals of the network:

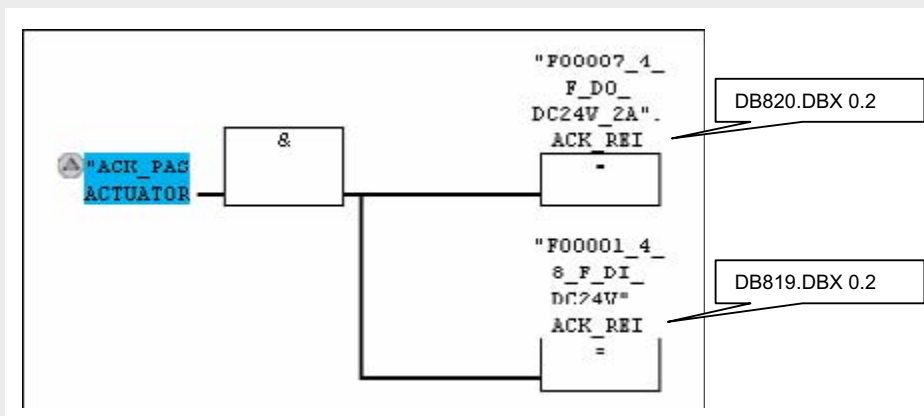
Signal	Source / Target	Meaning
F00007_4_F_DO_DC24V_2A.ACK_REQ	From F-I/O-module data block of F-DO	If "1": The error that caused the passivation has been removed. Acknowledgement for reintegration by the user is now possible.
REQ_ACK_PASS_ACTUATOR	To process (indicator light)	Indicates to the user, that reintegration requires acknowledgement.

Description of the network function:

A channel error at the F-DO in the sample code causes passivation of the F-DO channels. After removing the error, the F-DO is manually reintegrated.

The REQ_ACK_PASS_ACTUATOR indicator light shows the user, that reintegration requires acknowledgement.

FB3 / Network 4



Overview of the signals of the network:

Signal	Source / Target	Meaning
ACK_PASS_ACTUTOR	From process (button)	Acknowledgement by the user for manual reintegration
F00007_4_F_DO_DC24V_2A.ACK_REI	To F-I/O-module data block of F-DO	If "0->1": F-DO is reintegrated.
F00001_4_8_F_DI_DC24V.ACK_REI	To F-I/O-module data block of F-DI	If "0->1": F-DI is reintegrated.

Description of the network function:

F-DO and F-DI are reintegrated after acknowledgement by the user:

- Manual reintegration of the F-DO is necessary in the sample code after channel or F-communication error.
- Manual reintegration of the F-DI is necessary in the sample code only after F-communication error.

Description: FB 215, DB1 (F_ESTOP1)

The block is a TÜV certified application block from the Distributed Safety library.

Function and parameter of the F-blocks:

- See STEP 7 online-help

Operating instruction on the sample code

This chapter describes the operation of the functional example.

The operation is divided into different scenarios

Scenario	Page
Normal operation	343
Manual reintegration after wire-break at F-DO	344
Automatic reintegration after wire-break at F-DI	345
Reintegration after F-communication error	346

The following prerequisites must be fulfilled in order to operate the functional example:

- The hardware configuration, the standard program, and the safety program are located on the F-CPU
- Emergency stop unlocked

As a description, tables with uniform structure are used below. The columns of the table have the following meaning:

Column name	Column content
"Step"	Number of the operational step
"Action"	Action of user
"State"	The number marks the state reached after executing the action. An overview of all status is available at page 334.
"Comment"	Comments on the step.
"Indicator light"	Here the switch status of the five indicator lights and the SF LED is depicted which is set after executing the action. Switched indicator lights are marked with "1". (*1)
"SF-LED"	The column indicates the status of the collective error display on the F-I/O-module (red LED). (*1)

(*1): To recognize more clearly which bits change during a mode transition, they are shaded in gray: If a bit is shaded gray, it has changed compared with its previous state.

Operation: Normal operation

Operation in the following table shows the procedure:

- Start und emergency stop of the load

A more detailed description of the scenario, with overview image on the hardware setup, is available at page 328.

Step	Action	State (*1)	Comment	Indicator light / SF-LED					
				A	B	C	D	E	F
1	Mode switch at the F-CPU from STOP to RUN.	3		1	0	0	0	1	0
2	Press ACK_ESTP_ACTUATOR	10	Always after starting the F-CPU	0	0	0	0	1	0
3	Press START_ACTUATOR	11	Switch on load	0	0	0	1	1	0
4	Press ESTP_ACTUATOR	12	Press emergency stop	0	0	0	0	1	0
5	Unlock ESTP_ACTUATOR	13	Unlock emergency stop	1	0	0	0	1	0
6	Press ACK_ESTP_ACTUATOR	10	Acknowledge emergency stop	0	0	0	0	1	0
7	Press START_ACTUATOR	11	Switch load back on	0	0	0	1	1	0

Explanations on the table:

(*1):

At page 334 you find an overview of statuses and mode transitions of the sample code. The area in the figure marked as "Normal operation" is relevant here.

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Operation: Manual reintegration

Operation in the following table shows the procedure:

- Simulation of a wire-break at the load
- Passivating an F-DO channel
- Manual reintegration after removing the wire-break

Please observe the following:

- A wire-break at F-DO is only recognized when the channel is switched on.
- Reintegration of an F-DO may take several minutes.

A more detailed description of the scenario, with overview image on the hardware setup, is available at page 329.

Step	Action	State (*1)	Comment	Indicator light / SF-LED					
				A	B	C	D	E	F
---	---	11	This is the initial state for the following operations.	0	0	0	1	1	0
1	Disconnect F-DO ACTUATOR indicator light	30	Due to passivation of the channels the TEST indicator light remains switched on.	0	1	0	0	1	1
2	Restoring the connection	30	The state remains until the F-system recognizes that the wire-break has been removed.	0	1	0	0	1	1
		31	The F-system requests acknowledgement for reintegration.	0	1	1	0	1	0
3	Press ACK_PASS_ACTUATOR	10	After acknowledgement by the user, the F-DO channel is reintegrated.	0	0	0	0	1	0

Explanations on the table:

(*1):

At page 334 you find an overview of statuses and mode transitions of the sample code. The area in the figure marked as "Manual reintegration of F-DO" is relevant here.

Operation: Automatic reintegration

Operation in the following table shows the procedure:

- Simulating a wire-break at the emergency stop button.
- Passivation of the entire F-DI
- Automatic reintegration after removing the wire-break

A more detailed description of the scenario, with overview image on the hardware setup, is available at page 330.

Step	Action	State (*1)	Comment	Indicator light / SF-LED					
				A	B	C	D	E	F
---	---	11	This is the initial state for the following operations.	0	0	0	1	1	0
1	Disconnecting F-DI and ESTP_ACTUATOR emergency stop	20	Due to passivation of entire module, the TEST and ACTUATOR indicator lights are switched off.	0	1	0	0	0	1
2	Restoring the connection	20	The state remains until the F-system recognizes that the wire-break has been removed.	0	1	0	0	0	1
		13	The F-DI module is reintegrated.	1	0	0	0	1	0

Explanations on the table:

(*1):

At page 334 you find an overview of statuses and mode transitions of the sample code. The area in the figure marked as "Automatic reintegration of F-DI" is relevant here.

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Operation: F-communication error

Operating in the following table shows the procedure:

- Pulling the PROFIBUS DP cable from the F-CPU
- Restoring the connection
- Reintegration

A more detailed description of the scenario, with overview image on the hardware setup, is available at page 331.

Step	Action	Zustand (*1)	Comment	Indicator light / SF-LED					
				A	B	C	D	E	F
---	---	11	This is the initial state for the following operations.	0	0	0	1	1	0
1	Removing the PROFIBUS DP cable	-		0	0	0	0	0	0 (*2)
2	Restoring the connection	-		0	1	0	0	0	0 (*3)
	Press ACK_PASS_ACTUATOR	10	After acknowledgement by the user, the F-I/O-module is reintegrated.	1	0	0	0	1	0

Explanations on the table:

(*1):

At page 334 you find an overview of statuses and mode transitions of the sample code.

(*2):

The BF-LED at "IM 151 HF" lights up. The BF-LED at "IM 151 HF" is blinking.

(*3):

The BF-LEDs are off.

Background Knowledge on the Functional Example

This chapter provides background knowledge on "Passivation and Reintegration" in the "S7 Distributed Safety" system.

All of the information given is taken from the "S7 Distributed Safety" manuals and the STEP 7 online help.

Note

If already familiar with passivation and reintegration, you won't need to read this chapter.

This chapter is not necessary for setup and operation of this functional example.

Use the current "S7 Distributed Safety" manuals for your current project.

The following topics are described:

Topic	Page	Content
F-I/O-module	348	What are fail-safe I/O-modules? How does the user access inputs and outputs?
F-I/O-module data block	349	What is an F-I/O-module data block What is an F-I/O-module data block used for? What is the structure of an F-I/O-module data block?
Passivation (of entire module or channel)	353	What happens during passivation? What type of passivation exists? How is the "passivation of channels" realized?
Reintegration (of entire module or channel)	355	What happens during reintegration? What type of reintegration exists?
Process: channel / module error (automatic reintegration)	358	Description of variants of passivation and reintegration:
Process: channel / module error (manual reintegration)	359	What is the principal procedure? Which variables are involved in the F-I/O-module data block?
Process: F-communication error	360	
Process: safety program	361	
Process: group passivation	362	

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F-I/O-module

What are fail-safe I/O-modules?

Fail-safe I/O-modules differ from standard modules mainly by their internal two channel structure. Two integrated processors mutually monitor and test the input and output circuits automatically. The connected sensors and actuators are also monitored (wire-break, discrepancy, etc.). In case of an error, the processors turn the F-I/O-module fail-safe.

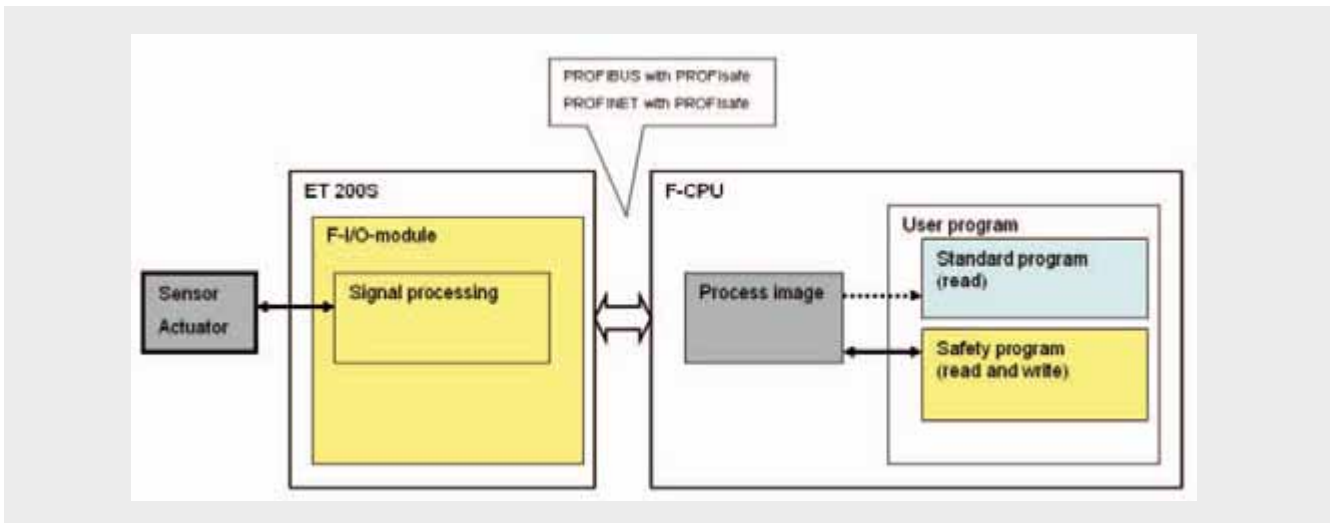
The F-CPU communicates with a distributed F-I/O-module via the fail-safe PROFIsafe profile. The PROFIsafe profile is integrated in the PROFIBUS and PROFINET telegrams.

How does the user access inputs and outputs?

The inputs and outputs of an F-I/O-module are accessed via the process image of the F-CPU:

Access to F-I/O-module	Process image	
	Inputs	Outputs
In standard program	read	read
In the safety program	read	write

The following figure illustrates the relationships.



F-I/O-module data block

What is an F-I/O-module data block

For every F-I/O-module one data block is automatically generated during compilation in the STEP 7 hardware configuration.

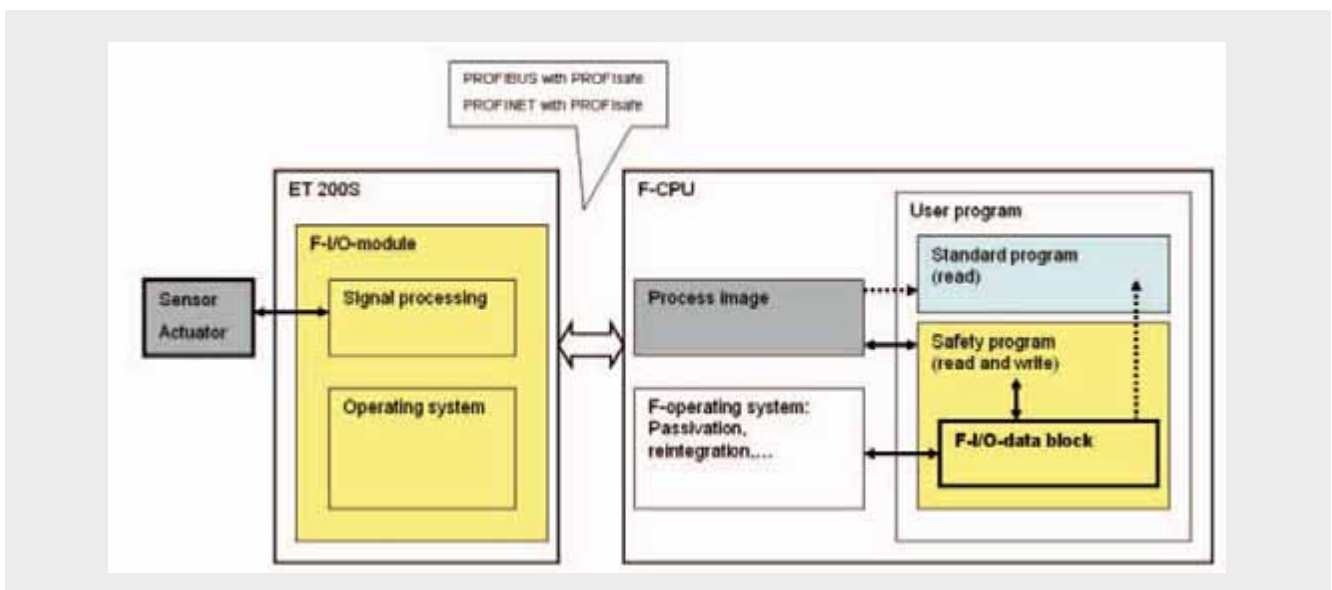
The F-I/O-module data block is the interface between the user program and the F-system. Control and status information of the F-I/O-module are exchanged via the interface.

The F-I/O-module data block contains variables which can be accessed by the safety program as well as the standard program. The F-I/O-module data block does not contain any process values. The process values are located in the process image of the F-CPU.

Access to the F-I/O-module data block

In standard program	read
In the safety program	read and write

The following figure illustrates the relationships.



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What is the F-I/O-module data block used for?

The following functions can be realized with the variables of the F-I/O-module data block:

- Checking whether current F-I/O-modules or individual F-I/O-module channels are passivated.
- Manual or automatic reintegration of F-I/O-modules after error recovery.
- Passivation and reintegration of F-I/O-modules via the safety program.
- Reconfiguration of fail-safe DP-standard slaves.

What is the structure of an F-I/O-module data block?

The two following tables explain the variables of the F-I/O-module data block. Both tables differ in the type of user access to the variables:

- Read and write access by the user: page 351
- Read access by the user: page 352

The variables of the F-I/O-module data block can, for example, be monitored with the variable table in STEP 7. The following table gives examples:

Operand	Symbol	Comment
DB819.DBX 0.0	"F00001_4_8_F_DI_DC24V".PASS_ON	Variable "PASS_ON" der F-DI
DB820.DBX 2.1	"F00007_4_F_DO_DC24V_2A".QBAD	Variable "QBAD" der F-DO

The user has read and write access to the following variables in the F-I/O-module data block.

Variable (Type)	Declaration	Address	Default value	What reactions can be triggered by the user?	Reaction of the F-Systems
PASS_ON (BOOL)	IN	0.0	0	Passivation and reintegration of F-I/O-module via the safety program.	"PASS_ON = 1": The F-I/O-module is reintegrated.
					"PASS_ON = 0": The F-I/O-module is reintegrated. The passivation was previously triggered with "PASS_ON = 1".
					Comment: PASS_OUT does not change its value when writing PASS_ON. The ACK_NEC and ACK_REI are not relevant here
ACK_NEC (BOOL)	IN	0.1	1	Selecting the type of reintegration: <ul style="list-style-type: none"> Manual: with user acknowledgement Automatic: without user acknowledgement 	"ACK_NEC = 1": Reintegration occurs manually. Reintegration requires user acknowledgement: Positive edge at ACK_REI
					"ACK_NEC = 0": Reintegration occurs automatically without acknowledgement by the user. For "F-communication error" automatic reintegration is not possible!
					Comment: Reintegration is only possible when the error causing the passivation has been removed. ACK_NEC is only relevant for "channel" and "module" errors.
ACK_REI (BOOL)	IN	0.2	0	Acknowledgement by the user at manual reintegration	"ACK_REI = 0->1" (positive edge): Reintegration occurs after positive edge.
					Comment: Acknowledgement by the user is only possible when the error causing the passivation has been removed. For "F-communication errors" acknowledgement by the user must always occur independent of ACK_NEC.
IPAR_EN (BOOL)	IN	0.3	0	---	Reconfiguration of fail-safe DP-standard slaves.

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The user has only read access to the following variables in the F-I/O-module data block.

Variable (Type)	Declaration	Address	Default value	Which information does the user receive when reading the variables?
PASS_ON (BOOL)	OUT	2.0	1	"PASS_OUT = 1": The F-I/O-module is passivated. Cause of the passivation: "F-communication error", "module error", "channel error" (see page 354).
				"PASS_OUT = 0 UND QBAD = 1": The F-I/O-module is passivated. Cause of the passivation: "PASS_ON = 1" was set in the safety program.
				Comment: Depending on the settings in the hardware configuration of STEP 7 the entire module or only faulty channels are passivated.
QBAD (BOOL)	OUT	2.1	1	"QBAD = 1": Currently the substitute value ("0") is used for at least one channel instead of the process value. Which channels are passivated is indicated via the QBAD_I_xx or QBAD_O_xx variables (see below).
ACK_REQ (BOOL)	OUT	2.2	0	"ACK_REQ = 1": The error that caused the passivation has been removed. Acknowledgement for manual reintegration (ACK_REI) by the user is now possible. Cause of the passivation: "F-communication error", "module error", "channel error" (see page 354).
				Comment: If the error causing the passivation has been removed, and this has been recognized by the F-system, the F-system sets "ACK_REQ = 1". After acknowledgement by the user, the F-operating system sets "ACK_REQ = 0".
IPAR_OK (BOOL)	OUT	2.3	0	Reconfiguration of fail-safe DP-standard slaves.
DIAG (BYTE)	OUT	3.0	0	Service information
QBAD_I_xx (BOOL)	OUT	4.0 bis 7.7	1	"QBAD_I_xx = 1": The input channel is passivated with number xx. The substitute value ("0") is used at input "xx".
				Comment: With the variables it can be detected which channels are passivated. The channel number xx has the value range: 00 to 31
QBAD_O_xx (BOOL)	OUT	8.0 bis 11.7	1	"QBAD_O_xx = 1": The output channel is passivated with number xx. The substitute value ("0") is used at output "xx". Example: "QBAD_O_00 = 1" means: Substitute value ("0") is currently output at output channel.

Passivation (of entire module or channel)

What happens during passivation?

The entire F-I/O-module or individual channels of an F-I/O-module can be passivated by the F-system or the safety program. The extent of passivation varies depending on the trigger of the passivation:

Cause of the passivation:	Extend of the passivation:
Safety program	The passivation affects the entire F-module. I.e. all channels of the F-I/O-module are passivated.
F-System	Passivation affects either the entire F-module, or only the faulty channels. The desired behavior can be adjusted via settings in the STEP 7 hardware configuration.

Passivation has the following effect:

Passivation:	Effect of passivation:
F-input module (F-DI)	The safety program is not provided with the process values pending at the input. The safety program is provided with the substitute values ("0") in the process image of the inputs.
F-output module (F-DO)	The output values provided by the safety program in the process image of the outputs are not transmitted to the outputs. At the outputs the substitute values ("0") are output.

Note

During passivation of F-input modules (F-DI) the process image of the respective inputs is only reset when processing the safety program.

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What type of passivation exists?

The following table gives an overview of the passivation:

Cause of the passivation		Effect of the passivation		Reaction in the F-I/O-module data block
Safety program	Setting "PASS_ON = 1" in the F-I/O-module data block	Passivation of the F-module		QBAD = 1 All channels: QBAD_I_xx = 1 QBAD_O_xx = 1
F-operating system	Startup of the F-CPU Establishing communication between the F-CPU and the F-I/O via the safety protocol according to PROFIsafe.	Passivation of the entire F-I/O		QBAD = 1 PASS_OUT = 1 All channels: QBAD_I_xx = 1 QBAD_O_xx = 1
	F-communication error Error at fail-safe communication between F-CPU and F-I/O.	Passivation of the F-module		
	F-I/O error (*1)	Module error <ul style="list-style-type: none"> • Configuration error • Overtemperature Channel error <ul style="list-style-type: none"> • Wire break • Short circuit • Discrepancy • Overload 	Configuration: (*2)	"Passivation of entire module"
		"Passivation channel"		

Explanations on the table:

(*1): "F-I/O faults" causes the following reaction:

- The error is reported at the F-CPU (as standard reaction):
 - The error is reported to the F-CPU via the slave diagnostics.
 - OB82 for I/O errors is called in the F-CPU. If it does not exist, it goes to the F-CPU in STOP.
- Either the entire F-module or only the affected channels are passivated (F-specific reaction).

(*2): In the hardware configuration of STEP 7 the project settings can be selected: "Passivate the entire module" or "Passivate the channels".

How is the "passivation of channels" realized?

Precondition

Passivation of channels requires:

- S7 Distributed Safety V5.4, and S7 F Configuration Pack V5.4 + SP1

■ "F-modules which support the passivation of channels
Currently, the following F-modules support passivation of channels:

ET 200	F module	Description
ET 200 S	6ES7138-4FA02-0AB0	4/8 F-DI DC 24 V PROFI-safe
	6ES7138-4FB02-0AB0	4 F-DO DC 24 V/2 A PROFI-safe
	6ES7138-4CF02-0AB0	PM-E F pm DC 24 V PROFI-safe
	6ES7138-4CF41-0AB0	PM-E F pp DC 24 V PROFI-safe
ET 200 M	6ES7326-2BF01-0AB0	SM 326F; DO 10xDC 24 V/2 A
	6ES7326-2BF40-0AB0	SM 326F; DO 8x DC 24 V/2 A P/M
	6ES7326-1RF00-0AB0	SM 326F; DI 8xNAMUR
	6ES7336-1HE00-0AB0	SM 336F; AI 6x13Bit
ET 200 PRO	6ES7148-4FA00-0XB0	8/16 F-DI DC 24 V PROFI-safe
	6ES7148-4FC00-0XB0	4/8 F-DI 4 F-DO DC 24 V/2 A PROFI-safe
ET 200 ECO	6ES7148-3FA00-0XB0	4/8 F-DI DC 24 V PROFI-safe

Configuration

In the hardware configuration of STEP 7 the following project settings options exist:

- "Passivate the entire module"
- "Passivate channel".

The configuration is made in the following tab of the F-I/O-module:

- "Module parameter" -> "Behavior after channel error"

At page 323 you find two respective examples:

- F-DI with "Passivate the entire module"
- F-DI with "Passivate the channel"

The respective configurations are shaded.

Reintegration (of entire module or channel)

What happens during reintegration?

Reintegration has the following effect:

Reintegration	Effect of reintegration:
F-input module (F-DI)	The safety program is provided with the process values pending at the input via the process image of the inputs.
F-output module (F-DO)	The output values provided by the safety program in the process image of the outputs are transmitted to the outputs.

Which types of reintegration exist?

The reintegration of an F-module can occur in two different ways (see page 356):

- manually:
- automatically:

During manual reintegration, the user must acknowledge in the safety program for the reintegration of the F-system to be performed. ACK_REI (see page 351) must be provided with a positive edge for this.

During automatic reintegration, the F-system integrates the F-module if the error causing the passivation has been removed. The user needs not acknowledge in the safety program.

Whether reintegration occurs manually or automatically is controlled via ACK_NEC (see page 351):

- ACK_NEC = 1: Manual (Default value)
- ACK_NEC = 0: Automatic (must be set in the safety program by the user)

Warning

Automatic reintegration is only permitted if an automatic startup of the plant is not possible after the error has been removed.

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The following table gives an overview of the reintegration.

Cause of the passivation:		Reintegration	
		Manual or automatic	Prerequisite for reintegration
Safety program	Setting "PASS_ON = 1" in the F-I/O-module data block	automatic	"PASS_ON = 0"
F-operating system	Startup of the F-CPU Startup of the F-CPU Establishing communication between the F-CPU and the F-I/O via the safety protocol according to PROFIsafe.	automatic	Communication established
	F-communication error Error at fail-safe communication between F-CPU and F-I/O.	manual	F-system has recognized that the error causing the passivation has been removed. (*1)
	F-I/O error	Depending on ACK_NEC: • If "0": automatic • "If "1": manual (Default value)	
Module error • Configuration error • Overtemperature			
	Channel error • Wire break • Short circuit • Discrepancy • Overload		

Explanations on the table:

(*1):

After removing the error, the SF-LED of the affected F-module and the S7-message system does not indicate an error anymore.

The passivation of the F-module remains until reintegration (see page 358 and 359).

Processes during passivation and reintegration

The following chapter describes the processes during passivation and reintegration. Considered are the following variants:

Variant	Page
Channel error and module error: automatic reintegration	358
Channel error and module error: manual reintegration	359
F-communication error: reintegration	360
Safety program	361
Group passivation	362

As a description, tables and figures with uniform structure are used below. The columns of the table have the following meaning:

Column name	Column content
"State"	The numbers correspond to the number of the state.
"Description of status and events"	In the column the states and events are described. Events cause mode transitions. For better discrimination the events are given in italics.
"F-I/O-module data block" (*1)	The column lists the relevant variable of the F-I/O-module data block. The symbols in the columns have the following meaning: <ul style="list-style-type: none"> • "0", "1": Status of the bit • "0->1": Positive edge • "x": Status of the bit irrelevant
"SF-LED" (*1)	The column indicates the status of the collective error display on the F-I/O-module (red LED).

(*1): To recognize more clearly which bits change during a mode transition, they are shaded in gray: If a bit is shaded gray, it has changed compared with its previous state.

The following background colors are used in the figures:

- Green background: the F-module is **not** passivated
- Red background: the F-module is passivated

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**Process: Channel / module error
(automatic reintegration)**

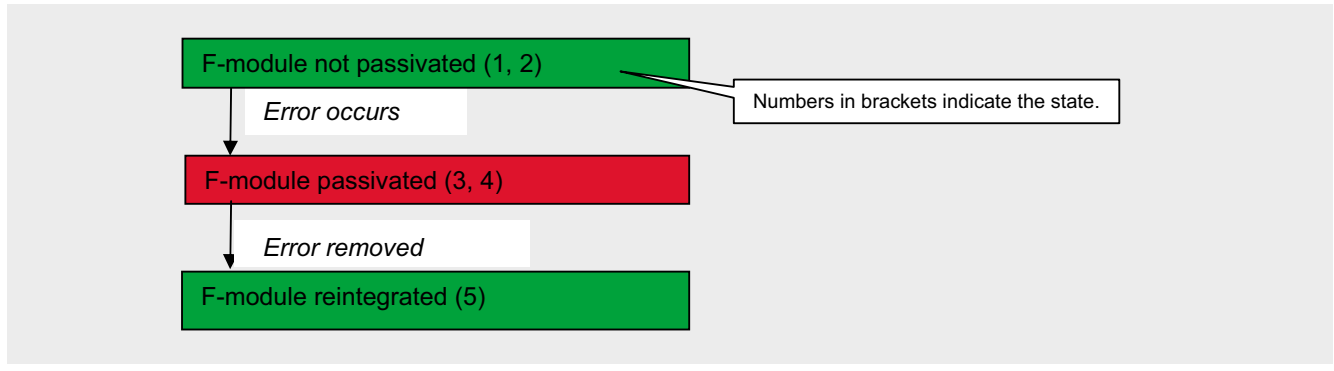
Precondition

The user has set "ACK_NEC = 0" in the safety program.

Process sequences

If an error is pending at the F-module (channel or module error), the F-module is passivated by the F-system. If the error has been removed and "ACK_NEC = 0", the F-module of the F-system is automatically reintegrated.

The following figure and table illustrates the process sequence.



Description of status and events		F-I/O-module data block / SF-LED			
State		A	B	C	D
1	F-module is not passivated. <i>Event: error occurs at the F-module.</i>	0	0	0	0
2	F-module has recognized the error. <i>Event: F-system recognizes the error at the F-module.</i>	0	0	0	1
3	F-system has passivated F-module. <i>Event: Removing the error at the F-module.</i>	0	1	1	1
4	F-module has recognized that the error has been removed <i>Event: F-system recognizes that the error at the F-module has been removed.</i>	0	1	1	0
5	F-system has reintegrated the F-module.	0	0	0	0

Process: Channel / module error (manual reintegration)

Precondition

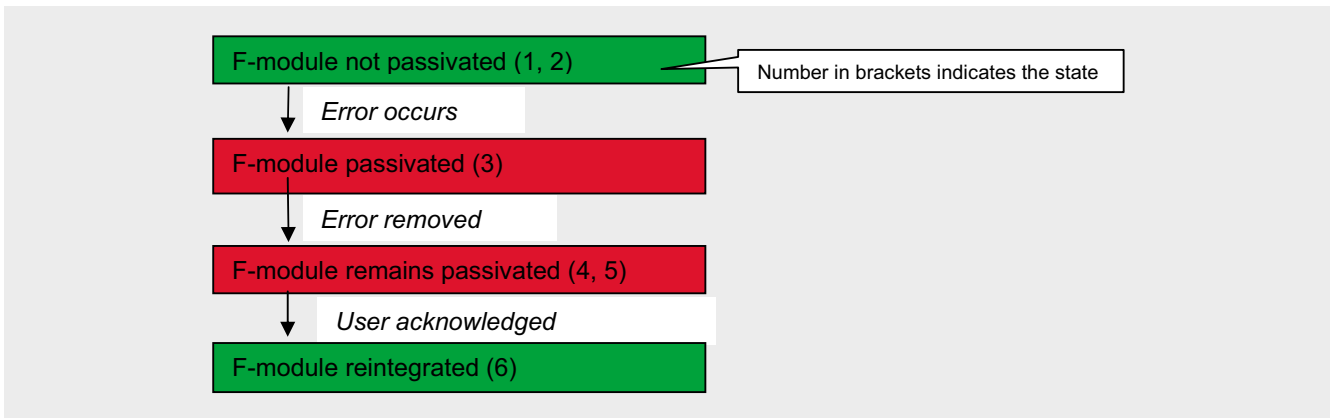
In the safety program the user acknowledges the reintegration by providing ACK_REI with a positive edge.

Process sequences

If an error is pending at the F-module (channel or module error), the F-module is passivated by the F-system. If the error has been removed and "ACK_NEC = 1"(default value), the

F-module is only reintegrated after acknowledgement by the user.

The following figure and table illustrates the process sequence.



Description of status and events		F-I/O-module data block / SF-LED					
State	A: ACK_NEC B: ACK_REI C: PASS_OUT D: QBAD E: ACK_REQ F: SF-LED						
	A	B	C	D	E	F	
1	F-module is not passivated.						
	<i>Event: error occurs at the F-module.</i>						
2	F-module has recognized the error.						1
	<i>Event: F-system recognizes the error at the F-module.</i>						
3	F-system has passivated the F-module.						1
	<i>Event: Removing the error at the F-module.</i>						
4	F-module has recognized that the error has been removed.						0
	<i>Event: F-system recognizes that the error at the F-module has been removed.</i>						
5	F-module remains passivated F-system requests user acknowledgement.						0
	<i>Event: User acknowledges (positive edge)</i>						0->1
6	F-system has reintegrated the F-module						0

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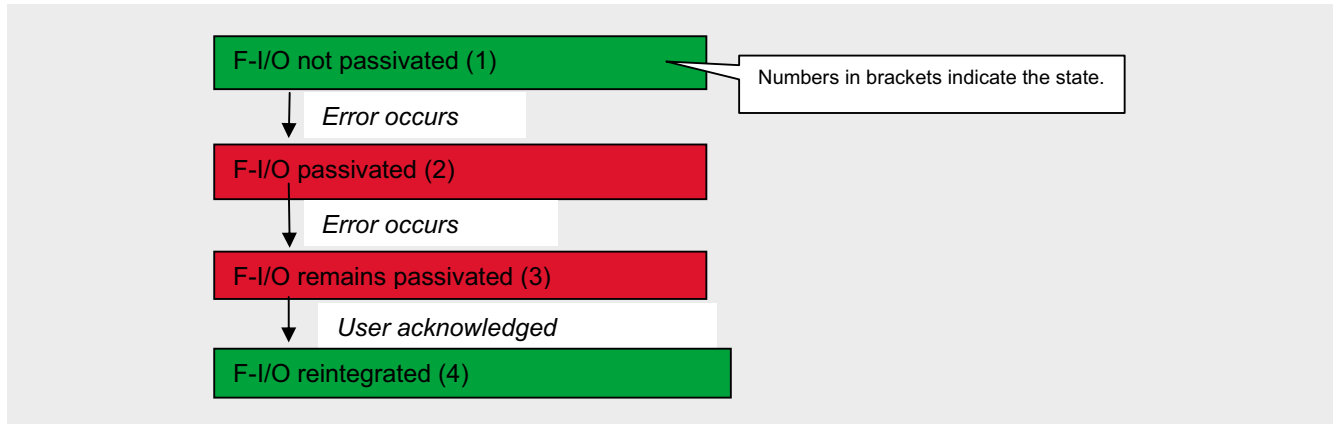
Process: F-communication error

Note
For "F-communication error" automatic reintegration is not possible!

Precondition
In the safety program the user acknowledges the reintegration by providing ACK_REI with a positive edge.

Process sequences

At F-communication error (e.g. due to disconnecting F-CPU and ET200) the entire affected F-I/O is passivated. If the error has been removed the F-I/O is only reintegrated after acknowledgement by the user. This applies irrespective of the ACK_NEC value. The following figure and table illustrates the process sequence.



Description of status and events		F-I/O data block F-DI and F-DO / SF-LED					
State	A: ACK_NEC B: ACK_REI C: PASS_OUT D: QBAD E: ACK_REQ F: SF-LED						
	A	B	C	D	E	F	
1 F-I/O is not passivated. <i>Event: Error occurs.</i>	x	0	0	0	0	0	
2 F-module is passivated. <i>Event: Error removed.</i>	x	0	1	1	0	0 (*1)	
3 F-I/O has recognized that the error has been removed. <i>Event: User acknowledges (positive edge).</i>	x	0	1	1	1	0 (*2)	
4 F-system has reintegrated the F-I/O.	x	x	0	0	0	0	

Explanations for the table:
(*1): BF-LED at IM 151 HF is on. BF-LED at F-CPU is blinking.
(*2): The BF-LEDs are off.

Process: Safety program

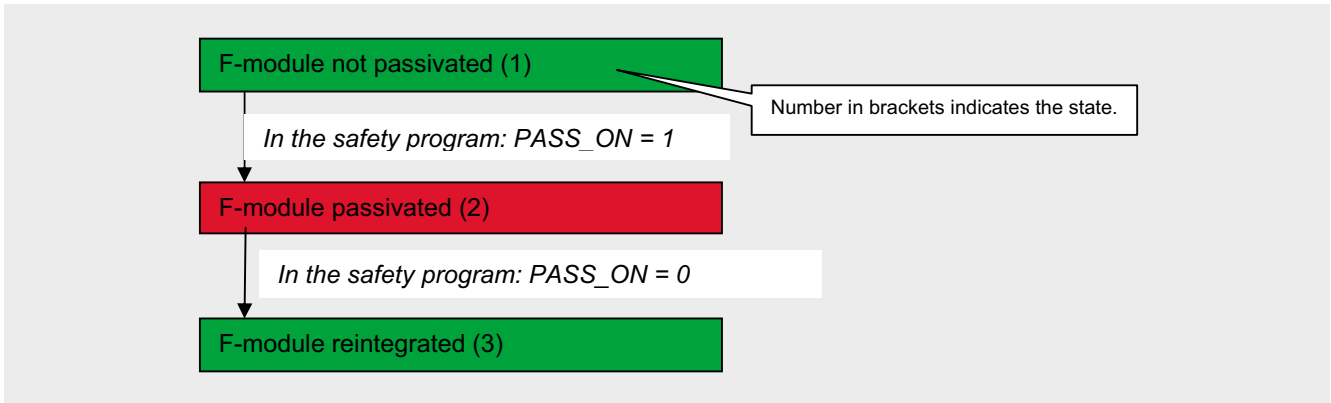
Precondition

The user can passivate and automatically reintegrate F-modules via the safety program. The PASS_ON variable is used for this.

Process sequences

The F-module is passivated with "PASS_ON = 1". The F-module is automatically reintegrated with "PASS_ON = 0".

The following figure and table illustrates the process sequence.



State	Description of status and events	F-I/O data block F-DI and F-DO / SF-LED			
		A	B	C	E
1	F-module is not passivated. Event: User sets "PASS_ON = 1" in the safety program	0	0	0	0
2	F-system has passivated the F-module. Event: User sets "PASS_ON = 0" in the safety program.	1	0	1	0
3	F-system has reintegrated the F-module.	0	0	0	0

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Process: Group passivation

What is group passivation?

Group passivation refers to simultaneous passivation of several G-modules. The following example explains the application of group passivation:

An end-switch has been connected at an F-DI. The end-switch is used to monitor the position of an axis. The drive of this axis is controlled via an F-DO. During wire-break at the end-switch, the drive must be switched off for safety reasons. This can be realized via the safety program: During passivation of F-DI, the entire F-Do is passivated at the same time.

How is a group passivation realized?

In the safety program, individual F-modules can be grouped together. The characteristic of a group is:

- If 1 F-module "x" from this group is passivated, then all other F-modules from this group are passivated.
- After manual or automatic reintegration of this F-module "x", the remaining F-modules of the group are automatically reintegrated.

The PASS_OUT and PASS_ON bits of the respective F-I/O data blocks (page 349) are used for a group passivation:

- All PASS_OUT variables of the F-module of this group must have a OR logic operation
- The result of the OR logic operation must be assigned to all PASS_ON variables of the F-modules of this group

In the following example a group is realized. The group consists of an F-DI and an F-DO:

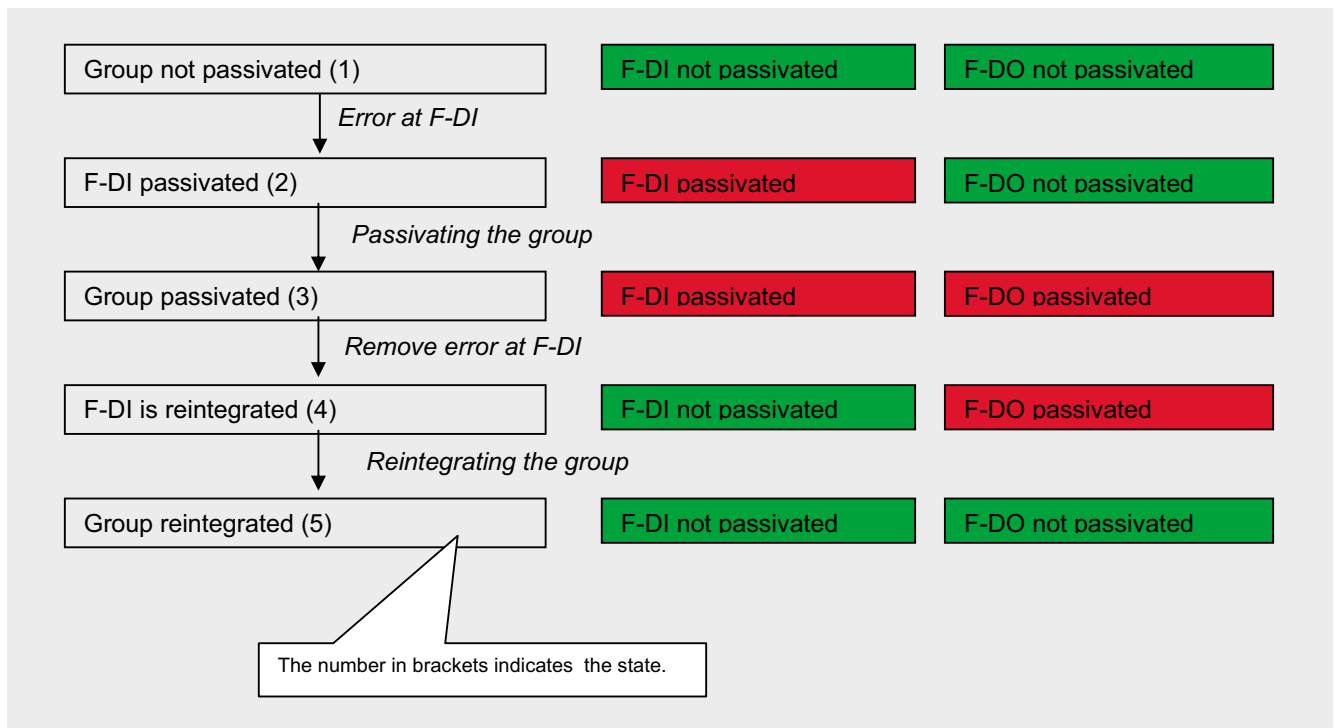
- If the F-DI is passivated, F-DO should also be passivated at the same time.
- If the F-DI is reintegrated, F-DO should also be reintegrated at the same time.

The example shows:

- What is the process of a group passivation?
- How do the relevant bits in the F-I/O data block of F-DI and F-DO behave?
- What is the design of the respective safety program?

The following figure and table illustrates the process sequence.

The following figure shows the process of a group passivation.



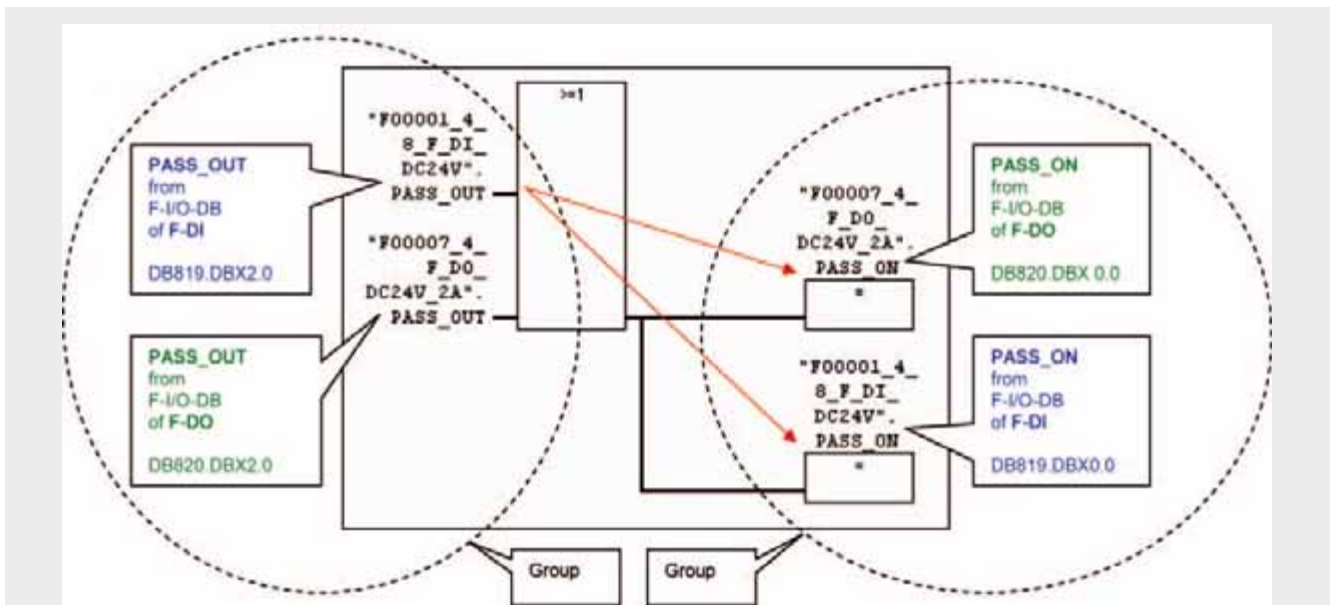
Warning

Automatic reintegration is only permitted if an automatic startup of the plant is not possible after the error has been removed.

The following table explains the process of a group passivation.

State	Description of status and events	F-I/O-module data block / SF-LED							
		F-DI				F-DO			
		A	B	C	D	A	B	C	D
1	Group is not passivated. <i>Event: F-operating system recognizes the error at the F-DI.</i>	0	0	0	0	0	0	0	0
2	F-system has passivated the F-DI. <i>Event: Group is passivated via the safety program.</i>	1	0	1	1	0	0	0	0
3	F-system has also passivated the F-DO. <i>Event: F-system recognizes that the wire-break at the F-DI has been removed.</i>	1	1	1	1	0	1	1	0
4	F-system has reintegrated the F-DI. <i>Event: Group is reintegrated via the safety program.</i>	0	1	0	0	0	1	1	0
5	Group is no longer passivated.	0	0	0	0	0	0	0	0

The figure below shows the setup of the safety program:



The above network is not realized in the sample code. It only serves as an illustration.

Safe Standstill Detection and Safely Reduced Speed with F-CPU and MASTERDRIVES in Category 3 of EN 954-1 or SIL 2 of IEC 62061

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Automation Function

Description of the functionality

Introduction

To ensure, that a drive is not causing any hazards, it must be detected safely when it is in standstill mode (speed $n=0$). Only when the state of safe standstill is reached, must actions be performed, as during normal operation they would otherwise be detected as hazard and cause the actuator to be switched off. Such actions may consist of:

- Entering a danger zone
- Opening a safety door
- Enabling further technological processes

Apart from **safe standstill** and **normal operation** this example also illustrates the "**safely reduced speed**" (**Sicher reduzierte Geschwindigkeit = SG**) operating mode (in this document referred to as "safe speed (SG)").

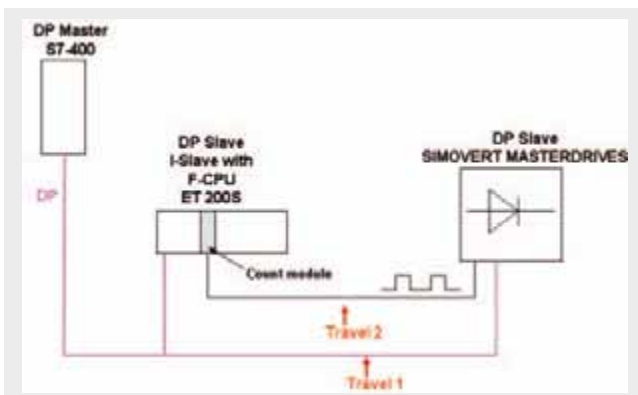
When does a "safe standstill" take place?

Within an applicative solution a safe standstill is referred to if

- a speed $n=0$ of the drive is recognized and
- this result is confirmed by a further evaluation of the operating mode of the drive (independent of the first evaluation).

Functional example

This functional example illustrates two independent methods of determining drive speed, and safe standstill in comparison with speed $n=0$.



- Method 1: Determining speed via PROFIBUS
- Method 2: Determining speed via standard count module
- The following overall functionalities are prepared:
- Emergency stop

- Simulation of a safety door
- Operating modes normal, "safe speed" (SG) and "drive standstill"

The actual speed value is determined in two different ways. The speed values determined this way are checked for plausibility in the operating modes "normal" and "safe speed" (SG). If one or several errors occur in "safe speed" (SG) mode, the drive is switched off fail-safe.

The plausibility check includes:

- the actual speed value determined in two different ways
- the comparison of the actual speed value with the N_MAX speed value, whose value must not be exceeded.
- To illustrate these functionalities, the example consists mainly of three parts:
- DP master CPU
- DP slave (I-Slave)
- DP slave (MASTERDRIVES)

These three blocks as well as the mentioned functionalities are described in greater detail below.

Note

The PFH-Calculation is not a part of this example.

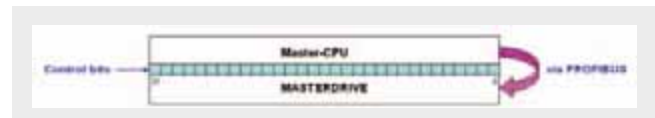
DP master CPU

Determining speed with PROFIBUS (method 1)

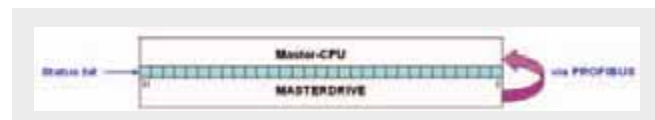
A CPU S7-400, connected with MASTERDRIVES via PROFIBUS, is used as DP master. In the master CPU the operation related switching is realized:

- Start the drive
- Stop the drive
- Acknowledgement (e.g. after an error)

To forward these commands to MASTERDRIVES, the master CPU **describes** the bits of the **control word**.



To detect the state of MASTERDRIVES, the master CPU **reads** the bits of the **control word**.



This communication is realized via PROFIBUS. This enables

- transferring the setpoint speed value to MASTERDRIVES
- detecting the actual speed value of MASTERDRIVES.

DP slave (I-Slave)

An ET 200S with intelligent and fail-safe interface (IM 151-7F-CPU) is used.

Note

In this example, the IM 151-7F CPU has already been configured as DP slave. However, if you require information for integrating an intelligent IM 151 interface as DP slave, please refer to the manual "ET 200S - Interface Module IM 151-7 CPU" (Entry-ID: [12714722](#))

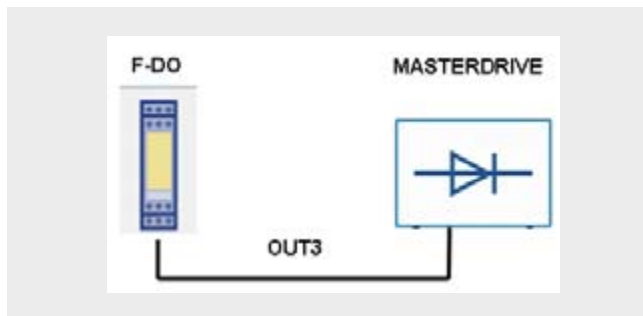
The I-Slave realizes the following functionalities:

Safe drive shut down

The drive is switched off safely for

- Triggered emergency stop
- Opening the safety door in normal operation
- Error during speed monitoring in "safe speed" (SG) mode

If one of these cases occurs, the drive is stopped immediately: The fail-safe output of the F-DO is connected with the OUT3 contact at MASTERDRIVES. At negative edge, OUT3 switches off the operation as fast as possible (fast stop).



Note

Fast stop is generally no primary safety function. However it enhances safety and helps reduce kinetic energy. OUT3 can also be connected to MASTERDRIVES via a standard module. The reason behind using OUT3 via an F-DO in this example is that otherwise an additional standard output module for ET 200S would be required.

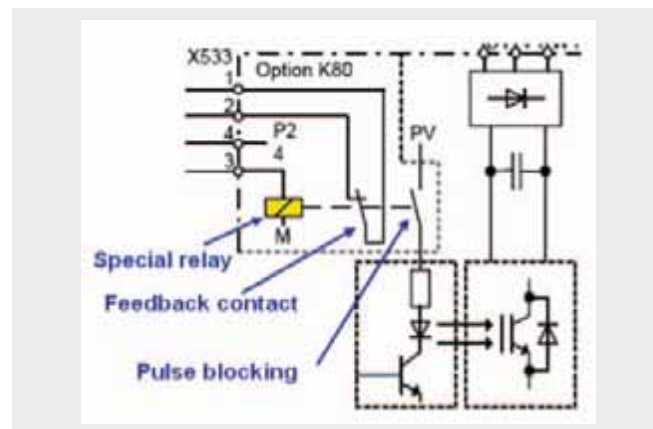
Reaching category 3 according to EN 954-1 requires two different methods for safe shut down:

- Option K80 for MASTERDRIVES
- Shutdown by contactor

Option K80 (shut down method 1)

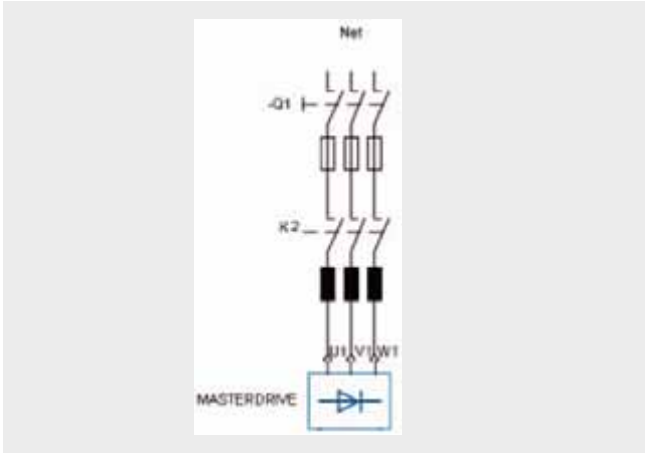
Option K80 for MASTERDRIVES contains a fail-safe relays with positively driven feedback contact, which shuts down power supply for controlling the power transistors (IGBTs). Pulse blocking occurs

- in case of an error with delay after fast stop (OUT3=0) via the F-DO
- in operating mode "safe speed" (SG) and drive standstill.



Shutdown by line contactor (shutdown method 2)

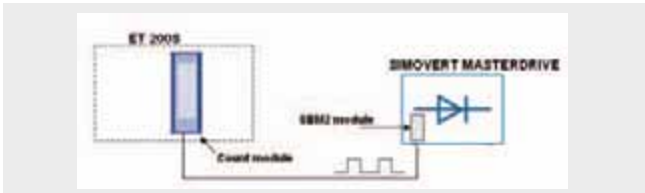
If an error is detected during evaluating the feedback contact of option K80, the contactor disconnects the drive from the network. If there is no readback error at option K80, the drive remains connected to the network; category 3 according to EN 954-1 remains true.



Attention
When using a contactor, its design must allow for this. In this example a contactor K2 was used for testing without connection to a load circuit.

Determining speed with count module (method 2)

ET 200S contains a standard count module which is connected with the SBM2 module (from module identification 0x95FF / EEPROM version 1.06) of MASTERDRIVES. The SBM2 module evaluates the signals of the optical sin-/cos encoders.



Operating mode "safe speed" (SG)

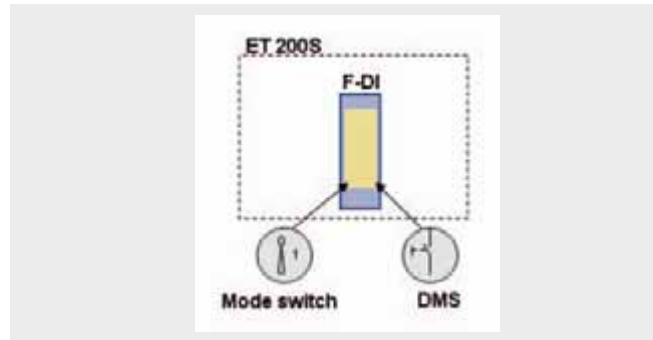
The operating mode "safe speed" (SG) can only be activated following drive standstill.

Attention
Depending on danger analysis and risk level assessment of the discussed machine, the drive can, in "safe speed" (SG) mode, also be operated with an open safety door.

Further preconditions for the operating mode "safe speed" (SG):

- Emergency stop button unlocked
- Mode switch set to SG
- DMS (Dead Man Switch) remains continuously pressed.
- Actual speed value of "safe speed" remains below limit value N_{SG}

Signals of the mode switch and DMS are read into an F-DI.



Emergency stop

Emergency stop is read into the F-DI and when pressed switches off the drive via the OUT3 parameter of the MASTERDRIVES (fast stop) and option K80 (pulse blocking). If a readback error occurs at option K80, the contactor (K2) additionally disconnects the drive from the network.

Safety door monitoring

The safety door is always monitored with a two channel safety door contact to show that

- during normal operation and opening of the safety door the drive is safely switched off,
- in "safe speed" (SG) mode an opening of the simulated safety door does not cause the drive to be switched off.

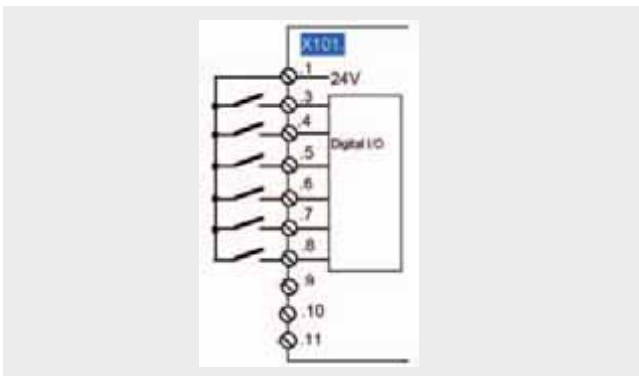
Attention
This example is not a complete solution of a safety door monitoring. For a respective solution please refer to Safety Function examples no. 2, 3 and 4.

DP Slave (MASTERDRIVES)

The description of MASTERDRIVES here is restricted to information on interfaces X101 and SBM2.

Interface X101

Terminals -X101/3 to -X101/6 can be used as digital inputs or outputs. In this example, contact 5 is configured as OUT3 and (via contactor K1) connected with the F-DO of the ET 200S. A "0" signal at OUT3 leads to fast stop of the drive.



Note

Fast stop is generally no primary safety function. However it enhances safety and helps reduce kinetic energy. OUT3 can also be connected to MASTERDRIVES via a standard module. The reason behind using OUT3 via an F-DO in this example is that otherwise an additional standard output module would be required for ET 200S.

Interface SBM2 module

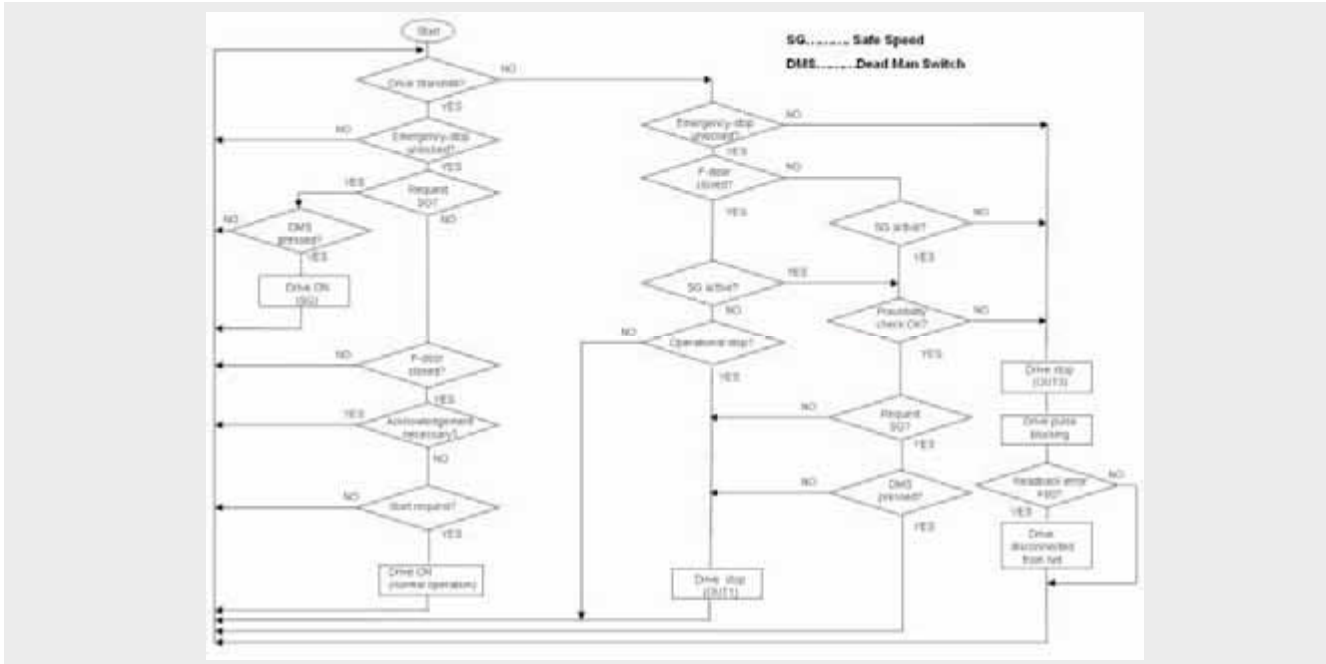
The SBM2 module (from module identification 0x95FF / EEPROM version 1.06) forms a pulse generator imitation from the speedometer signal of the motor (e.g. sin/cos encoder), which behaves like an incremental encoder located at the motor. This information is transmitted to the count module of the ET 200S which is operated in "speed detection" measuring mode.

Interface X533 (option K80)

This interface is used for safe shutdown (see page 365).

Flowchart

The flowchart below illustrates the functional relations.



"Check of plausibility OK?" in the flowchart involves:

- checking whether the actual speed value does not exceed a fixed speed value N_MAX.
- checking whether the actual speed value determined with PROFIBUS and the actual speed value determined with the ET 200S count module are equal.

If both points can be answered with "YES", then the plausibility check is "OK". For "NO" and "safe speed" mode, the drive is switched off safely.

Time sequence for different modes

The following time diagrams show the time sequence during:

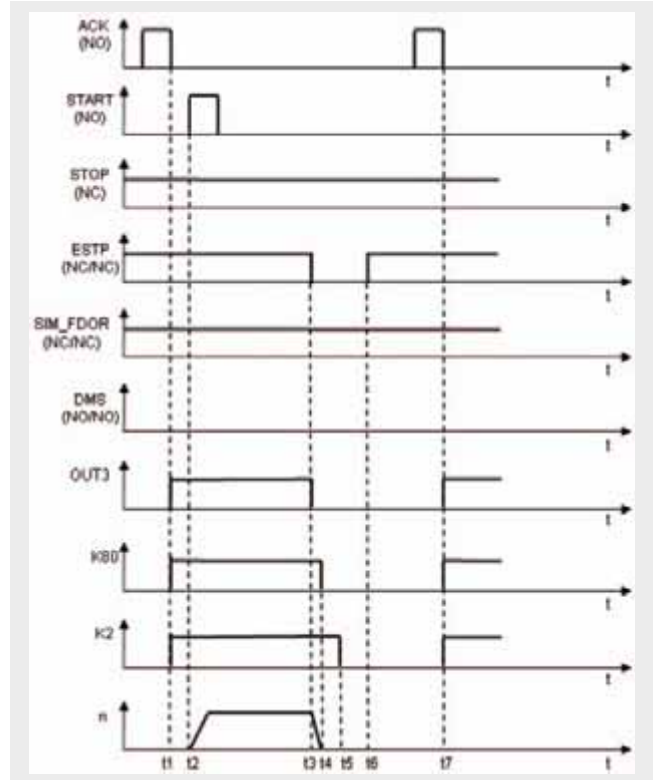
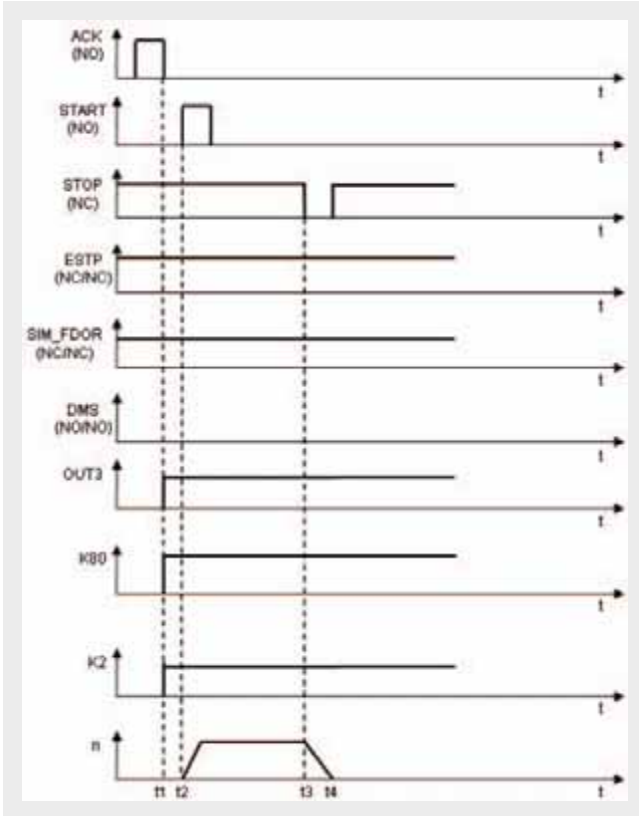
- Operational start and shutdown of the drive
- Emergency stop
- Operating mode "safe speed" (SG)

Before, the displayed parameters are explained. The names of the signals correspond to the ones of the S7 program code.

Symbol	Function	Convention
ACK	Acknowledgement	Acknowledgement depending on edge evaluation
START	Start request	1: Start request
STOP	Stop request	0: Stop request
ESTP	Emergency Stop	0: Activated emergency stop
SIM_FDOR	Simulated safety door	0: Opened safety door
DMS	Dead man switch	1: DMS pressed
OUT3	Parameter MASTERDRIVES	0: Fast stop
K80	Contactur for controlling the option K80	1: Safety relay of K80 option is controlled
K2	Line contactur	1: activated
n	Speed list value	

Operational start and shutdown of the drive

Time	Explanation
t1	Acknowledgement required prior to first start obligatory.
t2	Drive is started via START.
t3	Drive is stopped via STOP.
t4	Drive standstill



Emergency stop

Time	Explanation
t1	Acknowledgement required prior to first start obligatory
t2	Drive is started via START.
t3	Activates emergency stop: fast stop is triggered (OUT3=0).
t4	Option K80: pulse blocking
t5	Separating drive from network (only for readback error of option K80).
t6	Unlocking the emergency stop button.
t7	Negative edge of acknowledgement signal: Activates the contactor. OUT3 is reset to 1 signal. This is the prerequisite for the drive to be restarted with OUT1=1 (not depicted).

Note
The above time curve for OUT3, K80, K2 and n would also result if instead of triggering an emergency stop at t3, the safety door (simulated here) would be opened.

Note
The drive is only separated from the network, if the feedback contact of option K80 causes an error (see time value t5).

Ex. No.
12

Operating mode "safe speed" (SG)

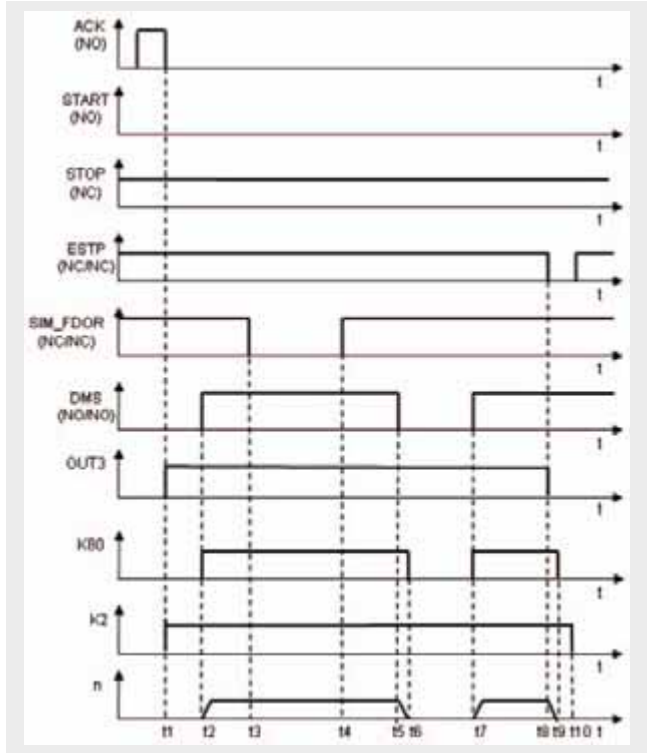
The signal curves described below require the mode switch to select "safe speed" (SG) mode.

Time	Explanation
t1	Acknowledgement required prior to first start obligatory.
t2	Pressing and keeping dead man switch (DMS=1) pressed switches the safety relay of the K80 option. The drive starts with SG.
t3	Opening...
t4	...and closing the (simulated) safety door does not cause the drive to stop (OUT3=1, n>0).
t5	Releasing the dead man switch (DMS=0)...
t6	...causes a stop and subsequent pulse blocking of the drive (n=0, K80=0)
t7	Renewed pressing and holding of the dead man switch (DMS=1) switches the safety relay of the K80 option. The drive starts with SG.
t8	Activates emergency stop: fast stop is triggered (OUT3=0).
t9	Pulse blocking through option K80.
t10	Separating drive from network (only for readback error of option K80).

Note
As depicted in the time diagram, the drive is only separated from the network, if the feedback contact of option K80 causes an error (see time value t10).

Advantage / Customer benefits

- No standstill monitor necessary.
- The used speed values for operating modes "normal" and "safely reduced speed" (SG) can be adjusted easily to the individual requirements.
- Use of prefabricated and certified failsafe blocks from the Distributed Safety library.



Required Components

Hardware components

Components	Type	MLFB / Order information	No.	Manufacturer
Power supply	PS 407 10A	407-0KA01-0AA0	1	Siemens AG
Power supply	PS 307 5A	6ES73071EA00-0AA0	1	
CPU S7-400	CPU 412-2	6ES7412-2XG04-0AB0	1	
S7F-CPU	IM 151-7F-CPU	6ES7151-7FA01-0AB0	1	
S7-400 input module	DI 32xDC24V	6ES7421-1BL01-0AA0	1	
Power module for ET 200S	PM-E DC24..48V AC24..230V	6ES7138-4CB10-0AB0	2	
Count module for ET 200S	1COUNT 5V/500kHz	6ES7138-4DE02-0AB0	1	
Electronic module for ET 200S	4/8 F-DI DC24V	6ES7138-4FA02-0AB0	1	
Electronic module for ET 200S	4 F-DO DC24V/2A	6ES7138-4FB02-0AB0	1	
Micro Memory Card	MMC 2MB	6ES7953-8LL11-0AA0	1	
Terminal module for ET 200S	TM-P15S23-A0	6ES7193-4CD20-0AA0	2	
Terminal module for ET 200S	TM-E30S44-01	6ES7193-4CG20-0AA0	1	
Terminal module for ET 200S	TM-E30C46-A1	6ES7193-4CF50-0AA0	2	
Terminating module for ET 200S		6ES7193-4JA00-0AA0	1	
Emergency stop	Push button, 1NC	3SB3801-0DG3	1	
Contact (for emergency stop)	1NC, screw-type connection	3SB3420-0C	1	
Position switch	Metal enclosed, 2NC	3SE2120-6XX	1	
Actuator		3SX3197	1	
Push button	Green, 1NO	3SB3801-0DA3	2	
Push button	Red, 1NC	3SB3801-0DB3	1	
Control element	With 2 switching elements (2NC)	3SB3400-0D	1	
Knob switch complete device	0-I snap-in, 1NC	3SB3202-2HA11	1	
Universal-Rack	UR2	6ES7400-1JA01-0AA0	1	
Mounting rail	482,6 mm	6ES7390-1AE80-0AA0	1	
Standard mounting rail	35 mm, length 483 mm	6ES5710-8MA11	1	
SIMOVERT MASTERDRIVES	Demonstration box	6SE7011-6EP60-Z	1	
Sensor module for encoder SBM2	Incl. connector and short instruction	6SX7010-0FE00	1	
Servo motor	N(nominal)=6000 U/min	1FT6031-4AK7	1	
Contactors	2NO +2NC	3RH1122-1BB40	2	
Contactors	NC	3RT1015-2BB42	1	

Note

The functionality was tested with the listed hardware components. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

Configuration software/tools

Component	Type	MLFB / Order information	No.	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.4	6ES7-8331FC02-0YA5	1	
Drive ES BASIC	V5.3 + SP3	6SW1700-5JA00-3AA0	1	

Setup and Wiring

Regarding the use of SIMOVERT MASTERDRIVES, please consider the following safety note:

Warning

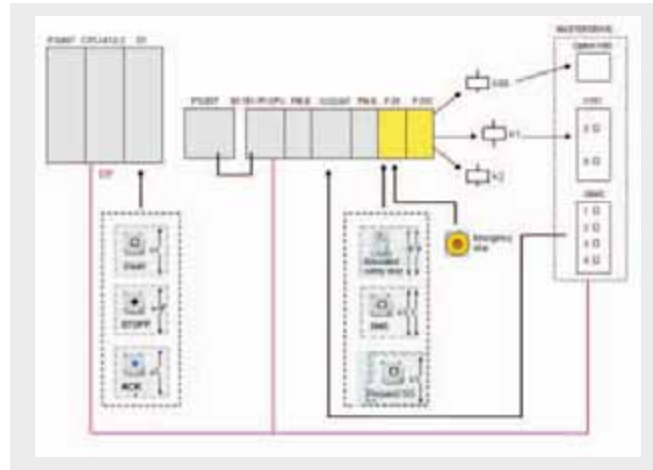
The MASTERDRIVE carries hazardous voltages and controls potentially dangerous rotating mechanical parts. Non-compliance with warnings or failure to follow the instructions contained in the MASTERDRIVE manual can result in loss of life, severe personal injury, or serious damage to property.

Overview of the hardware configuration

Arrangement of the PROFIBUS configuration:

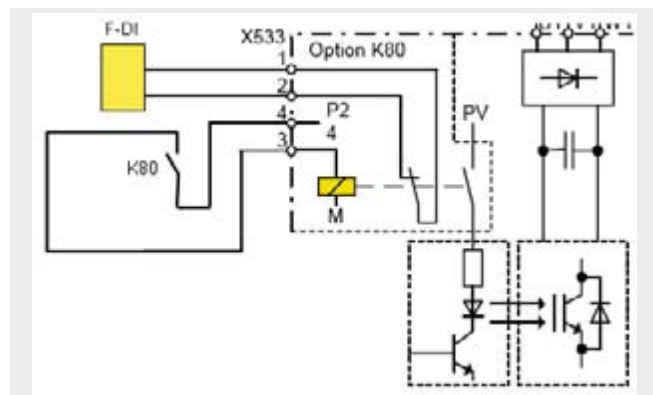
- S7-400 CPU as DP-Master
- ET 200S with IM157-7F-CPU as DP slave
- SIMOVERT MASTERDRIVES as DP slave

Overview picture



Notes on contactors and option K80

Comp.	Function	Note
K1	Contactor	Auxiliary contact (NO) switches parameter OUT3.
K2	Line contactor	Tested without connected load current circuit.
K80	Contactor	Auxiliary contact (NO) controls the safety relay of option K80 (see following circuit diagram).



Notes on configuring MASTERDRIVES

Note

Configuration of SIMOVERT MASTERDRIVES is in this example not discussed in detail.

The control signals and the setpoint speed value are forwarded to MASTERDRIVES using PROFIBUS. Signal OUT3 is controlled indirectly via the connecting terminal plate of MASTERDRIVES.

The following table affects the configuration of input OUT3 at MASTERDRIVES (see contact X101/5 in the circuit diagram).

P.-Nr.	Name	Parameter value
P558	Q.1AUS3 (SHalt)	B14 Dig. Input 3

Wiring of hardware components

Prerequisite: The power supplies are supplied with 230 V AC.
First check the addresses set at the hardware components listed below:

Hardware component	Address to be set	Note
IM 151-7F-CPU	6 (PROFIBUS address)	Can be changed.
F-DI	Switch position: 0011001000	The PROFIsafe addresses are automatically assigned when configuring the fail-safe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP 7.
F-DO	Switch position: 0011000111	

Note

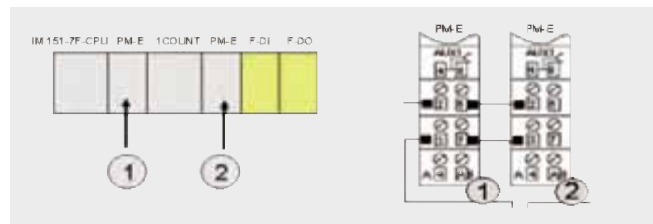
The DP interfaces of S7-400-CPU, IM 151-7F-CPU and SIMOVERT MASTERDRIVES must be inter-connected.

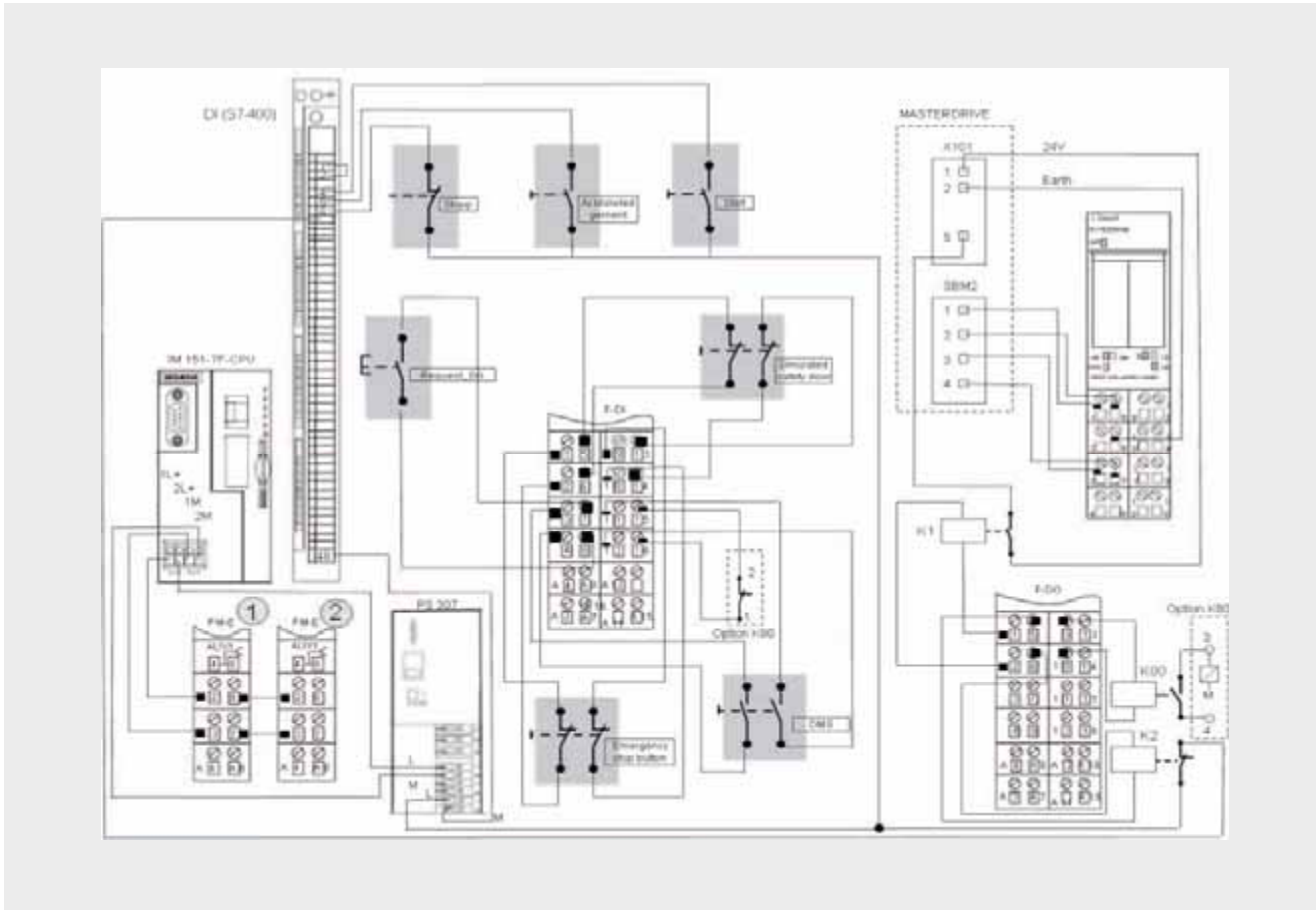
Note

The safety relay and the feedback contact of option K80 are displayed separately in the wiring plan (on the next page) for better clarity.

Note

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered so they can be allocated in the subsequent wiring plan.





Note
A connection between the MPI interface of this S7-CPU and the MPI interface of your PG/PC is required to download the S7 project to the CPU 412-2.

Attention
When using a contactor the design must provide for this. In this example a contactor K2 was used for testing without connection to a load circuit.

Function test

The inputs and outputs used can be checked with regard to their functionality, if

- the hardware components are wired
- the S7 project is located in the DP Master CPU (CPU412-2)
- the S7 project is located in the DP Slave CPU (IM 151-7F-CPU)
- MASTERDRIVES has been parameterized accordingly

Inputs and outputs used for the DP Master CPU (CPU412-2)

No.	HW component	Address	Symbol	Signal (default value)	Note
Nr.	Push button (NO)	E 0.0	START	"0"	Start request
1	Push button (NO)	E 0.1	ACK	"0"	Acknowledgement
2	Push button (NO)	E 0.2	STOP	"1"	Operational stop
3	Push button (NO)	E 0.0	START	"0"	Start request
No.	SW component	Address	Symbol	Signal (default value)	Note
4	Software output	Output DB2.DBX 3.0	OUT1	"0"	Bit in control word for MASTERDRIVES (for 1: drive starts).

Inputs and outputs used for the DP Slave CPU (IM 151-7F-CP)

No.	HW component	Address	Symbol	Signal (default value)	Note
1	Push button (NC/NC)	E 0.0	ESTP	"1"	Emergency-stop button
2	Push button (NC/NC)	E 0.1	SIM_FDOR	"1"	Position switch
3	Push button (NC/NC)	E 0.2	DMS	"0"	Dead Man Switch. Must remain pressed permanently in "safe speed" (SG) mode.
4	Switch engages	E 0.3	REQ_SG	"0"	Mode switch 0: Normal operation 1: "safe speed" (SG)
No.	SW component	Address	Symbol	Signal (default value)	Note
5	F-DO	A 6.0	OUT3	"0"	Connection from F-DO (via K1) to MASTERDRIVES. At signal change from 1->0 fast stop (immediate stop of the drive) is triggered.
6	F-DO	A 6.1	K2	"0"	Contactors (tested without connected load circuit).
7	F-DO	A 6.2	K80	"0"	Contactors for switching the safety relay of the K80 option of MASTERDRIVES.

Testing inputs and outputs

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

No.	Instructions					Response
		OUT1	OUT3	K2	K80	MASTERDRIVES
1	Press ACK and release	0	1	1	1	Standstill
2	Press START and release	1	1	1	1	Starts (normal operation)
3	Press STOP and release	0	1	1	1	Shuts down (operational stop)
4	Repetition No. 2	1	1	1	1	
5	Press ESTP	0	0	1	1	<ul style="list-style-type: none"> Shuts down (fast stop) Pulse blocking X: K2=1, if no readback error of option K80 (otherwise K2=0)
				time delay	X	
6	Unlock emergency-stop button	0	0	1	0	
7	Press ACK and release	0	1	1	1	Edge change from 0 to 1 at OUT3 is a prerequisite for OUT1 to be reset.
8	Repetition No. 2	1	1	1	1	
9	SIM_FDOR=0: Open safety door (simulated by pulling the position switch)	0	0	1	1	<ul style="list-style-type: none"> Shuts down (fast stop) Pulse blocking X: K2=1, if no readback error of option K80 (otherwise K2=0)
				time delay	X	
10	SIM_FDOR=1: Close safety door	0	0	X	0	Standstill
11	Press ACK and release	0	1	1	1	Edge change from 0 to 1 at OUT3 is a prerequisite for OUT1 to be reset.
12	Set REQ_SG to 1	0	1	1	1	Operating mode "safe speed" (SG) has been set
13	Press DMS and keep it pressed	1	1	1	1	Operating mode "safe speed" (SG) active
14	SIM_FDOR=0: Open safety door (simulated by pulling the position switch)	1	1	1	1	In operating mode "safe speed" (SG) the safety door can also be opened at active drive.
15	Release DMS	0	1	1	0	Shuts down to safe standstill

Note

An acknowledgement signal is required for starting the machine:

- Prior to the first start (normal operation)
- After triggering emergency stop
- After opening the safety door in normal operation
- After error recognition during plausibility checks for the speed value

Attention

The settings shown below contribute to meet the requirements of category 3 according to EN 954-1 and SIL 2 of IEC 62061. Changes at the settings may cause loss of the safety function.

If you implement changes (e.g. add an additional module), the sample code has to be adapted accordingly.

Important hardware component settings

Below, several important settings from the hardware configuration of STEP 7 are shown to provide you with an overview. These settings are available in the included STEP 7 project. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

Overview hardware configuration of DP Master CPU (CPU412-2)

Slot	Module	Order number	Firmware	MPI address	I address	Q address
1	PS 407 10A	6ES7 407-0AA01-0AA0				
3	CPU 412-2 DP	6ES7 412-2EX04-0AB0	V4.1	2		
X2	DP				400	
X7	APR/DP			2	400	
4	DC24DC 24V	6ES7 421-1BL01-0AA0			0..3	

Overview hardware configuration of the DP Slave CPU (IM 151-7F-CPU)

Slot	Module	Order number	Firmware	MPI address	I address	Q address
1	IM 151-7F-CPU		V2.1			
X7	APR/DP					
4	PS 407 10A	6ES7 407-0AA01-0AA0				
5	1 COUNT 30/500 kHz M	6ES7 130-4C010-0AB0	V1.0		272..279	272..279
6	PS 407 10A	6ES7 407-0AA01-0AA0				
7	4x DI DC24V	6ES7 130-4FA02-0AB0			0..5	0..3
8	4x DO DC24V/2A	6ES7 130-4FB02-0AB0			8..10	8..10



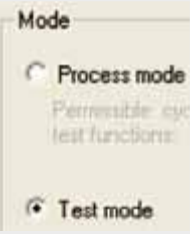
The view above (double-click ET 200S at the PROFIBUS line) displays the address area via which the DP Master CPU (CPU 412-2) communicates with the DP Slave CPU (IM 151-7F-CPU) (see screenshot below). In this example, bytes 14 to 45 are used for this. The inputs of the DP Master CPU (e.g. E20.1) are also the outputs of the DP Slave CPU (A20.1) and vice versa.

Row	Mode	Partner DP add.	Partner add.	Local add.	Length	Constitute
1	M5	2	0 14	1 14	32 Byte	Unit
2	M5	2	1 14	0 14	32 Byte	Unit

Ex. No.
12

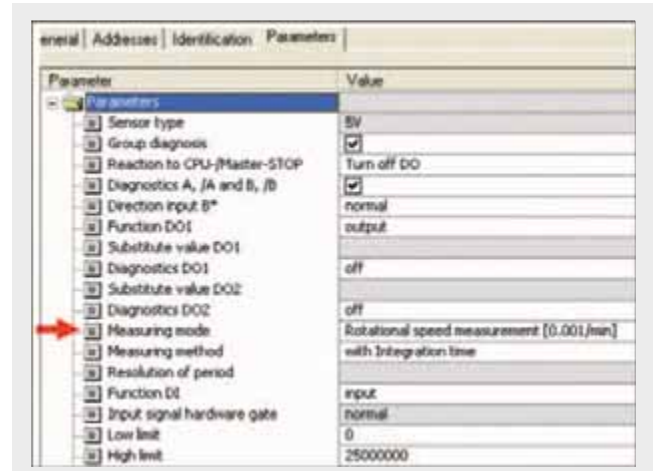
Settings of IM 151-7F-CPU

The settings are displayed after double-clicking "IM 151-7F-CPU" in the hardware configuration of STEP 7 (see "overview picture").

Picture	Note
	Default value: 100 ms. It must be ensured that the F-module monitoring time must be larger than the call time of OB 35.
	Available in the "Protection" tab (Level of protection). A password has to be allocated in order to be able to set the parameter "CPU Contains Safety Program". It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7. Password used here: siemens
	Set mode: "Test mode" During Process Mode, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed. During Test Mode, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time. Important: During test mode of the CPU, you have to make sure that the CPU or the process can "stand" large increases in cycle time.

Settings of count module "1 COUNT"



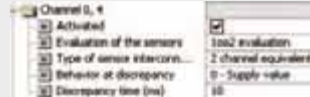
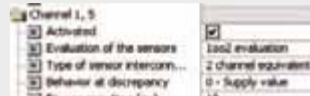

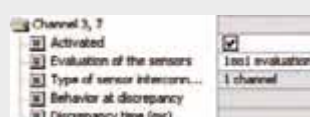
The settings are displayed after double-clicking "IM 151-7F-CPU" in the hardware configuration of STEP 7 (see "overview picture").



For accordingly parameterized measuring mode, the module offers the option of speed measurement. This setting is default in our example (see figure above).

Settings of the fail-safe F-DI



The settings are displayed after double-clicking "4/8 F-DI DC24V" (see "Overview picture").

Picture	Note
	<p><u>DIL switch settings</u> This value has to be set on the module (F-DI).</p> <p><u>F monitoring time</u> It has to be observed that the F monitoring time must be larger than the call time of OB 35.</p>
	<p>The connected sensors receive the power supply via the module. In this example, the respective channel is passivated during a channel error (not the entire module).</p>
	<p>Channel 0 Emergency stop push button (ESTP)</p>
	<p>Channel 1 Position switch (SIM_FDOR)</p>
	<p>Channel 2 Dead man switch (DMS) for activating the operating mode "safe speed" (SG)</p>
	<p>Channel 3 Mode switch (REQ_SG) 0: Normal operation 1: "safe speed" (SG)</p> <p>Channel 7 Readback contact of option K80 of MASTERDRIVES</p>

Ex. No.
12

Settings of the fail-safe F-DO

The settings are displayed after double-clicking "4 F-DO DC24V/2A" (see "Overview picture").

Picture	Note
	<p><u>DIL switch settings</u> This value has to be set on the module (F-DO).</p> <p><u>F monitoring time</u> It has to be observed that the F monitoring time must be larger than the call time of OB 35.</p> <p><u>Passivation</u> Passivation of channels in this example: ("Behavior after channel faults").</p>
	<p>The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive.</p> <p>Unused channels: Deactivate</p>

Basic Performance Data

DP Master:

Load and main memory (without program code)

	Total
Load memory	approx. 0.5 k
Main memory	approx. 0.4 k

DP Slave (IM 151-7F-CPU):

Load and main memory (without program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 41.6 k	approx. 0.1 k	approx. 41.5 k
Main memory	approx. 31.8 k	approx. 0.05 k	approx. 31.7 k

DP Master:

Load and main memory (with program code)

	Total
Load memory	approx. 8.9 k
Main memory	approx. 18.4 k

DP Slave (IM 151-7F-CPU):

Load and main memory (with program code)

	Total	S7 standard blocks	F blocks (fail-safe)
Load memory	approx. 61.7 k	approx. 1.3 k	approx. 60.4 k
Main memory	approx. 44.5 k	approx. 0.5 k	approx. 44.0 k

Cycle time (IM 151-7F-CPU)

Total cycle time (typical)	approx. 3 ms	Standard and safety program
Max. runtime of the safety program	10 ms	approx. 0.5 k

Sample Code

General information

Preliminary Remarks

In the attachment, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

The sample code is always assigned to the components used in the functional examples 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.

Password

In all cases, the password used for the safety-relevant part is siemens.

Use of the STEP 7 project

The STEP 7 project shows how using MASTERDRIVES enables realizing safe standstill monitoring.

Download

To call the corresponding project file, open the "as_fe_i_012_v10_code_sstill.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

To download the project to the F-CPU please proceed as follows:

No.	Instructions
1	Load the appropriate hardware configuration into the IM 151-7F-CPU.
2	Switch to the SIMATIC Manager
3	Select the "Blocks" folder (DP slave)
4	Menu "Options" -> Edit safety program
5	Click the "Download" button.
6	First load the hardware configuration to the DP-Master.
7	Switch to the SIMATIC Manager.
8	Select the "Blocks" folder (DP master)
9	Menu "Zielsystem" (target system) -> "Laden" (download)

The sample code with the given configurations enables the following:

- Operational start and stop respectively via one button
- Emergency stop
- Simulated safety door (position switch)
- Safe speed (SG)
- Safe standstill detection

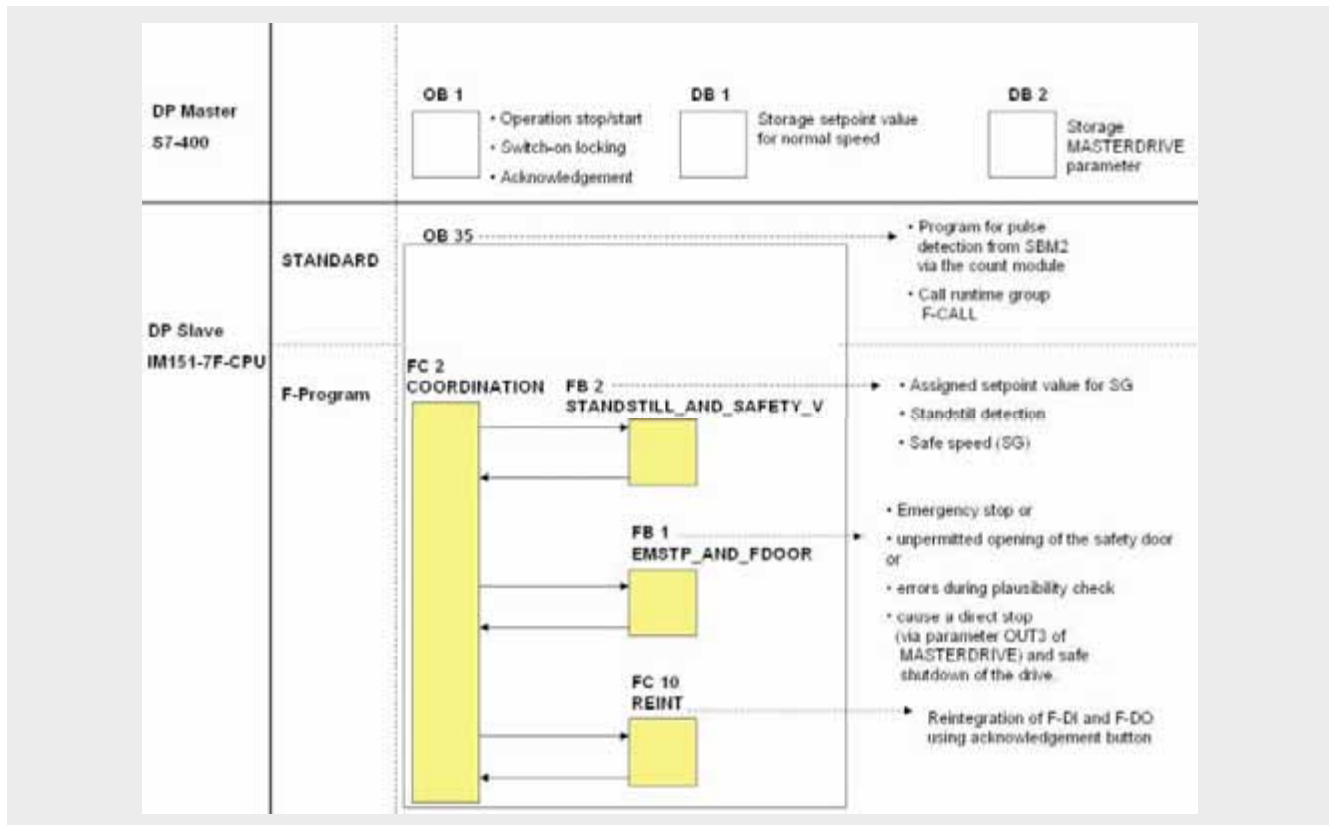
Attention
The safety door simulated with the position switch contains no complete safety door solution for a, but serves merely as a demonstration of the following behavior: In operating mode "safe speed" (SG) the drive may also be active at opened safety door.

Note
The example is designed for one rotational direction of the drive and does not take into account a change of direction.

Program sequence

General overview

The following figure shows the program structure of both S7-CPU's (S7-400 as DP Master and IM 151-7F-CPU as DP Slave).



Transfer area in the I/O address space

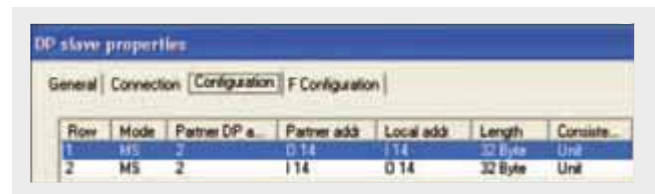
For an intelligent DP Slave (here: IM 151-7F-CPU) the DP Master does not access the connected inputs and outputs of the intelligent DP slaves, but accesses a transfer area in the input/output address space of the "preprocessing CPU". The input addresses of the DP Master CPU (S7-400) are output addresses of the DP Slave CPU (here: IM 151-7F-CP) and vice versa.

Note

The configured I/O areas for data exchange between master and slaves must not be "assigned" by I/O modules.

In this example, a transfer area of 32 bytes was reserved each for inputs and outputs (from byte 14). You reach the mask be-

low as follows: In the hardware configuration of STEP 7 you double-click the intelligent DP slave:



Note

All variables of the respective example, which are addressed via the above described transfer area, start their names with "C_" for "Couple" (e.g. C_OUT1).

Ex. No.
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S7 program of master CPU

DB "ENGINE SPEED" (DB 1)

DB 1 contains the setpoint speed value for normal operation. This value is not given in 1/min but as follows:
4000 hex (=16384 dec) correspond to 100% of the maximum speed

DB "PARAM_MDRIVE" (DB 2)

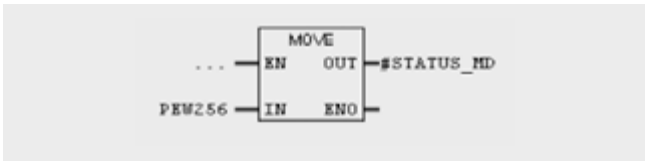
DB 2 contains the parameters of MASTERDRIVES.

OB 1

The S7 program of the master CPU consists mainly of the program sequences of OB 1. There the conditions for operational control of MASTERDRIVES are defined.

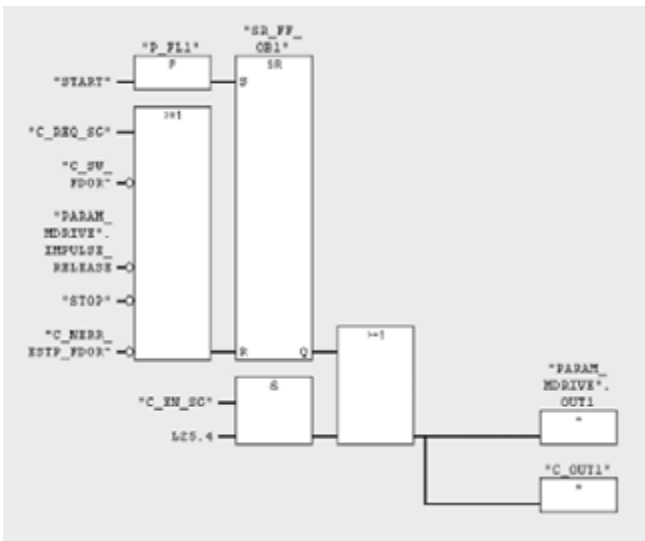
Network 1: Status MASTERDRIVES

The status of MASTERDRIVES is stored in the temporary variables STATUS_MD.



For NW2 the Bit L25.4 is required.

Network 2: Start and stop requests



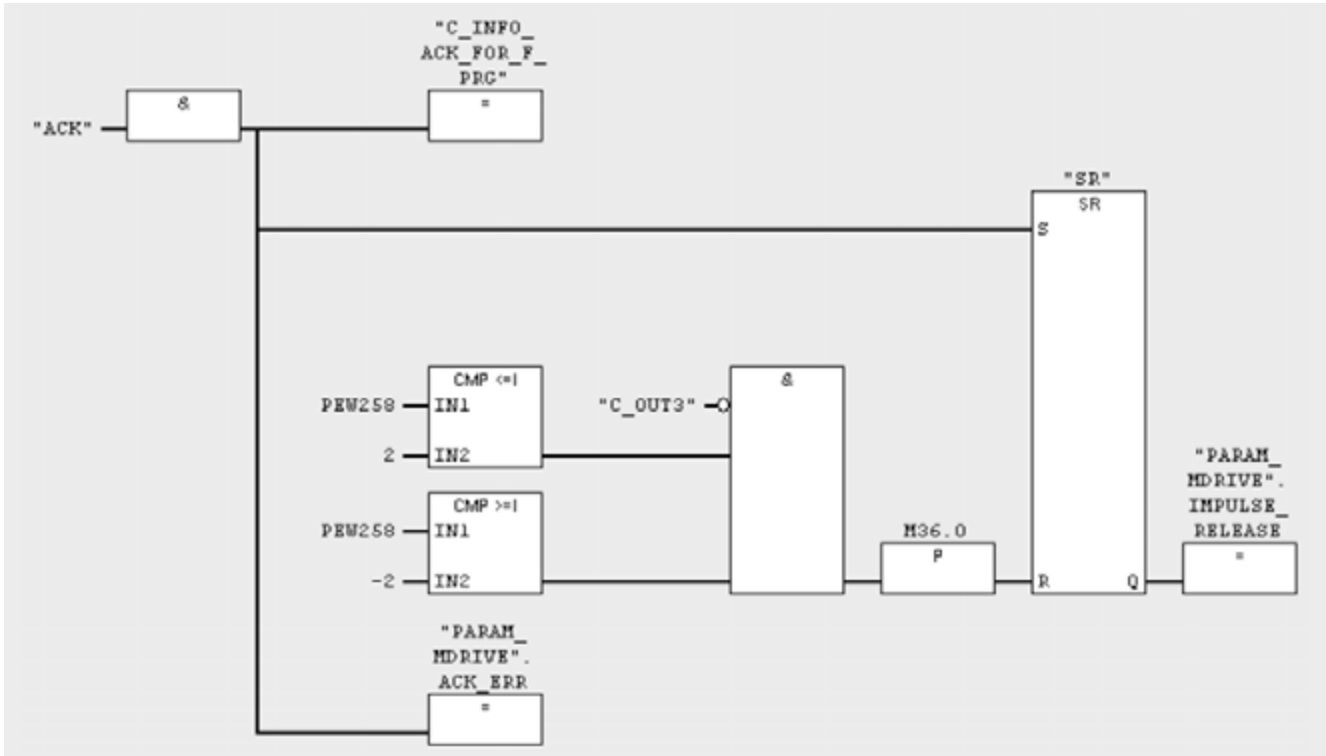
Symbol	Function	Explanation
START	Push button (NO)	1: start request
C_REQ_SG	Mode switch	Switch, which requests "safe speed" (SG) with "1" signal. Normal operation can only be started when this bit is on "0" signal.
C_SW_FDOR	Position switch	1: safety door closed
IMPULSE_RELEASE	Impulse release for MASTERDRIVES	See NW3
STOP	Push button (NC)	0: stop request
C_NERR_ESTP_FDOR	Error bit for switch-on locking	This bit represents the status on a flip-flop in the F-program which safely switches MASTERDRIVES off in the event of a failure. C_NERR_ESTP_FDOR=0, if at least one of the following events is true: <ul style="list-style-type: none"> • Safety door is opened during normal operation • Emergency stop push button is pressed • In operating mode "safe speed" (SG) the actual speed value exceeds a comparison value N_SG. • in "safe speed" (SG) mode, the actual speed value determined with PROFIBUS and the actual speed value determined with the ET 200S count module are deviating. • In operating mode "safe speed" (SG) the drive spins (SSTILL=0), even though no start request is pending (OUT1=0). • The readback signals from contactor K2 or option K80 are not pending correctly.
C_EN_SG	Enable "safe speed" (SG)	1: operating mode "safe speed" (SG) active
OUT1	Enable start of MASTERDRIVES	Parameter of MASTERDRIVES, controlled by S7-400 (Master-CPU) via PROFIBUS. "1" signal means: drive starts. OUT1=1 for the operating modes <ul style="list-style-type: none"> • Normal operation • Safe speed" (SG) OUT1=1 requires OUT3=1.
C_OUT1	Enable start of MASTERDRIVES	Information for the F-CPU

Without the AND logic operation of C_EN_SG with L 254.4 (OUT2) the drive would in operating mode "safe speed" (SG) not restart after standstill and pulse blocking. Reason: After pulse blocking MASTERDRIVES resets the Bit OUT2 internally to "0" signal and goes to "switch-on locking" mode. After pressing the dead man switch the safety relay of option K80 is controlled again, which causes MASTERDRIVES to reset the OUT2 bit to "1" signal. Only now must the start command assign "1" signal to the OUT1 bit.

Note

After unplugging the PROFIBUS connector from MASTERDRIVES (during runtime) the drives goes to standstill. Renewed starting requires pressing not only acknowledgement (ACK) but also the stop button (STOP) to reset OUT1 in the Master-CPU.

Network 3: Acknowledgement



With ACK=1 the following parameters are acknowledged:

Symbol	Function	Explanation
ACK	Push button (NO)	Acknowledgement <ul style="list-style-type: none"> Necessary prior to the first start. After error recovery
C_INFO_ACK_FOR_F_PRC	Information exchange from DP master to DP slave.	Acknowledgement signal for F-program
C_OUT3	Information exchange from DP slave to DP master.	0: Fast stop of drive (e.g. after triggering emergency stop) After standstill of the drive (determined by both CMP compare blocks) the pulse blocking at the drive is removed (resetting the SR flip-flop).
IMPULSE_RELEASE	Impulse release for MASTERDRIVES	0: Removing the pulse blocking for the drive
ACK_ERR	Acknowledgement MASTERDRIVES	Error pending at MASTERDRIVES is acknowledged with ACK=1.

Note

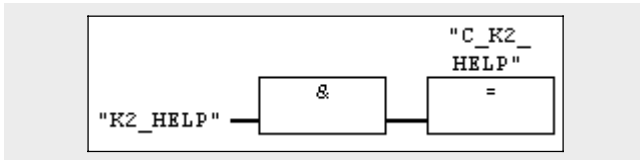
For resetting the pulse blocking of MASTERDRIVES it is sufficient to determine the safe standstill via PROFIBUS. Additional standstill detection via the count module of the ET 200S is not required here.

Note

When determining the standstill, the drive speed (here: PEW258) is not compared with 0, but with 2 and -2. This takes into account, that the incremental shaft encoder can also detect speeds not equal to 0 due to small movements of the drive. On average, however, the speeds are 0. The comparison value must be adjusted to your individual situation.

Network 4: Reading in the readback signals

The opening auxiliary contact of contactor K2 is connected with the digital input module of the S7-400 (K2_HELP). The readback signal is evaluated in the F-program. C_K2_HELP makes the readback signal available to the F-CPU.



Network 5-7: Speeds for MASTERDRIVES

NW	Task	Note/explanation	Code
5	Conversion of actual speed value in 1/min with PROFIBUS	This network determines the actual speed value read with PROFIBUS and provides this value to the DP slave for standstill evaluation. Maximum speed: 6000 1/min Maximum value of MASTERDRIVES: 4000hex=16384dec The ratio of both numbers make up a factor which initially is stored in a temporary variable #TEMP1. Via the PEW 258 the value representing the actual speed value is read in by MASTERDRIVES. Multiplication of this value with #TEMP1 results in the actual speed in 1/min. This value is transmitted to the F-CPU with C_N_ACT.	<pre>L 6.000000e+003 L 1.638400e+004 /R T #TEMP1 L PEW 258 ITD DTR L #TEMP1 *R END T "C_N_ACT"</pre>
6	Converting the setpoint speed value for the operating mode "safe speed" (SG):	The value C_N_SG is provided by the F CPU in 1/min. After conversion (4000hex correspond to 6000 1/min) this value is available in MASTERDRIVES as N_SG_FOR_MDRIVE.	<pre>L 1.638400e+004 L 6.000000e+003 /R T #TEMP1 L "C_N_SG" ITD DTR L #TEMP1 *R END T "N_SG_FOR_MDRIVE"</pre>
7	Normal operation or "safe speed" (SG)	If C_EN_SG=1, the "safe speed" stored in the F-program is transmitted to MASTERDRIVES (transfer command in PAW 258). For C_EN_SG=0 the setpoint speed value stored in DB1 is transferred to MASTERDRIVES for normal operation.	<pre>L DB1.DB 1 //Q1 T PAW 258 //Q2 S "C_EN_SG" //Q3 SFB 95 //Q4 L "N_SG_FOR_MDRIVE" //Q5 SFB 95 //Q6 MVAR: L "ENGINE_SPEED"-SETPOINT_N_NORMAL END: T "PAW_MDRIVE"-SPEED_OUTPUT T PAW 258 //...</pre>

OB "COMPLETE RESTART" (OB 100)

In OB 100 the values for MASTERDRIVES are default and become active on starting up the S7-CPU.

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S7 program of DP Slave

**Standard user program of the DP Slave CPU
(IM 151-7F-CP)**

OB 1

The networks of OB1 of the F-CPU describe the address transfer area to provide necessary information to the master CPU.

Timed alarm (OB 35):

In OB 35 the program for the count module of ET 200S is called up:

The count module receives pulses from the SBM2 module of MASTERDRIVES. OB 35 forms the interface for the S7 program by evaluating these pulses. The variable N_SBM2 delivers the actual speed value which in the F-program is used for standstill detection of the drive. The speed value determined by the count module is always displayed as a positive value.

Furthermore, the OB35 calls the F-runtime group (F-CALL).

F-program of the DP Slave (IM 151-7F-CP)

F-CALL (FC 1)

The F-runtime group F-CALL (FC 1) is called from the cyclic interrupt OB (OB 35). From here, the FC "COORDINATION" (FC 2) is processed first.

FC "COORDINATION" (FC 2)

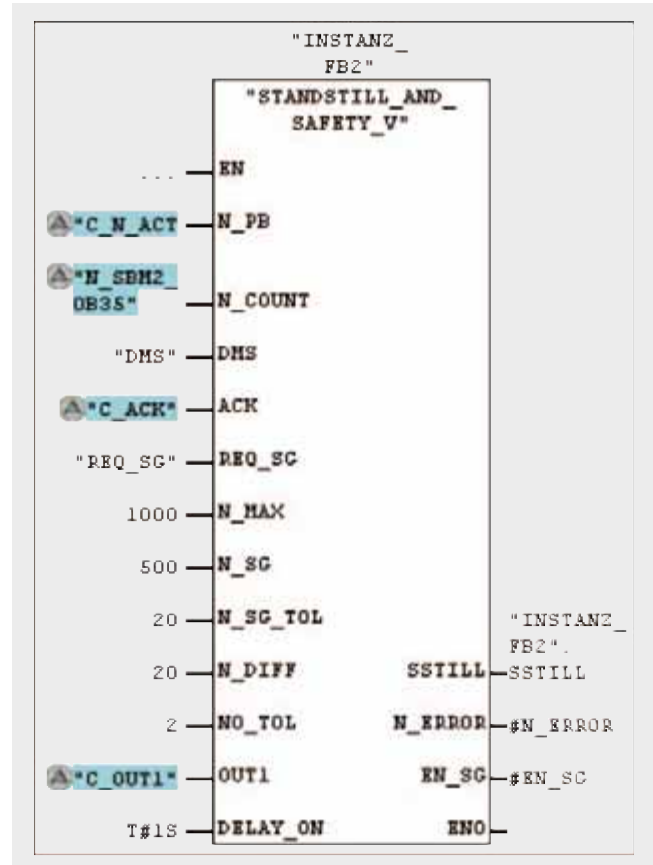
The FC2 successively processes the following F-blocks:

- FB "STANDSTILL_AND_SAFETY_V" (FB 2, DB 2)
- FB "EMSTP_AND_FDOOR" (FB 1, DB 1)
- FC "REINT" (FC 10)

FB "STANDSTILL_AND_SAFETY_V" (FB 2, DB 2)

Tasks of the FB "STANDSTILL_AND_SAFETY_V" (FB 2, DB 2)

- Standstill detection
- Enable operating mode "safe speed" (SG)
- Perform plausibility check of the determined actual speed values (via PROFIBUS and count module of the ET 200S).



Variables of FB "STANDSTILL_AND_SAFETY_V" (FB 2, DB 2):

Formal parameters	Data Type	Explanation
N_PB	INT	Actual speed value (determined via PROFIBUS). Provided by master CPU in 1/min.
N_COUNT	INT	Actual speed value (determined via SBM2 module of MASTERDRIVES and count module of the ET 200S). Provided by OB35 of the F-CPU in 1/min.
DMS	BOOL	"Dead Man Switch": Button (NO) which can start the drive from standstill when "safe speed" (SG) mode is set. SG remains active as long as <ul style="list-style-type: none"> the button (NO) stays pressed the operating mode "safe speed" (SG) is set the emergency stop push button is not pressed the plausibility checks of the speed is confirmative the readback signal of K2 is pending correctly
ACK	BOOL	Occurring errors are acknowledged with the acknowledge signal.
REQ_SG	BOOL	Mode switch 0: normal operation, 1: "safe speed" (SG)
N_MAX	INT	$N_ERR1=1$ for $N_PB > N_MAX$ or $N_COUNT > N_MAX$. In operating mode SG this causes safe shutdown of the drive.
N_SG	INT	Maximum speed value in 1/min for "safe speed" (SG).
N_SG_TOL	INT	Tolerance range for N_SG. The drive is safely shut down in "safe speed" (SG) mode if the actual speed value is larger than $N_SG + N_SG_TOL$.
N_DIFF	INT	Determined are <ul style="list-style-type: none"> the actual speed value determined via PROFIBUS and the actual speed value determined via the count module of ET 200S. If the differential value of both determined actual speed values exceeds the parameterized value N_DIFF, this is interpreted as plausibility error. N_ERR2 then becomes 1 and the drive is safely switched off.
NO_TOL	INT	When determining the standstill, the drive speed does not become 0, but is compared with the value parameterized at NO_TOL. This takes into account, that the incremental shaft encoder can also detect speeds not equal to 0 due to small movements of the drive. On average, however, the speeds are 0.
OUT1	BOOL	OUT1=1: start command for drive.
DELAY_ON	TIME	Switch-on delay. After the time has elapsed, the evaluation of the plausibility check becomes active. The delay is due to the inertia of the mechanical contacts.
SSTILL	BOOL	1: drive in standstill
N_ERROR	BOOL	Collective error: is set to 1, if in "safe speed" (SG) mode one of the following errors occurs. <ul style="list-style-type: none"> the actual speed value exceeds a speed value N_MAX ($N_ERR1=1$) the speed determined via PROFIBUS and the speed determined with the ET 200S count module deviate ($N_ERR2=1$). The drive is started in the DP master with OUT1=1. If there is a faulty transmission in the address transfer area then DP Slave OUT1=0 but the drive remains active ($SSTILL=0$). If this condition is true, then $N_ERR3=1$. The actual speed value exceeds the set speed value for safe speed ($N_ERR4=1$).
EN_SG	BOOL	1: "Safe speed" (SG) is active.

Note

The parameterized count values are sample values and must be adjusted according to their individual requirements.

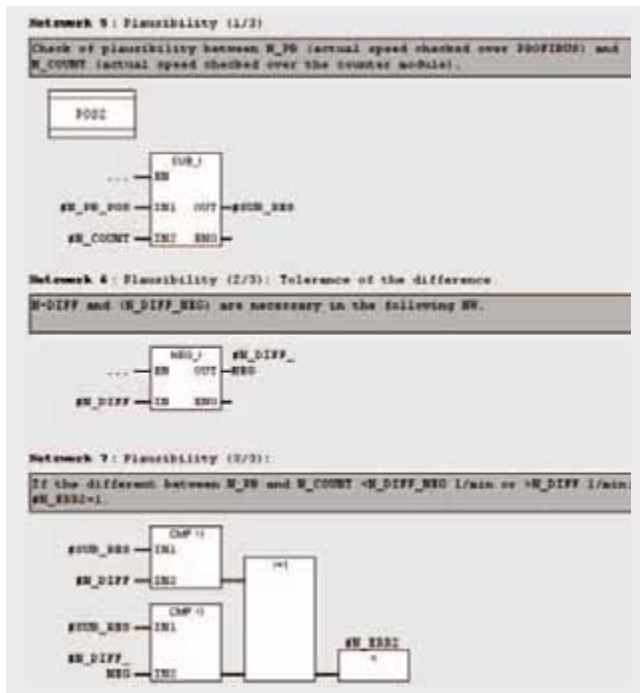
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Network 1 to 4

In these networks, the value of the speed determined by PROFIBUS is formed ($N_PB \rightarrow N_PB_POS$). This value is required further. The speed value determined via the count module of ET 200S is always positive.

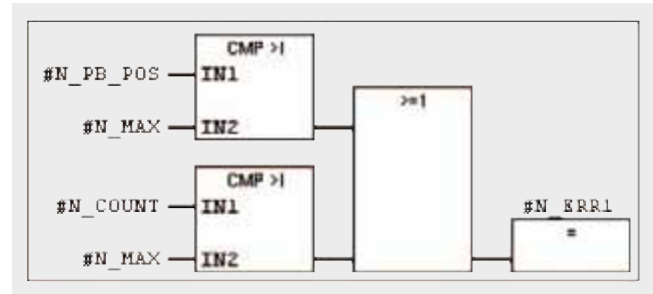
Network 5 to 7

In these networks the plausibility checks whether the actual speed value determined with PROFIBUS and the actual speed value determined with the ET 200S count module are deviating. First, the difference SUB_RES is formed of both determined values (NW5). This difference is in NW7 compared with the tolerance value N_DIFF . If the difference is outside this tolerance value, this is interpreted as error. In this case $N_ERR2=1$ which, if "safe speed" (SG) mode is set, causes a safe drive shutdown.



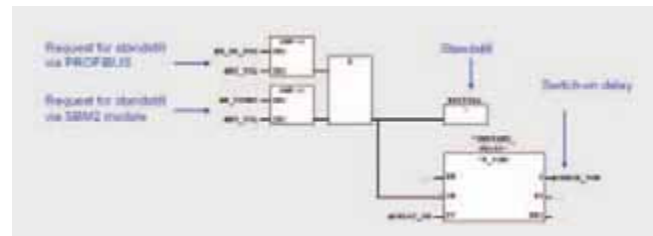
Network 8

In this network it is checked whether the actual speed value exceeds the limit value N_MAX . In this case $N_ERR1=1$ which in "safe speed" (SG) mode causes a safe drive shutdown.



Network 9

In this network the safe standstill is defined.



Note

When determining the standstill, the drive speed (here: N_PB_POS and N_COUNT) is not compared with 0, but with NO_TOL (here: 2). This takes into account, that the incremental shaft encoder can also detect speeds not equal to 0 due to small movements of the drive. On average, however, the speeds are 0. The comparison value must be adjusted to your individual situation.

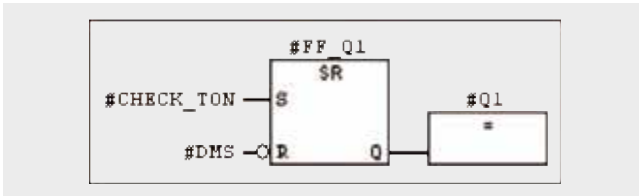
The switch-on delay $CHECK_TON$ becomes 1

- if the drive is not in standstill AND
- the time parameterized at PT has elapsed.

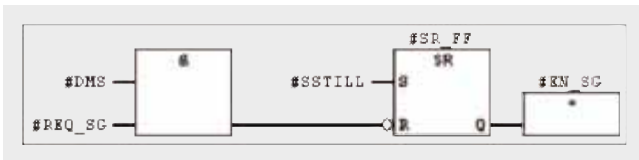
In case of an error at $CHECK_TON = 1$ during plausibility check in "safe speed" (SG) mode, the drive is switched off safely. Without the switch-on delay $CHECK_TON$ the drive would stop after switching on, as due to the inertia of the mechanical contacts, the plausibility conditions at times $t < DELAY_ON$ are not fulfilled.

Network 10

In this network, the time delay is assigned to a variable Q1, which in the last network determines the triggering a collective error N_ERROR.



Network 11

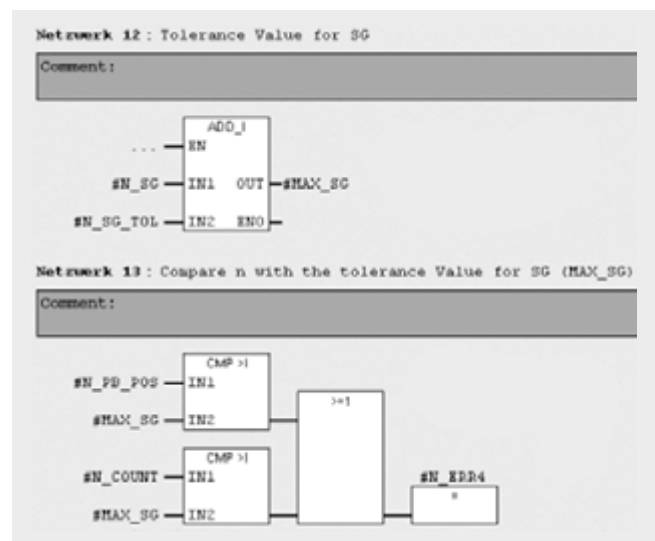


Operating mode "safe speed" (SG) active at EN_SG=1. SG is only possible

- from standstill (#SSTILL=1)
- at set operating mode switch REQ_SG=1
- if dead man switch remains DMS remains pressed
- the plausibility check agrees with the actual speed value
- if contactor K2 reports no readback error

Networks 12-13

The value of the actual speed value (N_PB_POS) determined with PROFIBUS and the actual speed value determined with the count module of ET 200S (N_COUNT) must not exceed the defined speed value f#or safe speed N_SG. A (parameterizable) tolerance value N_SG_TOL is added to the N_SG value (NW 12). The resulting value MAX_SG switches the drive off safely when exceeded (N_ERR4 in NW 13).



Network 14

The constellation OUT1=0 (is no standard requirement) and SSTILL=0 (drive spins) can occur in two occasions:

- During operational stop (drive shutdown)
- In case of an error (e.g. load causes spinning movement)

In case of an error a spinning movement of the drive detected in "safe speed" (SG) mode causes a safe drive shutdown.



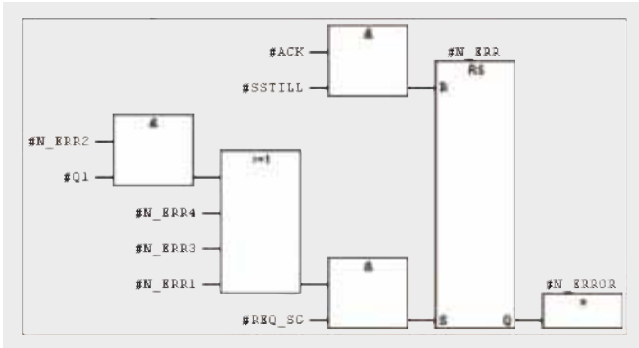
Note

An undesired electrical startup of the drive is in "safe speed" (SG) mode prevented with the K80 option by switching off the power supply for controlling the power transistors (IGBTs) during standstill (pulse blocking). More detailed information is available in the description of the FB1.

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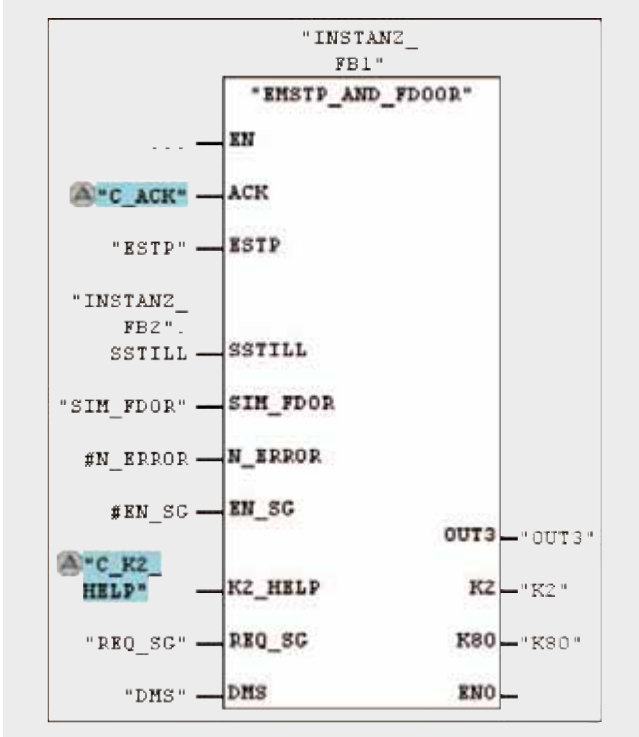
Network 15

In this network, a collective error N_ERROR is defined which in the FB1 causes safe shutdown of the drive. N_ERROR=1 only occurs in "safe speed" (SG) mode and can be acknowledged after error recovery and standstill of the drive.



FB "EMSTP_AND_FDOOR" (FB 1, DB 1)

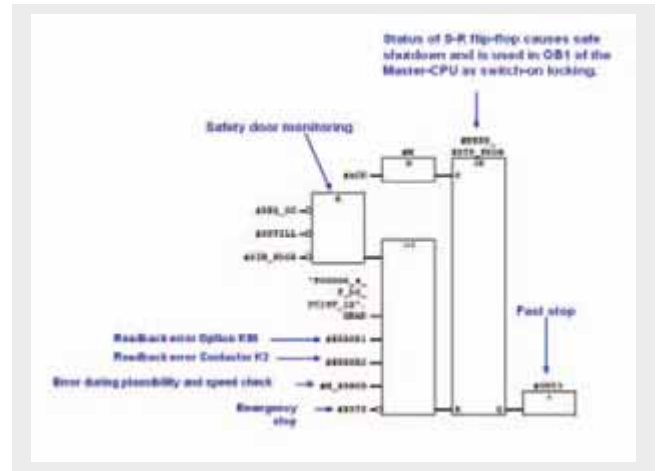
In case of an error, FB1 causes safe shutdown of the drive.



Variables of FB "EMSTP_AND_FDOOR" (FB 1, DB 1):

Formal parameters	Data Type	Explanation
ACK	BOOL	Acknowledgement signal (from the master CPU)
ESTP	BOOL	Emergency stop push button (NC / NC)
SSTILL	BOOL	1: Operating mode "safe speed" (SG) active
SIM_FDOR	BOOL	1: safety door closed.
N_ERROR	BOOL	Collective error determined in FB2.
EN_SG	BOOL	1: "safe speed" active
K2_HELP	BOOL	Readback signal of contactor K2
REQ_SG	BOOL	Mode switch: 0: normal operation, 1: "safe speed" (SG)
DMS	BOOL	"Dead Man Switch": Button (NO) which can start the drive from standstill when "safe speed" (SG) mode is set.
OUT3	BOOL	MASTERDRIVES evaluates the signal OUT3. If it changes its state from "1" to "0" signal, the drive stops (fast stop).
K2	BOOL	Line contactor
K80	BOOL	Contactor whose auxiliary contact (NO) controls the safety relay of the K80 option of MASTERDRIVES.

Network 1

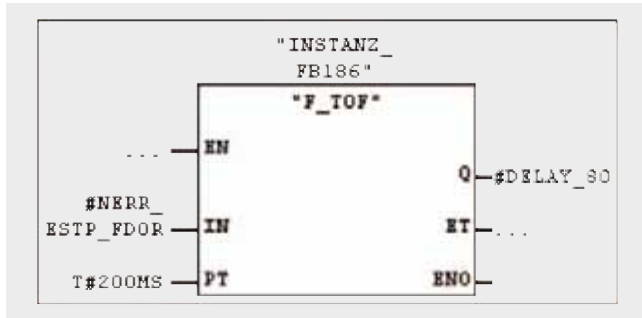


Note

For a renewed start (OUT1=1) of the drive, OUT3=1 must be true.

Network 2

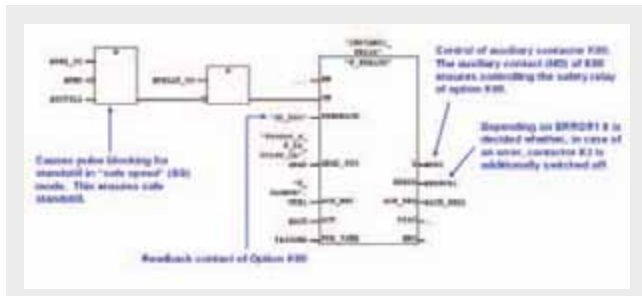
With OUT3=0 the drive is brought to standstill with fast stop. The subsequent safe shutdown becomes active with a time delay (see figure below). Without time delay, the pulse blocking (Option K80) would be active immediately so that a fast stop (with OUT3) would not be possible any more.



NERR_ESTP_FDOR receives the state of the SR flip-flop from NW1, which sets or resets OUT3. If OUT3 is reset, DELAY_80 is also reset after the time parameterized at PT has elapsed.

Network 3

FB F_FDBACK (FB216) is a certified block from the Distributed Safety block library.

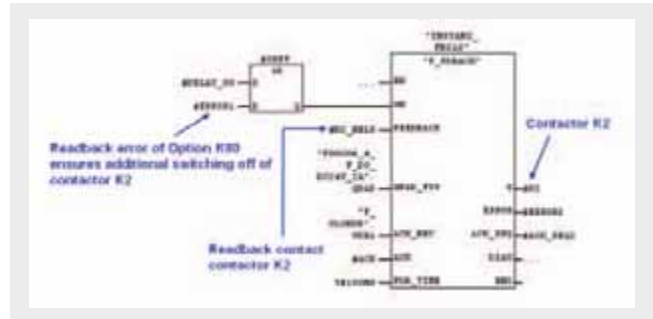


Note

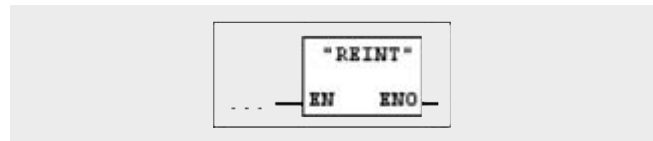
Further information on the FB216 is available for example by selecting it in the block editor and pressing F1.

Network 4

FB F_FDBACK (FB216) is a certified block from the Distributed Safety block library.

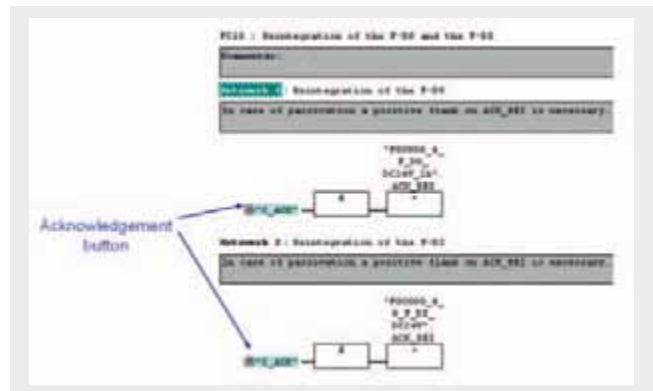


FC "REINT" (FC 10)



The FC 10 causes the reintegration of F-DI and F-DO, in order to depassivate them. This requires that:

- the error that caused the passivation has been removed and
- a positive edge has been set at the parameter ACK_REI of the respective F-Periphery DB.



A passivation is indicated by an illuminated LED "SF" on the module. The reintegration of an F module may take several minutes.

Ex. No.
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Operating instruction

Note
The configuration of MASTERDRIVES is not discussed in this example.

If the S7 projects in the S7-CPU's and MASTERDRIVES have been parameterized accordingly, you can start the drive. The following points should be checked before taking the actions below:

- Emergency stop button unlocked
- Actuator in position switch (simulates closed safety door).
- Neither F-DI nor F-DO are passivated.
- Mode switch in "normal operation" (0-signal).

No.	Instructions	Result / Note
1	Press the acknowledgement push button (NO) and release it.	Necessary prior to the first start.
2	Press the start push button (NO) and release it.	Drive starts.
3	Press the Stop button (NC).	Drive stops.

Note
An acknowledgement is required:

- Prior to the first start (normal operation)
- After triggering emergency stop
- After opening the safety door in normal operation
- After error recognition during plausibility checks for the speed value

Note
For further help on commissioning this example please refer to chapter 4.4 "Function test".

Safety Drives System

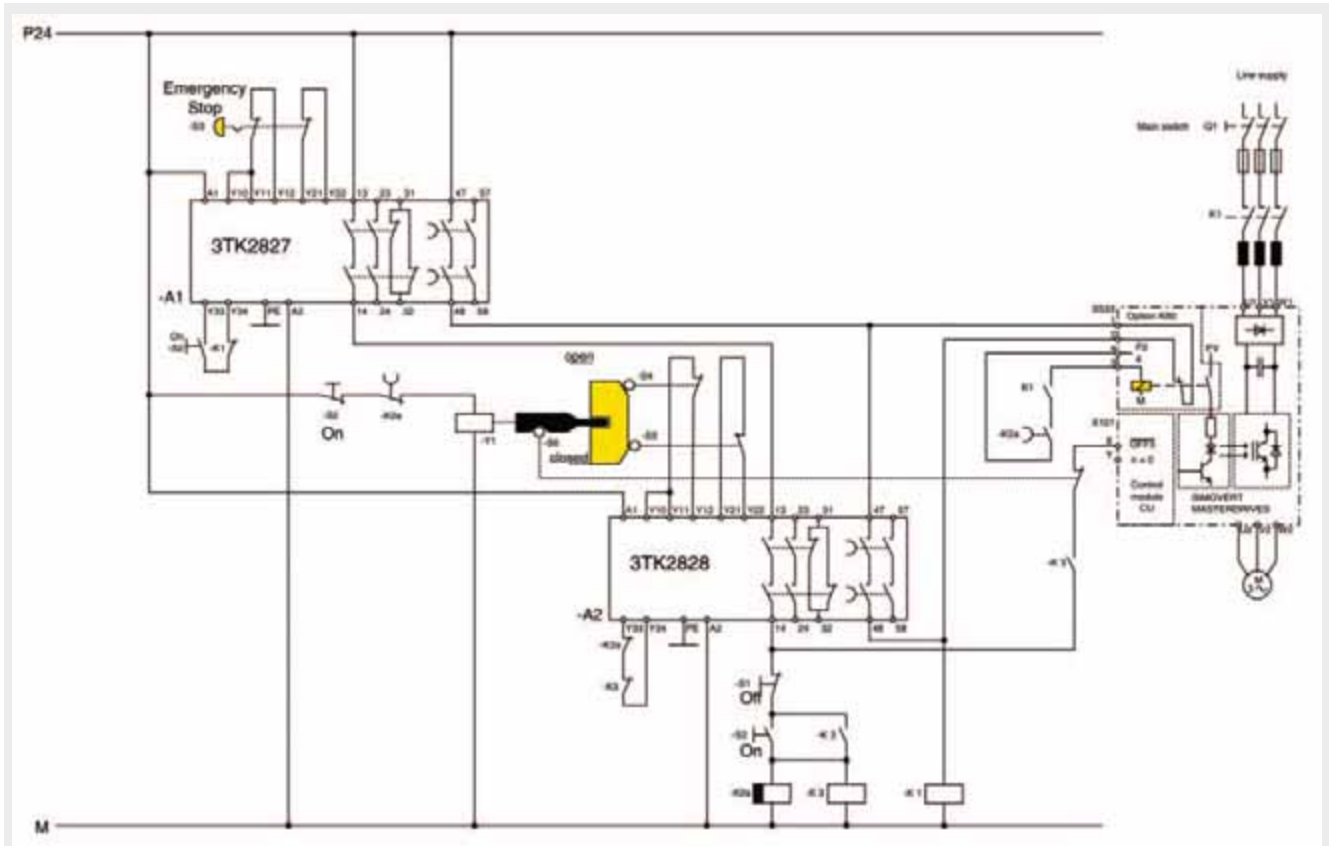


	1 SAFE STANDSTILL Category 3 acc. to EN 954-1 with SIMOVERT MASTERDRIVES	422	2.6 Safe standstill for non-interlocked protective doors, Emergency Stop, implemented with a safety combination and standard PLC
396	1.1 Safe standstill with interlocked protective doors, Emergency Stop implemented using safety combinations	424	2.7 Safe standstill for several non-interlocked protective doors and several drives, Emergency Stop implemented using safety combinations
398	1.2 Safe standstill for non-interlocked protective doors, Emergency Stop implemented using safety combinations		3 SAFE STANDSTILL Category 3 acc. to EN 954-1 with SINAMICS S120
400	1.3 Safe standstill for non-interlocked protective doors, implemented with one safety combination	428	3.1 Safe standstill, Safe Stop 1 implemented using safety combination
402	1.4 Safe standstill for non-interlocked protective doors, implemented with one safety combination	432	3.2 Safe standstill, implemented with one safety combination
404	1.5 Safe standstill for interlocked protective doors, Emergency Stop, implemented with safety combinations and standard PLC	434	3.3 Safe standstill for interlocked protective doors, Emergency Stop, implemented with safety combination and standard
406	1.6 Safe standstill for non-interlocked protective doors, Emergency Stop, implemented with a safety combination and standard PLC	436	4 Safe Monitoring of Drive Functions SIMOTION D/ SIMATIC S7-F
408	1.7 Safe standstill for several non-interlocked protective doors and several drives, Emergency Stop implemented using safety combinations		5 SINAMICS G120 - controlled via PROFIBUS
	2 SAFE STANDSTILL Category 3 acc. to EN 954-1 with SIMODRIVE 611 universal	463	5.1 Safety functions using PROFIsafe, Category 3 (EN 954-1) or SIL 2 (IEC 61508)
412	2.1 Safe standstill with interlocked protective doors, Emergency Stop implemented using safety combinations	487	5.2 Safety functions via terminals, Category 3 (EN 954-1) or SIL 2 (IEC 61508)
414	2.2 Safe standstill for non-interlocked protective doors, Emergency Stop implemented using safety combinations		
416	2.3 Safe standstill for non-interlocked protective doors, implemented with one safety combination		
418	2.4 Safe standstill for non-interlocked protective doors, implemented with one safety combination		
420	2.5 Safe standstill for interlocked protective doors, Emergency Stop, implemented with safety combinations and standard PLC		

SAFE STANDSTILL Category 3 acc. to EN 954-1 with SIMOVERT MASTERDRIVES

Safe standstill with interlocked protective doors, Emergency Stop implemented using safety combinations

Ex. No.
1.1



"Safe standstill" with MASTERDRIVES with interlocked protective door with safety combinations, Stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN 1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors. The drive is shut down (stopped) according to Stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4, S5 and S6 are positively opening position switches corresponding to EN 1088.
- The drive is shut down using the internal safety relay.
- On circuits of safety combinations A1 and A2 monitor whether line contactor K1 has dropped-out after Emergency Stop or whether time relay K2a and contactor K3 have dropped-out after the protective door circuit has been opened (this is necessary in the sense of control Category 3 according to EN 954-1!).

Behavior when Emergency Stop is issued

Button S3 ("Emergency Stop") is used to issue an Emergency Stop command. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of timer relay K2a and the delay time of the safety relay A1 are started; the drive must have come to a standstill before they expire.

Behavior when the protective doors are opened

Button S1 ("Off") requests that the protective doors are opened. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- Contactor K3 is longer energized. A 0 signal is entered, via its contact (NO contact), at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of time relay K2a is started and before this time has expired, the drive must have come to a standstill.
- After the drop-out delay time of time relay K2a has expired, the internal safety relay of the drive is no longer energized (**1st shutdown path!**). At the same time, the latch (tumbler) Y1 of the protective doors is opened.

Powering-up the drive

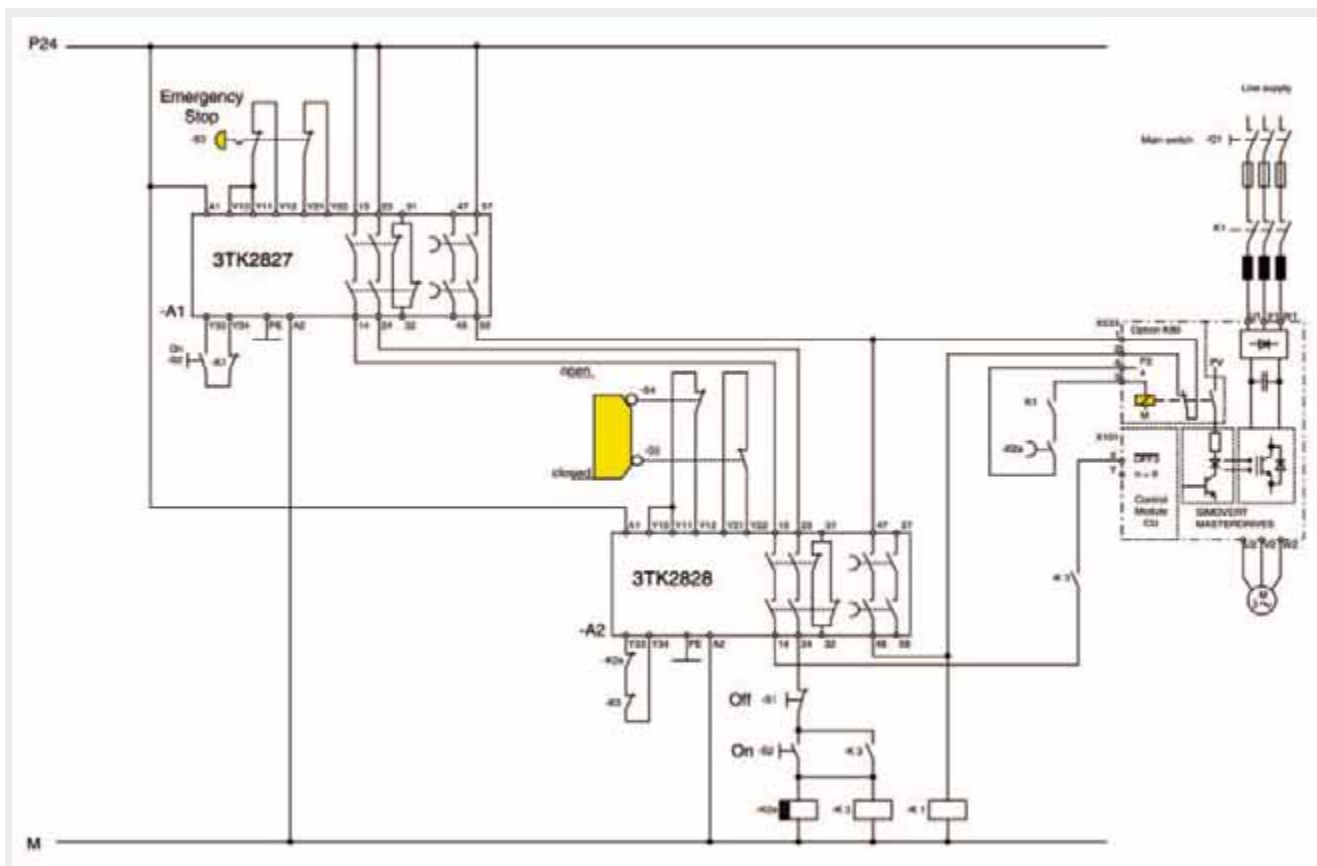
The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When pressing button S2 ("On"), safety combination A1 is brought into the operational state. The coil of latch (tumbler) Y1 is no longer energized, the protective doors are interlocked. Safety combination A2 is again in an operational state. Line contactor K1 is energized..
- Contactor K3 is energized and latches and at the same time, time relay K2a is energized. The integrated safety relay is energized, a 1 signal is entered at contact X101.X (OFF3) of the drive. The drive restarts.

- The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a has expired (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A1, line contactor K1 is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal from line contactor K1 is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an erroneous function, a restart after Emergency Stop is prevented.
- When the protective doors are opened the safety monitoring A2 of the safety circuit is interrupted. Before the selected delay time of safety combination A2 has expired, the internal safety relay of the drive must have already dropped-out. Its checkback signal contacts X533.1/2 indicate that the drive is in a safe condition.
- After the selected delay time has expired, the safely delayed enable contacts of the safety combination A2 open.
- If the internal safety relay of the drive is functioning correctly, its checkback signal contact X533.1/2 is closed, line contactor K1 does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts X533.1/2 are not closed, line contactor K1 drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

Safe standstill for non-interlocked protective doors, Emergency Stop implemented using safety combinations

Ex. No.
1.2



"Safe standstill" with MASTERDRIVES for a non-interlocked protective door with safety combinations, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down using the internal safety relay.
- On circuits of safety combinations A1 and A2 monitor whether line contactor K1 has dropped-out after Emergency Stop or whether time relay K2a and contactor K3 have dropped-out after the protective door circuit has been opened (this is necessary in the sense of control Category 3 according to EN 954-1!).

Behavior when Emergency Stop is issued

Button S3 ("Emergency Stop") is used to initiate an Emergency Stop command. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of timer relay K2a and the delay time of the safety relay A1 are started; the drive must have come to a standstill before they expire.

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to Stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered, via the enable contact of safety combination A2, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay time of timer relay K2a is started and before this time has expired, the drive must have come to a standstill.
- The internal safety relay of the drive is no longer energized after the drop-out delay time of timer relay K2a has expired (**1st shutdown path!**).
- Before the selected delay time of safety combination A2 has expired, the internal safety relay of the drive must have already dropped-out. Its checkback signal contacts X533.1/2 indicate that the drive is in a safe condition.

Powering-up and powering-down the drive

The drive can be started or stopped when the protective doors are closed and Emergency Stop button S3 is released.

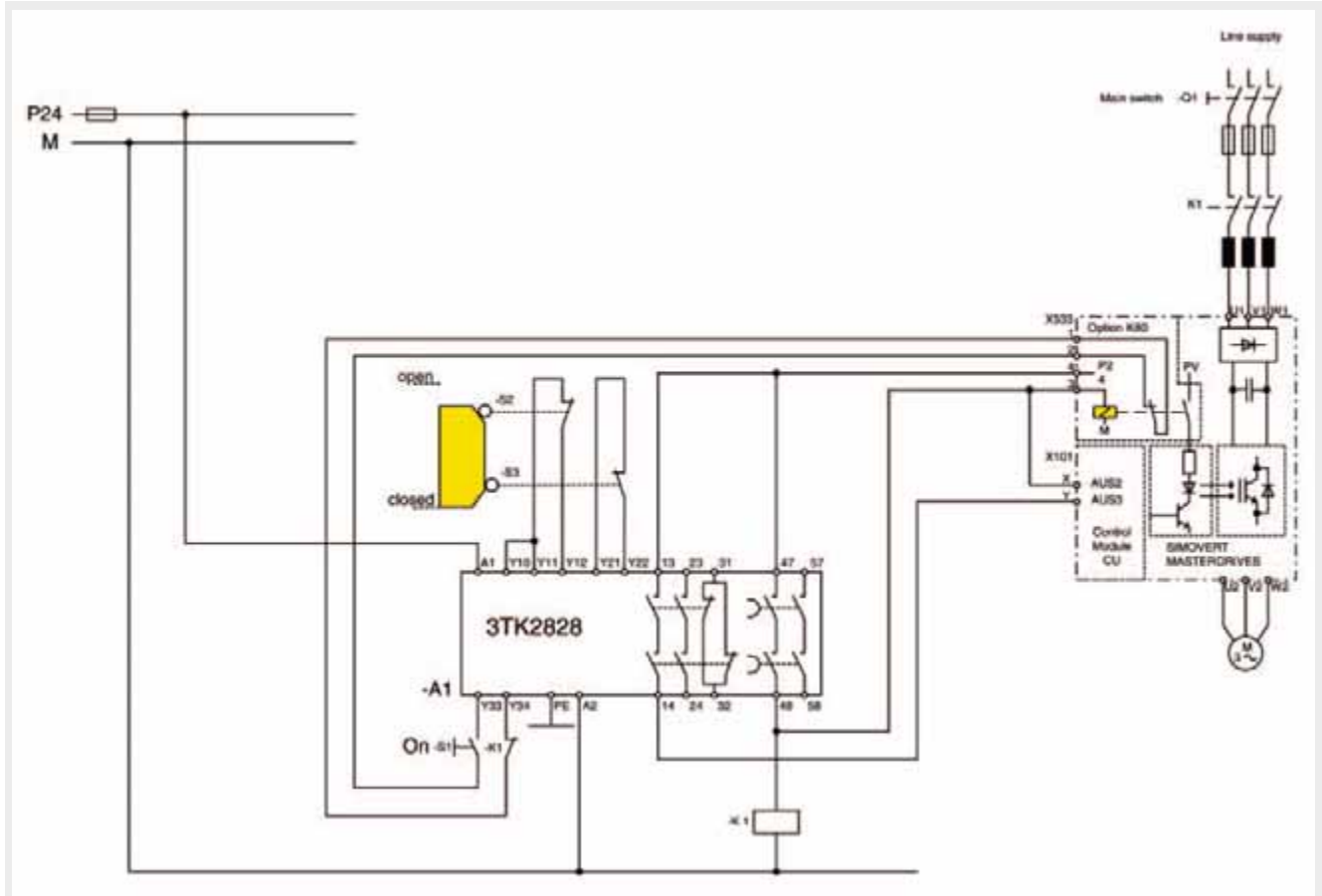
- When pressing button S2 ("On"), safety combination A1 is brought into the operational state. Line contactor K1 is energized.
- When pressing button S2 ("On"), contactor K3 is energized and latches; timer relay K2a is simultaneously energized. The internal safety relay is energized and a 1 signal is entered at contact X101.X (OFF3) of the drive. The drive restarts.

- The internal safety relay of the drive is no longer energized after the drop-out delay time of timer relay K2a has expired (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A1, line contactor K1 is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal from line contactor K1 is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an erroneous function, a restart after Emergency Stop is prevented.

- After the selected delay time has expired, the safely delayed enable contacts of the safety combination A2 open.
- If the internal safety relay of the drive is functioning correctly, its checkback signal contact X533.1/2 is closed, line contactor K1 does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts X533.1/2 are not closed, line contactor K1 drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

- When button S1 ("Off") is pressed, contactor K3 is no longer energized and the drop-out delay of timer relay K2a is simultaneously started. When contactor K3 drops-out, a 0 signal is entered at contact X101.X (OFF3). The drive is immediately braked down to 0 speed and the pulses are cancelled. The internal safety relay of the drive is no longer energized after the drop-out delay time of timer relay K2a has expired. The protective doors can be opened.

Safe standstill for non-interlocked protective doors, implemented with one safety combination



"Safe standstill" with MASTERDRIVES for a non-interlocked protective door with safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using one SIGUARD safety combination for the protective door. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combination for protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuit for protective door monitoring is monitored through 2 channels in a cross-circuit proof fashion.
- Switches S2 and S3 are positively opening position switches corresponding to EN 1088.

- The drive is shut down via the internal safety relay and the higher-level line contactor K1.
- On circuit of safety combination A1 monitors whether the line contactor K1 and internal safety relay of the drive have dropped-out after the protective doors have been opened. (This is necessary in the sense of control Category 3 in compliance with EN 954-1!).

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

■ A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.Y (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. The delay time of safety combination A1 is simultaneously started and the drive must have come to a standstill before it expires.

- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and line contactor K1 (**2nd shutdown path!**) are no longer energized.
- If the internal safety relay functions incorrectly or if line contactor K1 has not dropped-out, then its checkback signal contacts X533.1/2 in the on circuit of the safety combination A1 do not close. The safety combination cannot be switched-in.

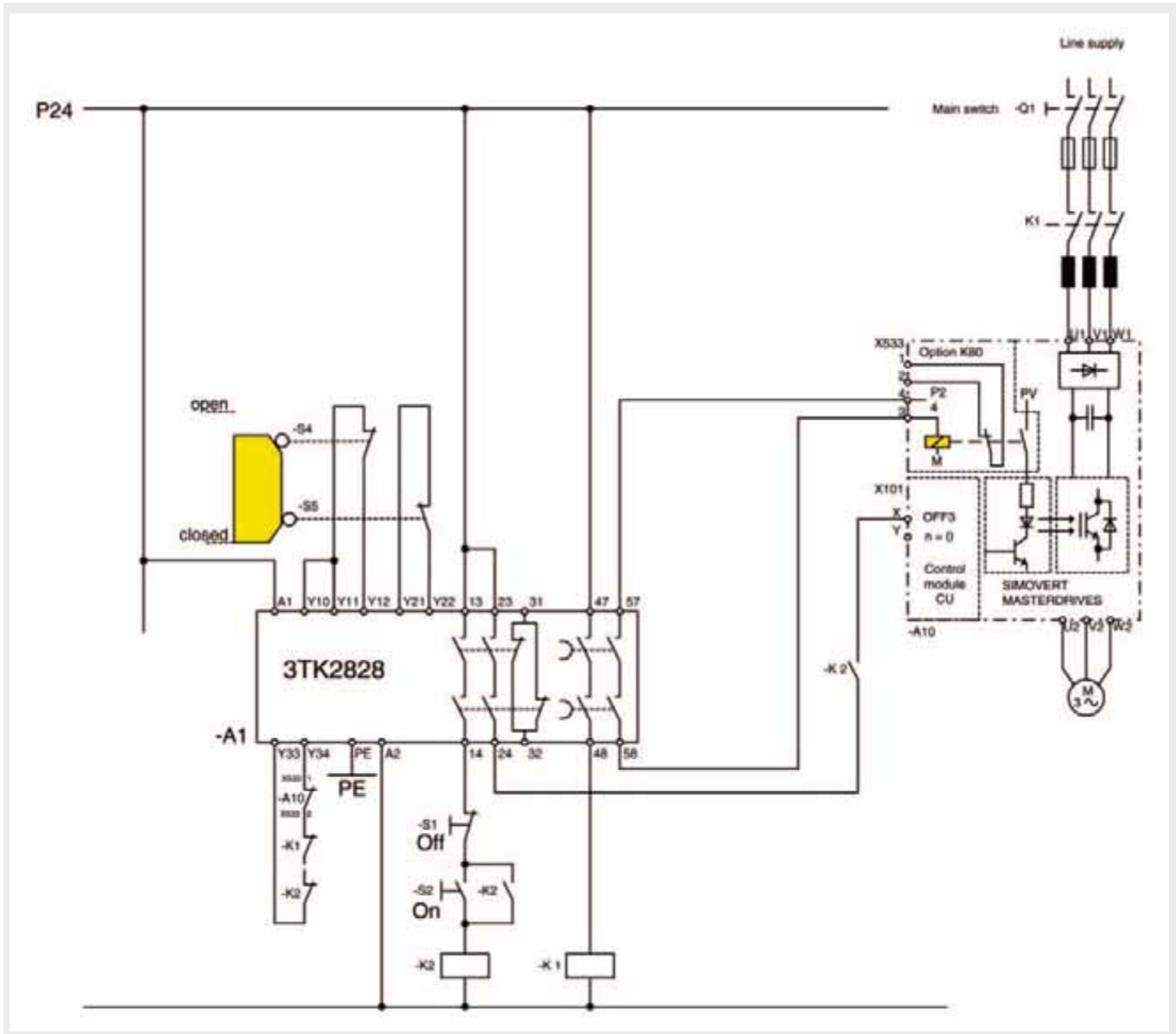
Powering-up the drive

The drive can be restarted (powered-up again) when the protective doors are closed.

■ When pressing button S1 ("On"), safety combination A1 is brought into an operational state. Contactor K1 and the internal safety relay are energized. The drive restarts.

Safe standstill for non-interlocked protective doors, implemented with one safety combination

Ex. No.
1.4



"Safe standstill" with MASTERDRIVES for a non-interlocked protective door with safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using one SIGUARD safety combination for the protective doors. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combination for protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuit for protective door monitoring is monitored through 2 channels in a cross-circuit proof fashion.

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. The delay time of safety combination A1 is simultaneously started and the drive must have come to a standstill before it expires.

Powering-up and powering-down the drive

The drive can be started or stopped when the protective doors are closed.

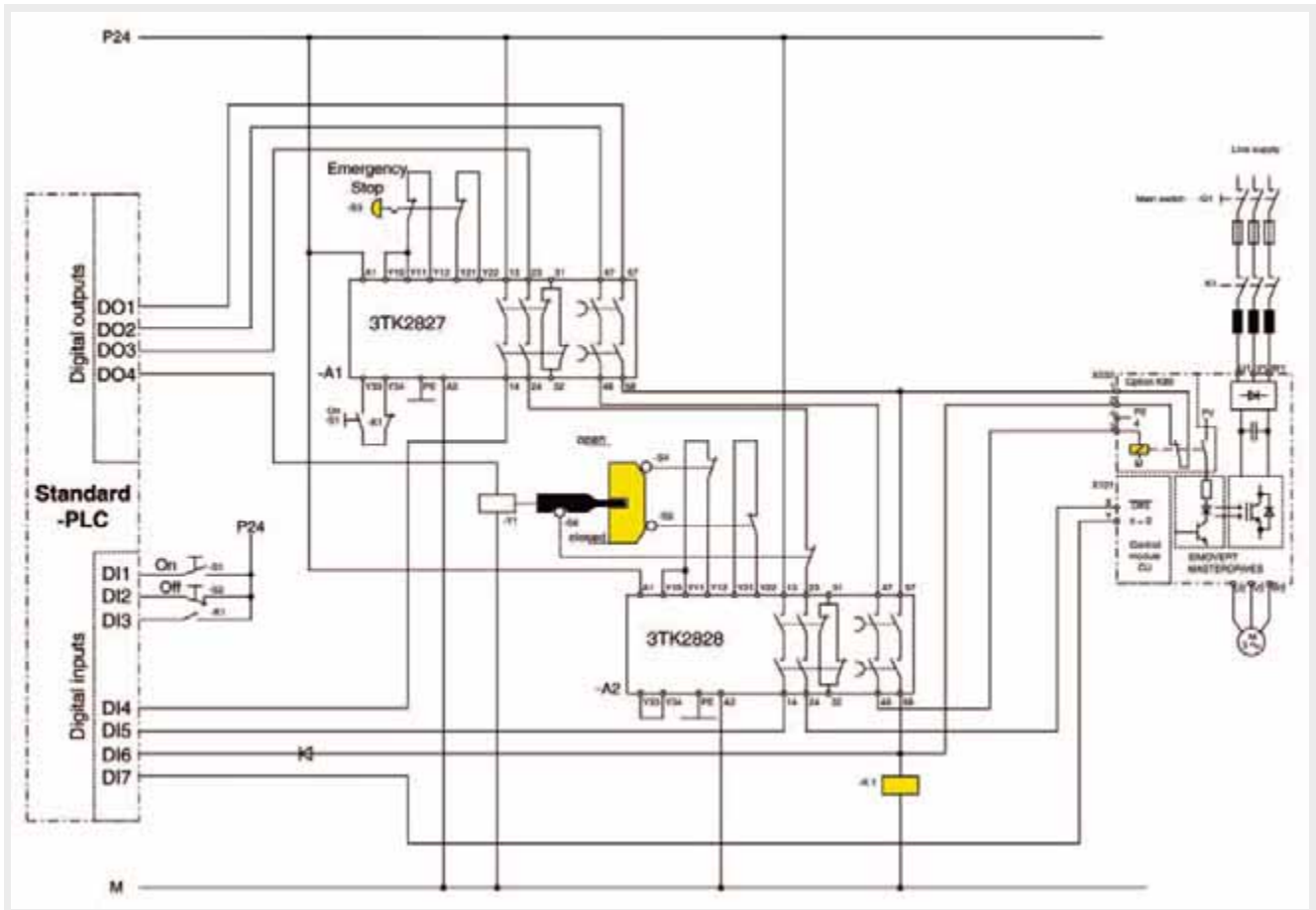
- When the internal safety relay and line contactor K1 are in the correct state, safety combination A1 is brought into an operational state.
- Line contactor K1 and the internal safety relay of the drive are energized.
- When pressing S2 ("On"), contactor K2 is energized and latches. A 1 signal is entered at contact X101.X (OFF3) of the drive and the drive starts.

- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay and the higher-level line contactor K1.
- On circuit of safety combination A1 monitors whether the line contactor K1, the internal safety relay of the drive, as well as contactor K2, have dropped-out after the protective doors have been opened. (This is necessary in the sense of control Category 3 in compliance with EN 954-1!).

- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and line contactor K1 (**2nd shutdown path!**) are no longer energized.
- If the internal safety relay functions incorrectly or if line contactor K1 has not dropped-out, then its checkback signal contacts X533.1/2 in the on circuit of the safety combination A1 are not closed. The safety combination cannot be switched-in.

- When button S1 ("Off") is pressed, contactor K2 is no longer energized and a 0 signal is entered at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. If the protective doors are opened, the safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and line contactor K1 (**2nd shutdown path!**) are no longer energized.

Ex. No.
1.5



"Safe standstill" with MASTERDRIVES for interlocked protective door, standard PLC and protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors and a standard PLC. The drive is shut down (stopped) with stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4, S5 and S6 are positively opening position switches corresponding to EN 1088.

- The drive is shut down via the internal safety relay.
- On circuit of safety combination A1 monitors whether line contactor K1 has dropped-out after Emergency Stop (this is necessary in the sense of control Category 3 in compliance with EN 954-1!).
- When implementing as higher-level circuit using contacts, the "safe standstill" function is guaranteed even when the PLC develops a fault or fails.

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). It is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), then PLC output DA2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts X533.1/2 close (**1st shutdown path!**).
- Before the selected delay time of safety combination A1 expires, the internal safety relay of the drive must have already dropped-out and its checkback signal contacts X533.1/2 indicate that the drive is in a safe condition.

Behavior when the protective doors are opened

Button S2 ("Off") requests that the protective doors are opened. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact X101.X (OFF3) of the drive by resetting the PLC output DO3. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), the PLC output DO2 of the PLC to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts X533.1/2 close (**1st shutdown path!**).
- The protective door interlocking is opened by setting PLC output DO4 to energize coil Y1. When the protective doors are opened the safety monitoring A2 of the safety circuit is interrupted.

Powering-up the drive

The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When pressing button S1 ("On"), safety combination A1 is brought into the operational state. The coil of latch (tumbler) Y1 is no longer energized by resetting PLC output DO4 - the protective doors are interlocked. Safety combination A2 is again in an operational state. Line contactor K1 is energized.

- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the line contactor K1 is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of line contactor K1 is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

- For a correctly functioning circuit, the internal safety relay of the drive has already fallen out by this time and its checkback signals contacts X533.1/2 closed. Line contactor K1 does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts X533.1/2 are not closed, the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

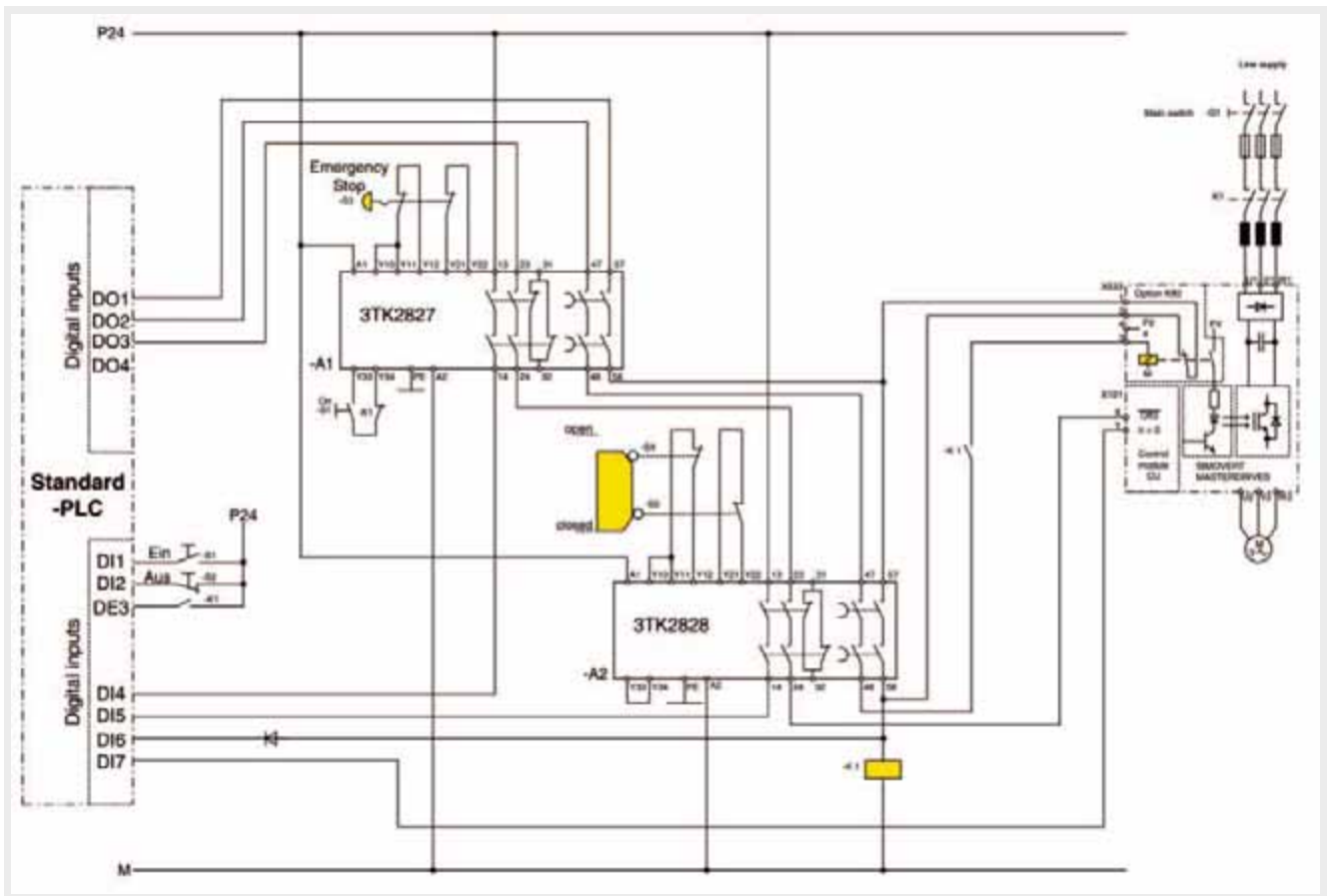
Note

If the protective door interlocking opens before the drive has braked down to 0 speed as a result of an erroneous PLC function, then a 0 signal is entered at contact X101.X (OFF3) of the drive via the switch S6. The drive is immediately braked down to speed = 0 and the pulses cancelled. Opening of the protective doors initiates the function "safe standstill". It must be ensured that potentially hazardous motion has come to a standstill before a person can reach the potentially hazardous area!

- The internal safety relay is energized (PLC output DO2), a 1 signal is entered (PLC output DO3) at contact X101.X (OFF3) of the drive. The drive restarts.

Safe standstill for non-interlocked protective doors, Emergency Stop, implemented with a safety combination and standard PLC

Ex. No.
1.6



"Safe standstill" with MASTERDRIVES for non-interlocked protective door, standard PLC and protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN 1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and the protective doors and a standard PLC. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.

- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay.
- The on circuit of safety combination A1 monitors whether line contactor K1 has dropped-out after an Emergency Stop (this is necessary in the sense of control Category 3 in compliance with EN 954-1!).
- When implementing as higher-level circuit using contacts, the "safe standstill" function is guaranteed even when the PLC develops a fault or fails.

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts X533.1/2 close (**1st shutdown path!**).

- Before the selected delay time of safety combination A1 expires, the internal safety relay of the drive must have already dropped-out and its checkback signal contacts X533.1/2 indicate that the drive is in a safe condition.
- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that line contactor K1 is no longer energized and the drive is electrically isolated from the line supply.
- The checkback signal of line contactor K1 is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered, via the enable contact of safety combination A2, at contact X101.X (OFF3) of the drive. The drive is immediately braked down to speed 0 and the pulses are cancelled. At the same time, the state of the safety combination is signaled to the control.
- Before the selected delay time of safety combination A2 has expired, the internal safety relay of the drive must have already dropped-out. Its checkback signal contacts X533.1/2 indicate that the drive is in a safe condition.

- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts X533.1/2 close. (**1st shutdown path!**)
- The safely delayed enable contacts of safety combination A2 open after the selected delay time has expired. This delay time must be set so that the checkback signal of the internal safety relay already indicates that the drive is in a safe condition.
- If the delay time of the contactor combination A2 has been correctly set and the function of the internal drive safety relay is correct, line contactor does not drop-out. If the delay time has been set too short or the internal safety relay is not functioning correctly, line contactor K1 drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

Powering-up and powering-down the drive

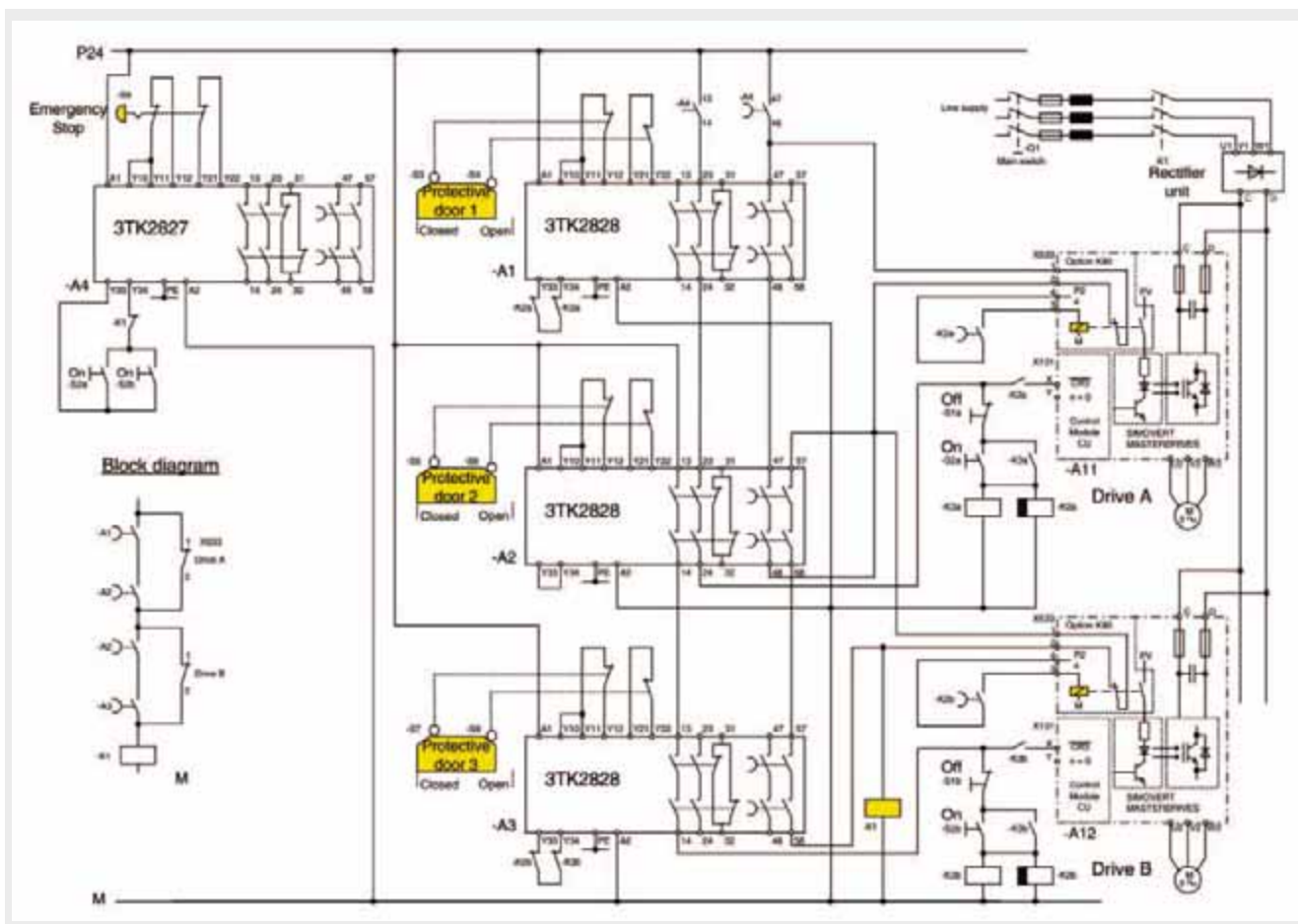
The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When button S1 ("On") is pressed, safety combination A1 is brought into the operational state. Safety combination A2 is again in an operational state. Line contactor K1 is energized.
- The internal safety relay is energized (PLC output DO2), a 1 signal is entered (PLC output DO3) at contact X101.X (OFF3) of the drive. The drive restarts.

- When button S2 is pressed ("Off"), PLC output DO3 is reset and a 0 signal is entered at contact X101.X (OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. If the drive is stationary (speed = 0), then the PLC output DO2 to the internal safety relay of the drive is reset. If the protective doors are opened, the safely delayed enable contacts of safety combination A2 open after the selected delay time has expired (**1st shutdown path!**). If the internal safety relay of the drive has still not dropped-out as a result of an incorrect function or a fault (PLC), line contactor K1 drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

Safe standstill for several non-interlocked protective doors and several drives, Emergency Stop implemented using safety combinations

Ex. No.
1.7



"Safe standstill" with MASTERDRIVES for non-interlocked protective door, several drives, protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using four SIGUARD safety combinations for Emergency Stop and protective doors. The drives are shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S3 and S8 are positively opening position switches corresponding to EN 1088.
- The drives are shut down via the internal safety relays.
- The on circuits of the safety combinations A1 to A4 monitor whether line contactor K1 has dropped-out after an Emergency Stop or whether time relay K2a/b and contactors K3a/b have dropped-out after opening the protective door circuits (this is necessary in the sense of control Category 3 according to EN 954-1!).

- This circuit principle is suitable for selectively shutting down **several** drives. Protective door 1 acts on drive A, protective door 2 on drives A and B, protective door 3 on drive B. When the internal safety relay of the drives functions correctly, line contactor K1 does not drop-out (also refer to the block diagram above). The following table shows how the two drives A and B are dependent on the state of the protective doors.

	Drive A	Drive B
Protective door 1 open	Safe standstill	Ready
Protective door 2 open	Safe standstill	Safe standstill
Protective door 3 open	Ready	Safe standstill

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S9 ("Emergency Stop"). This initiates that the drives are shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contacts X101.X (OFF3) of the drive via the enable contact of safety combination A4. The drives are immediately braked down to 0 speed and the pulses cancelled. At the same time, the drop-out delay of time relay K2a/b and the delay time of the safety combination A4 are started. The drives must have come to a standstill before these delay times have expired.

- After the drop-out delay time of time relay K2a/b has expired, the internal safety relays of the drives are no longer energized (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A4, line contactor K1 is no longer energized and the drives are electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of line contactor K1 is monitored in the on circuit of safety combination A4. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

Behavior when the protective doors are opened

When protective doors 1-3 are opened, it is initiated that the associated drives are shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered at contact X101.X (OFF3) of the drive/drives via the enable contact of the safety combinations A1, A2 or A3. The drives are immediately braked down to 0 speed and the pulses cancelled. At the same time, the drop-out delay of time relays K2a and/or K2b are started. The drive/drives must have come to a standstill before these delay times have expired.
- After the drop-out delay time of time relay K2a/b has expired, the internal safety relay of the drives are no longer energized (**1st shutdown path!**).

- Before the selected delay times of safety combinations A1-3 expire, the internal safety relays of the drives must have already dropped-out. Their checkback signal contacts X533.1/2 indicate that the drives are in a safe condition.
- After the selected delay time has expired, the safely delayed enable contacts of the safety combinations open.
- When the internal safety relays of the drives function correctly, their checkback signal contacts X533.1/2 are closed, line contactor K1 does not drop-out. When an internal safety relay does not function correctly, its checkback signal contacts X533.1/2 are not closed and line contactor K1 drops-out (**2nd shutdown path!**).

Powering-up and powering-down the drive

The drives can be started or stopped when the protective doors are closed and Emergency Stop button S9 is released.

- When button S2a/b ("On") is pressed, safety combination A4 is brought into the operational state. Line contactor K1 is energized.
- When button S2a/b ("On") is pressed, contactor K3a/b is energized and latches; time relay K2a/b is simultaneously energized. The internal safety relay is energized and a 1 signal is entered at contact X101.X (OFF3) of the drive A/B. The drive restarts.

- When button S1a/b ("Off") is pressed, contactor K3a/b is no longer energized. The drop-out delay of time relay K2a/b is simultaneously started. When contactor K3a/b drops-out, a 0 signal is entered at contact X101.X (OFF3) of the drive A/B. The drive is immediately braked down to 0 speed and the pulses cancelled. The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a/b has expired. The protective doors can be opened.

Ex. No.

1.7

Certificate

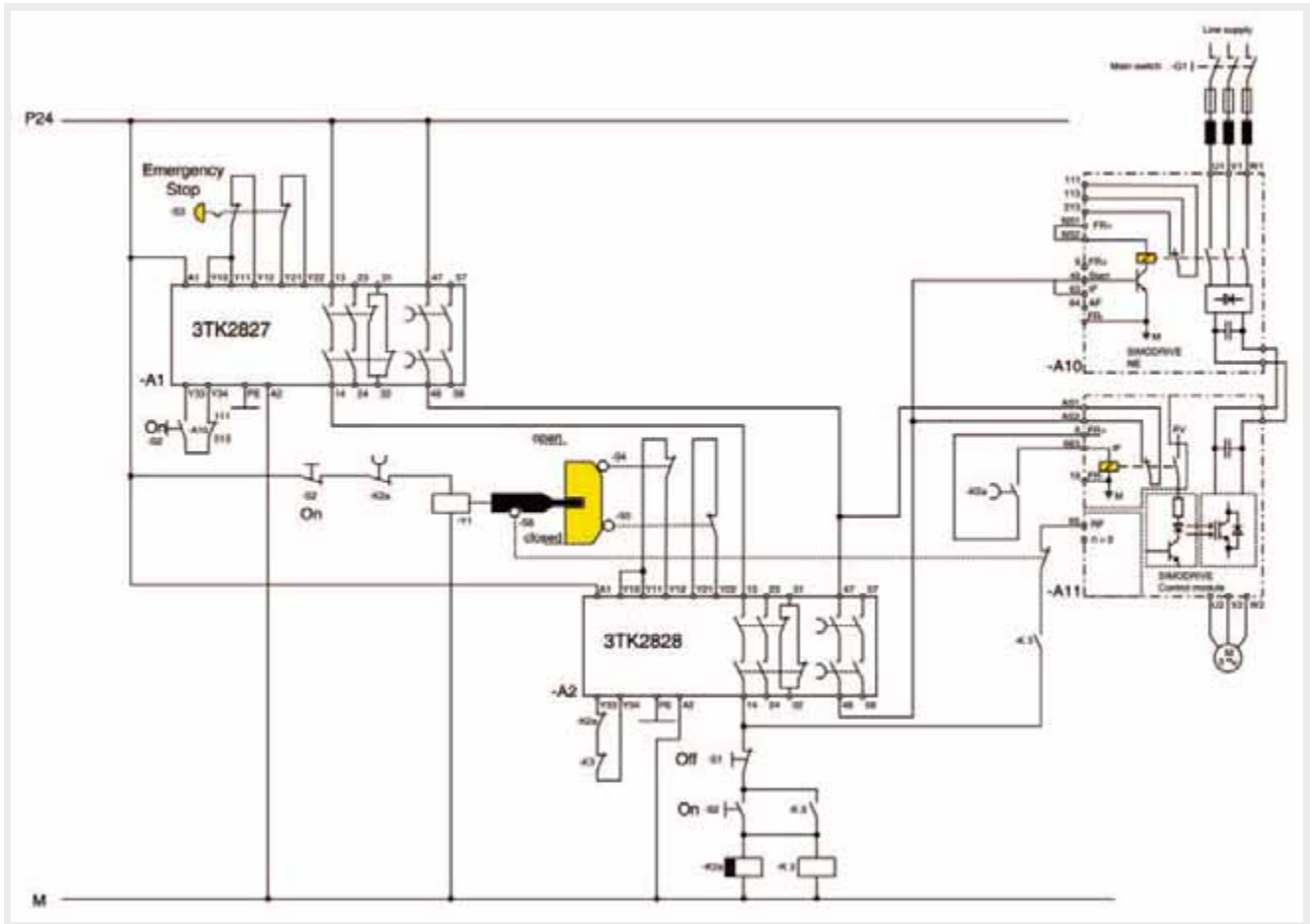
The examples shown in this document were examined and certified by the German Berufsgenossenschaft Fachausschuss Maschinenbau, Fertigungssystem, Stahlbau. (Certificate only available in German!)

		Fachauschuss Maschinenbau, Fertigungssysteme, Stahlbau Prüf- und Zertifizierungsstelle im BG-PRÜFZERT
		Hauptverband der gewerblichen Berufsgenossenschaften
Übereinstimmungsbescheinigung (Überprüfung der technischen Unterlagen)		03003 Bescheinigungsnummer
Name und Anschrift des Bescheinigungsinhabers (Auftraggeber)	Siemens AG, A & D MC P SM Frauenrainer Str. 80 D 91056 Erlangen	
Name und Anschrift des Herstellers:	siehe oben	
Zeichen des Auftraggebers:	Zeichen der Prüf- und Zertifizierungsstelle: 613.17-MFS	Ausstellungsdatum: 24.02.2003
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Prüfungsbasis:	DIN EN 154-1 Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen Teil 1 - Allgemeine Gestaltungsgrundsätze; Kategorie 3, 03.97; DIN EN 1037 "Sicherheit von Maschinen - Vermeidung von unerwartetem Anlauf" 04.96; DIN EN 60204-1 "Elektrische Ausrüstung von Maschinen-Teil 1: Allgemeine Anforderungen" 11.96;	
Die eingereichten technischen Unterlagen zu oben aufgeführten Produkt entsprechen den einschlägigen Vorschriften der Richtlinie 90/269/EEG (Maschinen).		
Die Unterlagen werden aufbewahrt bis zum:	29.02.2008	
und anschließend gemäß Wunsch des Auftraggebers weiter aufbewahrt, zurückgeschickt oder vernichtet.		
Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Oktober 1997.		
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SAFE STANDSTILL Category 3 acc. to EN 954-1 with SIMODRIVE 611 universal

Safe standstill with interlocked protective doors, Emergency Stop implemented using safety combinations

Ex. No.
2.1



"Safe standstill" with SIMODRIVE with interlocked protective door with safety combinations, Stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors. A stop function Category 1 in compliance with EN 60204-1 is achieved.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4, S5 and S6 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay.
- On circuits of safety combinations A1 and A2 monitor whether the internal line contactor of the rectifier unit has dropped-out after Emergency Stop or whether time relay K2a and contactor K3 have dropped-out after the protective door circuit has been opened (this is necessary in the sense of control category 3 according to EN 954-1!).

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact 65 (controller enable RF) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of timer relay K2a and the delay time of the safety relay A1 are started; the drive must have come to a standstill before they expire.

- The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a has expired (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A1, the internal line contactor of the rectifier unit is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of the internal line contactor of the rectifier unit is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

Behavior when the protective doors are opened

Button S1 ("Off") requests that the protective doors are opened. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- Contactor K3 is no longer energized and a 0 signal is entered at contact 65 (controller enable RF) of the drive via its contact (NO contact). The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of time relay K2a is started and before this time has expired, the drive must have come to a standstill.
- After the drop-out delay time of time relay K2a has expired, the internal safety relay of the drive is no longer energized (**1st shutdown path!**). At the same time, the latch (tumbler) Y1 of the protective doors is opened.

- When the protective doors are opened the safety monitoring A2 of the safety circuit is interrupted. Before the selected delay time of safety combination A2 has expired, the internal safety relay of the drive must have already dropped-out. Its checkback signal contacts AS1/2 indicate that the drive is in a safe condition.
- After the selected delay time has expired, the safely delayed enable contacts of the safety combination A2 open.
- If the internal safety relay of the drive is functioning correctly, its checkback signal contacts AS1/2 are closed and the internal line contactor of the rectifier unit does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts AS1/2 are not closed, the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

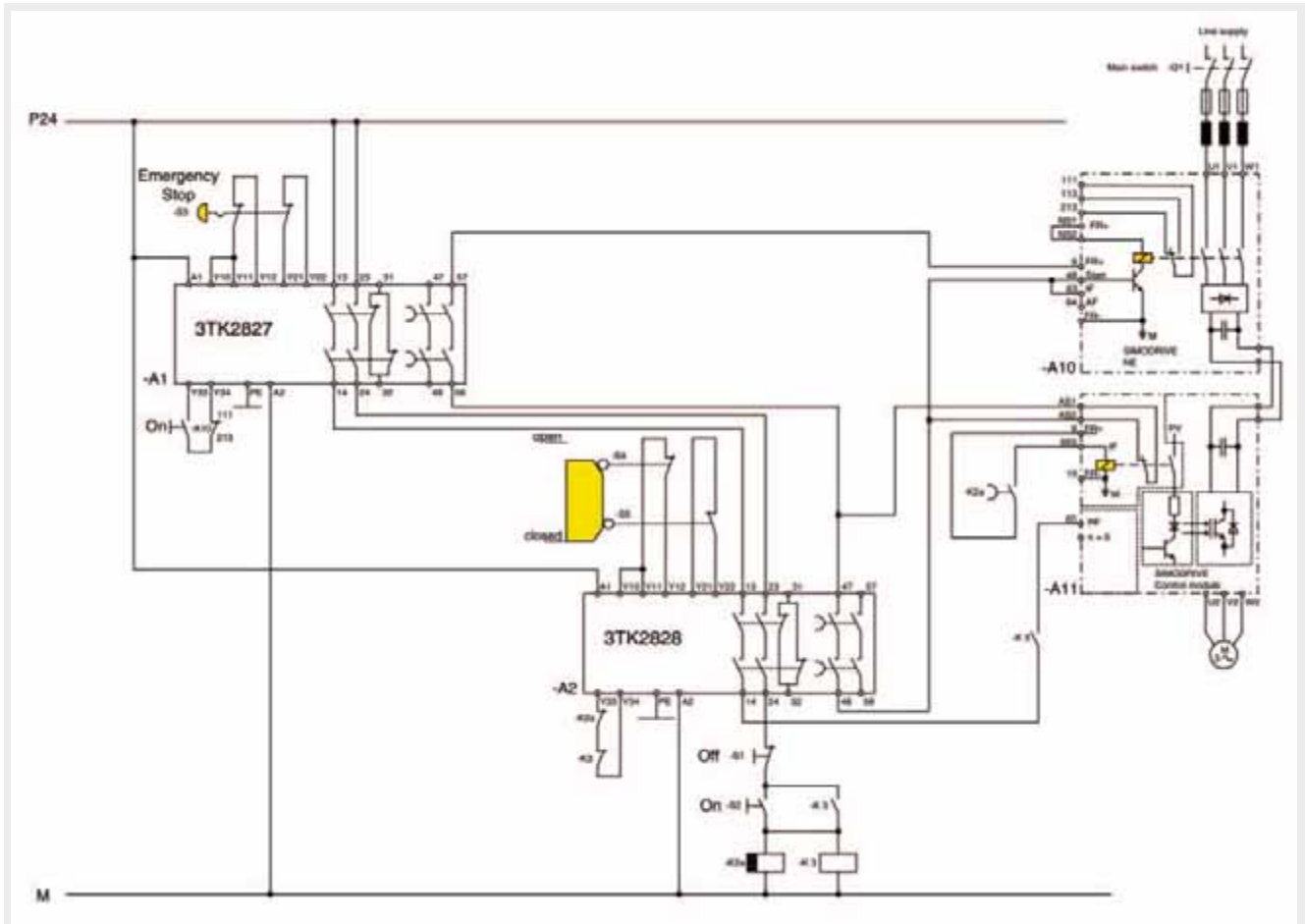
Powering-up the drive

The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When pressing button S2 ("On"), safety combination A1 is brought into the operational state. The coil of latch (tumbler) Y1 is no longer energized, the protective doors are interlocked. Safety combination A2 is again in an operational state. The internal line contactor of the rectifier unit is energized.
- Contactor K3 is energized and latches and at the same time, time relay K2a is energized. The integrated safety relay is energized and a 1 signal is entered at contact 65 (controller enable) of the drive. The drive restarts.

Safe standstill for non-interlocked protective doors, Emergency Stop implemented using safety combinations

Ex. No.
2.2



"Safe standstill" with SIMODRIVE for a non-interlocked protective door with safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.

- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay.
- On circuits of safety combinations A1 and A2 monitor whether the internal line contactor of the rectifier unit has dropped-out after Emergency Stop or whether time relay K2a and contactor K3 have dropped-out after the protective door circuit has been opened (this is necessary in the sense of control Category 3 according to EN 954-1!).

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the drop-out delay of timer relay K2a and the delay time of the safety relay A1 are started; the drive must have come to a standstill before they expire.

- The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a has expired (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A1, the internal line contactor of the rectifier unit is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of the internal line contactor of the rectifier unit is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A2. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the switch-out delay of time relay K2a is started and before this time has expired, the drive must have come to a standstill.
- The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a has expired (**1st shutdown path!**).

- Before the selected delay time of safety combination A2 has expired, the internal safety relay of the drive must have already dropped-out. Its checkback signal contacts AS 1/2 indicate that the drive is in a safe condition.
- After the selected delay time has expired, the safely delayed enable contacts of the safety combination A2 open.
- If the internal safety relay of the drive is functioning correctly, its checkback signal contacts AS1/2 are closed and the internal line contactor of the rectifier unit does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts AS1/2 are not closed, the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

Powering-up and powering-down the drive

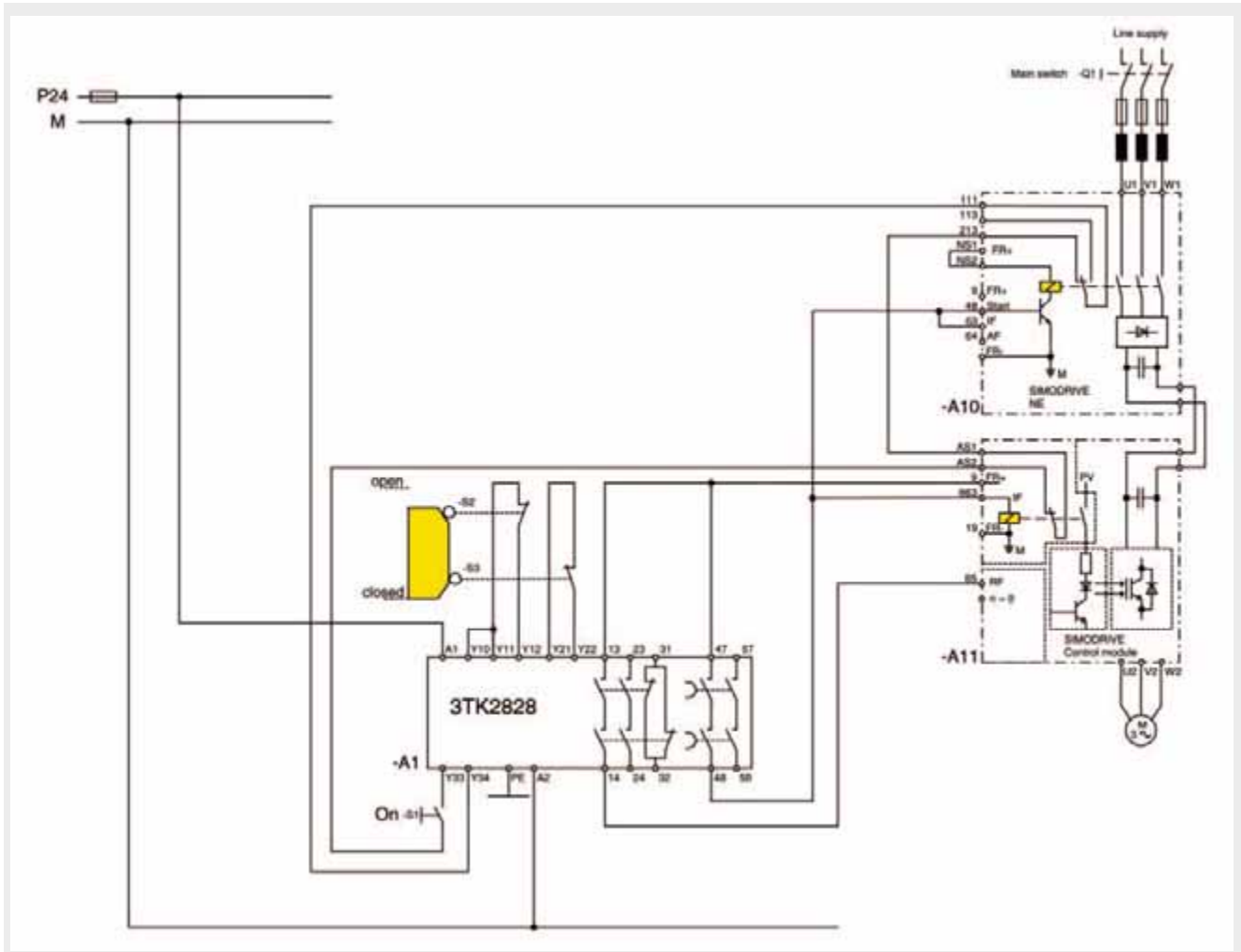
The drive can be started or stopped when the protective doors are closed and Emergency Stop button S3 is released.

- When pressing button S2 ("On"), safety combination A1 is brought into the operational state. The internal line contactor of the rectifier unit is energized
- When pressing button S2 ("On"), contactor K3 is energized and latches; time relay K2a is simultaneously energized. The internal safety relay is energized and a 1 signal is entered at contact 65 (controller enable) of the drive. The drive restarts.

- When button S1 ("Off") is pressed, contactor K3 is no longer energized and the drop-out delay of time relay K2a is simultaneously started. When contactor K3 drops-out, a 0 signal is entered at contact 65 (controller enable) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a has expired. The protective doors can be opened.

Safe standstill for non-interlocked protective doors, implemented with one safety combination

Ex. No.
2.3



"Safe standstill" with SIMODRIVE for a non-interlocked protective door with safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using one SIGUARD safety combination for the protective door. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combination for protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or category 3 (delayed enabled circuit).
- Circuit for protective door monitoring is monitored through 2 channels in a cross-circuit proof fashion.
- Switches S2 and S3 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay and the internal line contactor of the rectifier unit.
- The on circuit of safety combination A1 monitors whether the internal line contactor of the rectifier unit and the internal safety relay of the drive have dropped-out after the protective doors have opened. (This is necessary in the sense of control Category 3 in compliance with EN 954-1!).

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

■ A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled. The delay time of safety combination A1 is simultaneously started and the drive must have come to a standstill before it expires.

Powering-up the drive

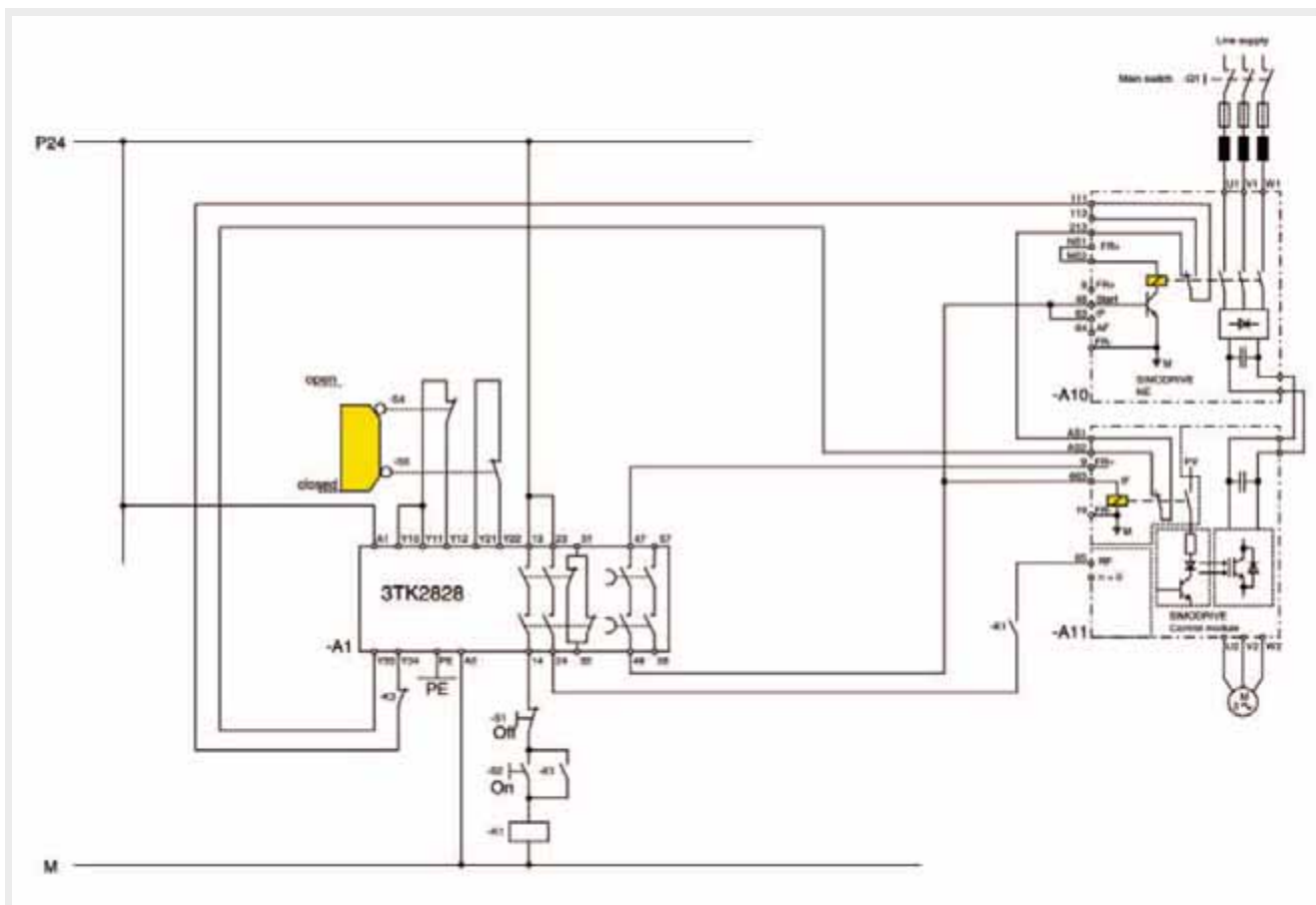
The drive can be restarted (powered-up again) when the protective doors are closed.

■ When button S1 ("On") is pressed, safety combination A1 is brought into the operational state. The internal line contactor of the rectifier unit and the internal safety relay are energized. The drive restarts.

- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and the internal line contactor of the rectifier unit (**2nd shutdown path!**) are no longer energized.
- If the internal safety relay or the internal line contactor of the rectifier unit have not dropped-out because of incorrect behavior (e.g. fault), then their checkback signal contacts in the on circuit of the safety combination A1 are not closed. The safety combination cannot be switched-in.

Safe standstill for non-interlocked protective doors, implemented with one safety combination

Ex. No.
2.4



"Safe standstill" with SIMODRIVE for a non-interlocked protective door with safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using one SIGUARD safety combination for the protective doors. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combination for protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or category 3 (delayed enabled circuit).
- Circuit for protective door monitoring is monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay and the internal line contactor of the rectifier unit.
- The on circuit of safety combination A1 monitors whether the internal line contactor of the rectifier unit and the internal safety relay of the drive as well as contactor K1 have dropped-out after the protective doors have opened. (This is necessary in the sense of control Category 3 in compliance with EN 954-1!).

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled. The delay time of safety combination A1 is simultaneously started and the drive must have come to a standstill before it expires.

Powering-up and powering-down the drive

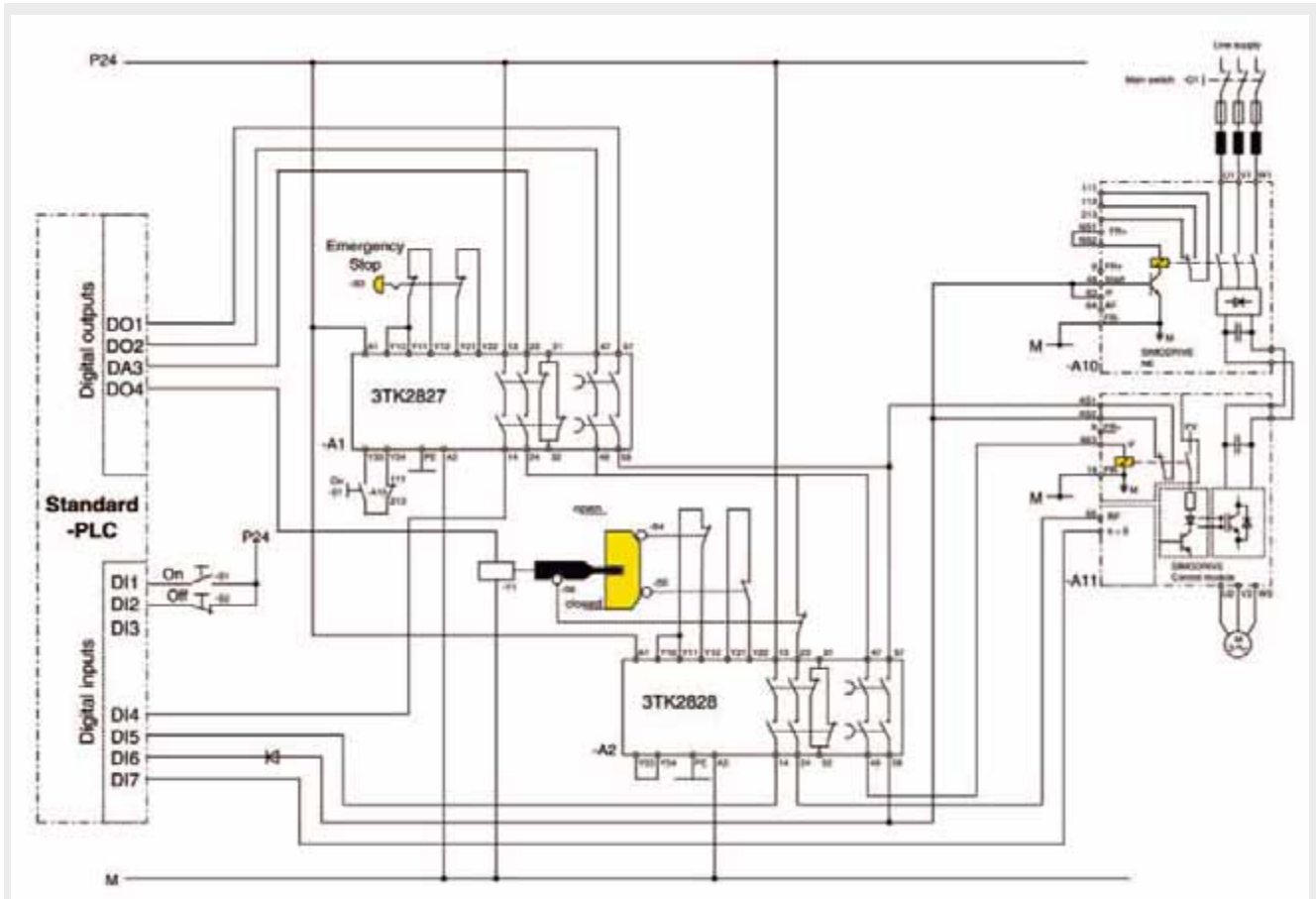
The drive can be started or stopped when the protective doors are closed.

- When the internal safety relay and the internal line contactor of the rectifier unit are in the correct state, safety combination A1 is brought into an operational state.
- The internal line contactor of the rectifier unit and the internal safety relay of the drive are energized.
- When pressing S2 ("On"), contactor K1 is energized and latches. A 1 signal is entered at contact 65 (controller enable) of the drive and the drive starts.

- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and the internal line contactor of the rectifier unit (**2nd shutdown path!**) are no longer energized.
- If the internal safety relay or the internal line contactors of the rectifier unit have not dropped-out because of incorrect behavior (e.g. fault), then their checkback signal contacts AS1/2 in the on circuit of the safety combination A1 are not closed. The safety combination cannot be switched-in.

- When button S1 ("Off") is pressed, contactor K1 is no longer energized and a 0 signal is entered at contact 65 (controller enable) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. If the protective doors are opened, the safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal safety relay of the drive (**1st shutdown path!**) and the internal line contactor of the rectifier unit (**2nd shutdown path!**) are no longer energized.

Ex. No.
2.5



"Safe standstill" with SIMODRIVE for interlocked protective door, standard PLC and protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors and a standard PLC. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- The circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.

- Switches S4, S5 and S6 are positively opening position switches corresponding to EN 1088
- The drive is shut down via the internal safety relay.
- The on circuit of safety combination A1 monitors whether the internal line contactor of the rectifier unit has dropped-out after an Emergency Stop (this is necessary in the sense of control Category 3 in compliance with EN 954-1!).
- When implementing as higher-level circuit using contacts, the "safe standstill" function is guaranteed even when the PLC develops a fault or fails.

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts AS 1/2 close (**1st shutdown path!**).

Behavior when the protective doors are opened

Button S2 ("Off") requests that the protective doors are opened. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact 65 (controller enable) of the drive by resetting the PLC output DO3. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts AS1/2 close (1st shutdown path!).
- The protective door interlocking is opened by setting PLC output DO4 to energize coil Y1. When the protective doors are opened the safety monitoring A2 of the safety circuit is interrupted.

Powering-up the drive

The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When button S1 ("On") is pressed, safety combination A1 is brought into the operational state. The coil of latch (tumbler) Y1 is no longer energized by resetting PLC output DO4 - the protective doors are interlocked. Safety combination A2 is again in an operational state. Line contactor K1 is energized.

- Before the selected delay time of safety combination A1 expires, the internal safety relay of the drive must have already dropped-out and its checkback signal contacts AS 1/2 indicate that the drive is in a safe condition.
- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal line contactor of the rectifier unit is no longer energized and the drive is electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of the internal line contactor of the rectifier unit is monitored in the on circuit of safety combination A1. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

- For a correctly functioning circuit, the internal safety relay of the drive has already fallen out by this time and its checkback signals contacts AS1/2 closed. The internal line contactor of the rectifier unit does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts AS1/2 are not closed, the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (2nd shutdown path!).

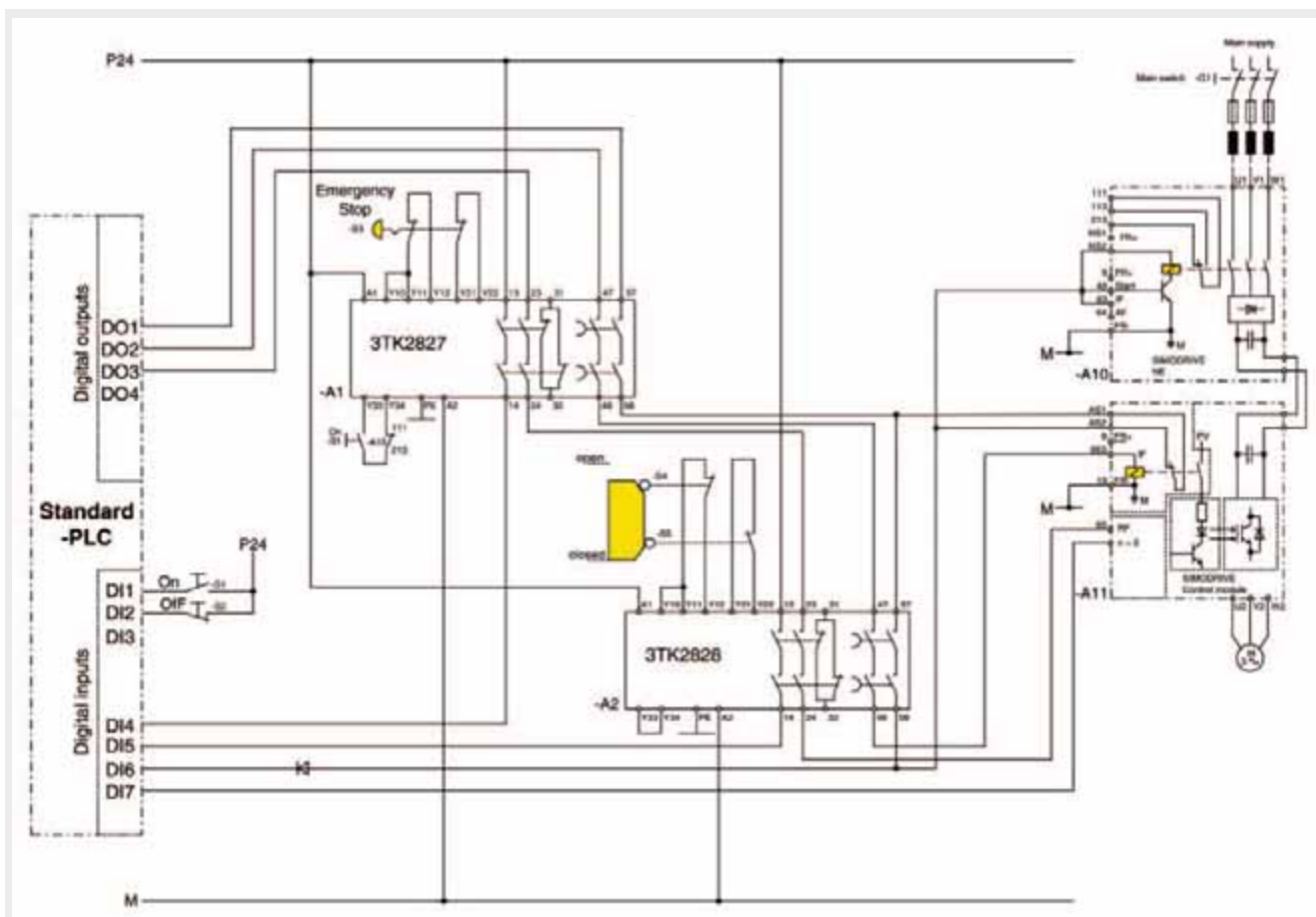
Note

If the protective door interlocking opens before the drive has braked down to 0 speed as a result of an erroneous PLC function, then a 0 signal is entered at contact 65 (controller enable) of the drive via the switch S6. The drive is immediately braked down to speed = 0 and the pulses cancelled. Opening of the protective doors initiates the function "safe standstill". It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- The internal safety relay is energized (PLC output DO2), a 1 signal is entered (PLC output DO3) at contact 65 (controller enable) of the drive. The drive restarts.

Safe standstill for non-interlocked protective doors, Emergency Stop, implemented with a safety combination and standard PLC

Ex. No.
2.6



"Safe standstill" with SIMODRIVE for non-interlocked protective door, standard PLC and protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors and a standard PLC. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4 and S5 are positively opening position switches corresponding to EN 1088.
- The drive is shut down via the internal safety relay
- The on circuit of safety combination A1 monitors whether the internal line contactor of the rectifier unit has dropped-out after an Emergency Stop (this is necessary in the sense of control Category 3 in compliance with EN 954-1!).
- When implementing as higher-level circuit using contacts, the "safe standstill" function is guaranteed even when the PLC develops a fault or fails.

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S3 ("Emergency Stop"). This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A1. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts AS1/2 close (**1st shutdown path!**).

Behavior when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered at contact 65 (controller enable) of the drive via the enable contacts of safety combination A2. The drive is immediately braked down to 0 speed and the pulses are cancelled. At the same time, the state of the safety combination is signaled to the control.
- Before the selected delay time of safety combination A2 expires, the internal safety relay of the drive must have already dropped-out and its checkback signal contacts AS1/2 indicate that the drive is in a safe condition.

Powering-up and powering-down the drive

The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

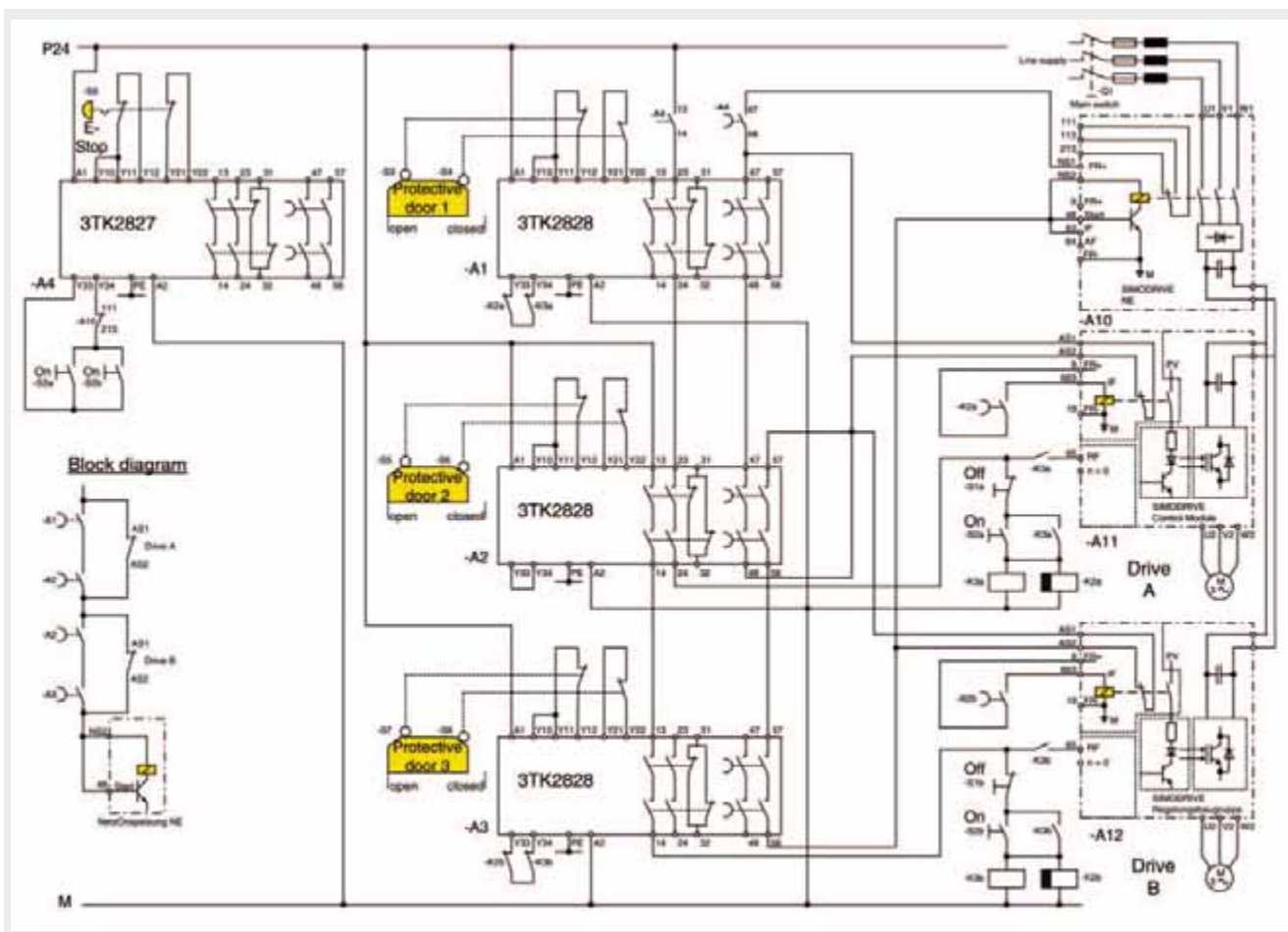
- When pressing button S2 ("On"), safety combination A1 is brought into the operational state. Safety combination A2 is again in an operational state. The internal line contactor of the rectifier unit is energized.
- The internal safety relay is energized (PLC output DO2), a 1 signal is entered (PLC output DO3) at contact 65 (controller enable) of the drive. The drive restarts.

- Before the selected delay time of safety combination A1 expires, the internal safety relay of the drive must have already dropped-out and its checkback signal contacts AS 1/2 indicate that the drive is in a safe condition.
- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the internal line contactor of the rectifier unit is no longer energized and the drive is electrically isolated from the line supply.
- The checkback signal of the internal line contactor of the rectifier unit is monitored. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

- If the drive is stationary (speed = 0), then PLC output DO2 to the internal safety relay of the drive is reset. The internal safety relay of the drive drops-out and its checkback signal contacts close (**1st shutdown path!**)
- The safely delayed enable contacts of safety combination A2 open after the selected delay time has expired. This delay time must be set so that the checkback signal of the internal safety relay already indicates that the drive is in a safe condition.
- If the delay time of the contactor combination A2 has been correctly set and the function of the internal drive safety relay is correct, the internal line contactor of the rectifier unit does not drop-out. If the delay time is set too short or if the internal safety relay does not function correctly, the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (**2nd shutdown path!**).
- When button S2 is pressed ("Off"), PLC output DO3 is reset and a 0 signal is entered at contact 65 (controller enable) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. If the drive is stationary (speed = 0), then the PLC output DO2 to the internal safety relay of the drive is reset. If the protective doors are opened, the safely delayed enable contacts of safety combination A2 open after the selected delay time has expired (**1st shutdown path!**). If the internal safety relay of the drive has still not dropped-out as a result of an incorrect function or a fault (PLC), the internal line contactor of the rectifier unit drops-out and isolates the drive from the line supply (**2nd shutdown path!**).

Safe standstill for several non-interlocked protective doors and several drives, Emergency Stop implemented using safety combinations

Ex. No.
2.7



Minimum circuit for the "safe standstill" with SIMODRIVE function

Function description

A structure in compliance with EN 954-1 control Category 3 and EN 1037 can be implemented using four SIGUARD safety combinations for Emergency Stop and protective doors. The drives are shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- Safety combinations for Emergency Stop and protective door monitoring functions correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S3 and S8 are positively opening position switches corresponding to EN 1088.
- The drives are shut down via the internal safety relays.
- The on circuits of the safety combinations A1 to A4 monitor whether the internal line contactor of the rectifier unit has dropped-out after and Emergency Stop or whether time relay K2a/b and contactors K3a/b have dropped-out after opening the protective door circuits (this is necessary in the sense of control Category 3 according to EN 954-1!).

- This circuit principle is suitable for selectively shutting down **several** drives. Protective door 1 acts on drive A, protective door 2 on drives A and B, protective door 3 on drive B. When the internal safety relay of the drives functions correctly, the internal line contactor of the rectifier unit does not drop-out (also refer to the block diagram above). The following table

shows how the two drives A and B are dependent on the state of the protective doors.

	Drive A	Drive B
Protective door 1 open	Safe standstill	Ready
Protective door 2 open	Safe standstill	Safe standstill
Protective door 3 open	Ready	Safe standstill

Ex. No.
2.7

Behavior when Emergency Stop is issued

Emergency Stop is initiated using button S9 ("Emergency Stop"). This initiates that the drives are shut down according to stop Category 1 in compliance with EN 60204-1.

- A 0 signal is entered at contacts 65 (controller enable) of the drive via the enable contact of safety combination A4. The drives are immediately braked down to 0 speed and the pulses cancelled. At the same time, the drop-out delay of time relay K2a/b and the delay time of the safety combination A4 are started. The drives must have come to a standstill before these delay times have expired.

- After the drop-out delay time of time relay K2a/b has expired, the internal safety relays of the drives are no longer energized (**1st shutdown path!**).
- After opening the safely delayed enable contact of safety combination A4, the internal line contactor of the rectifier unit is no longer energized and the drives are electrically isolated from the line supply (**2nd shutdown path!**).
- The checkback signal of the internal line contactor of the rectifier unit is monitored in the on circuit of safety combination A4. If the contactor does not drop-out due to an incorrect function, then the drive is prevented from restarting after an Emergency Stop.

Behavior when the protective doors are opened

When protective doors 1-3 are opened, it is initiated that the associated drives are shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered at contact 65 (controller enable) of the drive/drives via the enable contact of the safety combinations A1, A2 or A3. The drives are immediately braked down to 0 speed and the pulses cancelled. At the same time, the switch-out delay of time relays K2a and/or K2b are started. The drive/drives must have come to a standstill before these delay times have expired.
- The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a or K2b has expired (**1st shutdown path!**).

- Before the selected delay times of safety combinations A1-3 expire, the internal safety relays of the drives must have already dropped-out. Their checkback signal contacts AS1/2 indicate that the drives are in a safe condition.
- After the selected delay time has expired, the safely delayed enable contacts of the safety combinations open.
- If the internal safety relay of the drives is functioning correctly, their checkback signal contacts AS1/2 are closed and the internal line contactor of the rectifier unit does not drop-out. If the internal safety relay does not function correctly, its checkback signal contacts AS1/2 are not closed, the internal line contactor of the rectifier unit drops-out (**2nd shutdown path!**).

Ex. No.
2.7

Powering-up and powering-down the drive

The drives can be started or stopped when the protective doors are closed and Emergency Stop button S9 is released.

- When button S2a/b ("On") is pressed, safety combination A4 is brought into the operational state. The internal line contactor of the rectifier unit is energized.
- When button S2a/b ("On") is pressed, contactor K3a/b is energized and latches; time relay K2a/b is simultaneously energized. The internal safety relay is energized and a 1 signal is entered at contact 65 (controller enable) of drive A/B. The drive restarts.
- When button S1a/b ("Off") is pressed, contactor K3a/b is no longer energized. The drop-out delay of time relay K2a/b is simultaneously started. When contactor K3a/b drops-out, a 0 signal is entered at contact 65 (controller enable) of the drive A/B. The drive is immediately braked down to 0 speed and the pulses cancelled. The internal safety relay of the drive is no longer energized after the drop-out delay time of time relay K2a/b has expired. The protective doors can be opened.

Certificate

The examples shown in this document were examined and certified by the German Berufsgenossenschaft Fachausschuss Maschinenbau, Fertigungssystem, Stahlbau (Certificate only available in German!).

		Fachausschuss Maschinenbau, Fertigungssysteme, Stahlbau Prüf- und Zertifizierungsstelle im BG-PRÜFZERT
Hauptverband der gewerblichen Berufsgenossenschaften		
Übereinstimmungsbescheinigung (Überprüfung der technischen Unterlagen)		<div style="border: 1px solid black; padding: 2px;">03002</div> Bescheinigungsnummer
Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Siemens AG A & D MC Friedenstraße 89 D 91056 Erlangen	
Name und Anschrift des Herstellers	siehe oben	
Zeichen des Auftraggebers:	Zeichen der Prüf- und Zertifizierungsstelle: 012.17-MFB	Ausstellungsdatum: 24.02.2003
Produktbezeichnung:	Applikationsbeispiele SIMODRIVE 611 Universal	
Typ:	SH_50_Applikationen (1.1 - 1.7 vom 21.10.2002)	
Zugehöriger Prüfbericht:	Informationen zum Prüfungsumfang siehe Prüfbericht Nr. 3023-303	
Prüfgrundlage:	DIN EN 954-1 Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen Teil 1- Allgemeine Gestaltungsgrundsätze; Kategorie 3; 03.97; DIN EN 60204-1 "Elektrische Ausrüstung von Maschinen-Teil 1: Allgemeine Anforderungen" 11.98; DIN EN 1037 "Sicherheit von Maschinen - Vermeidung von unerwartetem Anlauf" 04.96,	
Die eingereichten technischen Unterlagen zu oben aufgeführten Produkt entsprechen den einschlägigen Vorschriften der Richtlinie 86/375/EG (Maschinen).		
Die Unterlagen werden aufbewahrt bis zum:		<div style="border: 1px solid black; padding: 2px;">25.02.2008</div>
und anschließend gemäß Wunsch des Auftraggebers weiter aufbewahrt, zurückgeschickt oder vernichtet.		
Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Oktober 1997.		
		 Unterschrift (Dr. Untewal)
F09/03 13.04		Postadresse: Postfach 37 80 58027 Mainz
		Hausadresse: VW Theodor-Platz-Straße 15 55130 Mainz
		Telefon: 06131/802-0 Telefax: 06131/802-220

SAFE STANDSTILL Category 3 according EN 954-1 with SINAMICS S120

Application examples SINAMICS S120

Safe standstill, Safe Stop 1 implemented using safety combination

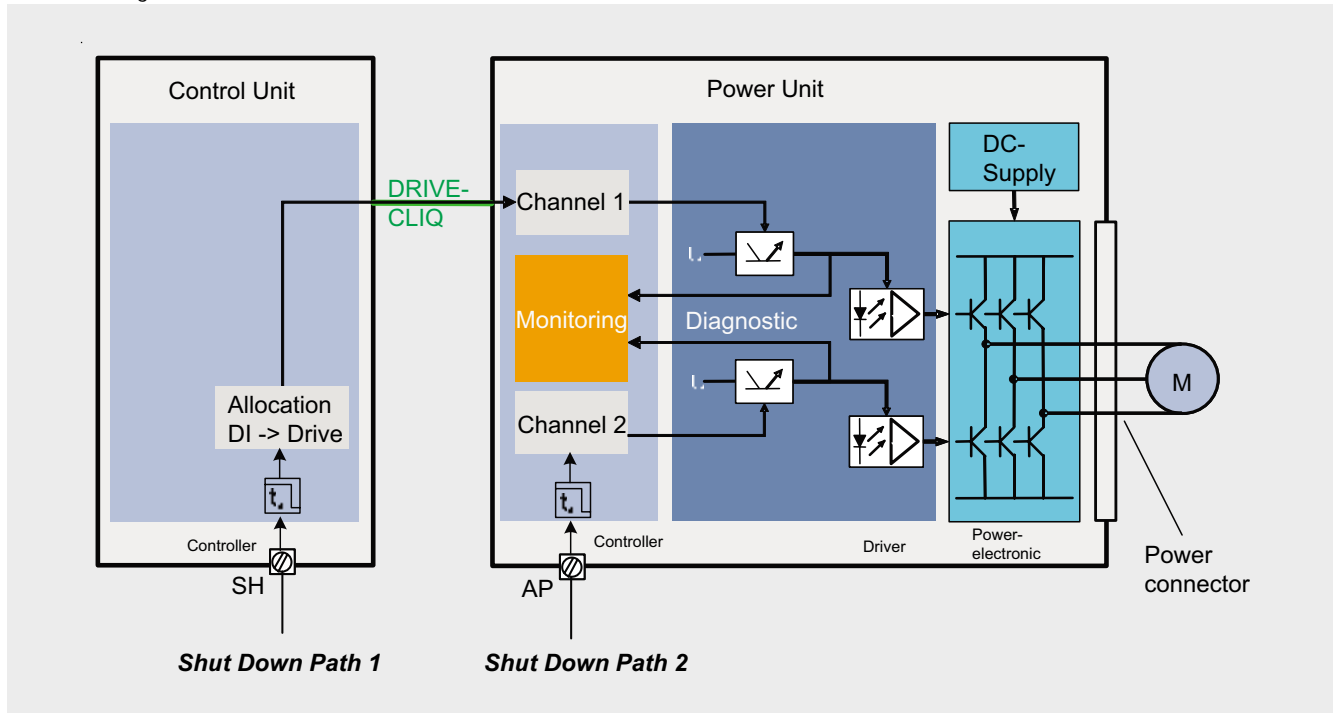
Bsp. -Nr.
3.1

In accordance with the standard prIEC61800-5-2, the designation Safe Standstill is replaced by Safe Torque Off (STO).

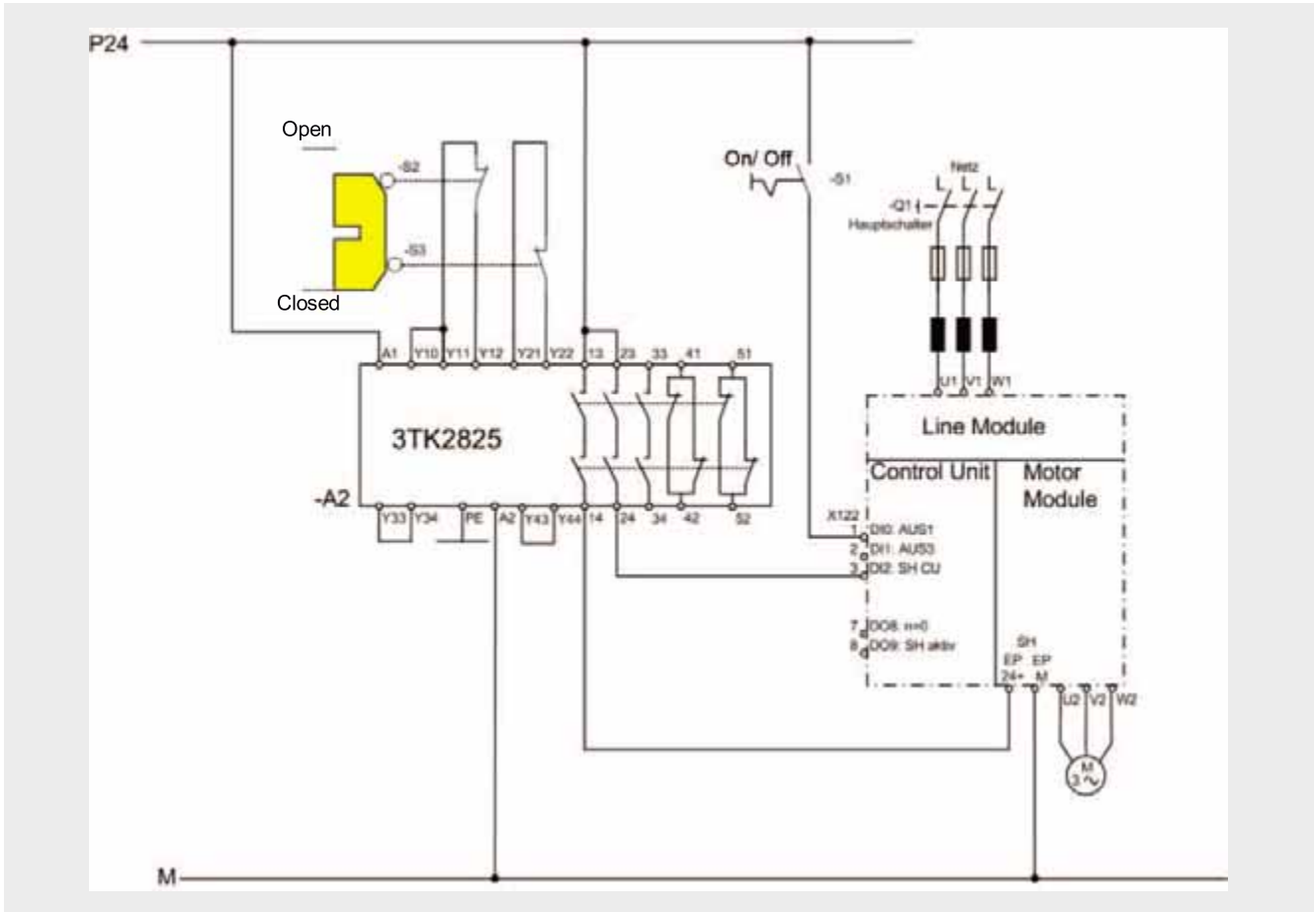
The Safe Stop 1 (SS1) function is integrated in SINAMICS S120 version V2.4 or later.



Schematic diagram



Schematic diagram of the internal control of both shutdown paths



"Safe standstill" with SINAMICS using safety combination and "Safe Stop 1", Stop category 1, Category 3 acc. to EN 954-1 and SIL 2 acc. IEC 61508

Description of functions

- A structure in compliance with EN 954-1 control category 3 and EN1037 can be implemented using a SIGUARD safety combination for the protective door. The drive is stopped according to Stop function Category 1 acc. to EN 60204-1.
- A master line contactor is not required since the "Safe standstill" safety function integrated in the drive corresponds to Category 3 acc. to EN 954-1. Before performing work on the motor or converter, the unit has to be deenergized via a (lockable) main switch.
- The safety combination for the protective door monitoring function corresponds to Category 4 (instantaneous enable circuit).
- The circuits for protective door monitoring are monitored through two channels using a cross-circuit proof connection.
- Switches S2 and S3 are positive-opening position switches according to EN 1088.

Behavior when the protective door is opened

Opening of the protective door initiates that the drive is stopped according to Stop category 1 acc. to EN 60204-1. It must be ensured that potentially hazardous motion comes to a standstill before a person can reach the potentially hazardous area !

- A signal 0 is entered via the enable contacts of the safety combination A1, at terminal X122.3 (DI 2: SH CU) of the drive. The drive is immediately decelerated along the OFF3 ramp (p1135).
- SH/SBC is triggered automatically after the delay time (p9652/p9852) has expired.

Powering up the drive

The drive can be started when the protective door is closed:

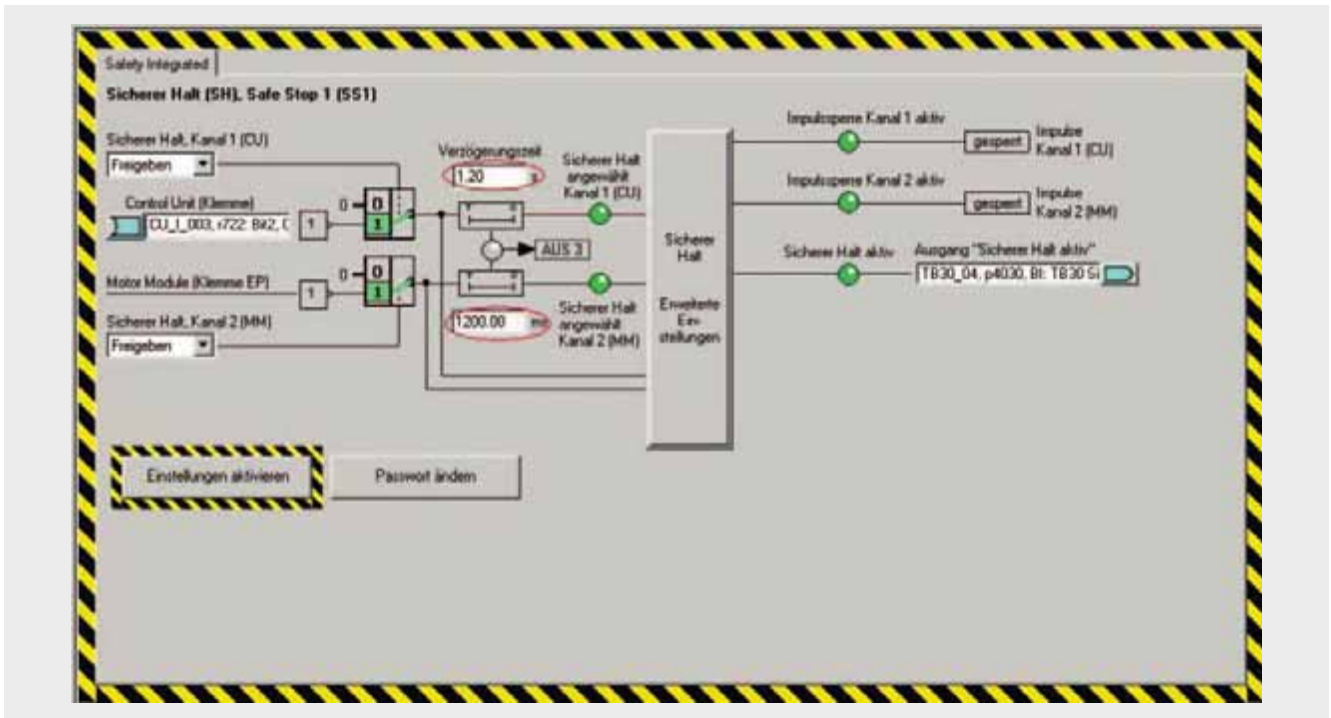
- Signal 1 is present both at the EP terminal of the power unit and the digital input, the Safe standstill function is deselected. When actuating knob switch S1 ("OFF-ON"), the drive is brought into the operational state via a rising edge at input DI 0 (OFF1).

"Safe Stop 1" features

- SS1 is activated by p9652 and p9852 (delay time) unequal "0".
- This function can only be activated in combination with "safe standstill".
- When selecting SS1, the drive is decelerated along the OFF3 ramp (p1135) and SH/SBC is triggered automatically after the delay time (p9652/p9852) has expired.
- After activating the function, the delay time elapses even if the function has been deselected before. In this case, the SH/SBC function is selected and deselected again when the delay time has elapsed.
- SS1 is selected through two channels. The drive, however, is decelerated along the OFF3 ramp through a single channel only.

"Safety Integrated" settings

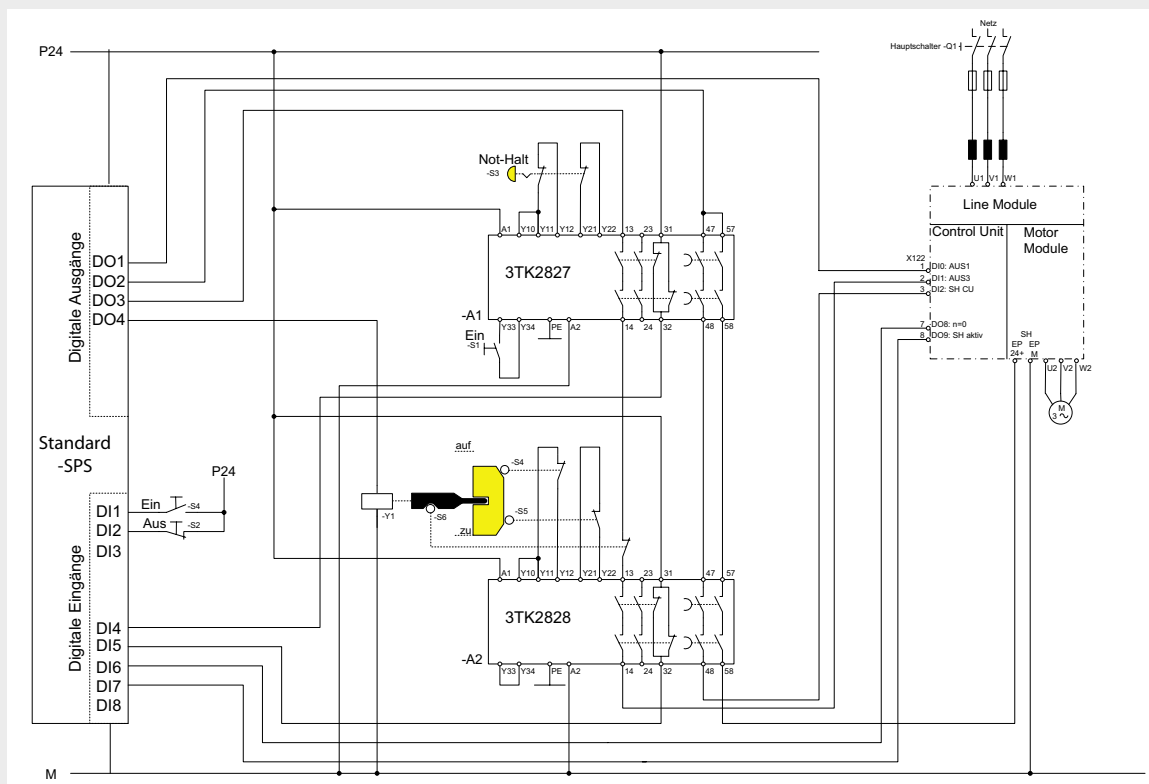
The delay time has to be specified for each path in the "Safe Stop 1" input window. If this value is 0, Safe Stop 1 is deactivated. In this case, the pulses are disabled immediately.



Settings for Safety Integrated STARTER/SIMOTION Scout

Safe standstill, implemented with one safety combination

In addition to the SINAMICS version V2.4 (or later) described above, the traditional OFF 3 circuit can still be used.



"Safe Standstill" with SINAMICS using safety combination, Stop-Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using one SIGUARD safety combination for the protective door. The drive is shut down (stopped) according to stop function Category 1 according to EN 60204-1.

- The integrated safety function "safe standstill" corresponds to Category 3 according to EN 954-1 and SIL 2 according to IEC 61508. Therefore a line contactor is not necessary. The Emergency Stop function doesn't mandatory require an isolation from the line supply. When carrying-out work on the motor or the frequency converter, the equipment must

always be isolated from the line supply with a (lockable) main switch.

- Safety combination for protective door monitoring functions corresponds to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuit for protective door monitoring is monitored through 2 channels in a cross-circuit proof fashion.
- Switches S2 and S3 are positively opening position switches corresponding to EN 1088.

Behavior, when the protective doors are opened

When the protective doors are opened, it is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1. It must be ensured that potentially hazardous motion must have come to a standstill before a person can reach the potentially hazardous area!

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X122.2 (DI 1: OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled. The delay time of safety combination A1 is simultaneously started and the drive must have come to a standstill before it expires.
- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the EP-terminal of the line modul and the digital input (DI 2 SH) of the control unit are no longer energized. The safety function "safe standstill" is activated.

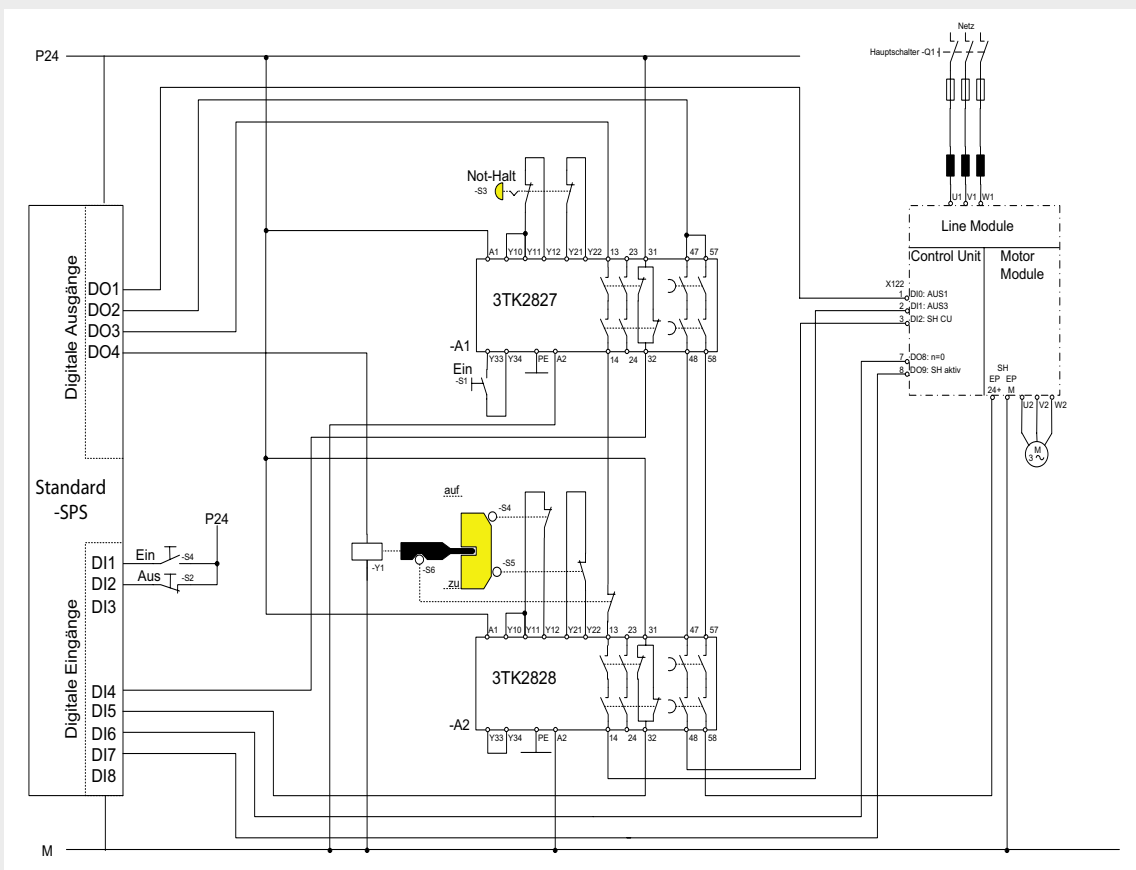
Powering-up the drive

The drive can be restarted (powered-up again) when the protective doors are closed.

- A 1 signal is entered at the EP-terminal of the line modul and the digital input (DI 2: SH) of the control unit. The function "safe standstill" is deactivated. When actuating the knop-operated switch S1 ("Off-On"), the drive is brought into an operational state with a rising edge at the digital input DIO (Out 1).

Bsp. -Nr.
3.3

Safe standstill for interlocked protective doors, Emergency Stop, implemented with safety combinations and standard PLC



"Safe Standstill" with SINAMICS for interlocked protective door, standard PLC and protective safety combination, stop Category 1, Category 3 acc. to EN 954-1

Function description

A structure in compliance with EN 954-1 control Category 3 and EN1037 can be implemented using two SIGUARD safety combinations for Emergency Stop and protective doors and a standard PLC. The drive is shut down (stopped) with stop function Category 1 according to EN 60204-1.

- The integrated safety function "safe standstill" corresponds to Category 3 according to EN 954-1 and SIL 2 according to IEC 61508. A non-safety checkback signal "Safe Standstill active" is sufficient.
- Safety combinations for Emergency Stop and protective door monitoring correspond to Category 4 (instantaneous enable circuit) or Category 3 (delayed enable circuit).
- Circuits for Emergency Stop and protective door monitoring are monitored through 2 channels in a cross-circuit proof fashion.
- Switches S4, S5 and S6 are positively opening position switches corresponding to EN 1088.
- When implementing as higher-level circuit using contacts, the "safe standstill" function is guaranteed even when the PLC develops a fault or fails.
- The communication via digital in- and outputs between drive and PLC can be displaced with a non-safe standard communication (e.g. PROFIBUS).
- The Emergency Stop function doesn't mandatory require an isolation from the line supply. When carrying-out work on the motor or the frequency converter, the equipment must always be isolated from the line supply with a (lockable) main switch.

Behavior at Emergency Stop

Emergency Stop is initiated using button S3 ("Emergency Stop"). It is initiated that the drive is shut down according to stop Category 1 in compliance with EN 60204-1:

- A 0 signal is entered, via the enable contact of safety combination A1, at contact X122.2 (DI 1: OFF3) of the drive. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- The safely delayed enable contacts of safety combination A1 open after the selected delay time has expired. This means that the function "safe standstill" of the drive is two-channel activated and given feedback via terminal S122.8 (DO 9: SH active).
- The checkback signals of the safety combination and the drives were monitored and evaluated by the PLC.

Behavior when the protective doors are opened

Button S2 ("Off") requests that the protective doors are opened. This initiates that the drive is shut down according to stop Category 1 in compliance with EN 60204-1:

- A 0 signal is entered at contact X122.2 (DI 1:OFF3) of the drive by resetting the PLC output DO3. The drive is immediately braked down to 0 speed and the pulses are cancelled.
- If the drive is stationary (DO 8: speed = 0), then PLC output DO2 to the drive is reset. This means that the EP-terminal of the line modul and the digital input (DI 2: SH) of the control unit are no longer energized. The safety function "Safe standstill" is activated.
- Detecting that the function "safe standstill" is active (PLC DI 7: SH active), the protective door interlocking is opened by setting PLC output DO4 to energize coil Y1.
- When the protective door is opened the safety monitoring A2 of the safety circuit is interrupted

Note

If the protective door interlocking opens before the drive has braked down to 0 speed as a result of an erroneous PLC function, then a 0 signal is entered at contact X122.2 (DI 1: OFF3) of the drive via the switch S6. The drive is immediately braked down to speed = 0 and the pulses cancelled. Opening of the protective doors initiates the function "safe standstill". It must be ensured that potentially hazardous motion has come to a standstill before a person can reach the potentially hazardous area!

Powering-up the drive

The drive can be started when the protective doors are closed and Emergency Stop button S3 is released.

- When pressing button S1 ("On"), safety combination A1 is brought into the operational state. The coil of latch (tumbler) Y1 is no longer energized by resetting PLC output DO4 - the protective doors are interlocked. Safety combination A2 is again in an operational state.
- A 1 signal is entered both at the PLC outputs DO2 and DO3, the functions "safe standstill" and quick stop at terminal X122.2 (DI 1: Out 3) are deactivated
- Entering a rising edge at the PLC Output DO1 to the terminal X122.1 (DI 0: Out 1), the drive is set again in an operational state.

Safe Monitoring of Drive Functions SIMOTION D/ SIMATIC S7-F

Overview

Concept

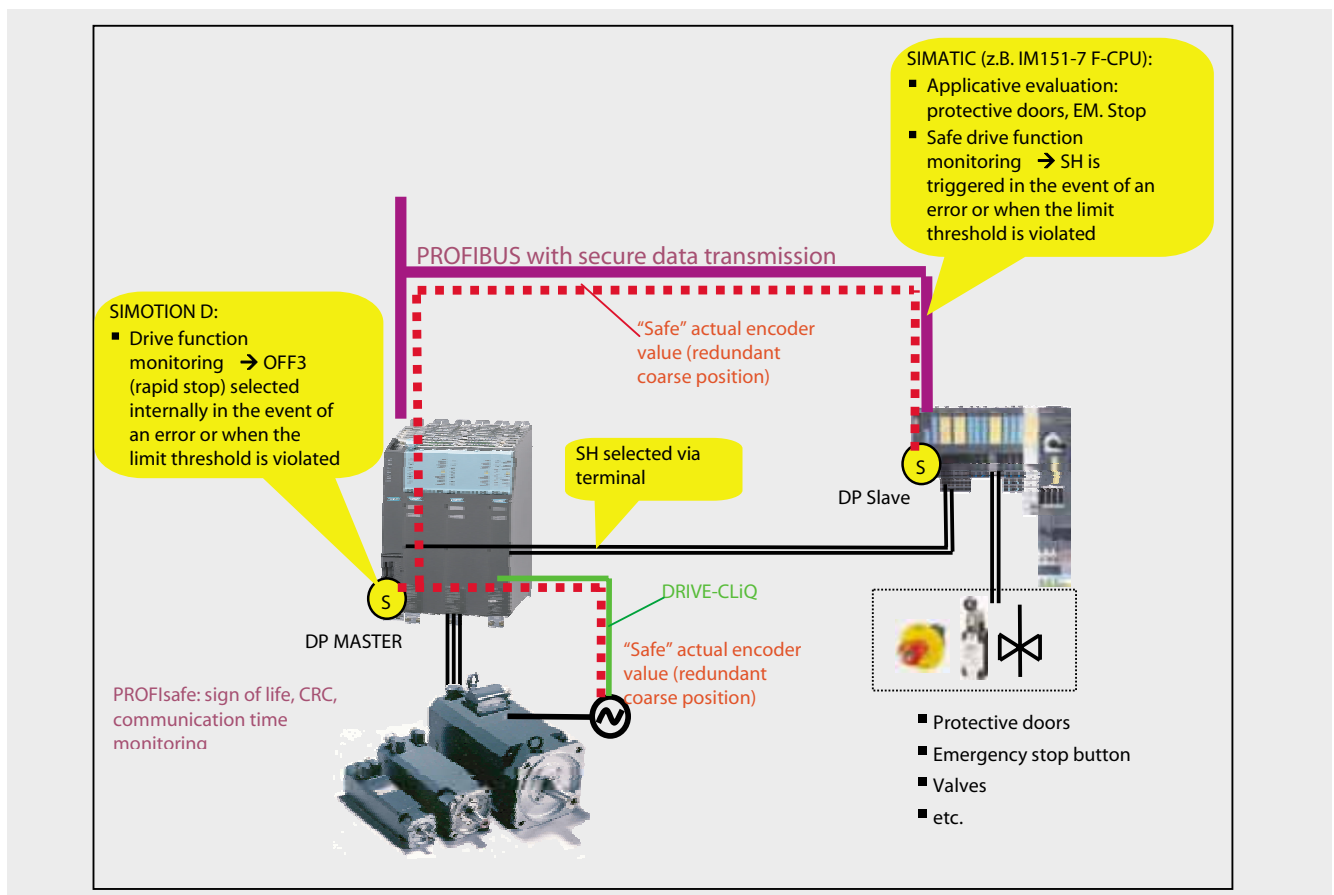
Ex. No.

4

Our objective is to introduce a safety concept comprising the SIMOTION D motion controller, a sin/cos encoder equipped with encoder module SMx20 and a fail-safe SIMATIC S7-F controller, which has been designed to implement the following safety functions using an encoder system:

- Safe standstill
- Safely limited speed
- Safe operating stop (standstill monitoring)
- Safe shutdown (via Stop categories)

In this concept, the Simatic F-CPU controller - equipped with the function block "F_DRIVE" certified according to DIN EN 954-1 and IEC 61508 - monitors the above-mentioned drive functions and activates the "Safe standstill" (SH) resp. Safe Torque Off (STO) safety function in the drive each time that a monitoring threshold is violated in order to bring the drive into a safe state.



Safety concept

The safety requirements are fulfilled through the evaluation of a "redundant coarse position" defining the encoder position in the SIMOTION controller and the fail-safe SIMATIC S7-F controller. The encoder information (position data and redundant coarse position) is checked for plausibility on both controllers. If an error occurs, the corresponding shutdown responses are triggered by both controllers.

Safe encoder signal and communication data monitoring between the drive system and the F-CPU according to Cat. 3 is performed by the SIMATIC F-CPU. To ensure swift error response, the encoder signal and communication data are monitored simultaneously in the SIMOTION CPU (by the SIMOTION function block "C_DRIVE").

Safety functions such as the monitoring of emergency stop buttons, protective doors resp. valve positions can be implemented with a fail-safe SIMATIC S7-F using approved function blocks.

Ex. No.

4

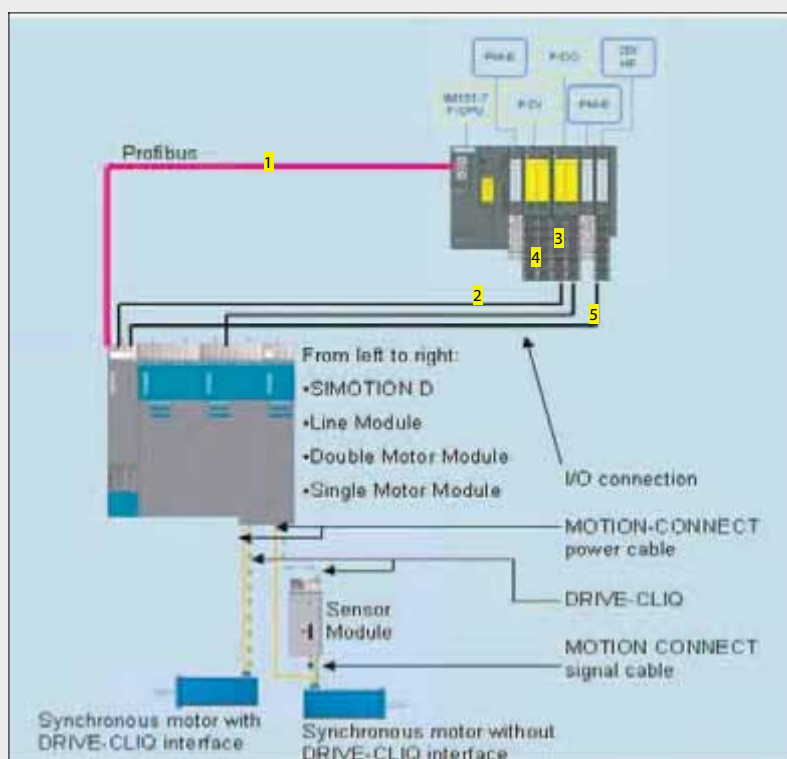
Overview of the Hardware Configuration (Minimum Configuration)

The following hardware components are used:

SIMOTION/SINAMICS drive system

- sin/cos encoder
- SMx20 encoder module (the figure shows both - SMI20 and SMC20)
- Fail-safe Distributed Safety System

These components have to be connected using the appropriate signal cables (see following figure).

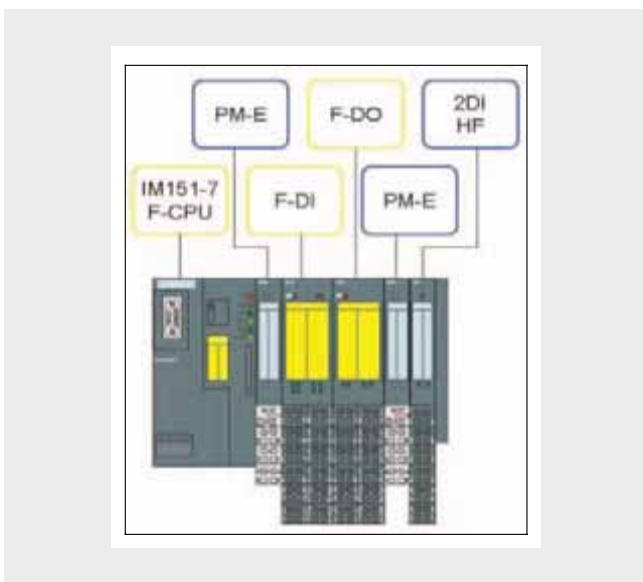


Hardware components

1. The SIMOTION drive system and the fail-safe Simatic CPU must be connected via a bus cable.
2. The SH in the drive system is controlled by the F-CPU via terminals.
3. According to enumeration item 2, a fail-safe output module of the fail-safe Distributed Safety System has to be used.
4. At least one fail-safe input module of the fail-safe Distributed Safety System must be provided for signals such as protective doors, acknowledgement buttons, etc.
5. In addition to this, the SH checkback signal transferred within the drive system has to be connected to a digital output which must then be connected to a digital SIMATIC I/O input. This input can be implemented as a fail-safe input or standard input since the checkback signal output by the safe stop has been implemented as a standard function rather than a safety function.

This document describes the example of a IM151-7 F-CPU equipped with fail-safe ET 200S I/O components. These components can be replaced by Distributed Safety System components with identical functions.

Hardware components for the F-CPU controller (minimum requirements):



Sample connection for ET 200S (F-CPU)

Caution

To ensure compliance with Cat.4 / SIL3 when setting up an ET 200S station, the standard modules need to be electrically isolated from the safety modules.

Further information is provided in the Hardware Installation and User Manual ET 200S - Fail-Safe Modules.

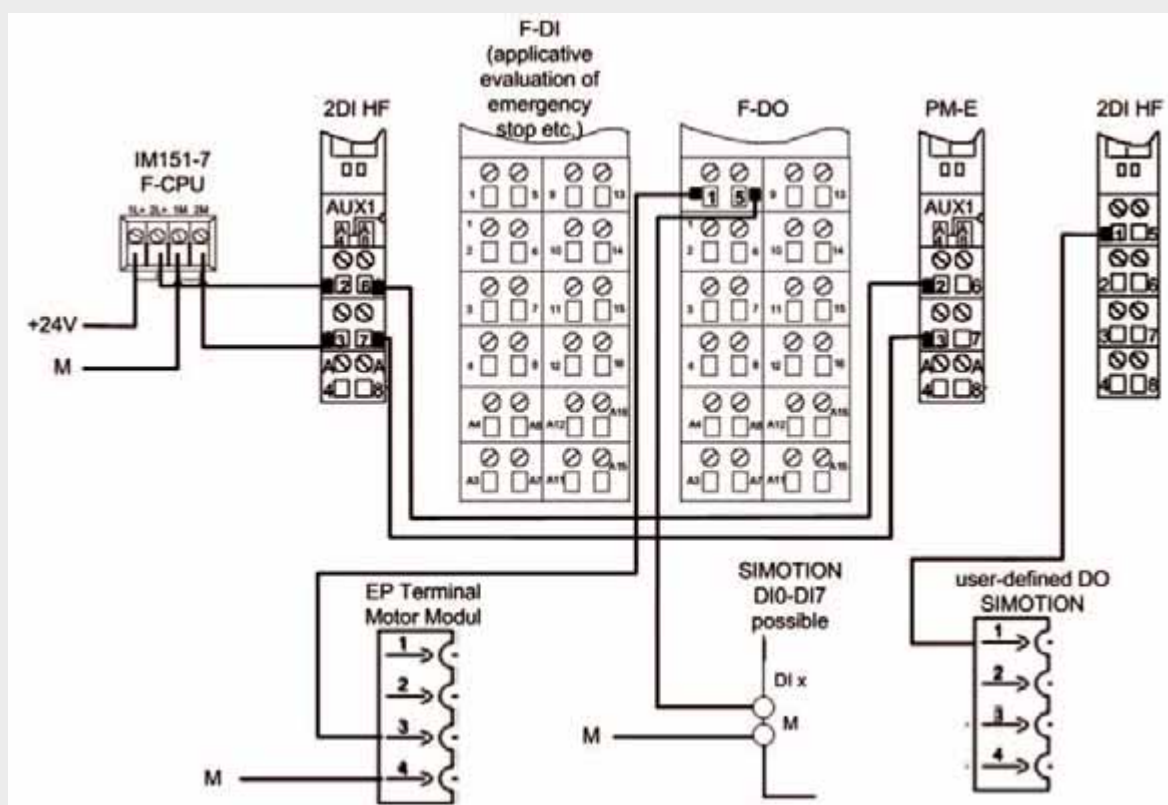
Ex. No.
4

Order No.	Designation	Quantity
6ES5710-8MA11	Stand. sectional rail,width 35 mm, length 483 mm, for 19" cabinets	1,00
6ES7131-4BB01-0AB0	Electronic module, 2DI, DC 24 V, High Feature (5 pcs.)	0,20
6ES7138-4CB11-0AB0	Power module PM-E DC 24...48 V, AC 120...230 V f. elec. mod. diag+fuse	2,00
6ES7138-4FA02-0AB0	Electronic module, 4/8F-DI, DC 24 V, PROFIsafe (1 pc.)	1,00
6ES7138-4FB02-0AB0	Electronic module, 4F-DO, DC 24 V/2 A, PROFIsafe (1 pc.)	1,00
6ES7151-7FA01-0AB0	IM 151-7 F-CPU RS 485 for ET 200S, with PROFIBUS DP interface	1,00
6ES7193-4CA40-0AA0	Universal terminal module; screw connection (5 pcs.)	0,20
6ES7193-4CD20-0AA0	Terminal module for AUX1 supply; screw connection	2,00
6ES7193-4CF40-0AA0	Terminal module for electronic module 30 mm: screw term.; AUX1	2,0

Hardware component wiring

Safe stop is activated in the drive system through the selection of two terminals (motor module and CU). These two clamps have to be connected to a fail-safe digital output module.

The following connection example illustrates the connection of a positive switching ET 200 output with a CU input. Another output switches the EP terminal at the motor module.



Component wiring

Software Required

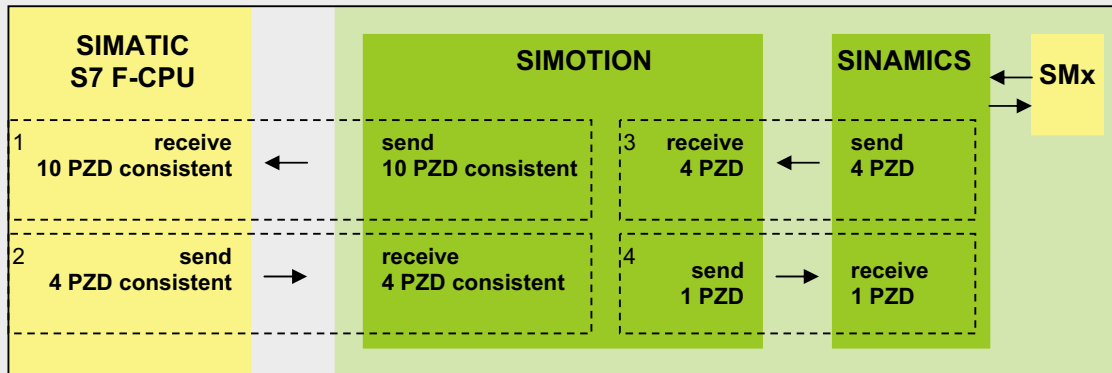
The program supplied with the Installation Guide has been created with the following software releases of the Engineering Tools resp. Runtime Systems:

- STEP7 V5.4 SP1
- Distributed Safety V5.4 (S7 F Configuration Pack V5.5)
- SCOUT V4.0
- STARTER V2.3
- SIMOTION FW V4.0
- SINAMICS FW V2.4.

Communication Configuration and Interface Description

The F-CPU controller communicates with SIMOTION via a bus connection (slave) resp. via a transceiver. The scope of transmit and receive words per axis has to be set up as shown in the following figure. It is configured in the HW Config of the SIMATIC Manager.

Overview of interfaces and communication scope



Bus interface

Detailed interface description

Explanation regarding 1

F-CPU Address	Data	SIMOTION Address
EWx (*)	Sign of life from the drive (INT)	ARRAY [x] ... PQW
	Error message output by the drive (INT)	
	Control word from the drive (INT)	
	Redundant coarse position (INT)	
	Coarse position information (INT)	
	Actual speed from the drive (INT)	
	CRC via speed (INT)	
	Calculated encoder module start CRC (WORD)	
	CRC via redundant coarse position (INT)	
EWx+ 9	Function block version from the SIMOTION function block (INT)	

Detailed interface information

(*) If the data received are not displayed in the process image of the F-CPU, communication in the standard program has to be established using the emitter and receiver blocks SFC14 ("DP_RD_DAT").

Bit memory address areas are required to transfer data into the safety program.

Ex. No.
4

Explanation regarding 2

F-CPU Address	Data	SIMOTION Address
AWx	Sign of life to the SIMOTION / CU (INT)	ARRAY [x] ... PIW
	Control word to the SIMOTION (WORD)	
	Speed reduced for monitoring in SIMOTION (WORD)	
AWx+ 3	Max. delta of encoder increments for standstill monitoring (INT)	ARRAY [x+3] ...PIW

F-CPU transmit data

(*If the data received are not displayed in the process image of the F-CPU, communication in the standard program has to be established using the emitter and receiver blocks SFC15 ("DP_WR_DAT").

Bit memory address areas are to be used to transfer data into the safety program.

Explanation regarding 3

SIMOTION Address	Data	SINAMICS Address
PIDx	Redundant coarse position (r484 ... DWORD)	P2061.x (Achse)
PIWz	Encoder status (r481 ... WORD)	P2051.y (Achse)
PIWy	Sign of life (INT)	P2051.z (CU)

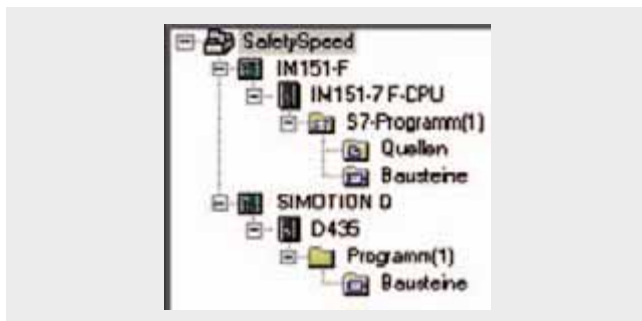
SIMOTION receive data

Explanation regarding 4

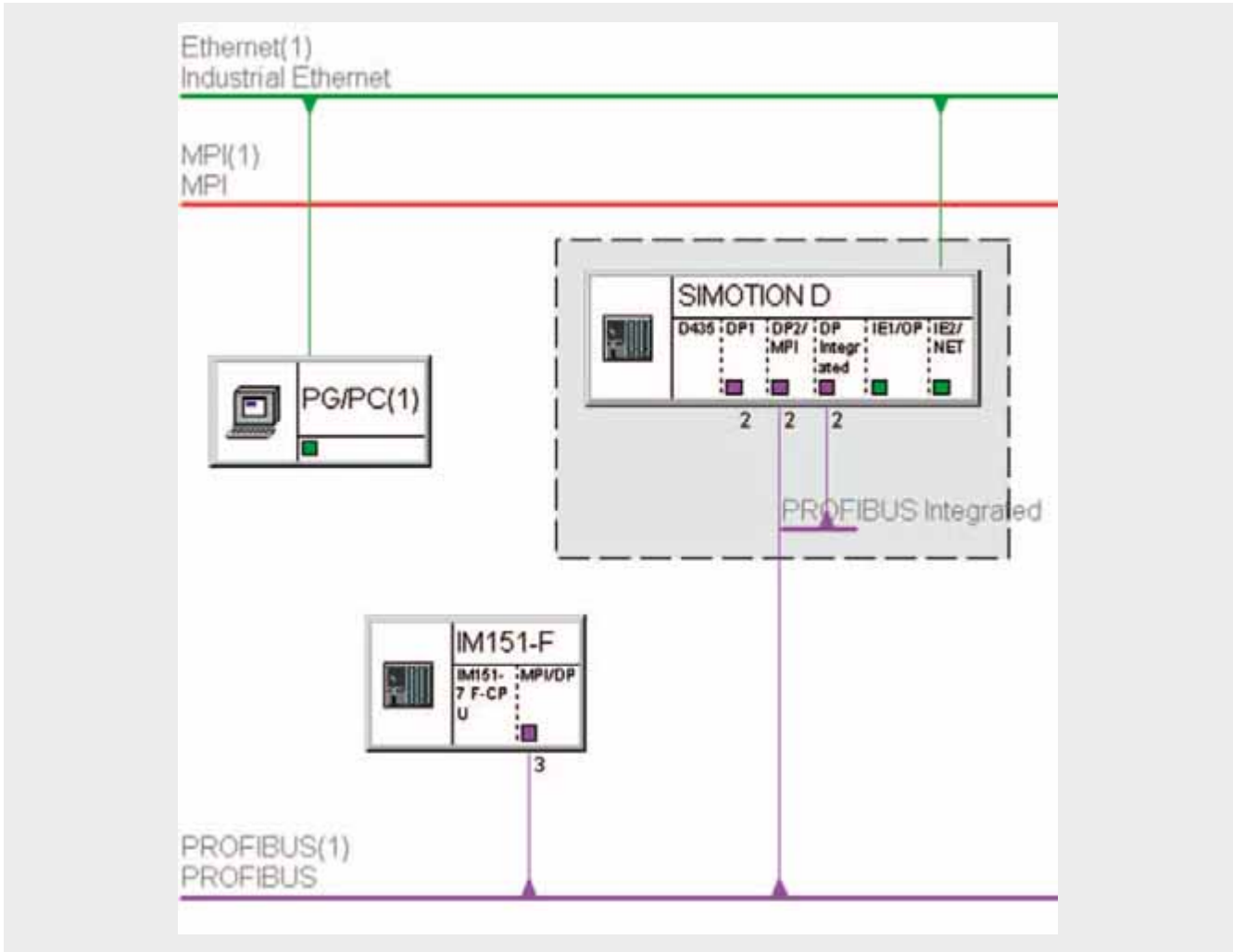
SIMOTION Address	Data	SINAMICS Address
PQWx	Sign of life (INT)	r2050.x (CU)

SIMOTION transmit data

Overview of the STEP7 project



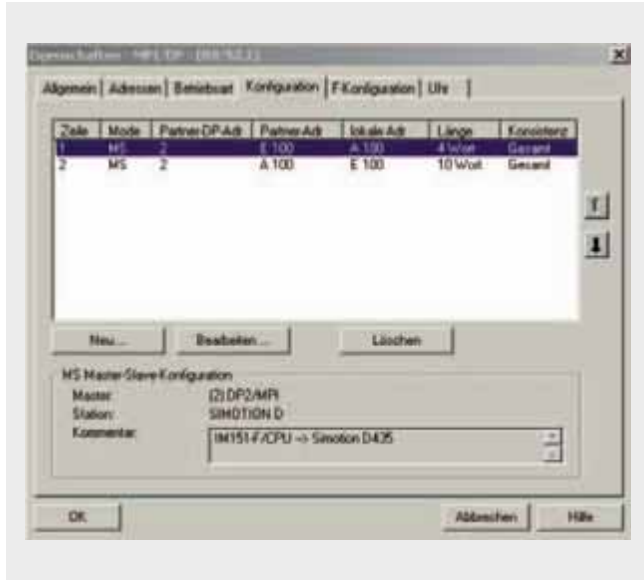
Overview of the network configuration



Ex. No.
4

Ex. No.
4

Sample communication configuration for one axis



Sample communication configuration

The F-CPU controller receives 10 consistent data words via the I/O address 100; 4 words are transmitted. The input data are processed as input words, the output data are processed as output words.

The data are transferred resp. received by the SIMOTION controller using the I/O address 100 as well. They are postprocessed using ARRAY. The arrays are created in the I/O data.

**SINAMICS Runtime System
Parametization of the SINAMICS drive system**

The drive system is commissioned via the STARTER commissioning tool. The parameterization procedure is described in the following.

It is assumed that the motion application of the axis is functional. The safety-related Motion Control functions are not explained in this document.

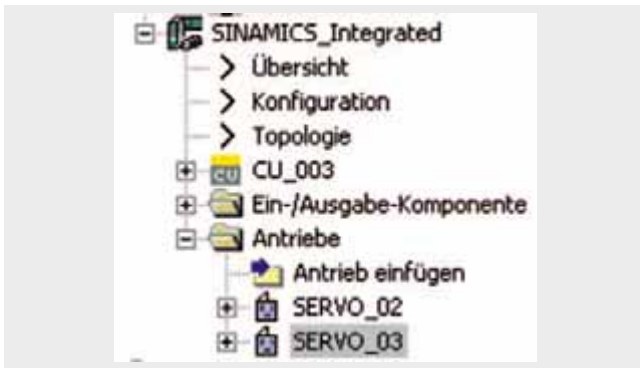
The sample application included uses the example of a motor encoder for a demonstration case to illustrate the configuration procedure.

The axis to be monitored has to be created as a positioning axis!

1. Program example

The program example supplied describes how to configure an axis (Servo_3...Achse_Blau).

The modifications described have to be integrated into the existing project.



2. Program example

PROFIBUS configuration for demonstration case.

PROFIBUS-Telegramm | Versionsübersicht

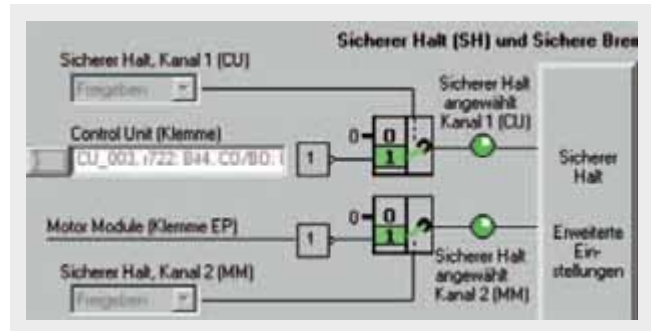
Die Antriebsobjekte werden in der folgenden Reihenfolge mit Daten aus dem PROFIBUS-Telegramm

Objekt	Antriebsobjekt	Telegrammtyp	E-Adresse	A-Adresse	SIMOTION Achse
1	SERVO_02	Freie Telegrammprojekte	296..293	296..277	Achse_red
2	SERVO_03	Freie Telegrammprojekte	304..341	304..325	Achse_blaue
3	TB30_04	Freie Telegrammprojekte	296..299	296..299	---
4	CU_003	Freie Telegrammprojekte	300..303	300..303	---

3. SINAMICS Safety Integrated

The Safe standstill function has to be started up and checked as described in the "SINAMICS S120

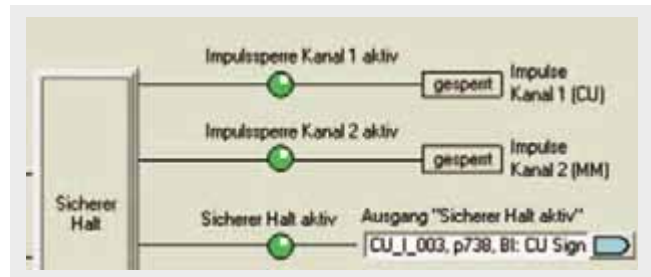
Commissioning Manual", Chapt. 5.2 Safe standstill (SH).



4. SINAMICS Safety Integrated

The message "Safe standstill active" has to be connected to the digital SIMOTION/SINAMICS output.

This output must be connected to the digital input of the Simatic I/O.



5. SINAMICS Safety integrated

Redundant coarse position sensing is activated as follows: P430.0 = E0080000H

with Safety actual position value acquisition = yes

p430[0]	E	-	Sensor Module Konf	E0080000H
p430[0].17	E		Burst-Oversampling	Nein
p430[0].19	E		Safety-Lageistwert	Ja

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6. Axis communication startup

The redundant coarse position information has to be connected to the PROFIBUS and transferred to SIMOTION as follows: P2061.x = r484

The redundant coarse position information is required as a double word.



7. Axis communication startup

The encoder status word has to be connected to the encoder to be monitored (if not already done in the standard configuration):

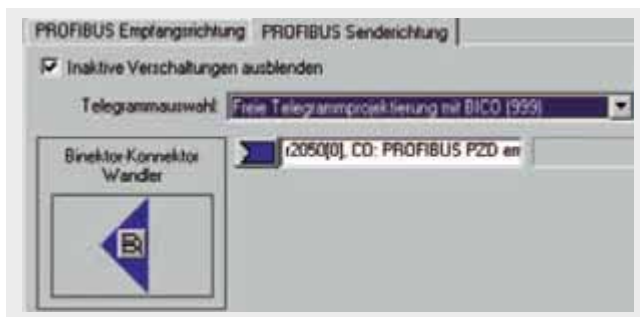
P2051.x = r481

The coarse position information is only required as a word.



8. Control Unit (CU) startup

The sign of life signal is transferred via the Control Unit (see Chapt. 6.4). That means, one transmit and receive word must be configured for each axis
e.g. P2051.x = r2050.x



Note

The communication configuration in the HW Config must be extended by the additional transmit and receive words.

SIMOTION Runtime System

Starting up the program section in the SIMOTION controller

The SIMOTION SCOUT tool is required for commissioning. The drive has to be parameterized as described at page 440 before the following steps can be performed successfully.

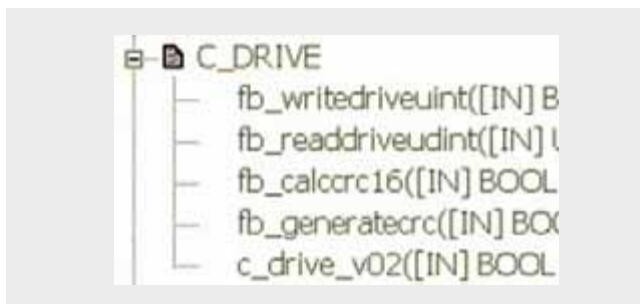
9. Axis technology object (TO)

The axis technology object is configured in the SIMOTION SCOUT. In the example described, it is called Axis_blue and connected to SERVO_3.



10. Integration of the function block "C_DRIVE"

The program "C_DRIVE" supplied has to be integrated into the user project.

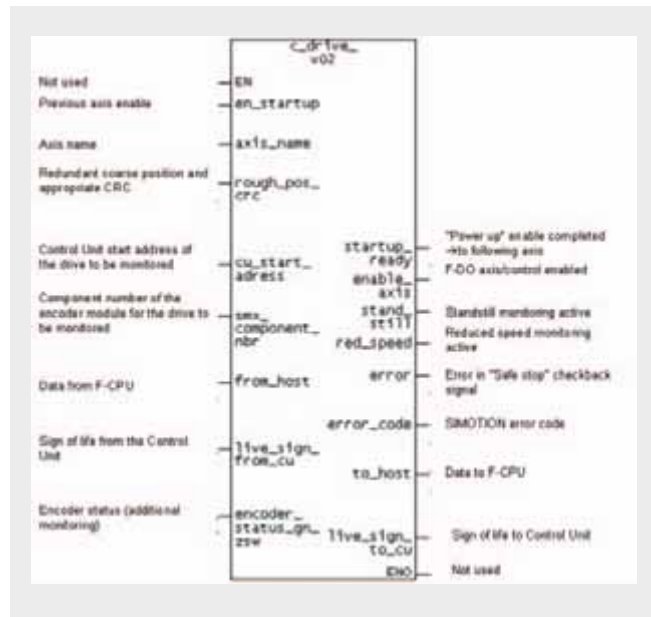


11. Integration of the program "C_DRIVE"

Only the function block "c_drive_v02" is required to call the user.



Description of the function block "C_DRIVE"



Function block "c_drive_v02"

I/O variables for the function block "C_DRIVE"

	Name	IO-Adress	H	Datentyp	Feldlänge	P	Strategie
1	live_sign_read_blue	PNV 300		INT	1		Ersatzw
2	live_sign_send_blue	PGW 300		INT	1		Ersatzw
3	f_cpu_read_4_words_blue	PNV 100		Array	4		Ersatzw
4	f_cpu_send_10_words_blue	PGW 100		Array	10		Ersatzw
5	roughposition_redundant_blue	PD 324		DWORD	1		Ersatzw
6	encoder_status_blue	PNV 314		WORD	1		Ersatzw

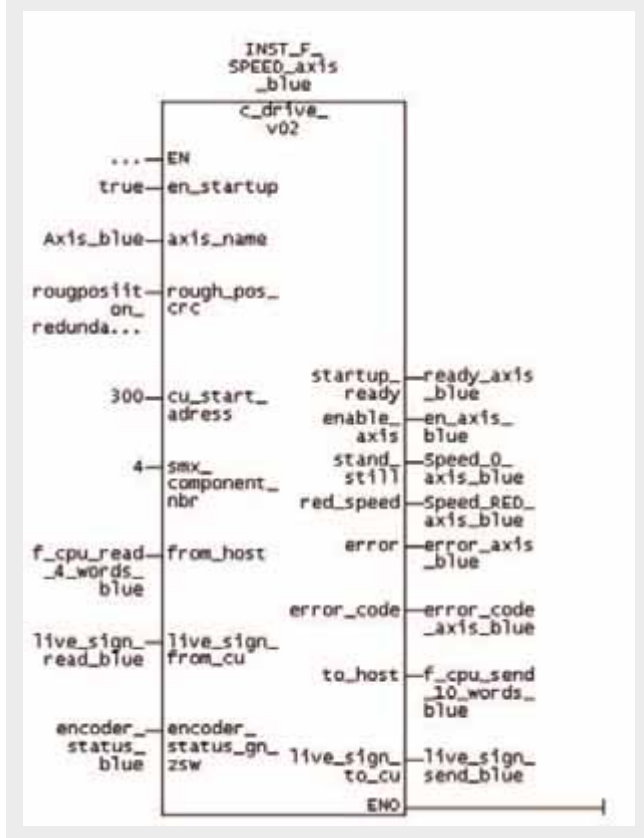
I/O configuration of the sample application

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The following communication variables have to be created in the I/O configuration:

- I/O input and output variables for sign-of-life monitoring via the CU (position 1,2)
- Transmit and receive arrays for establishing communication with the safety control 10/4 words (position 3,4)
- Redundant coarse position information from the axis encoder module SMx (position 5)
- Encoder status of the axis encoder module SMx (position 6)

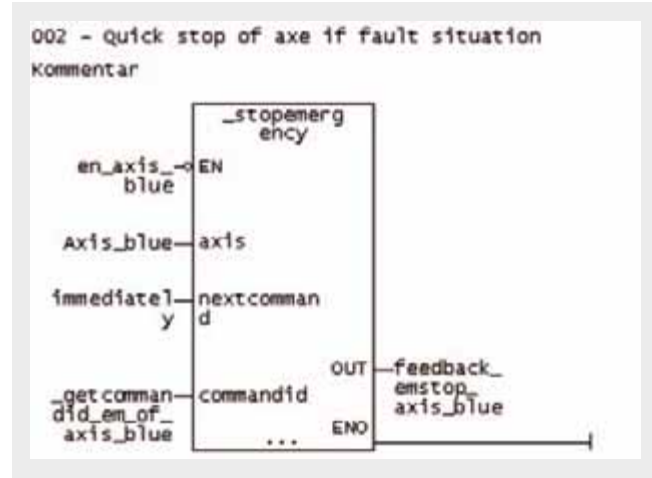
Integration of the function block "C_DRIVE" into the application



Integration of c_drive

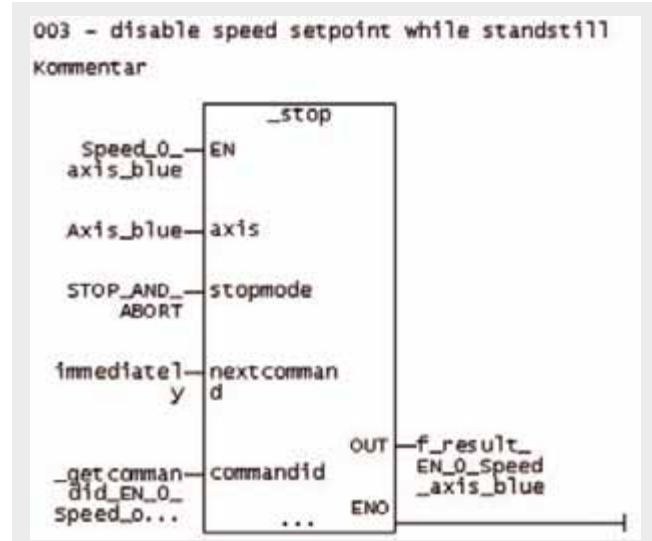
Possible responses in the SIMOTION application

Immediate stop in the event of an axis monitoring fault



If the axis monitoring function has not been enabled, the axis performs an emergency stop.

Default setting for stop command with active axis standstill monitoring



If the axis performs an operational stop, a cyclic stop command is preset.

SIMATIC Runtime System Function Block "F_DRIVE" for safe monitoring of drive functions

The safety-related function block "F_DRIVE" requires the safety-related Distributed Safety System. The system manual Safety Engineering in SIMATIC S7" (s. Chapt. 2.2.1) provides a detailed description of this safety system.

The function block "F_DRIVE" ensures safe monitoring of the drive functions and establishes safety-related communication between the SIMOTION/SINAMICS drive system and the fail-safe Simatic CPU. A sin/cos encoder has to be connected to the SMx20 module issuing signals that will be evaluated.

In the event of an error, safe drive standstill is activated via a F-DO thus bringing the drive into a safe operational state.

The following safety functions can be implemented depending on the relevant application:

- Safe standstill
- Safe shutdown
- Safe operating stop
- Safely limited speed

Caution

Before inserting the fail-safe application block FB300 "F_DRIVE", you have to copy the fail-safe blocks FB186 "F_TOF", FC174 "F_SHL_W" and FC176 "F_BO_W" from the block container F-Application Blocks of the fail-safe Distributed Safety library (V1) into the block container of your S7 program (if not already done).

The blocks must be assigned the above-mentioned numbers and may not be renumbered.

Caution

The block functions are only ensured by setting the relevant parameters in the hardware configuration.

Caution

A function test is required to check the block functions.

Notice

The fail-safe monitoring time and the fail-safe mode of the module are described analogously to the manual "Safety Engineering in SIMATIC S7 System Description"!

Note

The constants "VKE0" and "VKE1" must be used in the program block through fully qualified access to "F_GLOBDB". "VKE0" is reproduced by "F_GLOBDB".VKE0, "VKE1" by "F_GLOBDB".VKE1.

They are used to permanently connect the inputs of the function block and may not be modified by the safety program.

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Block identification

Before you can integrate the safety-relevant function block "F_DRIVE" into the existing program structures, you may have to change the block number resp. the symbolic name.

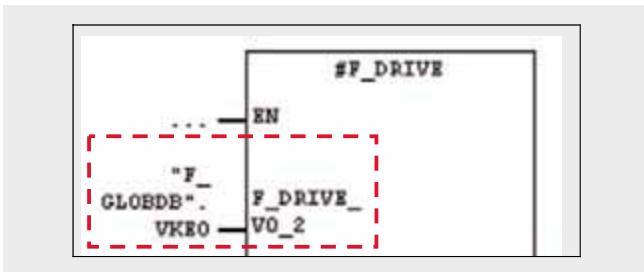
In order to unambiguously identify the blocks, the block header and the block version of the relevant function block have been designed as an input block.

This input block is always the second input block (after "EN").

The input name is composed as follows:

- "_Header_FB-NAME_FB-Version"

Input name of the function block "F_DRIVE"



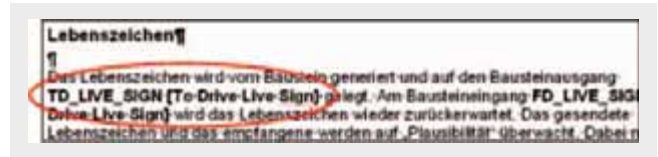
Block identification

The input block used for identifying the block has no functional significance and is therefore connected to VKRO.

Information on the formal operands

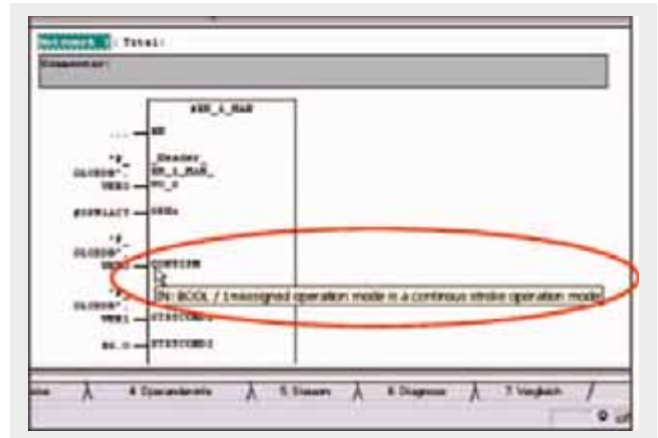
The names used for the individual formal operands of block "F_DRIVE" are derived from English terms. In order to achieve a better understanding, the related English term is added in square brackets when using a formal operand for the first time (refer to the Chapter Description of functions).

Example:



Formal operands

The operands are described in detail in the FBD / LADDER editor using a hint.



Formal operands with hint

Overview of the function block "F_DRIVE"

Header: F_DRIVE V0.2 / Date July 10, 2006 Time 15:50:59 /
Checksum: D2D2

		Parameter	Beschreibung
		IN	
EN		EN	Enable input, not used
F_DRIVE_V0_2		F_DRIVEV0_3	Block name/block version
AREA_PROTECTED		AREA_PROTECTED	1 = Protection zone closed 0 = Standstill monitoring active
ENABLE_MOTION		ENABLE_MOTION	1 = safe state monitoring, Reduced speed
SAFE_STOP		SAFE_STOP	0 = Safe standstill active
ACK		ACK	Acknowledgement
MAX_SPEED		MAX_SPEED	Maximum speed (see SIMOTION)
MAX_ENC_INC_PER_TIME		MAX_ENC_INC_PER_TIME	Maximum encoder increments / End of cycle
DELTA_INC_STANDSTILL		DELTA_INC_STANDSTILL	Delta of increments with Standstill monitoring
F_TIME		F_TIME	Sign of life time discrepancy
FD_LIVE_SIGN		FD_LIVE_SIGN	Sign of life
FD_FAULT_MESSAGE		FD_FAULT_MESSAGE	Error message from the drive
FD_CONTROL_MESSAGE		FD_CONTROL_MESSAGE	Control word from the drive
FD_RED_ROUGH_POS		FD_RED_ROUGH_POS	Redundant coarse position (RGL)
FD_ROUGH_POS		FD_ROUGH_POS	Standard coarse position (GL)
FD_SPEED_SIMO		FD_SPEED_SIMO	Actual drive speed
FD_CRC_SIMO		FD_CRC_SIMO	CRC via "sign of life" and Actual drive speed"
FD_START_CRC		FD_START_CRC	Start CRC encoder module
FD_CRC_PSAFE		FD_CRC_PSAFE	CRC via "RGL"
FD_VERSION		FD_VERSION	SIMOTION function block version
		OUT	
ENABLE_AXIS		ENABLE_AXIS	Safe standstill to SINAMICS
ERROR		ERROR	Error
DIAG		DIAG	Diagnostic information
TD_LIVE_SIGN		TD_LIVE_SIGN	Sign of life to SIMOTION / CU
TD_CONTROL_MESSAGE		TD_CONTROL_MESSAGE	Control word to SIMOTION
TD_SPEED		TD_SPEED	red. V for SIMOTION monitoring
TD_DELTA_INC_SS		TD_DELTA_INC_SS	Max delta of incr. for standstill monitoring
ENO		ENO	Not used

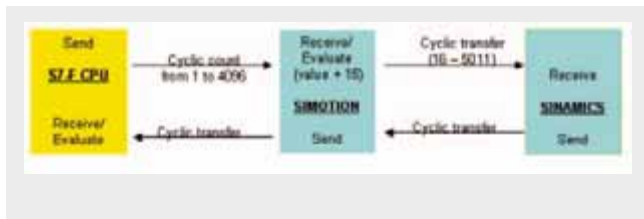
Functionality of the function block "F_DRIVE"

Sign of life

The sign of life is generated by the block and transmitted to the output block TD_LIVE_SIGN [To Drive Live Sign]. The input block FD_LIVE_SIGN [From Drive Live Sign] awaits the sign of life. The "plausibility" of the sign of life transmitted and the one received is checked. The sign of life in the drive system must be incremented by 15 (function containing SIMOTION function block).

The FB300 permanently converts the signs of life received into new signs of life using the principle of serial numbers.

If a sign of life transmitted does not correspond to the sign of life received, the sign of life expected is transmitted again. This is tolerated until a time parameterized at input block F_TIME has expired. Then, an error is output and the output ENABLE_AXIS is reset. This principle corresponds to a time expected with acknowledgement.



Caution

The time set at input block F_TIME has to be set to the lowest possible value to ensure that the function block "F_DRIVE" immediately detects any errors arising during data transmission.

Error acknowledgement / enable of safe standstill

Errors can be reset only with AREA_PROTECTED = 1 through a rising edge at ACK [Acknowledgement].

ENABLE_AXIS only possible if AREA_PROTECTED = 1, if no errors are pending and if a rising edge is applied to ACK.

Fail-safe output(s) of the fail-safe Distributed Safety system must be controlled via the ENABLE_AXIS output. The "Safe standstill" safety function of the SINAMICS drive system is triggered via this output.

Protection zone closed

If the protection zone is closed (AREA_PROTECTED=1), speed or standstill monitoring is not performed. The sign of life, CRC and the relevant position of the control signals with respect to each other (AREA_PROTECTED and ENABLE_MOTION) are still monitored.

The ENABLE_MOTION signal - which constitutes, for example, the evaluated signal transmitted from an acknowledgement button - may only include a high signal if AREA_PROTECTED=0, which can be connected, for example, to the evaluated signal transmitted from protective doors of a certain protection zone. If this is not the case, ENABLE_AXIS is set to 0.

Safe operating stop / standstill monitoring, e.g. protection zone open

The actual position FD_RED_ROUGH_POS [From Drive Redundant Rough Position] is permanently stored in the block and verified as the standstill position when axis standstill monitoring is requested (AREA_PROTECTED = 0). The standstill monitoring function is activated when the AREA_PROTECTED signal is changed from 1 to 0. When standstill monitoring is active, the system tolerates position changes by the value entered in FD_RED_ROUGH_POS +/- the value that can be parameterized by the user DELTA_INC_STANDSTILL [Delta Increments Standstill]. This yields both a positive and a negative standstill limit. If the encoder value does not exceed the limits specified, then ENABLE_AXIS=1 and the drive can still be controlled even if it has stopped.

If the position is changed and one of the above-mentioned limits violated, the monitoring function is violated and the safe standstill function on the drive triggered via the output block ENABLE_AXIS = 0, thus setting a restart inhibit.

The maximum delta increments permissible during standstill are transmitted to the output block TD_DELTA_INC_SS [To Drive Delta Increments Standstill]. They can thus be simultaneously monitored in SIMOTION.

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Überwachung auf sicher red. Geschwindigkeit z.B. Schutzbereich offen und Zustimmung betätigt

Monitoring for safely limited speed, e.g. protection zone open and enable function active

With AREA_PROTECTED=0 and ENABLE_MOTION=1, the minimum drive speed value is monitored. If this value is exceeded, the block sets parameter ENABLE_AXIS =0.

FB300 must be called via the safety program using a time interrupt OB. The actual position of these two calls is saved via FD_RED_ROUGH_POS yielding a delta. This delta may not exceed the value of MAX_ENC_INC_PER_TIME [Maximum Encoder Increments Per Time] parameterized at the input.

The following formula shows how to calculate the value to be assigned to MAX_ENC_INC_PER_TIME from the speed to be monitored:

Signals / values required:

- a = max. speed;
→ The SIMOTION controller can read out the max. speed via the axis information entered in TypeOfAxis.SetPoint-DriverInfo.DriveData.maxSpeed
- b=Leadscrew pitch
→ The SIMOTION controller can read out the leadscrew pitch via the axis information entered in LeadScrew.pitch-Val
- c=Gear ratio1
→ The SIMOTION controller can read out the gear ratio 1 via the axis information entered in TypeOfAxis.NumberOf-DataSets.DataSet_(n).Gear.numfactor
- d=Gear ratio2
→ The SIMOTION controller can read out the gear ratio 2 via the axis information entered TypeOfAxis.NumberOf-DataSets.DataSet_(n).Gear.denfactor
- Number of increments per revolution (incremental encoder) → The SIMOTION controller can read out the relevant value via P408
- Number of increments per revolution (absolute encoder) → The SIMOTION controller can read out the relevant value via P423
- Time interrupt (call interval of the function block "F_DRIVE" in a time interrupt OB) → The SIMOTION controller can read out the time interrupt via OB3X_EX_FREQ

Calculation:

The maximum speed is calculated as follows:

$$V_{\max} [\text{mm/sec}] = a \times b \times c / d / 60$$

The max. increments are calculated as follows:

$$\text{Incmax} [1/\text{sec}] = a \times P408 (p423) / 60$$

The permissible increments are calculated as follows:

$$\text{MAX_INC_PER_TIME} = \text{Incmax} \times (\text{SLS} / V_{\max}) \times t / 1000$$

In addition, the block is notified about the maximum permissible speed in degrees resp. mm/s via the input MAX_SPEED [Maximum Speed]. This value is compared with the value set for FD_SPEED_SIMO [From Drive SIMOTION], analogously to the speed monitoring function using increments. FD_SPEED_SIMO is the speed which is transferred by the SIMOTION controller to the FB300.

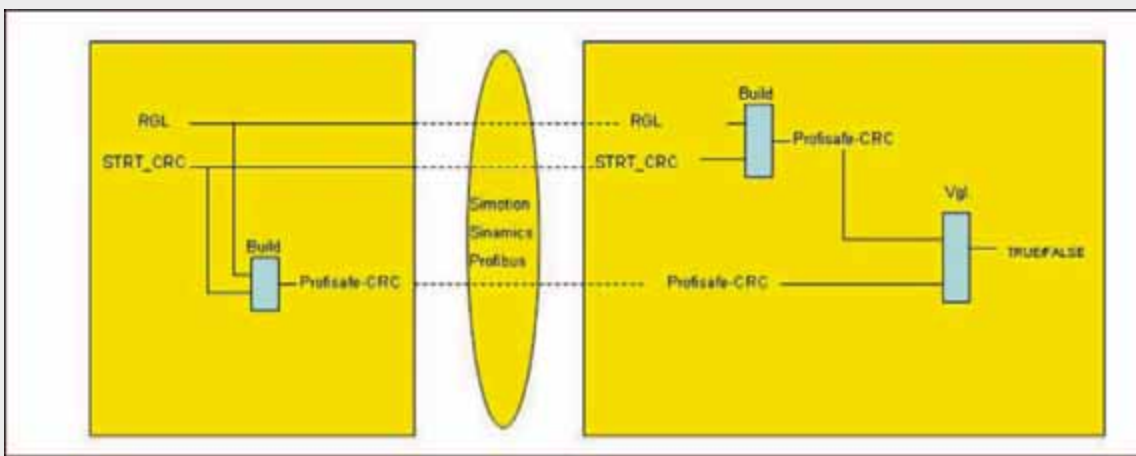
This value is stored using a CRC which has to be connected to FD_CRC_SIMO [From Drive CRC SIMOTION]. The CRC is defined by the values FD_CRC_SIMO = "SIMOTION speed" and FD_LIVE_SIGN = "sign of life".

The speed parameterized at MAX_SPEED is output by the output block TD_SPEED [To Drive Speed]. This speed is, for example, sent to the SIMOTION function block where it is monitored simultaneously.

Unconditional trigger of safe standstill

The output ENABLE_AXIS can be directly set to 0 via the input SAFE_STOP. This is achieved by setting SAFE_STOP to 0.

PROFIsafe CRC



PROFIsafe CRC

The so-called PROFIsafe CRC has to be connected to the input FD_CRC_PSAFE [From Drive CRC PROFIsafe]. This CRC is defined by the redundant coarse position and the START-CRC in the SMx20 encoder module. The PROFIsafe CRC is simulated in the function block "F_DRIVE" and compared with the CRC already transmitted. To simulate the PROFIsafe CRC, encoder information such as the redundant coarse position data has to be transmitted to the formal operand FD_RED_ROUGH_POS and the START-CRC to the operand FD_START_CRC.

Coarse position in relation to the redundant inverted coarse position

In addition to the redundant coarse position, forwarded to FD_RED_ROUGH_POS, the standard coarse position information of the encoder has to be transferred to the relevant block parameter FD_ROUGH_POS. FB300 then checks whether these two values match.

Stop categories

The delay times for Stop categorie 1 are to be stored in the safety program by means of an application.

In SIMOTION Version V4.0 / SINAMICS 2.4 or later, OFF 3 can be parameterized upon triggering of safe standstill stating a delay time for the safe standstill.

START-CRC

The START-CRC is applied to parameter FD_START_CRC. The PROFIsafe CRC is again defined from the redundant coarse position.

The START-CRC consists of the one-to-one NODE-ID of the SMx20 encoder module.

This information avoids incorrect resp. double addressing, thus applying the PROFIsafe principle "Identification for transmitter resp. receiver".

SIMOTION CRC

The FD_SPEED_SIMO and FD_LIVE_SIGN data transmitted by the SIMOTION controller are saved by the SIMOTION function block using a CRC. This is expected at the input FROM_DRIVE_8 and simulated resp. compared in FB300.

Version comparison

The consistency of the function blocks "SIMOTION" and "Simatic F-CPU" is checked by means of a certain number before they can be used. The correct version of the SIMOTION function block has to be created at the input FD_VERSION [From Drive Version].

Plausibility check: Motion command for the speed

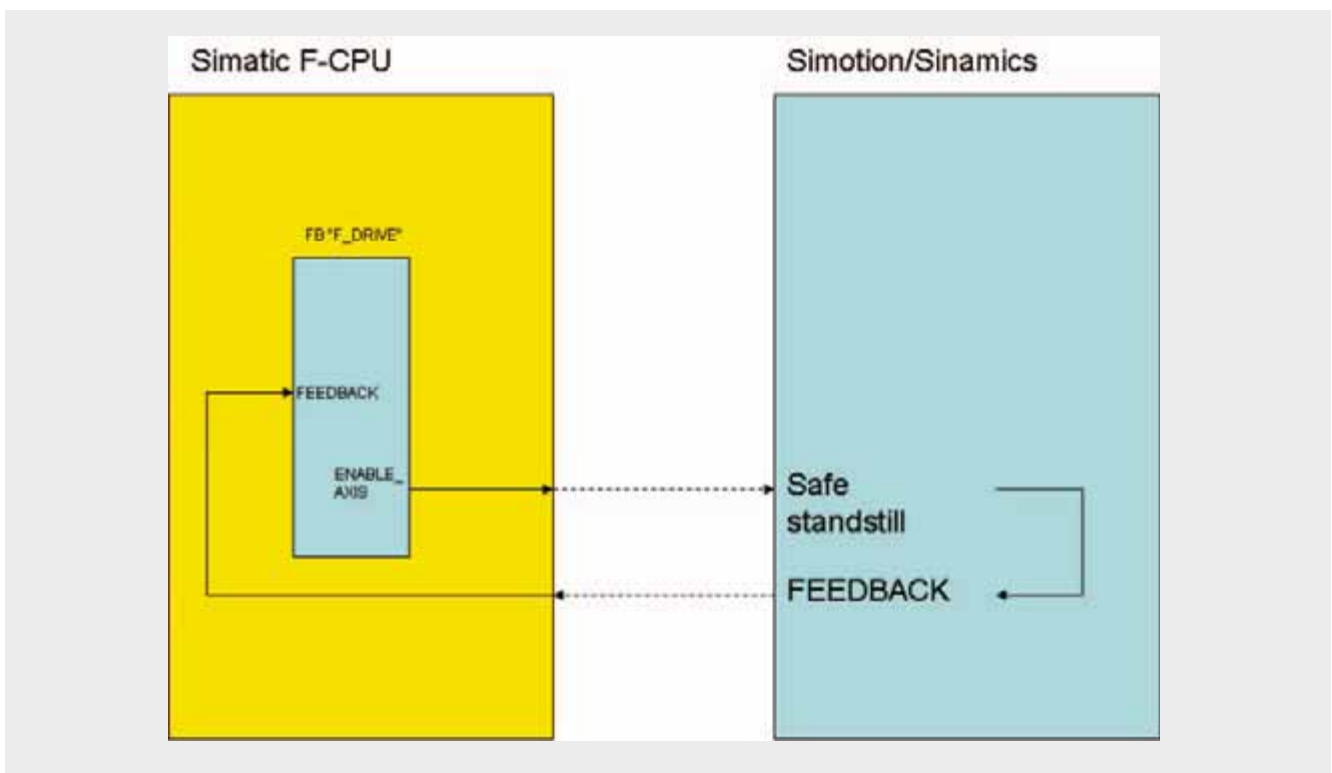
The SIMOTION controller must transfer a motion command to the block via the input `FD_CONTROL_MESSAGE`, where 1 corresponds to setpoint = 0 and 0 corresponds to setpoint 0. The plausibility of these two signal states is checked by the block, by opposing the signal `FD_SPEED_SIMO`. If the plausibility check yields a negative result, the output `ENABLE_AXIS` is reset.

These two signals are checked for discrepancy by means of an equivalent (identical signal states) evaluation. Non-equivalent values (non-identical signal states) of up to 500ms are tolerated. When the time discrepancy has expired, the output `ENABLE_AXIS` is set to 0. The output can only be reset after restarting the CPU. The current status of the inputs `ENABLE_AXIS` and `FEEDBACK` can be visualized via the output `ERROR`.

Plausibility check: Safe standstill and feedback

Safe drive standstill is triggered via the output `ENABLE_AXIS`. The drive feedback stating that the Safe standstill function has been activated has to be connected to the input block `FEEDBACK`.

`ERROR = 0` → `ENABLE_AXIS` and `FEEDBACK` are equivalent
`ERROR = 1` → `ENABLE_AXIS` and `FEEDBACK` show non-equivalent statuses when the time discrepancy of 500ms has expired.



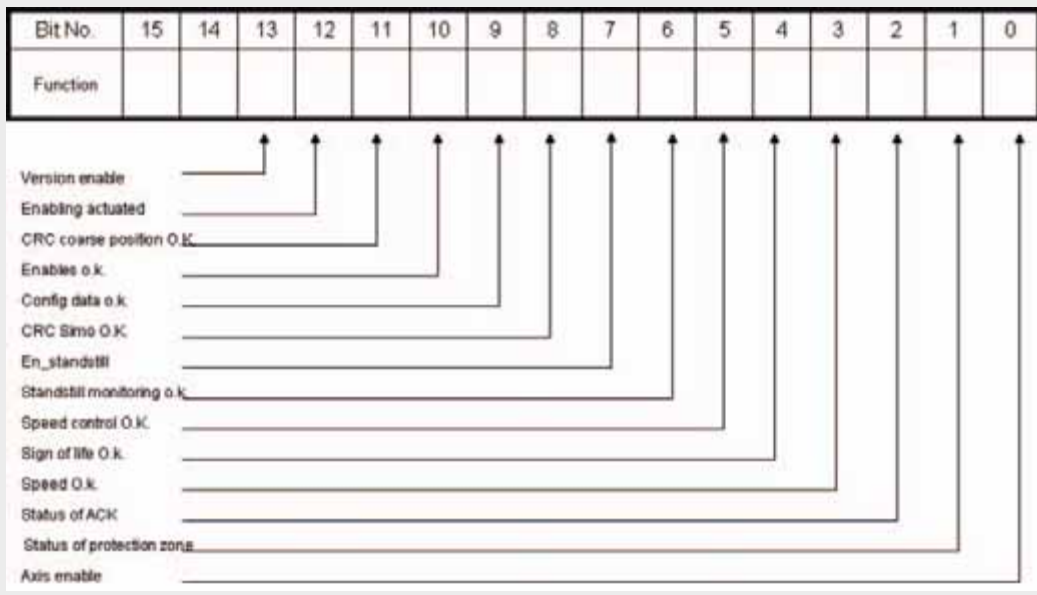
Safe standstill feedback

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Information regarding parallel evaluation

In order to implement the drive function monitoring option also on the SIMOTION controller, the function block "F_DRIVE" notifies the SIMOTION drive system about the functions required via the output TD_CONTROL_MESSAGE. These signals are connected to the output DIAG for diagnostic purposes.

Diagnostic information from the F-CPU diagnostic word



Diagnosis message

Porting PROFIsafe to the application

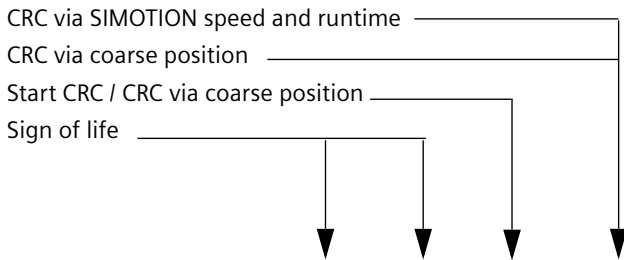
Safe position detection is based on three signals:

- Coarse position
 - Redundant inverted coarse position
- Fail-safe principles: Two channels and diversity

- CRC via the redundant coarse position
- Plausibility check

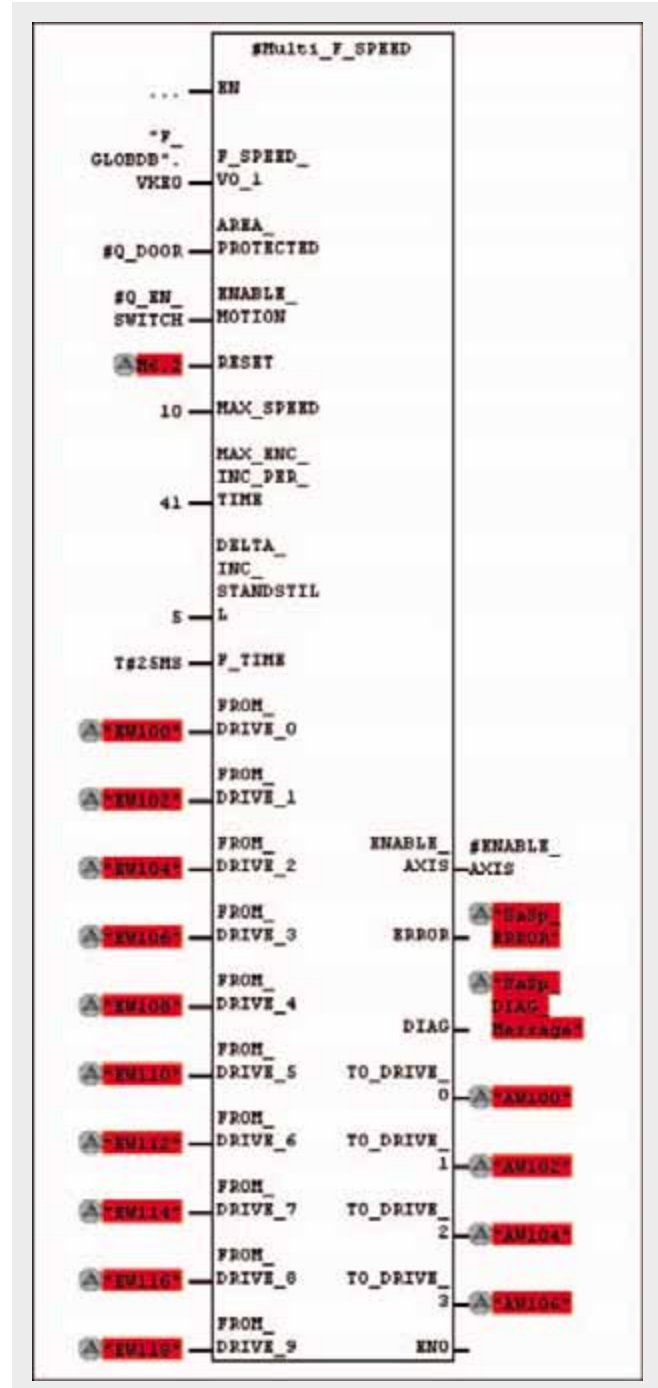
Before these safe signals can be transferred from the SIMOTION controller to the F-CPU, you have to port the PROFIsafe profile to the relevant application.

This is why the error detection measures are ported from PROFIsafe to the communication between the SIMOTION controller and the F-CPU.



	Serial number	Time expected with acknowledgement	Identifier for transmitter and receiver	CRC data backup
Repetition	X			
Loss	X	X		
Insertion	X	X	X	
Incorrect sequence	X			
Corrupted data				X
Delay		X		
Linking of safety-related and standard messages (masquerade)		X	X	X
FIFO error		X		

PROFIsafe principles



Integration of F_DRIVE

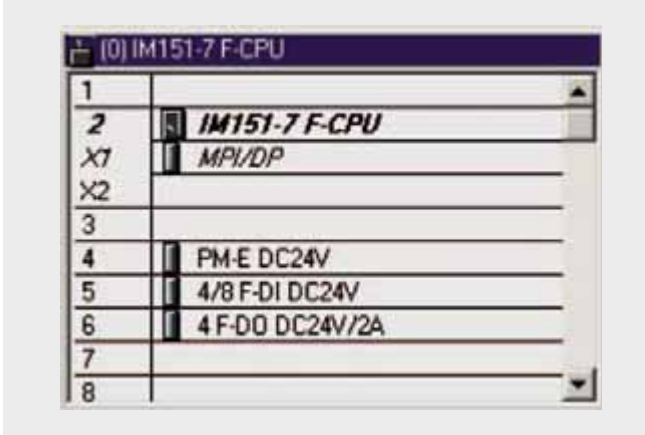
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Starting up the Program Section in the F-CPU

Before you can start up this program section successfully, you have to acquire the relevant safety knowledge and familiarize yourself with the Distributed Safety tool.

A sample start up is performed using the IM151 F-CPU module.

Hardware configuration of the fail-safe components



Module 4/8 F-DI:

Fail-safe input module for protective equipment, enabling and acknowledgement.

Module 4 F-DO:

Fail-safe output module for activating the channels 1 and 2 for the „Safe standstill“ function of the SINAMICS drive system.

I/O variables for the function block "F_DRIVE"

Input variables

E6.0	E 6.0	BOOL	NO_SFDOOR
E6.1	E 6.1	BOOL	NO_EN_SWITCH
E6.2	E 6.2	BOOL	ACK_BUTTON
E6.4	E 6.4	BOOL	NC_SFDOOR
E6.5	E 6.5	BOOL	NO_EN_SWITCH
EW100	EW 100	INT	SaSp_In_LIVE_SIGN
EW102	EW 102	INT	SaSp_In_FAULT
EW104	EW 104	WORD	SaSp_In_CONTROL_WORD
EW106	EW 106	INT	SaSp_In_ROUGH_POSITION
EW108	EW 108	INT	SaSP_In_SHIFTED_ACT_POS
EW110	EW 110	INT	SaSp_In_ACT_SPEED
EW112	EW 112	INT	SaSp_In_CRC
EW114	EW 114	WORD	SaSP_START_CRC
EW116	EW 116	INT	SaSP_CRC_ROGH_POS
EW118	EW 118	INT	SaSP_FB_VERSION

Output variables

A1.0	A 1.0	BOOL	SaSp_Out_Safety_Stop_0
A1.2	A 1.2	BOOL	SaSp_Out_Safety_Stop_1
AW100	AW 100	INT	SaSp_Out_LIVE_SIGN
AW102	AW 102	WORD	SaSp_Out_CONTROL_WORD
AW104	AW 104	WORD	SaSp_Out_SPEED
AW106	AW 106	INT	SaSP_Out_DELTA_INC_STAND

Fail-safe runtime group configuration

The configuration parameters for the fail-safe runtime group must be set in order to provide swift response times.

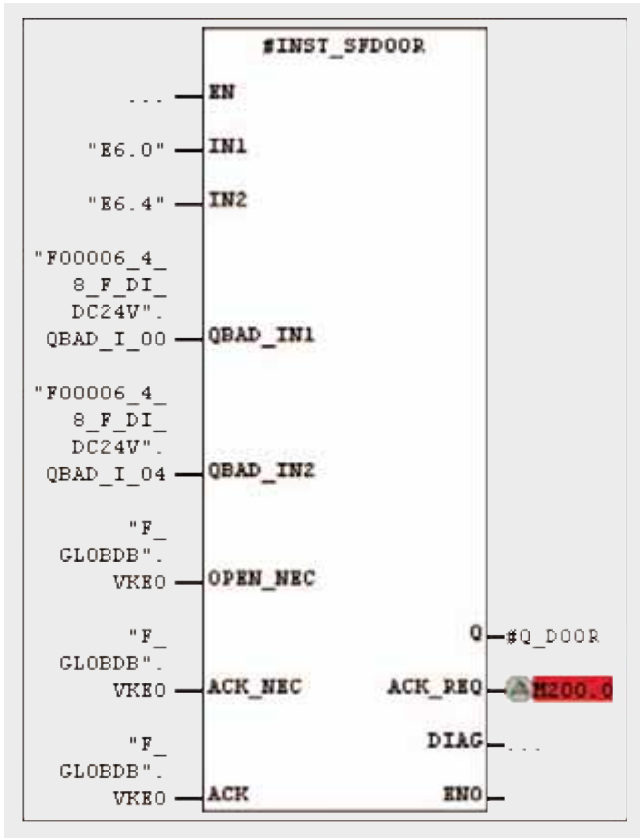
The safety program has to be called in a time interrupt task (time interrupt OB).

The configuration of the fail-safe program has to be performed and tested accordingly, as described in the manual "Distributed Safety Configuring and Programming".

Input signal conditioning

The incoming operand AREA_PROTECTED can be linked to the conditioned signal transmitted from one or several protective doors (see page 452).

You can use, for example, the function block "F_SFDOOR" from the Distributed Safety library to evaluate the signals transmitted from a protective door:

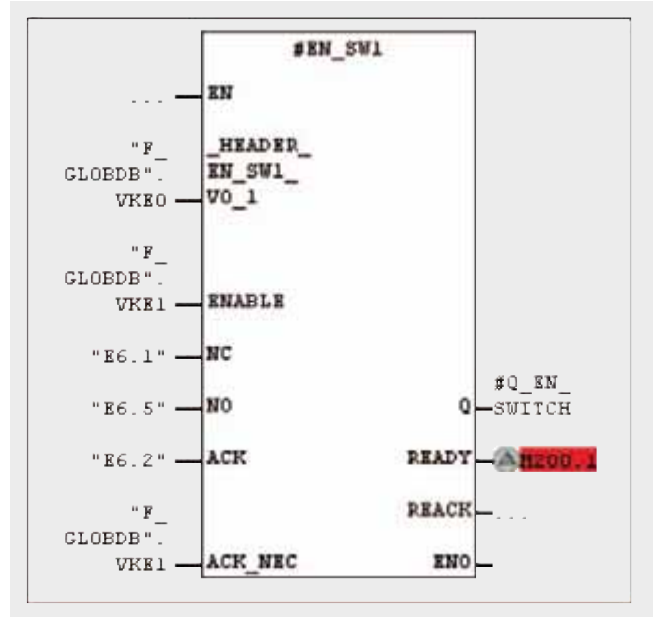


Function block "SF_DOOR"

Depending on the respective application, the incoming operand ENABLE_MOTION can be linked to the conditioned signal of an acknowledgement button.

You can use, for example, the function block "EN_SW_1" from the SIMATIC S7 F/P library to evaluate signals transmitted from an acknowledgement button.

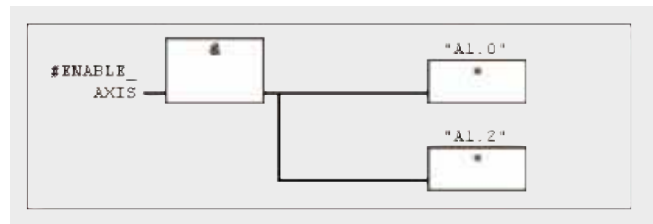
The block description of the SIMATIC S7 F/P V2.0 press safety library provides a detailed description of this block.



Function block "EN_SW1"

In order to transmit the axis enable of the function block "F_DRIVE" via the output parameter ENABLE_AXIS (see fig.) to two outputs of a fail-safe output module, you have to link a static variable such as ENABLE_AXIS to the output block.

The subsequent network links this static variable to the appropriate outputs by means of parameter assignment.







Axis enable link

Certificates

EC-type examination certificate for SINAMICS S120 booksize "SH/SBC"

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Prüf- und Zertifizierungsstelle im BG-PRÜFZERT		 BGIA Berufsgenossenschaftliches Institut für Arbeitsschutz Hauptverband der gewerblichen Berufsgenossenschaften	
Baumusterprüfbescheinigung		0406013 <small>Bescheinigungsnummer</small>	
Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Siemens AG, A&D MC Frauenausracher Straße 80, 91050 Erlangen		
Name und Anschrift des Herstellers:	Siemens AG, A&D MC Frauenausracher Straße 80, 91050 Erlangen		
Zeichen des Auftraggebers: A&D MC	Zeichen der Prüf- und Zertifizierungsstelle: 2004 21078-01 Rf/Ag/IMkr	Ausstellungsdatum: 17.01.2005	
Produktbezeichnung:	Antriebssteuerung für Maschinen mit integrierten Sicherheitsfunktionen		
Typ:	SINAMICS S120 Stand der Hardware / Software siehe Anlage		
Bestimmungsgemäße Verwendung:	Maschinensteuerung zur Realisierung sicherer Maschinenfunktionen		
Prüfgrundlage:	[1] DIN EN 954-1 (1996) [2] IEC 61508, Teil 1-7 (1998-2000) [3] DIN EN 60204 (1998) [4] DIN EN 50178 (1998) [5] IEC 61800-3 (2001)		
Zugehöriger Prüfbericht:	2004 21078-01		
Bemerkungen:	Die Antriebssteuerung erfüllt für die Sicherheitsfunktionen Sicherer Halt und sichere Bremsenansteuerung die Anforderungen des Sicherheits-Integrations-Level (SIL) 2 nach IEC 61508 und die Steuerungskategorie 3 nach DIN EN 954-1.		
Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 98/37/EG (Maschinen).			
Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom April 2004.			
Leiter der Zertifizierungsstelle  (Hr.-Dr. rer. nat. Diemar Reinert)	Fachzertifizierer  (Dipl.-Ing. Ralf Apfel)		
FE3100 05.04	 Postadresse: 33754 Senft Auegeln	Hauptadresse: Alte Feuerstraße 111 33757 Senft Auegeln	Telefon: 0 52 41/2 31-05 Telefax: 0 52 41/2 31-22 34

TÜV certificate (issued by the TÜEV Group, German Technical Inspectorate) for SIMATIC S7 - Distributed Safety

TÜV Certificate No.: Z2 02 03 20411 009 "SIMATIC S7 Distributed Safety", March 26, 2002

Ex. No.

4



BG-Certificate for function block "F_DRIVE"

Ex. No.
4



Fachausschuss Maschinenbau
Hebezeuge, Hütten- und
Walzwerksanlagen
Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

Hauptverband der gewerblichen
Berufsgenossenschaften

Baumusterprüfbescheinigung

06 074
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers (Auftraggeber)	Siemens AG Frauenrucher Straße 60 91056 Erlangen	
Name und Anschrift des Herstellers	siehe oben	
Zeichen des Auftraggebers	Zeichen der Prüf- und Zertifizierungsstelle: M-BW 012 1 012 26-UB 52/4	Ausstellungsdatum: 02. Oktober 2006
Produktbezeichnung	F_Drive; FB 300 V 0.4	
Typ	FB 300; CRC: 90FB; Datum: 11.08.2006; Schnittstellendatum: 08.08.2006	
Bestimmungsgemäße Verwendung:	Der FB 300 ist ein abgeschlossener Funktionsbaustein, der im Anwendungsprogramm des sicherheitsgerichteten Automatisierungssystems SIMATIC 57-7/8 Distributed Safety aufgerufen und parametrisiert werden kann. Der sichere Halt, das sichere Stillsetzen, der sichere Betriebsstillstand und die sicher reduzierte Geschwindigkeit/ Drehzahl werden vom Baustein über das Protokoll ausgewertet. Der Baustein ist nicht dafür geeignet, die Antriebsfunktionen zu steuern. Die Einhaltung der aufgeführten bzw. anzuwendenden Normen setzt die Verwendung des sicherheitsgerichteten Automatisierungssystems SIMATIC ST Distributed Safety, eine korrekte Verschaltung und Einbindung der Funktionsbausteine in das Anwendungsprogramm voraus.	
Prüfgrundlage:	<ul style="list-style-type: none"> • Richtlinie 36/37/EG (Maschinen) • Prüfgrundlagen für die Prüfung der Arbeitssicherheit und des Gesundheitsschutzes von Elektrischen, Elektronischen programmierbaren Steuerungen und Busssystemen, G5-MB-BW-30, Ausgabe 07/2005, soweit zutreffend 	
Zugehöriger Prüfbericht:	Nr. 041/2006 vom 7. Juli 2006	
Bemerkungen:	Applikationen sowie die Bewertung von Hardware (Geber, Umrichter usw.) waren nicht Bestandteil der Prüfungen. Es ergibt sich eine Fehlreaktionszeit von 800 ms, da eine Anfahrzeit bis zu 900ms im Baustein toleriert wird.	

Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 36/37/EG (Maschinen).
Diese Bescheinigung wird spätestens ungültig am:

01.10.2009

Welters über die Gültigkeit, eine Gültigkeitsverlängerung und andere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom April 2004.




Unterschrift (Dipl.-Ing. Heitke)



INFORM
06.06

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SINAMICS G120 - controlled via PROFibus

Safety functions using PROFIsafe, Category 3 (EN 954-1) or SIL 2 (IEC 61508)

Automation function

Description of the functionality

The SINAMICS G120 drive inverter is a modular drive inverter system that essentially comprises the two function units Control Unit (CU) and Power Module (PM).

When using the Control Unit CU240S DP-F, you have access to the following safety functions that are integrated in the drive inverter:

Designation	Function	Description
STO	Safe Torque Off (acc. to EN 60204)	Prevents the drive from accidentally starting
		The drive is safely brought into a no-torque condition
		Preventing a restart does not require electrical isolation between the motor and drive inverter
SS1	Safe Stop 1 (acc. to EN 60204)	The drive is quickly stopped and safely monitored
		Independent and continuous monitoring guarantees the shortest response times when a fault occurs
		A speed encoder is not required
SLS	Safety Limited Speed (acc. to EN 60204)	The drive speed is limited and monitored
		Independent and continuous monitoring guarantees the shortest response times when a fault occurs
		A speed encoder is not required
SBC	Safe Brake Control	An external brake is safely controlled
		In this case, it is necessary to use the Safe Brake Relay

(all safety functions are certified according to EN 954-1, Cat. 3 and IEC 61508, SIL 2)

The safety functions are either controlled through two fail-safe digital inputs (4 digital inputs, which are evaluated through 2 channels in a fail-safe fashion in the CU 240S DP F) or via PROFIsafe in conjunction with a fail-safe CPU.

Functionality of the function example

Task description

A SINAMICS G120 with its integrated safety functions is to be controlled using an S7-300 F CPU via PROFIBUS.

Solution

In this particular function example, a specific program example will be used to demonstrate the control of a SINAMICS G120 (control word and frequency setpoint) and the control of the safety-relevant functions (STO, SLS and SS1) in an S7-300-F CPU.

This program example comprises an S7 program to control the SINAMICS G120, an S7 safety program and a configured SINAMICS G120

Advantages / customer benefits

Combining safety-relevant and standard programs in one common CPU and establishing communications between the CPU and drive inverter via a common Profibus simplify the system design.

The safety functions are integrated in the drive inverter and are implemented without any speed feedback signal. This means that to some extent complex external shutdown and monitoring devices can be eliminated.

A SINAMICS G120 with Safety Control Unit can replace an existing drive inverter. This means that safety functions can be added to an existing system with low associated costs and expenditure.

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Restrictions

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Caution

Please take careful note that the two safety functions SLS and SS1 may not be used for loads that can drive the motor or loads that are continually in the regenerative mode.

Elevating platforms, winders, wind turbines are examples of such loads that can drive motor or continually regenerate in to the line supply.

An important prerequisite when using fail-safe functions is that the closed-loop control functions absolutely perfectly. The drive (system comprising the drive inverter + motor + driven load) must be engineered so that all operating situations of the particular application are always completely under control.

Caution

After the STO and SS1 safety functions have been activated there is no electrical isolation between the line power supply of the SINAMICS G120 and the motor. If this electrical isolation is required in your particular application, then you must install an appropriate line contactor upstream of the SINAMICS G120.

Required components

An overview of the hardware and software components required for the function example is provided here.

Hardware components

Component	Type	Order No	Qty	Manufacturer
S7 control				
Power supply	PS307 5A	6ES7307-1EA00-0AA0	1	Siemens AG
S7-F CPU	CPU 317F-2DP	6ES7317-6FF00-0AB0	1	
Memory Card	MMC 2MB	6ES7953-8LL11-0AA0	1	
DI / DO simulation module	SM374	6ES7374-2XH01-0AA0	1	
Safety digital input	SM326	6ES7326-1BK01-0AB0	1	
Front connector	40 pol	6ES7392-1AM00-0AA0	1	
Profile rail	Profile rail	6ES7390-1AE80-0AA0	1	
PROFIBUS connector	PROFIBUS connector	6ES7972-0BB50-0XA0	1	
PROFIBUS cable	PROFIBUS cable	6XV1830-3BH10	2 m	
Drive				
SINAMICS G120 Control Unit*	CU240S DP F	6SL3244-0BA21-1PA0	1	Siemens AG
SINAMICS G120 Power Module*	PM240	6SL3224-0BE21-5UA0	1	
Basic Operator Panel*	BOP	6SL3255-0AA00-4BA1	1	
Motor*	Three-phase induction motor	1LA7060-4AB10	1	
PROFIBUS connector	PROFIBUS connector	6GK1500-0FC00	1	
Command devices				
Empty enclosure	Empty enclosure with 4 command sources (e.g. pushbuttons)	3SB3804-0AA3	1	Siemens AG
Emergency Stop mushroom pushbutton (to activate STO and SS1)	Emergency Stop mushroom pushbutton	3SB3000-1HA20	2	
Mushroom pushbutton (to activate SLS)	Mushroom pushbutton, red	3SB3000-1DA21	1	
Pushbutton (acknowledge safety functions)	Pushbutton, red	3SB3000-0AA21	1	
Contact	1NC, screw terminal	3SB3420-0C	6	
Contact	1NO, screw terminal	3SB3420-0B	2	

As an alternative to the components marked with *, the SINAMICS G120 training case can also be used that is additionally equipped with a 24V HTL encoder and a mechanical brake. This training case can be ordered by specifying Order No. 6ZB2480-0CD00.

Note

The functionality was tested with the specified hardware components. Similar components that are different from those listed above can be used. Please note that in such a case it may be necessary to change the code example (e.g. setting other addresses).

Software components

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Component	Type	Order No	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1	Siemens AG
SIMATIC Distributed Safety	V5.4	6ES7833-1FC02-0YA5	1	
Drive ES BASIC	V5.4	6SW1700-5JA00-4AA0	1	

Configuration and wiring

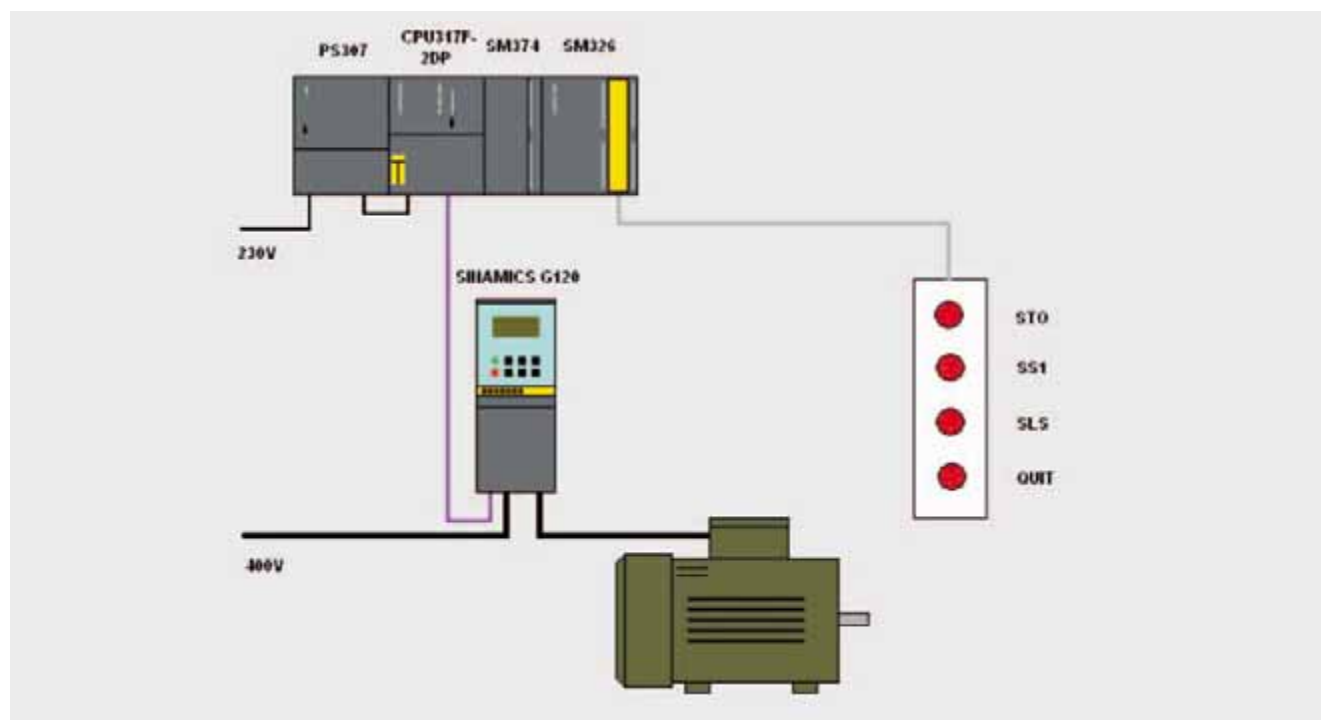
The hardware configuration and connecting-up the function example are described in this Chapter.

Please carefully observe the following safety information & instructions when using the SINAMICS G120:

Warning

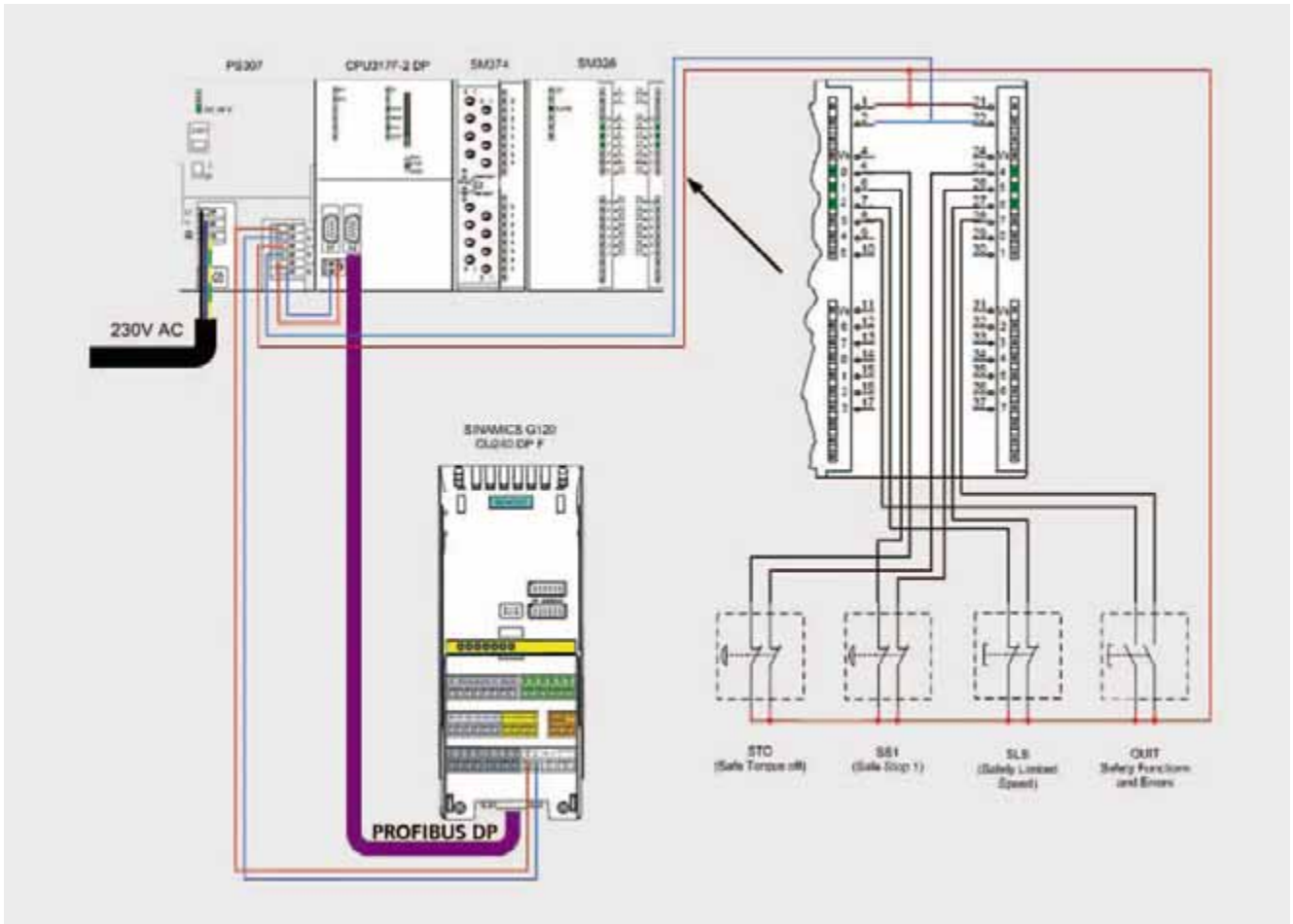
The SINAMICS G120 has hazardous voltages and controls rotating mechanical parts that can also be potentially hazardous. If the warning information is not observed or the information & instructions from the instructions belonging to SINAMICS G120 are not complied with this could result in death, severe bodily injury or significant material damage.

Overview of the hardware configuration



Connecting-up the hardware components

S7-300 control and CU240S DP F

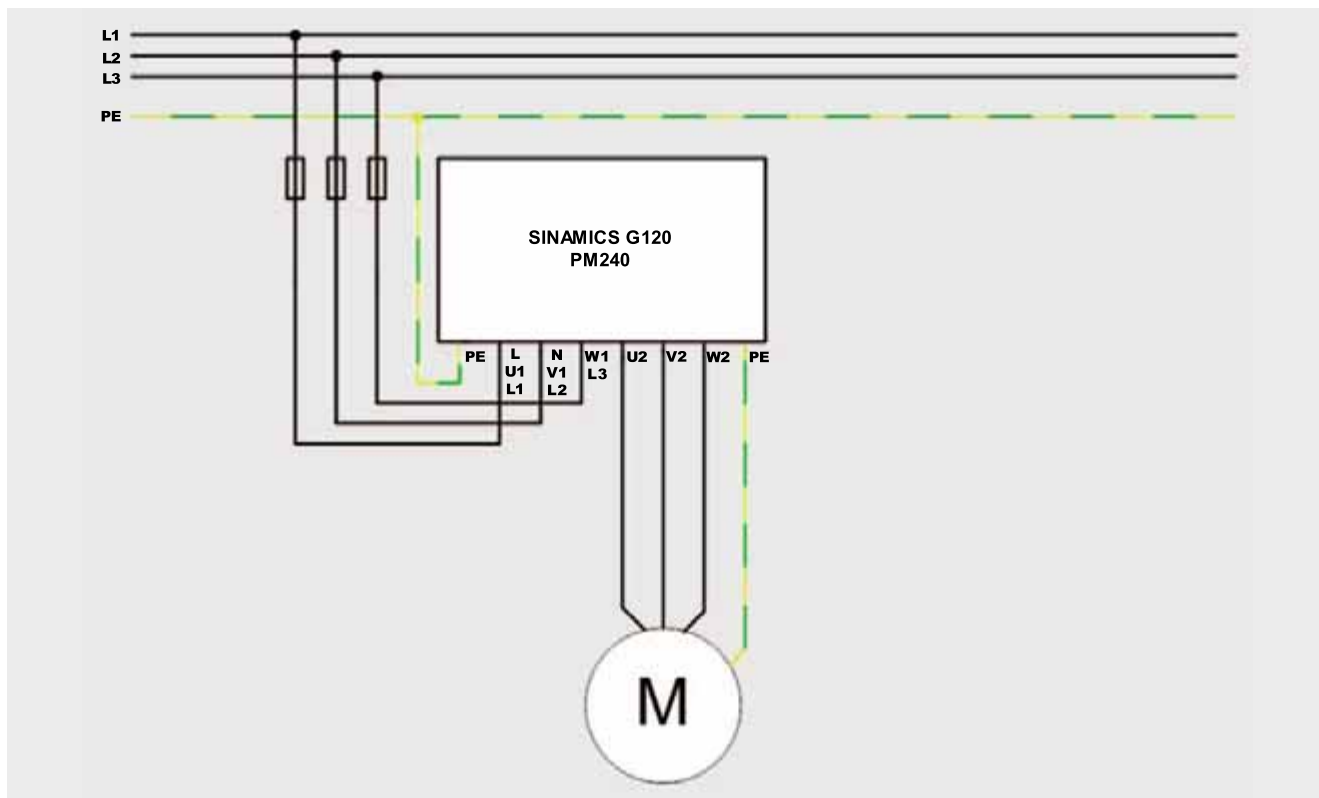


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PM240 and motor

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For more detailed information regarding the installation please refer to the SINAMICS G120 Hardware Installation Manual Power Module PM240

Fault 395 (acceptance test / acknowledgement present)

Fault F395 is output when powering-up for the first time and after replacing the Control Unit CU or the Power Module PM.

This fault does not represent an incorrect drive inverter function. The reason for this fault message is to monitor the individual drive inverter components (CU and PM) to prevent them from being replaced by unauthorized personnel.

Acknowledging fault F395

To acknowledge the F395 in conjunction with a CU240S DP F, proceed as follows:

- Set parameter p0010 to 30
- Enter the safety password (standard = 12345) into parameter p9761
- Set parameter p7844 to 0
- F395 will no longer be displayed
- For safety reasons you now have to run an acceptance test. For more information see the G120 Operation Instructions, Appendix, Acceptance Log.

For information:

For a CU without safety information it is sufficient to acknowledge fault F395 using "acknowledge fault" (SINAMICS G120 terminal strip or PROFIBUS).

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Important hardware component settings

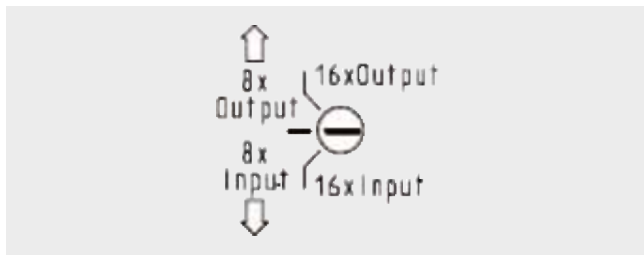
Most of the module/board settings are made in the HW Config in the software. Hardware settings are only required for the following modules/boards.

The modules/boards must be set with the control system in a no-voltage state.

SM374 simulation module

This module can be operated as 16 x DO (output via LED), 16 x DI (input via switch) or as combined 8 x DI / 8 x DO. The last combination is used in this function description. The function of the module is selected using a rotary switch behind the front cover between the series of switches.

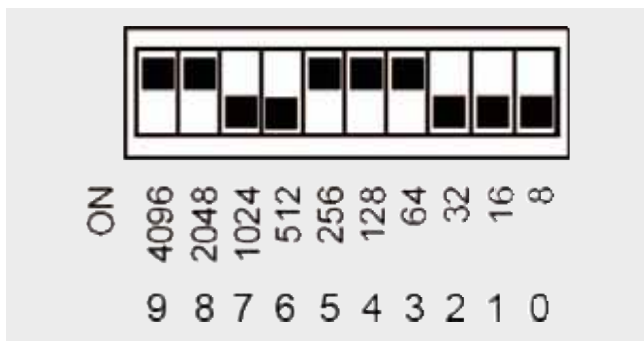
- As shown in the following diagram set the function switches to the setting 8 x Output 8 x Input.



Safety digital input module SM326

Before installation, the PROFIsafe address must be set at the rear of the module according to HW Config.

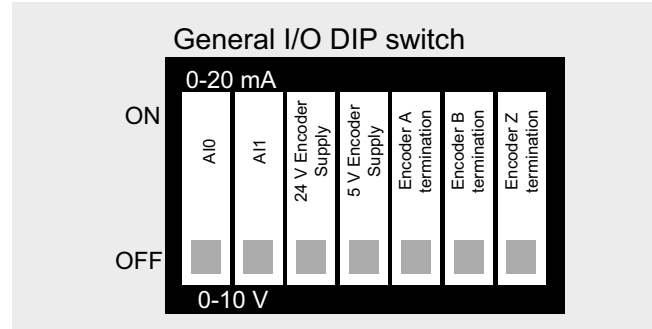
- Set the DIL switches as shown in the following diagram.



SINAMICS G120, CU240S DP F

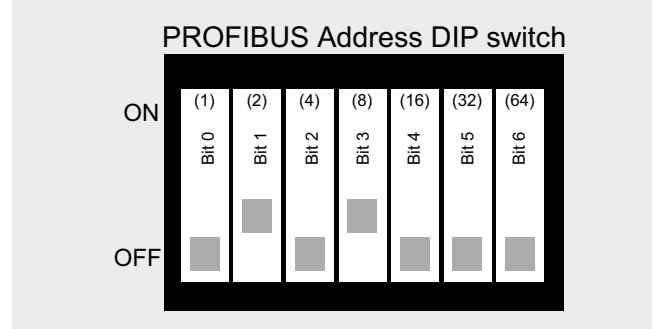
Two DIP switch blocks are located under the BOP (Operator Panel) in the upper section of the module.

The upper DIP switch block is for general CU functions - and is not relevant for this function example.



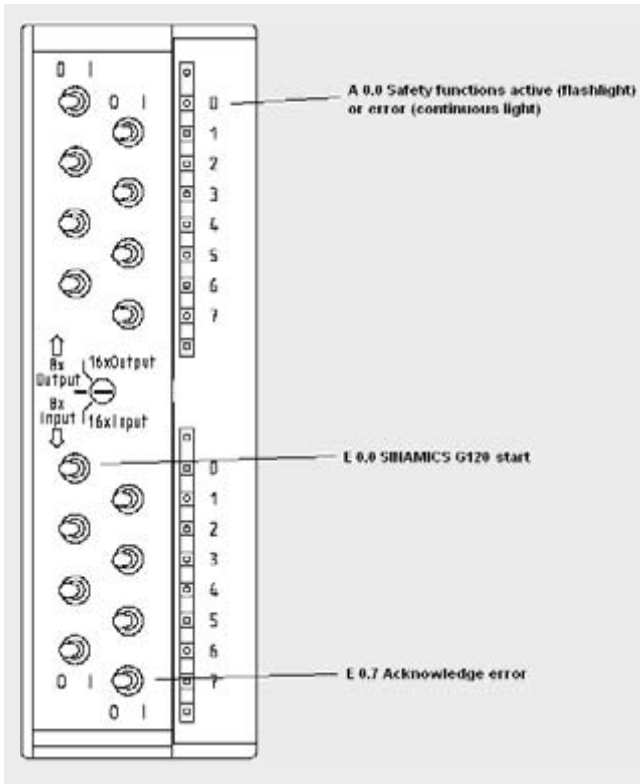
The Profibus address of the SINAMICS G120 can be set using the lower DIP switch block. Alternatively, the PROFIBUS address can also be set using parameter p918. It should be noted that the setting using DIP switches has priority over parameter p918.

- Set the DIP switches to address 10 as shown in the following diagram.



Overview of inputs and outputs

Simulation module SM374



Address	Function	Symbolic address	Default	Explanation
O 0.0	Indicator lamp Safety functions active or error	Safe_stop_or_error	0	Activated safety functions (flashing light) and faults (steady light) are signaled via this output.
I 0.0	SINAMICS G120 start	Start_G120	0	The motor connected to SINAMICS G120 is started by activating the input.
I 0.7	Acknowledge error	ACK_error	0	Fault messages that are present can be acknowledged using this input.

Overview of the pushbuttons that are connected:

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Address	Function	Symbolic address	Default	Explanation
I 24.0	STO pushbutton	Safety_PB_STO	1	The safety function STO (Safe Torque Off) is initiated using this pushbutton
I 24.1	SS1 pushbutton	Safety_PB_SS1	1	The safety function SS1 (Safe Stop 1) is initiated using this pushbutton
I 24.2	SLS pushbutton	Safety_PB_SLS	1	The safety function SLS (Safely Limited Speed) is initiated using this pushbutton
I 24.3	Pushbutton for safety functions and acknowledging faults	Safety_PB_ACK	0	The activated safety functions and fault messages that may be present are acknowledged

SINAMICS G120

The SINAMICS G120 is controlled and the feedback signals read-in via the I/O addresses listed below.

Address	Designation	Function
S7 program -> SINAMICS G120		
PQW256	STW1	Control word 1
PQW258	N_SOLL_A	Frequency setpoint
PQW260	M_LIM	Torque setpoint
PQW262	STW2	Control word 2
PQW264	- Reserve -	- Reserve -
PQW266	- Reserve -	- Reserve -
SINAMICS G120 -> S7 program		
PIW256	ZSW1	Status word 1
PIW258	N_IST_A_GLATT	Frequency actual value
PIW260	I_IST_GLATT	Current actual value
PIW262	ZSW2	Status word 2
PIW264	FAULT_CODE	Fault number
PIW266	WARN_CODE	Alarm number

For more detailed information about the configuration of the individual signals, please refer to SINAMICS G120 Operating Instructions Control Unit CU240S, Chapter Commissioning (software), Commissioning with PROFIBUS DP.

The safety functions of the SINAMICS G120 are controlled from the S7 safety program and the status of the safety functions of the SINAMICS G120 is signaled back to the S7 safety program using the following signals:

Address	Symbolic address	Function
S7 safety program -> SINAMICS G120		
O 14.0	Safety_S7->G120_STO	By switching out this signal, the STO function (Safe Torque Off) is activated in the SINAMICS G120
O 14.1	Safety_S7->G120_SS1	By switching out this signal, the SS1 function (Safe Stop 1) is activated in the SINAMICS G120
O 15.0	Safety_S7->G120_SLS	By switching out this signal, the SLS function (Safely Limited Speed) is activated in the SINAMICS G120
SINAMICS G120 -> S7 safety program		
I 14.0	Safety_G120->S7_STO	Feedback signal from SINAMICS G120 to the S7 safety program, STO (Safe Torque Off) was activated
I 14.1	Safety_G120->S7_SS1	Feedback signal from SINAMICS G120 to the S7 safety program, SS1 (Safe Stop 1) was activated
I 15.0	Safety_G120->S7_SLS	Feedback signal from SINAMICS G120 to the S7 safety program, SLS (Safely Limited Speed) was activated

Download

S7 program

To download the S7 program, you will require a connection between the MPI interface of your PG/PC and the MPI interface of the S7 CPU.

- Start the **SIMATIC Manager**.
- De-archive the function example supplied.
- Open the **Safety application G120** project.
- Open **HW-Config** and download this into the control. After the download re-close **HW-Config**.
- In the SIMATIC Manager, select **CPU 317F-2**.
- Open the **Safety Program** dialog box using **Options > Edit safety program**.
- Press the **Download** button and in the dialog window that is then displayed, press **Yes** to download the standard blocks.
- Enter **siemens** as password in the dialog window **Password for Safety Program**.
- After you have successfully downloaded the standard blocks you can re-close the **Safety Program** dialog box.


After the download, changeover the interface of your PC/PG to PROFIBUS and changeover the connecting cable to the PROFIBUS interface of the S7-CPU. You can access all of the devices of your configuration from this interface.

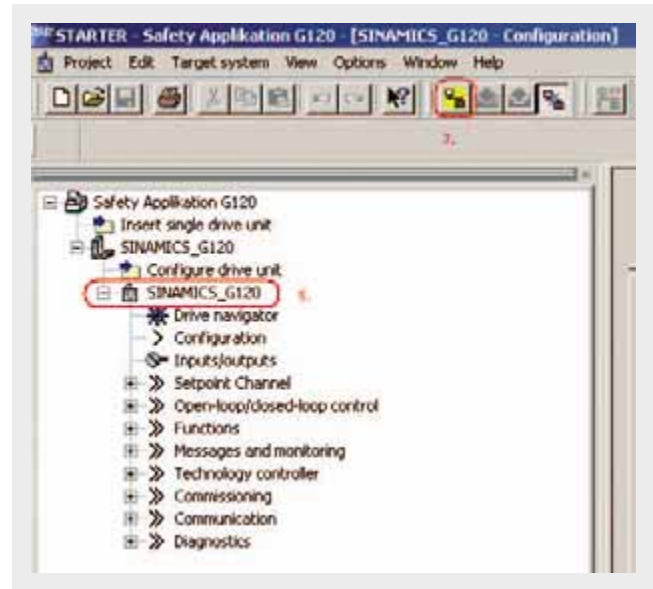
SINAMICS G120 configuration


When this has been completed, download the SINAMICS G120 configuration using the STARTER parameterizing tool.

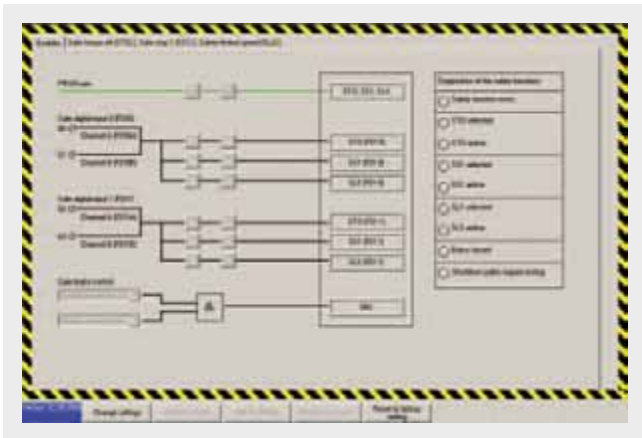
- Starting from the main path of the SIMATIC Manager, start the STARTER parameterizing software by double clicking on the **SINAMICS_G120** icon



- Then, in the Project Navigator of the STARTER parameterizing software select the object "**SINAMICS_G120**" (1.) and press the button  (2.) to establish the online connection to the drive inverter.

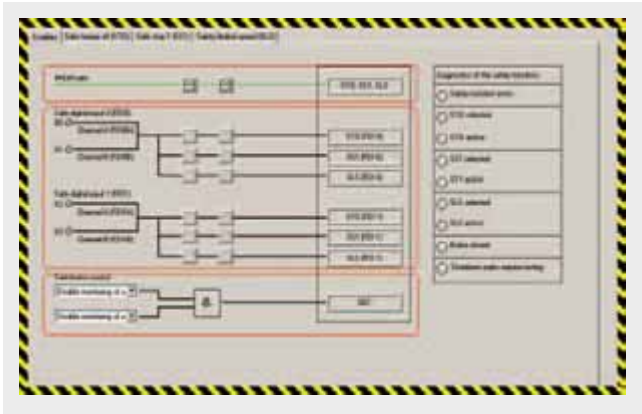


- After you have established the online connection, press the button  to download the SINAMICS G120 drive parameters.
- Follow the instructions on the screen and acknowledge the prompt "**After loading, copy RAM to ROM**".
- "You must then enter the safety parameters of the SINAMICS G120. These may not be - and cannot for safety reasons - be transferred into the drive inverter by downloading from the PG / PC.
- First, the PROFIsafe destination address must be entered into parameter p9810. To do this, in the Project Navigator, highlight the object "**SINAMICS_G120**" (1.) and after pressing the righthand mouse key, select the expert list using **Expert > Expert** list. Then, enter a value of 200 into parameter p9810.
- In the Project Navigator, select **Functions** and then open the dialog box for the safety functions by double clicking on **Safety Integrated**.



- Then press the button **Change settings** and enter **12345** (standard password) in the password screen that then opens.
- From the following screen forms transfer the appropriate values into your project. Take into consideration that in certain instances there are different value formats for processor 1 and 2 (e.g. s and ms, Hz and kHz).

"Enables" tab



In this screen form you parameterize the source from which you activate the SINAMICS G120 safety functions. Please note that the safety functions can either be controlled via **PROFIsafe** or via the **safety digital inputs**.

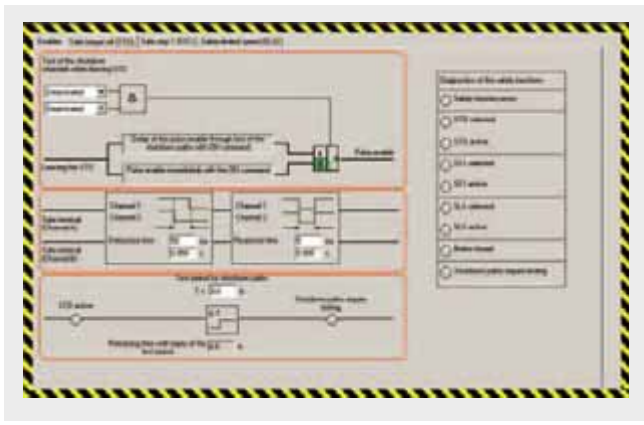
- Upper section:** Path to activate via PROFIsafe (this is used in this particular function example).
- Center section:** Path to activate via the **Safe digital input 0 and 1**.

- Lower section:** Here, the monitoring of the **Safe brake control** module can be activated; however, this is not used in this particular function example.

It should be noted that the parameterization is always carried out twice (in this screen form this can be identified as a result of the two switch symbols in series). The reason for this is that for the two processors in SINAMICS G120 - that operate in parallel and must provide the same result - there are separate parameter sets for safety reasons.

After you have parameterized the enable signals, then select the tab **Safe Torque Off**.

"Safe Torque Off (STO)" tab



The shutdown paths of a safety-relevant plant or system must be subject to a forced checking procedure at regular intervals. This is in order to identify "dormant" errors. SINAMICS G120 automatically carries out a forced checking procedure of the shutdown paths in the drive unit. This procedure is known as the forced checking procedure.

A reduced form of the forced checking procedure limited to self-test the brakes and processor is always automatically executed after "Safe Torque Off" (STO) is exited. This type of forced checking procedure is known as the process checking procedure.

Further, by appropriately parameterizing the system, it is possible to initiate a forced checking procedure each time that STO is exited.

- Upper section:** Using **Test of the shutdown channels when leaving STO**, you can select how the forced checking procedure for the shutdown channels is carried-out.
 - Activated:** A forced checking procedure is carried-out each time the drive unit is powered-up and when exiting "Safe Torque Off" (STO). Checking the shutdown chan-

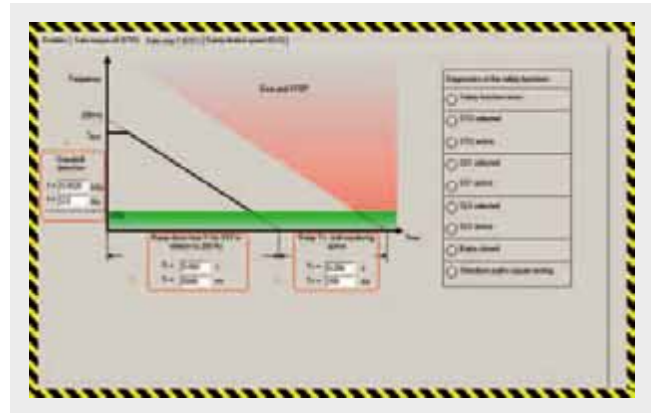
nels takes approximately 2.4s. This delay time must be taken into account at each On command.

- **Deactivated:** The shutdown channels are only checked after the function "Latched Safe Torque Off" (LSTO) when an error occurs. When exiting an STO, a delay time is not incurred as only the process checking procedure is carried-out.

- **Center section:** When activating the safety functions via the safe digital inputs of the SINAMICS G120, a **debounce time** and a filter for the **response time** can be set here. These settings are not relevant for the function example described here.
- **Lower section:** The SINAMICS G120 automatically monitors when a forced checking procedure was carried-out the last time. Set the time up to the next forced checking procedure in the field **Test periods for shutdown paths**. The time can be selected between 0.1 and 8760 hours (6 min up to 1 year). The timer is re-started after each forced checking procedure. Alarm A1699 is output in operation to flag you that this monitoring time has expired. A process checking procedure does not replace forced checking procedure and therefore does not reset the timer.

After you have parameterized the **Safe Torque Off** function, select the tab **Safe Stop 1**.

Safe Stop 1 (SS1) tab



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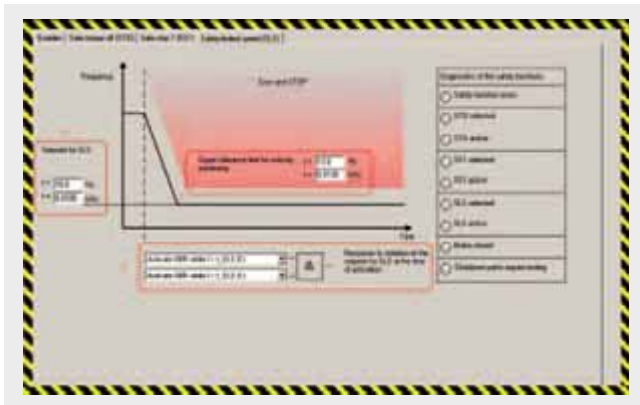
The parameters relevant for "Safe Stop 1" (SS1) are set in this screen form.

- (1.) Using the threshold value **Standstill detection**, define the speed at which standstill (zero speed) is detected and "Safe Torque Off" (STO) is activated. Please note that the value should be entered once in kHz and once in Hz.
- (2.) The **Ramp-down time Tr for SS1 ...** should then be entered. Please note that the value is entered once in s and once in ms. The ramp-down time Tr always refers to the safety reference frequency of 200Hz in the drive itself. This ramp-down time is also used for the deceleration for "Safely Limited Speed" (SLS).
- (3.) The monitoring tolerance is set using **Delay Tv, until monitoring active**. The drive inverter continually monitors - with tolerance Tv - the braking of the drive. If the tolerance is selected too low, then the monitoring function could be incorrectly tripped. If the tolerance is too high, then if an actual fault does develop, an unnecessarily long time is wasted. Please note that the value is entered once in s and once in ms.

After you have parameterized the function **Safe Stop 1**, select the tab **Safely Limited Speed**.

Safely Limited Speed (SLS) tab

Ex. No.
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The parameters relevant for "Safely Limited Speed" are entered in this screen form.

- (1.) The SLS mode is defined here. The following three modes - with the appropriate properties - are available:

SLS mode	Properties
Mode 0	<p>Limiting to a safely limited speed</p> <p>If, when SLS is activated, the actual frequency is greater than the Upper tolerance limit for velocity monitoring, SS1 is activated and then LSTO (safe torque shutdown with latching).</p> <p>If, when SLS is activated, the actual frequency lies between the Upper tolerance limit for velocity monitoring and the Setpoint for SLS, then the Setpoint for SLS is activated. The frequency cannot be changed.</p> <p>If the actual frequency lies below the Setpoint for SLS, the actual frequency is kept. The frequency cannot be changed.</p> <p>STO is activated if the actual frequency falls below 1Hz.</p> <p>The drive can be stopped using OFF2, withdrawing/cancelling the function or by activating another safety function.</p>
Mode 1	<p>Reducing to a safely limited speed</p> <p>If, when activating SLS, the actual frequency is greater than the Upper tolerance limit for velocity monitoring, the Setpoint for SLS is activated and the drive is braked down to this setpoint using the safe braking ramp.</p> <p>If the actual frequency lies below the Setpoint for SLS, the actual frequency is kept. The frequency cannot be changed.</p> <p>STO is activated if the actual frequency drops below 1Hz.</p> <p>The drive can be stopped using OFF2, withdrawing the function or by activating another safety function.</p>



SLS mode	Properties
Mode 2	<p>Limiting to a safely limited speed - the speed can be changed</p> <p>If, when activating SLS, the actual frequency is greater than the Upper tolerance limit for velocity monitoring, LSTO (safe torque shutdown with latching) is activated.</p> <p>If, when activating SLS, the actual frequency lies below the Upper tolerance limit for velocity monitoring, the frequency is kept. The frequency can be changed between 1 Hz and the Upper tolerance limit for velocity monitoring (Caution: For V/f, take into account the slip compensation).</p> <p>If the actual frequency drops below 1Hz or the Upper tolerance limit for velocity monitoring is reached, STO is activated. If the upper tolerance limit for velocity monitoring is exceeded, then STO is latched - i.e. LSTO.</p> <p>The drive can be stopped with ON/OFF1 and the remaining OFF commands - but it can only be re-started if SLS has been withdrawn.</p>

Please refer to the Operating Instructions CU240S, Chapter *Functions* under *Fail-safe Functions* for more detailed information about the SLS modes.

- (2.) These input fields are displayed for SLS mode (1.) 0 and 1. **Set-point for SLS** is used to set the frequency to which the frequency set-point is internally limited in the drive unit after the function Safely Limited Speed SLS has been selected. Please note that the value is entered once in Hz and once in kHz.
- (3.) The monitoring limit is set using the **Upper tolerance limit for velocity monitoring**. If Safely Limited Speed SLS is active and the actual speed exceeds this value, then SINAMICS G120 outputs a fault message and goes into the safe condition (Safe Torque Off, STO). Please note that the value should be entered once in Hz and once in kHz.
- After you have made all of the settings press the **Accept settings** button.
- You can now change the standard password. If you are still not certain that your safety parameterization has been completed, then you should press the **Later** button. However, after you have completed the commissioning phase, do not forget to change the standard password for a password that only you know or a person that you trust. Only then can you be sure that only authorized persons can change/modify safety parameters.
- To complete the parameterization of the safety functions you must now acknowledge the checksums of the two processors. To do this, transfer the first checksum, processor 1 into the set checksum, processor 1. Do exactly the same for the checksum of processor 2.

Please note that the two actual checksums and therefore the two set checksums must be the same. If this is not the case, then you must re-check your parameterization of the safety functions and resolve the different values.



- If you don't wish to set any additional parameters, then you can now exit the STARTER commissioning tool.
- To do this first disconnect the PG/PC from SINAMICS G120 by pressing the  button.
- You can then exit STARTER using **Project > Close** or by pressing the  button.
- You'll now be prompted to save changes - acknowledge this with **Yes**.

Function test

The function test can be carried-out, if

- The hardware components are connected-up
- The hardware settings have been made
- The S7 project is in the CPU
- The configured software has been downloaded into the SINAMICS G120 and the safety functions have been parameterized
- The CPU is in the RUN state.

No.	Action	Response
1	If it is pressed, re-lease the Emergency Stop pushbutton	
2	Press the pushbutton "Acknowledge safety functions and faults"	The signal lamp (A0.0) for "Safety functions activated or fault" goes dark. At SINAMICS G120 LEDs RDY , STO , SS1 and SLS are bright -> the drive and all of the safety functions are in the ready state.
3	Press the switch "SINAMICS G120 Start"	The motor starts to run.
Safety function STO (Safe Torque Off)		
1	Press the Emergency Stop pushbutton STO	The motor coasts down and is not braked. The signal lamp (A0.0) for "Safety functions activated or fault" starts to flash. At the SINAMICS G120 the LED ES is bright and LED STO flashes -> STO is active, the motor is brought into a no-torque condition. At the SINAMICS G120 the alarm A1696 is displayed -> this alarm is displayed as long as the start signal is still present.
2	De-activate the control of the SINAMICS G120 using the switch "SINAMICS G120 Start".	At the SINAMICS G120 the alarm A1696 is no longer displayed.

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No.	Action	Response
3	Release the Emergency Stop pushbutton STO and press the pushbutton "Acknowledge safety functions and faults"	The signal lamp (A0.0) for "Safety functions activated and fault" goes dark. At the SINAMICS G120, the LEDs RDY, STO, SS1 and SLS are bright -> the drive and all safety functions are in the ready state.
4	Press the switch "SINAMICS G120 Start"	The motor starts to operate again.
Safety function SS1 (Safe Stop 1)		
1	Press the Emergency Stop pushbutton SS1	The motor follows the parameterized braking ramp down to the minimum frequency and stops. The signal lamp (A0.0) for "Safety functions activated and fault" starts to flash. At the SINAMICS G120 the LED ES is bright and LED SS1 flashes -> SS1 is active, the motor has been brought into a no-torque condition. At the SINAMICS G120 alarm A1696 is displayed -> this alarm is displayed as long as the start signal is present.
2	De-activate the control of the SINAMICS G120 using the switch "SINAMICS G120 Start" .	The alarm A1696 is no longer displayed at the SINAMICS G120.
3	Release the Emergency Stop pushbutton SS1 and press the pushbutton "Acknowledge safety functions and faults"	The signal lamp (A0.0) for "Safety functions activated or fault" goes dark. At the SINAMICS G120 the LEDs RDY, STO, SS1 and SLS are bright -> the drive and all of the safety functions are in the ready state.
4	Press the switch "SINAMICS G120 Start"	The motor starts to operate again.

No.	Action	Response
Safety function SLS (Safely Limited Speed)		
1	Press the pushbutton SLS and keep it pressed	The motor follows the parameterized braking ramp down to the safely limited speed. The signal lamp (A0.0) for "Safety functions activated and fault" is not bright (is dark). At the SINAMICS G120 the LED ES is bright and LED SLS flashes -> SLS is active, the motor is monitored to ensure that it does not exceed the safely limited speed.
2	Release pushbutton SLS again	The motor accelerates back to the normal speed. At the SINAMICS G120 LEDs RDY, STO, SS1 and SLS are bright -> the drive and all safety functions are in the ready state.

Acceptance test and acceptance report

An acceptance test must be carried-out when the machine is commissioned for the first time and also if a completely saved set of the safety-relevant parameters is changed. This procedure is used to verify the safety-relevant parameters. This acceptance test must be appropriately documented. The acceptance reports must be appropriately stored and archived.

The checksum ensures that all subsequently made changes are identified.

Information about the acceptance test and the acceptance report are provided in **SINAMICS G120 Operating Instructions Control Units CU240S** in the Chapter **Commissioning (software)**.

An example of an acceptance report is provided in the **SINAMICS G120 Operating Instructions Control Units CU240S** in the **Appendix**.

Key performance data

Load memory and working memory

	Total
Load memory	approx. 54 k
Working memory	approx. 39 k

Cycle time

Total cycle time (typical)	approx. 3ms	Standard and safety program
----------------------------	-------------	-----------------------------

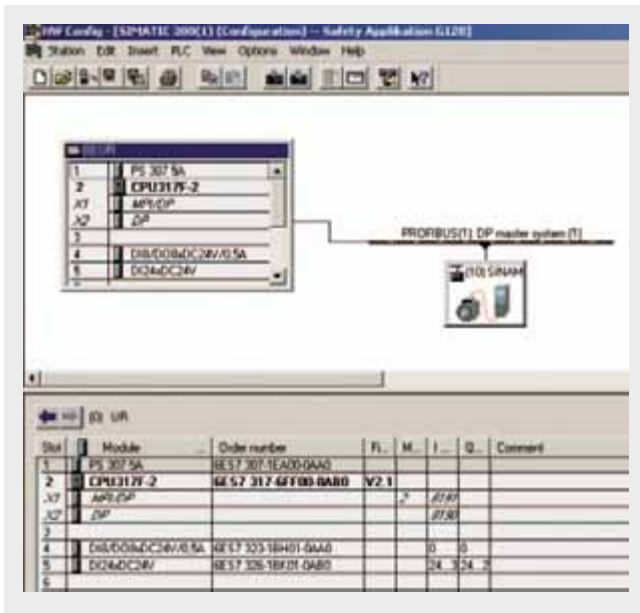
Example code

The example code supplied is fully functional for the described application. The individual functions of the example code are explained in the following Chapters so that you are in a position to implement your own projects.

Note

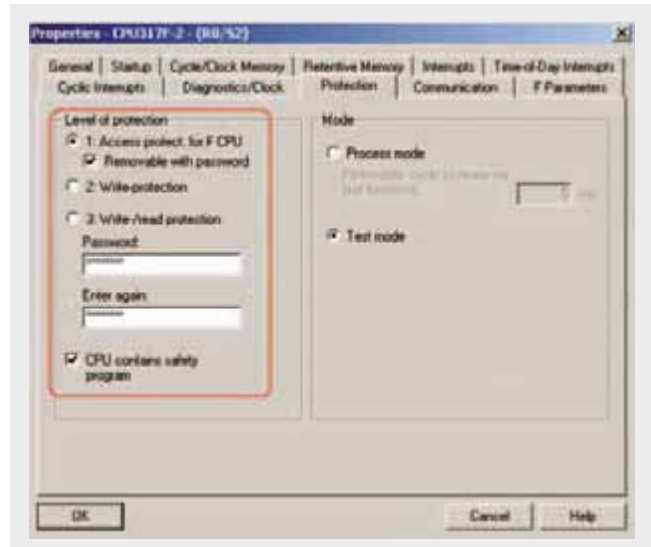
In this example code, passwords are used for the safety functions. These are as follows:
 S7 safety program and HW Config: **siemens**
 STARTER Safety Screens: **12345**

Settings in the hardware configuration



Properties of the CPU

Before the safety functions of the CPU can be used, they must be released. The properties window of the CPU is opened by double clicking on the CPU317F-2.



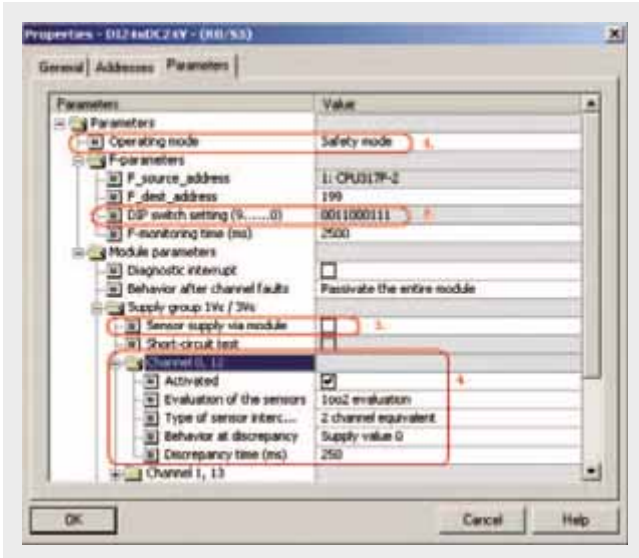
Under the **Protection** tab, the safety functions of the CPU are enabled by selecting the following functions:

- **Level of protection; 1: Access protect for F CPU,**
- **Activate Removable with password,**
- **Enter a password (in this example code, siemens),**
- **Activate CPU contains safety program.**

Properties of the F-DI module

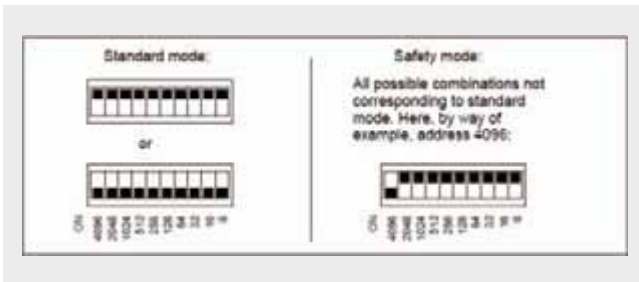
The signal sources for the safety functions (pushbuttons to acknowledge STO, SS1, SLS and Emergency Stop) are read-in using the fail-safe module DI24xDC24V (6ES7326-1BK01-0A0). The Properties dialog box opens after double clicking on the module. The properties of the module can be parameterized by selecting the **Parameters** tab.

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- (1.) Also for this module, safety-relevant operation must be enabled by selecting **Safety mode** as the operating mode.
- (2.) The binary code that is specified under **DIL switch setting (9.....0)** must be set at the rear of the module.

DIL switch on the module:

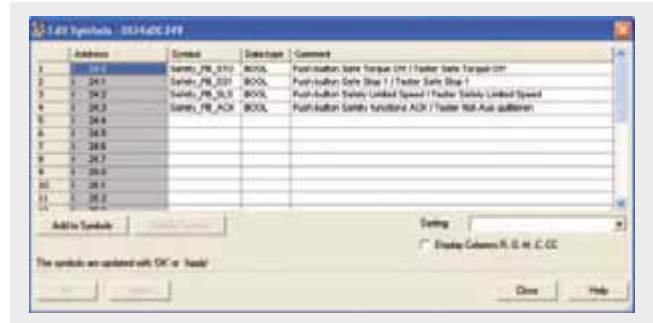


- (3.) The short-circuit and cross-circuit fault monitoring of the channel group is activated by selecting the function **Sensor supply via module**.
- (4.) The properties of the individual channels of the module are parameterized as shown under channel 0, 12.

For more detailed information please refer to the *Manual SIMATIC Automation System S7-300 Fail-Safe Signal Modules*.

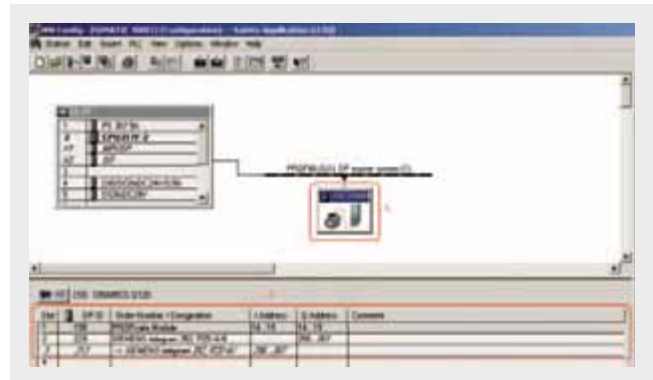
- "In order that the SINAMICS G120 safety functions can be used in the safety program, symbolic addresses must be assigned to the inputs of the safety input module. The input window for the symbolic addresses is opened by

selecting the module, pressing the righthand mouse key and selecting **Edit Symbols...**




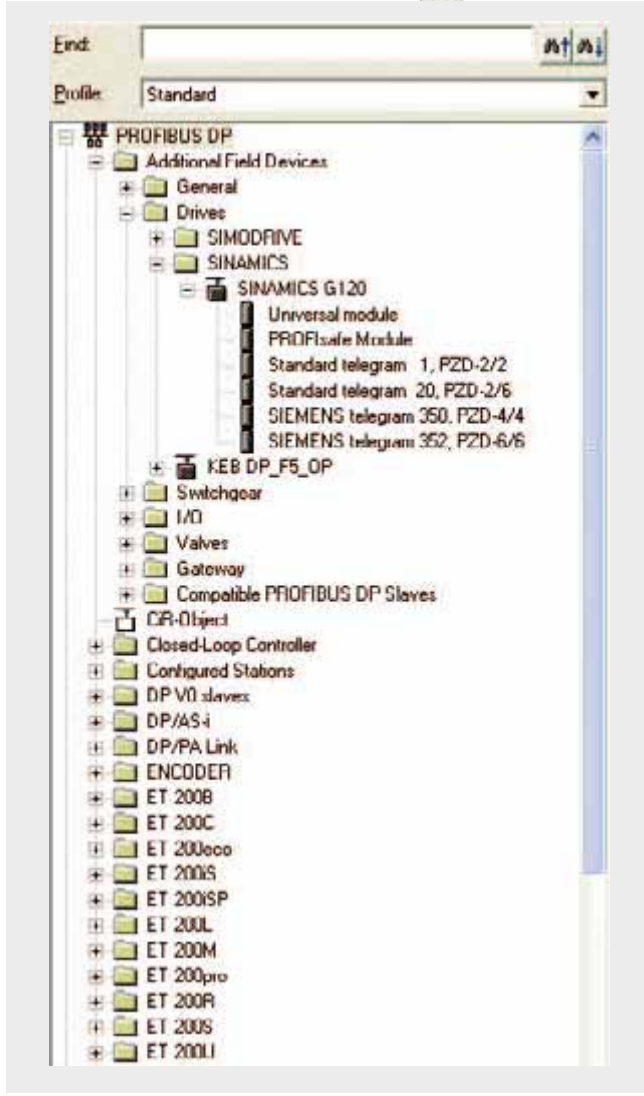
Properties of the SINAMICS G120

The window of the SINAMICS G120 PROFIBUS properties (2) is displayed by clicking once on the SINAMICS G120 icon (1).



The PROFIBUS telegram (2.) between the CPU and the SINAMICS G120 comprises two components. On one hand the **PROFisafe module** for the safety functions - that must be first entered - and the **Siemens telegram** to control the SINAMICS G120 (control signals, status word, frequency set-point, frequency actual value etc.).

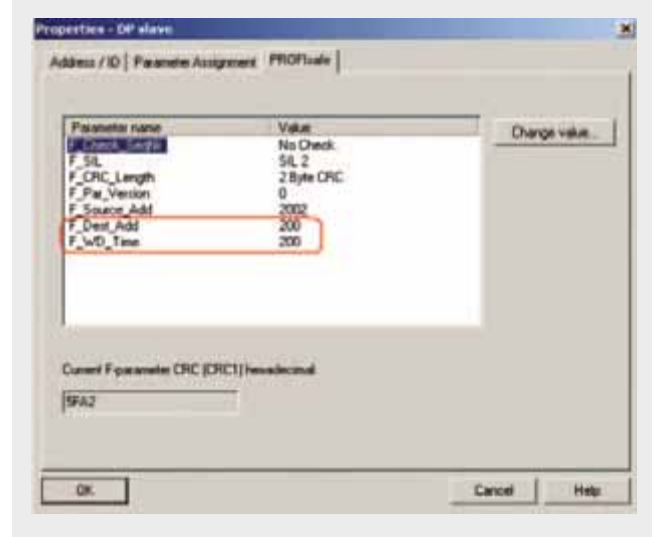
The individual telegram components are selected in the Catalog after pressing the following button 



PROFIsafe module

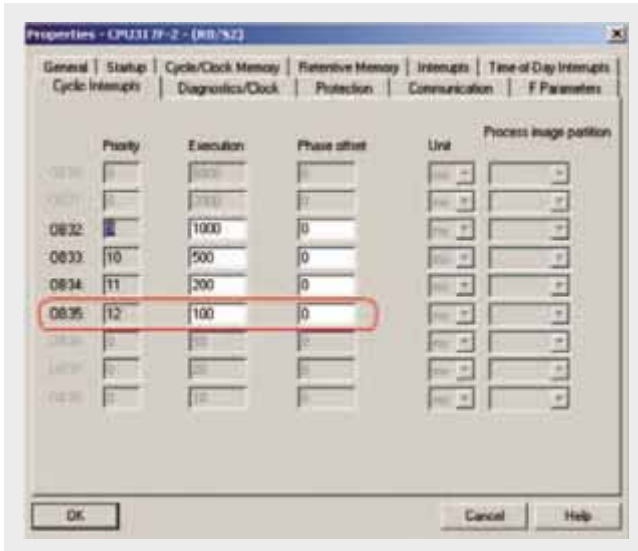
PROFIBUS communications of the SINAMICS G120 safety functions are realized using the **PROFIsafe module**.

The Properties window of the module is opened by double clicking on the **PROFIsafe module**. Open the **PROFIsafe** tab.



- The value of **F_Dest_Add** specified by HW Config (PROFIsafe address of the SINAMICS G120) must be entered into SINAMICS G120 parameter p9810.
- For **F_WD_Time** (PROFIsafe Watchdog Time) twice the value of the call environment cycle of the S7 safety program must be entered. In this particular function example the S7 safety program is called every 100 ms in OB35 (refer to **HW Config, Properties CPU, Cyclic Interrupts**).

For more detailed information about the different telegram types please refer to *SINAMICS G120 Operating Instructions Control Units CU240S* in the Chapter *Commissioning (software), Commissioning with PROFIBUS DP*.



■ This means that a value of 200 must be entered for F_WD_Time.

Siemens telegram 352, PZD 6/6

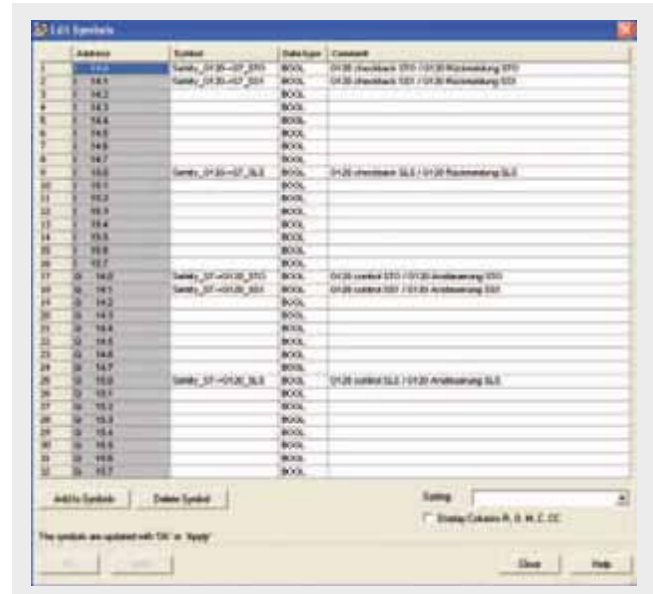
The standard control (control word, frequency setpoint etc.) of SINAMICS G120 is implemented using the Siemens telegram.

In SINAMICS G120, instead of telegram 352 (fixed assignment of the control/feedback signal words), telegram 999 is used (free assignment of the control/feedback signal words).

In this case, in SINAMICS G120, to start, telegram type 350 should be selected in parameter p922. This pre-assigns the BICO connections. Telegram type 999 (free interconnection via BICO) should then be selected and the following interconnections made:

- p2051[4] = r2131 (error number)
- p2051[5] = r2110 (alarm number)

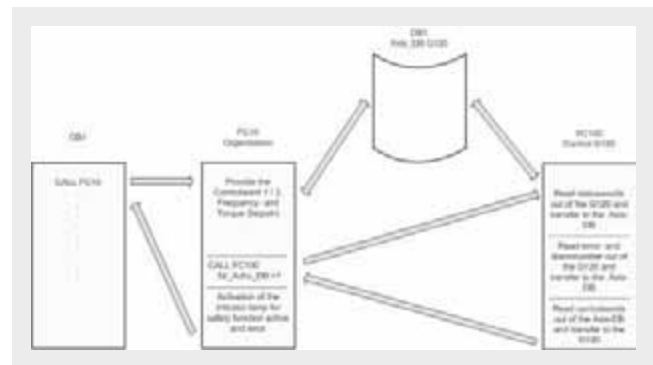
In order that SINAMICS G120 can use the safety functions in the safety program, symbolic addresses must be assigned for the inputs and outputs of the **PROFIsafe module**. The input window for the symbolic addresses is opened by selecting the PROFIsafe module, pressing the righthand mouse key and selecting **Edit symbols...**



Only the inputs and outputs listed in this example are relevant for communications.

Functions of the STEP 7 program (without safety program)

Program overview



The STEP 7 program essentially comprises blocks FC10, FC100 and DB1 that are called in the cyclic program (OB1).

DB1, axis_DB

The axis_DB represents the interface between the S7 program and the SINAMICS G120 via FC100.

Axis_DB is generated from **UDT 1 (Axis_DB_G120)**

Principal structure of axis_DB

Address	Symbolic name	Type	Function
Internal data			
DBW0	Basic_Data.Moduleaddress	INT	I/O start address of the SINAMICS G120 (refer to HW Config)
DBB3	Basic_Data.Drivetyp	Byte	Drive type, must be 2
S7 -> SINAMICS G120			
DBW4	Control_signals.STW2	Bool	Control word 2 (for details, refer to the S7 program)
DBW6	Control_signals.STW1	Bool	Control word 1 (for details, refer to the S7 program)
DBW8	Control_signals.Frequency_set	INT	Frequency setpoint in x.x %
DBW10	Control_signals.Torque_set	INT	Torque setpoint in x.x %
SINAMICS G120 -> S7			
DBW14	Status_signals.ZSW2	Bool	Status word 2 (for details, refer to the S7 program)
DBW16	Status_signals.ZSW1	Bool	Status word 1 (for details, refer to the S7 program)
DBW18	Status_signals.Actual_frequency	INT	Frequency actual value in x.x %
DBW20	Status_signals.Actual_current	INT	Current actual value in x.xx A
Fehlermeldungen			
DBW24	Faults.Drive_error_number	INT	Actual error number of the SINAMICS G120
DBW26	Faults.Drive_alarm_number	INT	Actual alarm number of the SINAMICS G120

In this function example the individual data of the DB1 are supplied in FC10.

FC10, organization

This block is called-up in absolute terms in OB1 and in turn calls up FC100.

Principle of the FC10

Network	Function
1	Controls the SINAMICS G120 via the axis-DB, DB1. Calls the SINAMICS G120 control block FC100. This network can be used as template for additional SINAMICS G120 control functions.
2	Controls the signal lamp for "Safety function activated or fault".

FC100, control of SINAMICS G120

SINAMICS G120 is controlled using the FC100 via PROFIBUS.

Only signals from the axis_DB are used to control the block - but no fixed addresses - this is the reason that instances can be used.

This block can be used in the same way for both a standard and a Safety SINAMICS G120.

Formal operands of the FC100

Formal operands	Type	Description
Nr_Achs_DB	IN	Number of the axis-DB generated using UDT1
Internal_Error	OUT	Displays an internal error 0 = no error 1 = incorrect axis-DB type

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Principle structure of the FC100

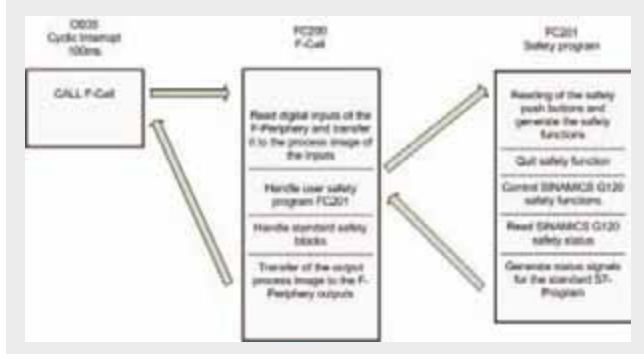
Network	Function
1	Opens the axis_DB specified using the formal operands Nr_Axis_DB . Generates the internal error message.
2	Reads-in the SINAMICS G120 status words, processes these and saves them in the axis_DB.
3	Resets internal error messages.
4	Converts frequency and torque setpoint from the axis_DB (entered in x.x %) into the SINAMICS G120 format (hex).
5	Enters SINAMICS G120 error and alarm number into the axis_DB.
6	Sends control words from the axis_DB to the SINAMICS G120

Functions of the STEP 7 safety program

The basic programming of Distributed Safety - the S7 programming tool for F control systems - is not discussed in this function example.

This function example only explains and discusses the FC201 user block for safety functions.

Program overview



FC201, safety program

The individual safety sensors are read into the FC201, interlocked with one another (logically combined) and the SINAMICS G120 safety functions controlled.

It is necessary to enter the safety password to process/handle the FC201. This password is **siemens**.

Principle structure of the FC201

Network	Function
1	Safe Torque Off (STO) Reads-in the Emergency Stop pushbutton Safety_PB_STO (I 24.0), logically interlocked using the F-Standard block FB215 (F_ESTOP1) and forms auxiliary lag No_STO . Acknowledges the safety function using the acknowledge button Safety_PB_ACK
2	Safe Stop 1 (SS1) Reads-in the Emergency Stop pushbutton Safety_PB_SS1 (I 24.1), logically interlocked using the F-Standard block FB215 (F_ESTOP1) and forms auxiliary flag No_SS1 Acknowledges the safety function using the acknowledge button Safety_PB_ACK
3	Controls the SINAMICS G120 safety function STO (O 14.0).
4	Controls the SINAMICS G120 safety function SS1 (O 14.1).
5	Controls the SINAMICS G120 safety function SLS (O 15.0).
6	De-passivates the safety modules.
7	Acknowledges safety communication errors between the S7-CPU and the SINAMICS G120 using the acknowledge button Safety_PB_ACK
8	Acknowledges safety communication errors between the S7-CPU and the safety digital input module SM326 via the standard input ACK_error (I 0.7).
9	Emergency Stop ok -> standard program.
10	Signal "Emergency Stop acknowledge" -> standard program.
11	Feedback signal STO from SINAMICS G120 -> standard program.
12	Feedback signal SS1 from SINAMICS G120 -> standard program.
13	Feedback signal SLS from SINAMICS G120 -> standard program.

SINAMICS G120 - parameterizing the safety functions

Refer to page 485: „SINAMICS G120 parameterization“


SINAMICS G120 parameterization

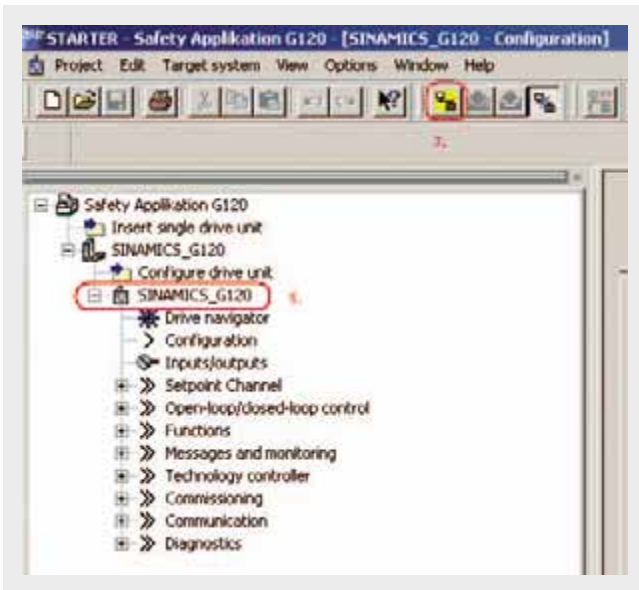
In order that the basic SINAMICS G120 functions can be parameterized, the safety functions in the S7-CPU and in the drive inverter itself must already have been commissioned.


The reason for this is that during parameterization a motor identification routine is carried-out (the motor and cables are measured) - and if vector control is activated - the controller is optimized. Both of these functions require that the safety functions are in the ready state.

- Starting from the main path of the SIMATIC Manager, start the STARTER parameterizing software by double clicking on the **SINAMICS_G120** icon

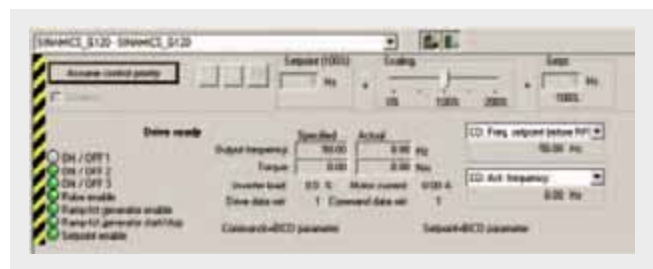


- "Then, in the Project Navigator of the STARTER parameterizing software select the object **"SINAMICS_G120"** (1.) and press button  (2.) to establish an online connection to the drive inverter.

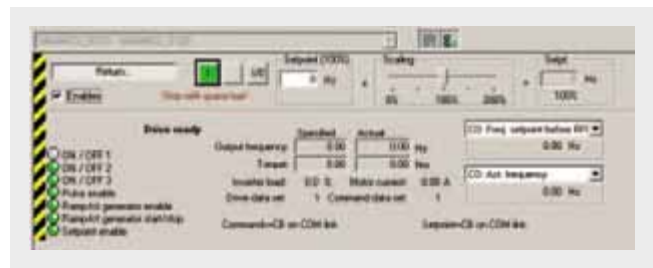





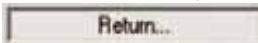
- The screen form with the actual configuration is opened by double clicking on **Configuration** in the Project Navigator.
- "The quick commissioning Wizard is started after pressing the  button.

- Enter the appropriate values into all of the screen forms.
- In the screen form **Drive functions**, select for **Motor identification**, the function **Ident. of al param. in standstill incl. the saturation curve (3)**.
- In the screen form **Calculation of the motor data**, select **Restore factory setting and calculate motor data**.
- In the screen form **Summary** do not activate the function **RAM -> ROM**, but instead press the **Finish** button.
- After completing the quick commissioning, alarm **A0541** (Motor data-identification active) is displayed. Please carefully note that when starting the motor identification routine current flows in the motor. For hanging (suspended) axes the load must always be supported.
- To start the motor data identification routine, in the Project Navigator select the menu item **Commissioning** and activate by double clicking on **Control panel**.



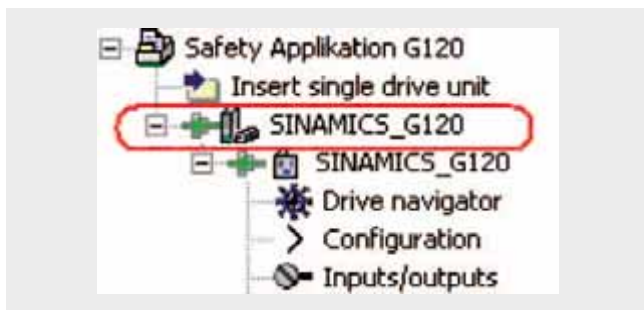
- Press **Assume control priority** and carefully note the security/safety information and instructions. Then activate **Enables**.




- The motor data identification routine is started by pressing the  button. Do not exit the STARTER software and go to another task as otherwise the motor data identification routine will be interrupted for safety reasons.
- Please wait until the  button changes back to the  button.
- Return the control priority to the S7 control by pressing the  button.

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- Finally, you only have to save the SINAMICS G120 configured software in the ROM memory of the drive inverter. To do this in the Project Navigator select the menu item **SINAMICS_G120**.



- In the function bar press the  button.
- Please wait until the download operation has been completed.

SINAMICS G120 - controlled via PROFIBUS safety functions via terminals, Category 3 (EN 954-1) or SIL 2 (IEC 61508)

Automation function

Description of the functionality

The SINAMICS G120 drive inverter is a modular drive inverter system that essentially comprises the two function units Control Unit (CU) and Power Module (PM).

When using the Control Unit CU240S DP F, you have access to the following safety functions that are integrated in the drive inverter:

Designation	Function	Description
STO	Safe Torque Off (acc. to EN 60204)	Prevents the drive from accidentally starting
		The drive is safely brought into a no-torque condition
		Preventing a restart does not require electrical isolation between the motor and drive inverter
SS1	Safe Stop 1 (acc. to EN 60204)	The drive is quickly stopped and safely monitored
		Independent and continuous monitoring guarantees the shortest response times when a fault occurs
		A speed encoder is not required
SLS	Safety Limited Speed (acc. to EN 60204)	The drive speed is limited and monitored
		Independent and continuous monitoring guarantees the shortest response times when a fault occurs
		A speed encoder is not required
SBC	Safe Brake Control	An external brake is safely controlled
		In this case, it is necessary to use the Safe Brake Relay

(all safety functions are certified according to EN 954-1, Cat. 3 and IEC 61508, SIL 2)

The safety functions are either controlled through two fail-safe digital inputs (4 digital inputs, which are evaluated through 2 channels in a fail-safe fashion in the CU 240S DP F) or via PROFIsafe in conjunction with a fail-safe CPU.

Functionality of the function example

Task description

The SINAMICS G120 is to be controlled from an S7-300 CPU via PROFIBUS.

The integrated safety functions of the SINAMICS G120 are to be controlled via the fail-safe digital inputs of the SINAMICS G120.

Solution

In this function example, the control of a SINAMICS G120 (control word and frequency setpoint) will be demonstrated using an S7-300 CPU and a specific program example.

This program example comprises an S7 program to control the SINAMICS G120 and the appropriate configuration in the SINAMICS G120.

Advantages / customer benefits

The safety functions are integrated in the drive inverter and are implemented without any speed feedback signal. This means that to some extent complex external shutdown and monitoring devices can be eliminated.

A SINAMICS G120 with Safety Control Unit can replace an existing drive inverter. This means that safety functions can be added to an existing system with low associated costs and expenditure.

Ex. No.

5.2

Restrictions

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Caution

Please take careful note that the two safety functions SLS and SS1 may not be used for loads that can drive the motor or loads that are continually in the regenerative mode.

Elevating platforms, winders, wind turbines are examples of such loads that can drive motor or continually regenerate in to the line supply.

An important prerequisite when using fail-safe functions is that the closed-loop control functions absolutely perfectly. The drive (system comprising the drive inverter + motor + driven load) must be engineered so that all operating situations of the particular application are always completely under control.

Caution

After the STO and SS1 safety functions have been activated there is no electrical isolation between the line power supply of the SINAMICS G120 and the motor. If this electrical isolation is required in your particular application, then you must install an appropriate line contactor upstream of the SINAMICS G120.

Required components

An overview of the hardware and software components required for the function example is provided here.

Hardware components

Component	Type	Order No	Qty	Manufacturer
S7 control				
Power supply	PS307 5A	6ES7307-1EA00-0AA0	1	Siemens AG
S7 CPU	CPU 315-2DP	6ES7315-2AG10-0AB0	1	
Memory Card	MMC 2MB	6ES7953-8LL11-0AA0	1	
DI / DO simulation module	SM374	6ES7374-2XH01-0AA0	1	
Profile rail	Profile rail	6ES7390-1AE80-0AA0	1	
PROFIBUS connector	PROFIBUS connector	6ES7972-0BB50-0XA0	1	
PROFIBUS cable	PROFIBUS cable	6XV1830-3BH10	2 m	
Drive				
SINAMICS G120 Control Unit*	CU240S DP F	6SL3244-0BA21-1PA0	1	Siemens AG
SINAMICS G120 Power Module*	PM240	6SL3224-0BE21-5UA0	1	
Basic Operator Panel*	BOP	6SL3255-0AA00-4BA1	1	
Motor*	Three-phase induction motor	1LA7060-4AB10	1	
PROFIBUS connector	PROFIBUS connector	6GK1500-0FC00	1	
Command devices				
Empty enclosure*	Empty enclosure with 2 command sources (e.g. pushbuttons)	3SB3802-0AA3	1	Siemens AG
Emergency Stop mushroom pushbutton (to activate SS1)*	Emergency Stop mushroom pushbutton	3SB3000-1HA20	1	
Mushroom pushbutton (to activate SLS)*	Mushroom pushbutton, red	3SB3000-1DA21	1	
Contact	1NC, screw terminal	3SB3420-0C	4	

As an alternative to the components marked with *, the SINAMICS G120 training case can also be used that is additionally equipped with a 24V HTL encoder and a mechanical brake. This training case can be ordered by specifying Order No. 6ZB2480-0CD00.

Note

The functionality was tested with the specified hardware components. Similar components that are different from those listed above can be used. Please note that in such a case it may be necessary to change the code example (e.g. setting other addresses).

Software components

Component	Type	Order No	Qty	Manufacturer
SIMATIC STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1	Siemens AG
Drive ES BASIC	V5.4	6SW1700-5JA00-4AA0	1	

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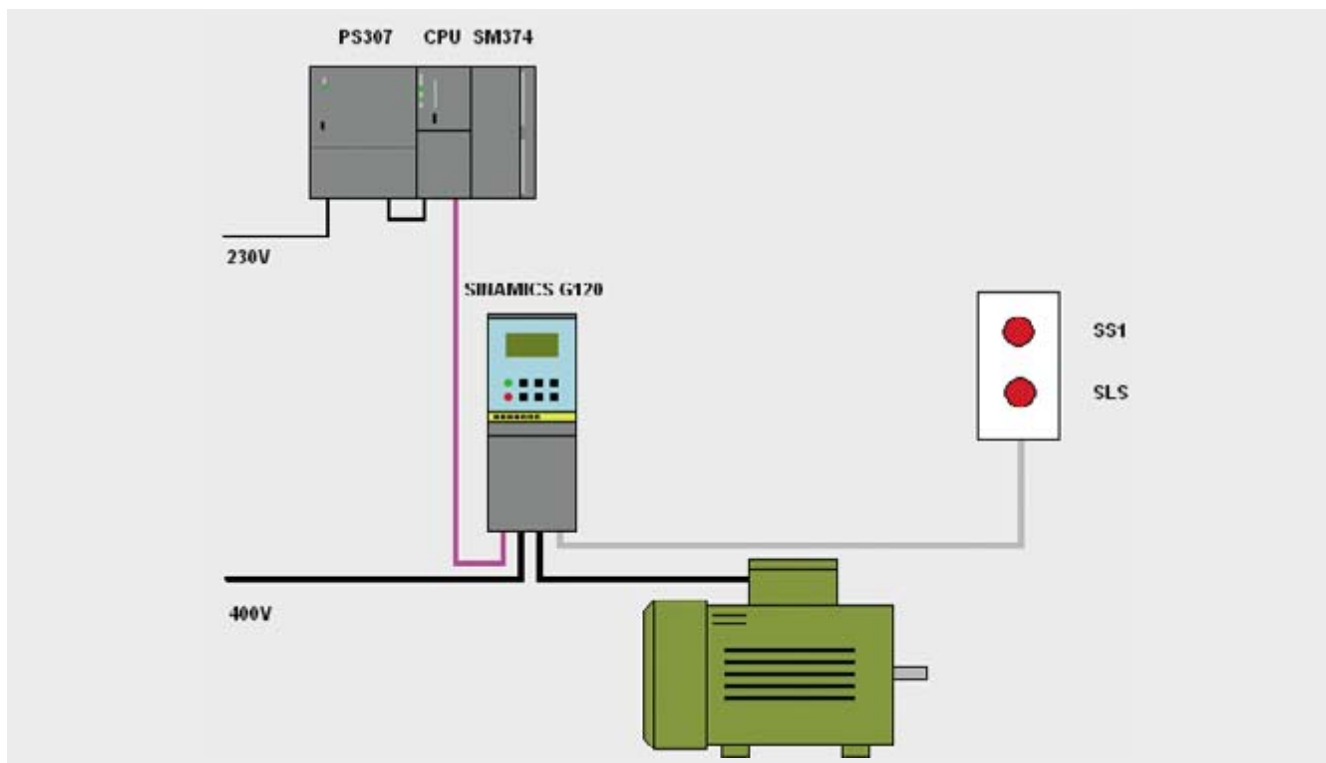
Configuration and wiring

The hardware configuration and connecting-up the function example are described in this Chapter.

Please carefully observe the following safety information & instructions when using the SINAMICS G120:

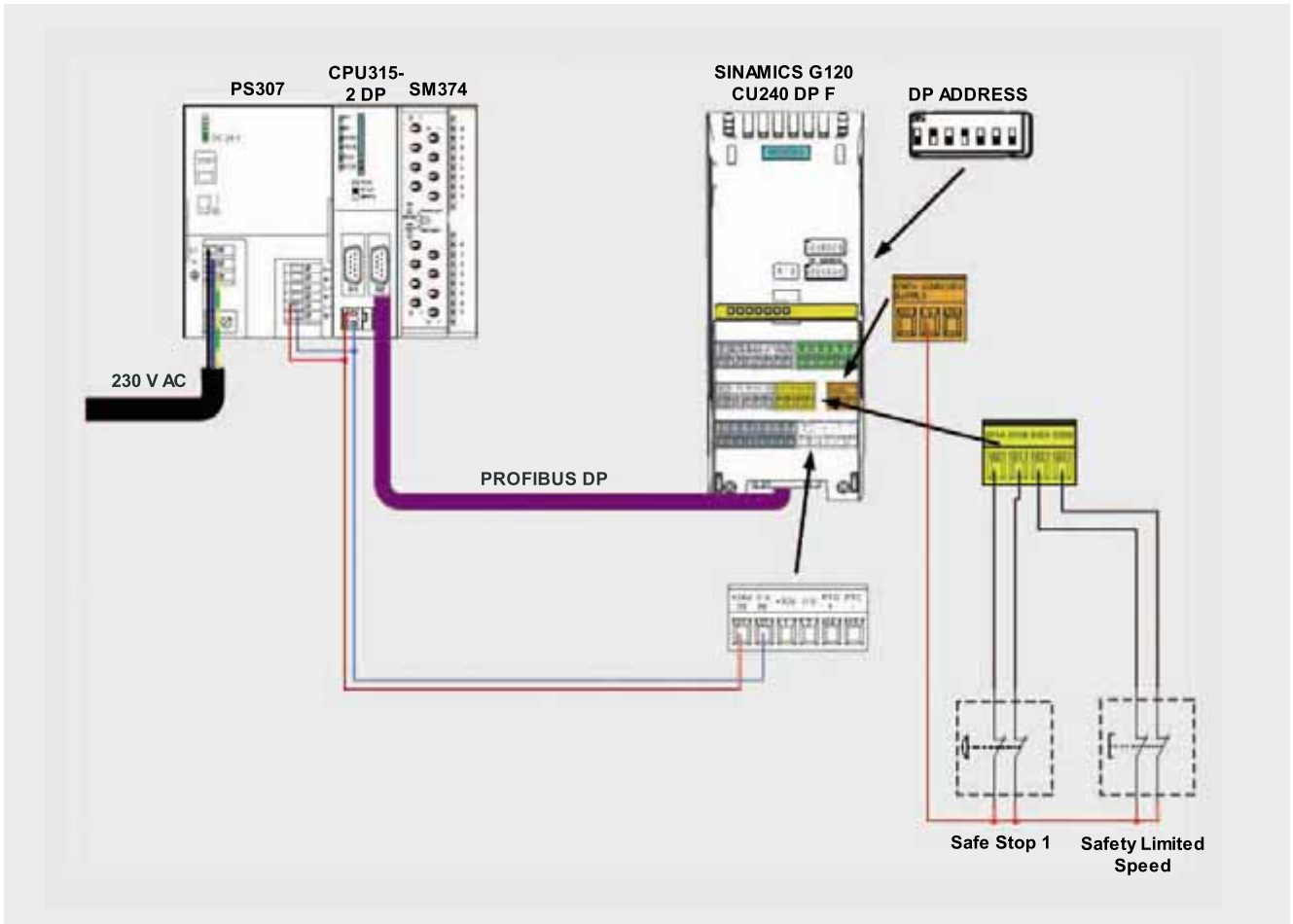
Warning
The SINAMICS G120 has hazardous voltages and controls rotating mechanical parts that can also be potentially hazardous. If the warning information is not observed or the information & instructions from the instructions belonging to SINAMICS G120 are not complied with this could result in death, severe bodily injury or significant material damage.

Overview of the hardware configuration



Connecting-up the hardware components

S7-300 control and CU240S DP F

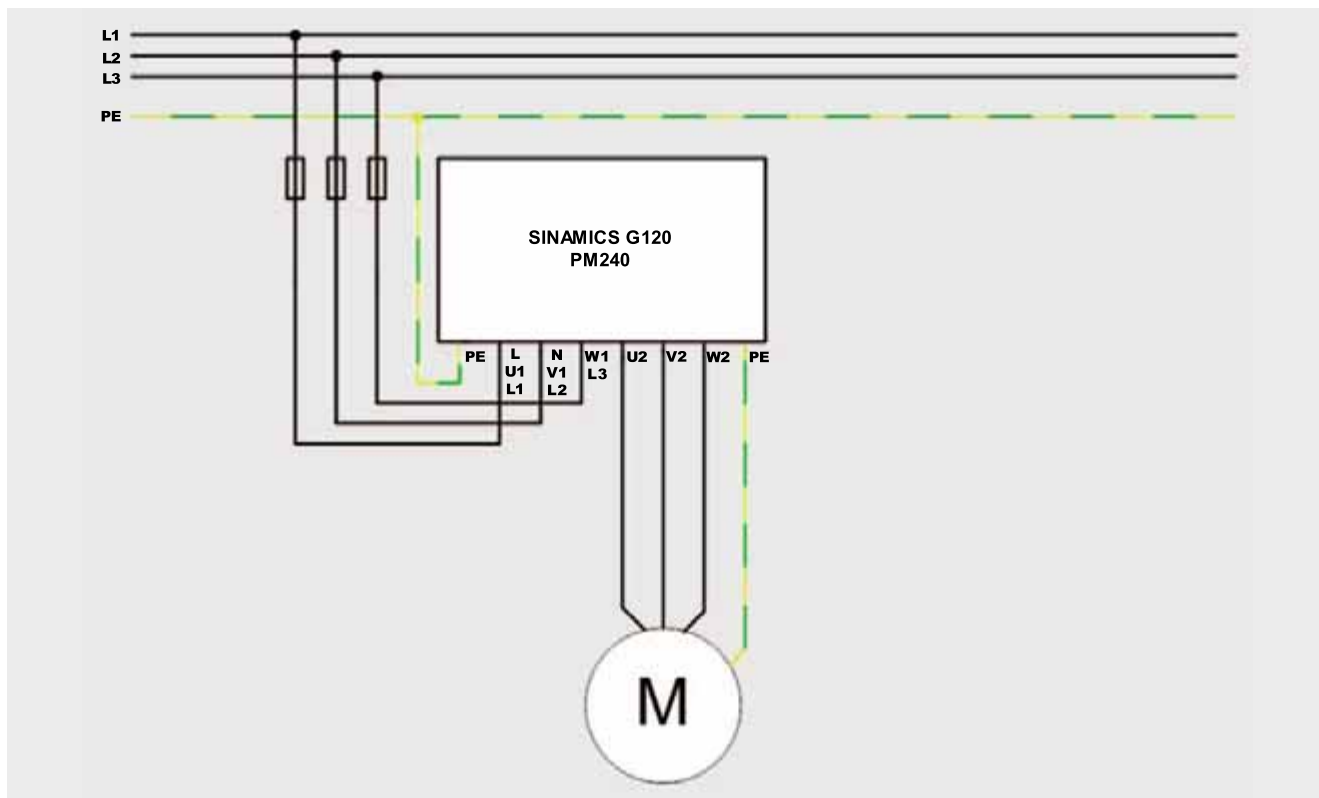


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PM240 and motor

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5.2



For more detailed information regarding the installation please refer to the SINAMICS G120 Hardware Installation Manual Power Module PM240

Fault 395 (acceptance test / acknowledgement present)

Fault F395 is output when powering-up for the first time and after replacing the Control Unit CU or the Power Module PM. This fault does not represent an incorrect drive inverter function. The reason for this fault message is to monitor the individual drive inverter components (CU and PM) to prevent them from being replaced by unauthorized personnel.

Acknowledging fault F395

To acknowledge the F395 in conjunction with a CU240S DP F, proceed as follows:

- Set parameter p0010 to 30
- Enter the safety password (standard = 12345) into parameter p9761
- Set parameter p7844 to 0
- F395 will no longer be displayed
- For safety reasons you now have to run an acceptance test. For more information see the G120 Operation Instructions, Appendix, Acceptance Log.

For information

For a CU without safety information it is sufficient to acknowledge fault F395 using "acknowledge fault" (SINAMICS G120 terminal strip or PROFIBUS).

Important hardware component settings

Most of the module/board settings are made in the HW Config in the software. Hardware settings are only required for the following modules/boards.

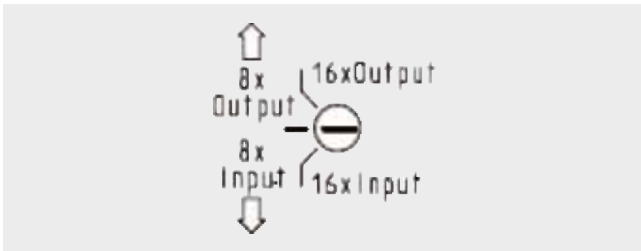
The modules/boards must be set with the control system in a no-voltage state.

SM374 simulation module

This module can be operated as 16 x DO (output via LED), 16 x DI (input via switch) or as combined 8 x DI / 8 x DO. The last combination is used in this function description.

The function of the module is selected using a rotary switch behind the front cover between the series of switches.

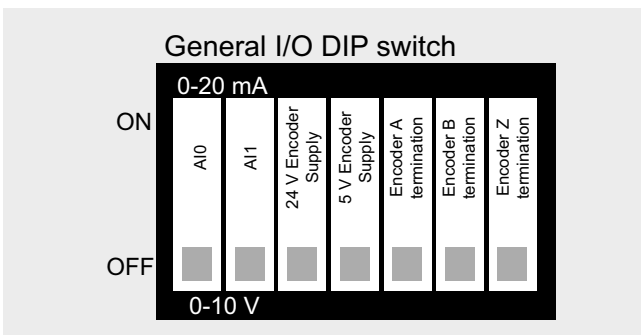
- As shown in the following diagram set the function switches to the setting **8 x Output 8 x Input**.



SINAMICS G120, CU240S DP F

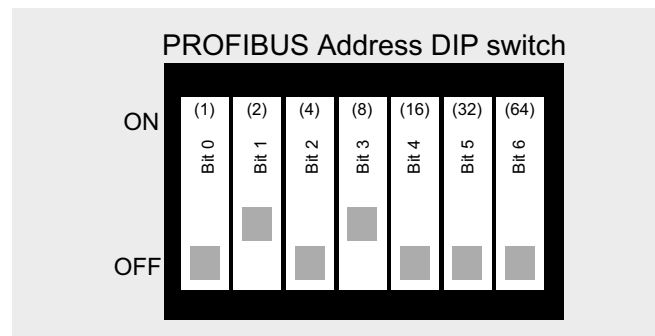
Two DIP switch blocks are located under the BOP (Operator Panel) in the upper section of the module.

The upper DIP switch block is for general CU functions - and is not relevant for this function example.



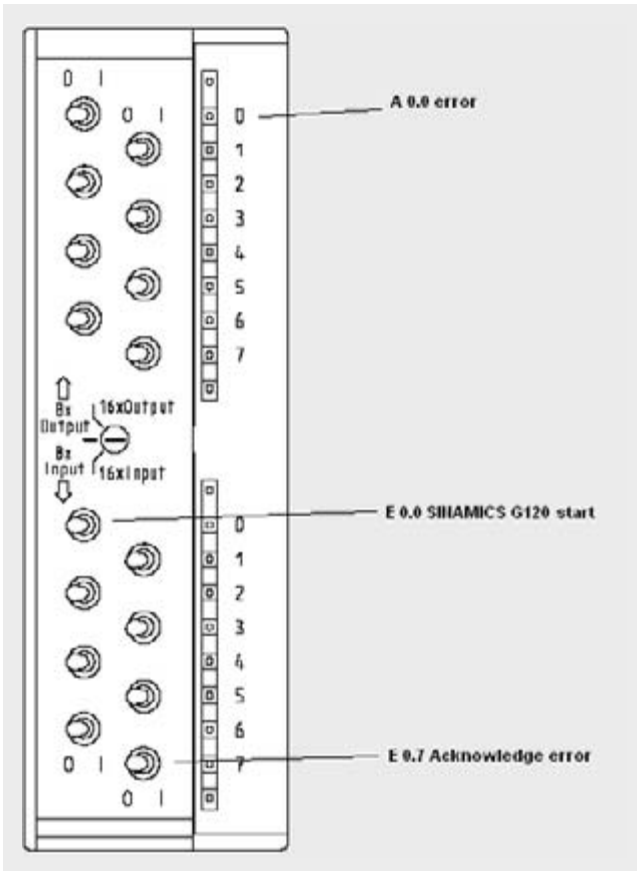
The PROFIBUS address of the SINAMICS G120 can be set using the lower DIP switch block. Alternatively, the PROFIBUS address can also be set using parameter p918. It should be noted that the setting using DIP switches has priority over parameter p918.

- Set the DIP switches to address 10 as shown in the following diagram.



Overview of inputs and outputs

Simulation module SM374



Address	Function	Symbolic address	Default	Explanation
O 0.0	Indicator lamp error	error	0	Faults are signaled via this output.
I 0.0	SINAMICS G120 start	Start_G120	0	The motor connected to SINAMICS G120 is started by activating the input.
I 0.7	Acknowledge error	ACK_error	0	Fault messages that are present can be acknowledged using this input.

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SINAMICS G120

The SINAMICS G120 is controlled and the feedback signals read-in via the I/O addresses listed below.

Address	Designation	Function
S7 program -> SINAMICS G120		
PQW256	STW1	Control word 1
PQW258	N_SOLL_A	Frequency setpoint
PQW260	M_LIM	Torque setpoint
PQW262	STW2	Control word 2
PQW264	- Reserve -	- Reserve -
PQW266	- Reserve -	- Reserve -
SINAMICS G120 -> S7 program		
PIW256	ZSW1	Status word 1
PIW258	N_Ist_A_GLATT	Frequency actual value
PIW260	I_Ist_GLATT	Current actual value
PIW262	ZSW2	Status word 2
PIW264	FAULT_CODE	Fault number
PIW266	WARN_CODE	Alarm number

For more detailed information about the configuration of the individual signals, please refer to SINAMICS G120 Operating Instructions Control Unit CU240S, Chapter Commissioning (software), Commissioning with PROFIBUS DP.

Download

S7 program

To download the S7 program, you will require a connection between the MPI interface of your PG/PC and the MPI interface of the S7 CPU.

- Start the **SIMATIC Manager**.
- De-archive the function example supplied.
- Open the **Safety application2 G120** project.
- Open **HW-Config** and download this into the control. After the download re-close **HW-Config**.
- In SIMATIC Manager, select the block folder via **CPU315-2 > S7 Program > Blocks**.
- Download all of the S7 program blocks into the CPU.


After the download, changeover the interface of your PC/PG to PROFIBUS and changeover the connecting cable to the PROFIBUS interface of the S7-CPU. You can access all of the devices of your configuration from this interface.

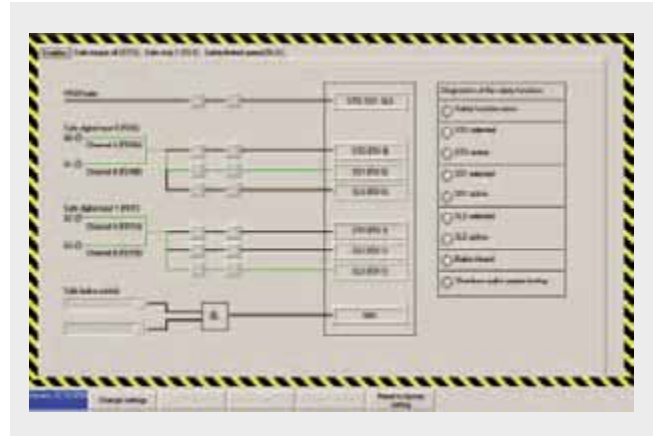
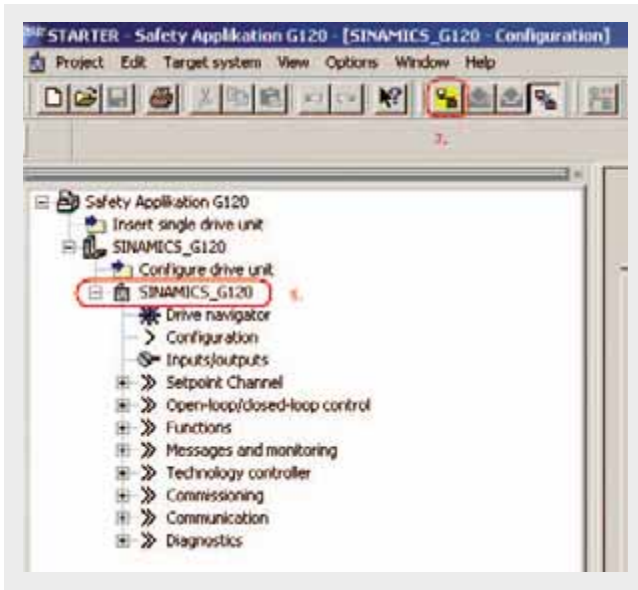
SINAMICS G120 configuration

When this has been completed, download the SINAMICS G120 configuration using the STARTER parameterizing tool.

- Starting from the main path of the SIMATIC Manager, start the STARTER parameterizing software by double clicking on the **SINAMICS_G120** icon




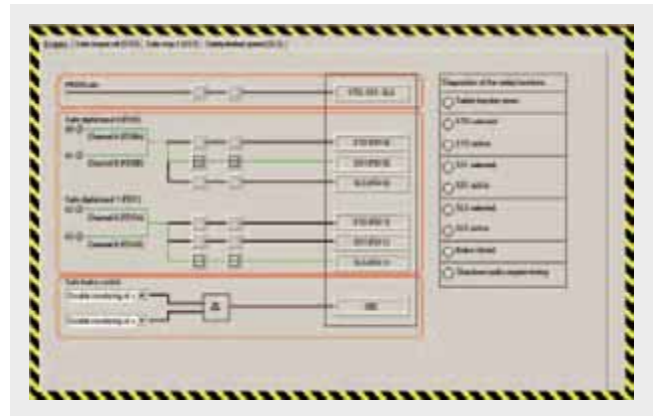
- Then, in the Project Navigator of the STARTER parameterizing software select the object "SINAMICS_G120" (1.) and press the button  (2.) to establish the online connection to the drive inverter.



- Then press the button **Change settings** and enter 12345 (standard password) in the password screen that then opens.
- From the following screen forms transfer the appropriate values into your project. Take into consideration that in certain instances there are different value formats for processor 1 and 2 (e.g. s and ms, Hz and kHz).

"Enables" tab

- After you have established the online connection, press the button  to download the SINAMICS G120 drive parameters.
- Follow the instructions on the screen and acknowledge the prompt "After loading, copy RAM to ROM".
- You must then enter the safety parameters of the SINAMICS G120. These may not be - and cannot for safety reasons - be transferred into the drive inverter by downloading from the PG / PC.
- In the Project Navigator, select **Functions** and then open the dialog box for the safety functions by double clicking on **Safety Integrated**.



In this screen form you parameterize the source from which you activate the SINAMICS G120 safety functions. Please note that the safety functions can either be controlled via **PROFIsafe** or via the **safety digital inputs**.

- Upper section:** Path to activate via **PROFIsafe**.
- Center section:** Path to activate via the **Safe digital input 0 and 1** (this is used in this particular function example).

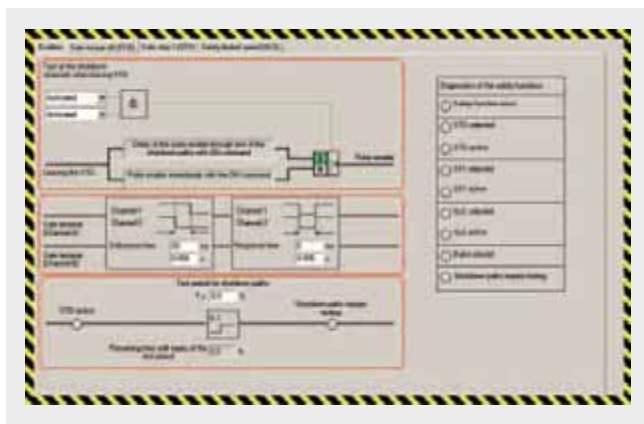
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■ **Lower section:** Here, the monitoring of the **Safe brake control** module can be activated; however, this is not used in this particular function example.

It should be noted that the parameterization is always carried-out twice (in this screen form this can be identified as a result of the two switch symbols in series). The reason for this is that for the two processors in SINAMICS G120 - that operate in parallel and must provide the same result - there are separate parameter sets for safety reasons.

After you have parameterized the enable signals, then select the tab **Safe Torque Off**.

"Safe Torque Off (STO)" tab



The shutdown paths of a safety-relevant plant or system must be subject to a forced checking procedure at regular intervals. This is in order to identify "dormant" errors. SINAMICS G120 automatically carries out a forced checking procedure of the shutdown paths in the drive unit. This procedure is known as the forced checking procedure.

A reduced form of the forced checking procedure limited to self-test the brakes and processor is always automatically executed after "Safe Torque Off" (STO) is exited. This type of forced checking procedure is known as the process checking procedure.

Further, by appropriately parameterizing the system, it is possible to initiate a forced checking procedure each time that STO is exited.

■ **Upper section:** Using **Test of the shutdown channels when leaving STO**, you can select how the forced checking procedure for the shutdown channels is carried-out.

– **Activated:** A forced checking procedure is carried-out each time the drive unit is powered-up and when exiting "Safe Torque Off" (STO). Checking the shutdown chan-

nels takes approximately 2.4 s. This delay time must be taken into account at each On command.

– **Deactivated:** The shutdown channels are only checked after the function "Latched Safe Torque Off" (LSTO) when an error occurs. When exiting an STO, a delay time is not incurred as only the process checking procedure is carried-out.

■ **Center section:** When activating the safety functions via the safe digital inputs of the SINAMICS G120, a **debounce time** and a filter for the **response time** can be set here. These settings are not relevant for the function example described here.

■ **Lower section:** The SINAMICS G120 automatically monitors when a forced checking procedure was carried-out the last time. Set the time up to the next forced checking procedure in the field **Test periods for shutdown paths**. The time can be selected between 0.1 and 8760 hours (6 min up to 1 year). The timer is re-started after each forced checking procedure. Alarm A1699 is output in operation to flag you that this monitoring time has expired. A process checking procedure does not replace forced checking procedure and therefore does not reset the timer.

After you have parameterized the **Safe Torque Off** function, select the tab **Safe Stop 1**.

Safe Stop 1 (SS1) tab



The parameters relevant for "Safe Stop 1" (SS1) are set in this screen form.

- (1.) Using the threshold value **Standstill detection**, define the speed at which standstill (zero speed) is detected and "Safe Torque Off" (STO) is activated. Please note that the value should be entered once in kHz and once in Hz.
- (2.) The **Ramp-down time T_r for SS1 ...** should then be entered. Please note that the value is entered once in s and once in ms. The ramp-down time T_r always refers to the safety reference frequency of 200 Hz in the drive itself. This ramp-down time is also used for the deceleration for "Safely Limited Speed" (SLS).
- (3.) The monitoring tolerance is set using **Delay T_v , until monitoring active**. The drive inverter continually monitors - with tolerance T_v - the braking of the drive. If the tolerance is selected too low, then the monitoring function could be incorrectly tripped. If the tolerance is too high, then if an actual fault does develop, an unnecessarily long time is wasted. Please note that the value is entered once in s and once in ms.

After you have parameterized the function **Safe Stop 1**, select the tab **Safely Limited Speed**.

Safely Limited Speed (SLS) tab



The parameters relevant for "Safely Limited Speed" are entered in this screen form.

- (1.) The SLS mode is defined here. The following three modes - with the appropriate properties - are available:

SLS mode	Properties
Mode 0	<p>Limiting to a safely limited speed</p> <p>If, when SLS is activated, the actual frequency is greater than the Upper tolerance limit for velocity monitoring, SS1 is activated and then LSTO (safe torque shutdown with latching).</p> <p>If, when SLS is activated, the actual frequency lies between the Upper tolerance limit for velocity monitoring and the Setpoint for SLS, then the Setpoint for SLS is activated and the drive is braked down to the Setpoint for SLS. The frequency cannot be changed.</p> <p>If the actual frequency lies below the Setpoint for SLS, the actual frequency is kept. The frequency cannot be changed.</p> <p>STO is activated if the actual frequency falls below 1 Hz.</p> <p>The drive can be stopped using OFF2, withdrawing/cancelling the function or by activating another safety function.</p>
Mode 1	<p>Reducing to a safely limited speed</p> <p>If, when activating SLS, the actual frequency is greater than the Upper tolerance limit for velocity monitoring, the Setpoint for SLS is activated and the drive is braked down to this setpoint using the safe braking ramp.</p> <p>If the actual frequency lies below the Setpoint for SLS, the actual frequency is kept. The frequency cannot be changed.</p> <p>STO is activated if the actual frequency drops below 1 Hz.</p> <p>The drive can be stopped using OFF2, withdrawing the function or by activating another safety function.</p>

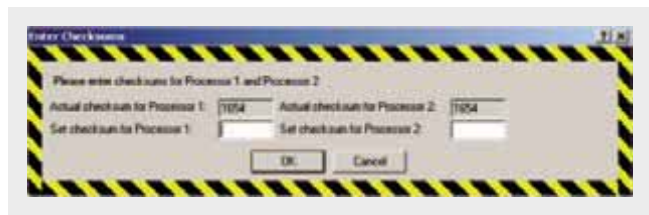
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SLS mode	Properties
Mode 2	<p>Limiting to a safely limited speed - the speed can be changed</p> <p>If, when activating SLS, the actual frequency is higher than the Upper tolerance limit for velocity monitoring, LSTO (safe torque shutdown with latching) is activated.</p> <p>If, when activating SLS, the actual frequency lies below the Upper tolerance limit for velocity monitoring, the frequency is kept. The frequency can be changed between 1 Hz and the Upper tolerance limit for velocity monitoring (Caution: For V/f, take into account the slip compensation).</p> <p>If the actual frequency drops below 1 Hz or the Upper tolerance limit for velocity monitoring is reached, STO is activated. If the upper tolerance limit for velocity monitoring is exceeded, then STO is latched - i.e. LSTO.</p> <p>The drive can be stopped with ON/OFF1 and the remaining OFF commands - but it can only be re-started if SLS has been withdrawn.</p>

Please refer to the Operating Instructions CU240S, Chapter *Functions* under *Fail-safe Functions* for more detailed information about the SLS modes.

- (2.) These input fields are displayed for SLS mode (1.) 0 and 1. **Set-point for SLS** is used to set the frequency to which the frequency set-point is internally limited in the drive unit after the function Safely Limited Speed SLS has been selected. Please note that the value is entered once in Hz and once in kHz.
- (3.) The monitoring limit is set using the **Upper tolerance limit for velocity monitoring**. If Safely Limited Speed SLS is active and the actual speed exceeds this value, then SINAMICS G120 outputs a fault message and goes into the safe condition (Safe Torque Off, STO). Please note that the value should be entered once in Hz and once in kHz.
- After you have made all of the settings press the **Accept settings** button.
- You can now change the standard password. If you are still not certain that your safety parameterization has been completed, then you should press the **Later** button. However, after you have completed the commissioning phase, do not forget to change the standard password for a password that only you know or a person that you trust. Only then can you be sure that only authorized persons can change/modify safety parameters.

- To complete the parameterization of the safety functions you must now acknowledge the checksums of the two processors. To do this, transfer the first checksum, processor 1 into the set checksum, processor 1. Do exactly the same for the checksum of processor 2. Please note that the two actual checksums and therefore the two set checksums must be the same. If this is not the case, then you must re-check your parameterization of the safety functions and resolve the different values.



- If you don't wish to set any additional parameters, then you can now exit the STARTER commissioning tool.
- To do this first disconnect the PG/PC from SINAMICS G120 by pressing the  button.
- You can then exit STARTER using **Project > Close** or by pressing the  button.
- You'll now be prompted to save changes - acknowledge this with **Yes**.

Function test

The function test can be carried-out, if

- The hardware components are connected-up
- The hardware settings have been made
- The S7 project is in the CPU
- The configured software has been downloaded into the SINAMICS G120 and the safety functions have been parameterized
- The CPU is in the RUN state.

No.	Action	Response
1	If it is pressed, release the Emergency Stop pushbutton	
2	Press the pushbutton "Acknowledge faults"	The signal lamp (A0.0) for "Error" goes dark. At SINAMICS G120 LEDs RDY , STO , SS1 and SLS are bright -> the drive and all of the safety functions are in the ready state.
3	Press the switch "SINAMICS G120 Start"	The motor starts to run.
Safety function SS1 (Safe Stop 1)		
1	Press the Emergency Stop pushbutton SS1	The motor follows the parameterized braking ramp down to the minimum frequency and stops. At the SINAMICS G120 the LED ES is bright and LED SS1 flashes -> SS1 is active, the motor has been brought into a no-torque condition. At the SINAMICS G120 alarm A1696 is displayed -> this alarm is displayed as long as the start signal is present.
2	De-activate the control of the SINAMICS G120 using the switch "SINAMICS G120 Start".	The alarm A1696 is no longer displayed at the SINAMICS G120.
3	Release the Emergency Stop pushbutton SS1	At the SINAMICS G120 the LEDs RDY , SS1 and SLS are bright -> the drive and all of the safety functions are in the ready state.
4	Press the switch "SINAMICS G120 Start"	The motor starts to operate again.

No.	Action	Response
Safety function SLS (Safely Limited Speed)		
1	Press the pushbutton SLS and keep it pressed	The motor follows the parameterized braking ramp down to the safely limited speed. At the SINAMICS G120 the LED ES is bright and LED SLS flashes -> SLS is active, the motor is monitored to ensure that it does not exceed the safely limited speed.
2	Release pushbutton SLS again	The motor accelerates back to the normal speed. At the SINAMICS G120 LEDs RDY , SS1 and SLS are bright -> the drive and all safety functions are in the ready state.

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Acceptance test and acceptance report

An acceptance test must be carried-out when the machine is commissioned for the first time and also if a completely saved set of the safety-relevant parameters is changed. This procedure is used to verify the safety-relevant parameters. This acceptance test must be appropriately documented. The acceptance reports must be appropriately stored and archived.

The checksum ensures that all subsequently made changes are identified.

Information about the acceptance test and the acceptance report are provided in **SINAMICS G120 Operating Instructions Control Units CU240S** in the Chapter **Commissioning (software)**.

An example of an acceptance report is provided in the **SINAMICS G120 Operating Instructions Control Units CU240S** in the **Appendix**.

Key performance data

Load memory and working memory


	Total
Load memory	approx. 4 k
Working memory	approx. 1 k

Cycle time

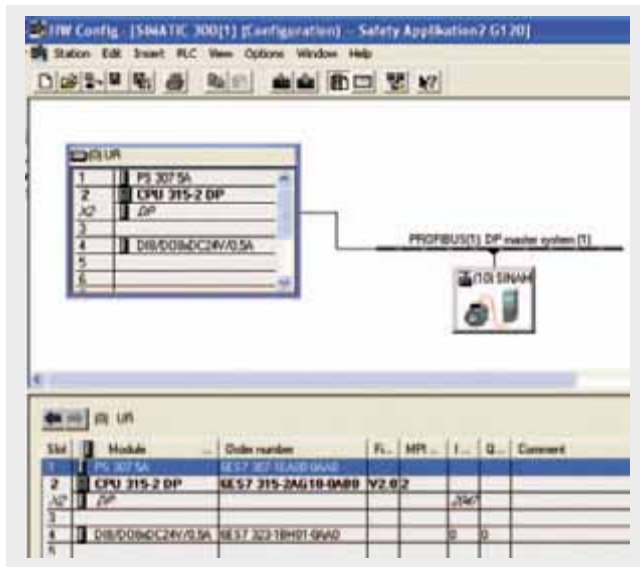
Total cycle time (typical)	approx. 1-2 ms	Standard program
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Example code

The example code supplied is fully functional for the described application. The individual functions of the example code are explained in the following Chapters so that you are in a position to implement your own projects.

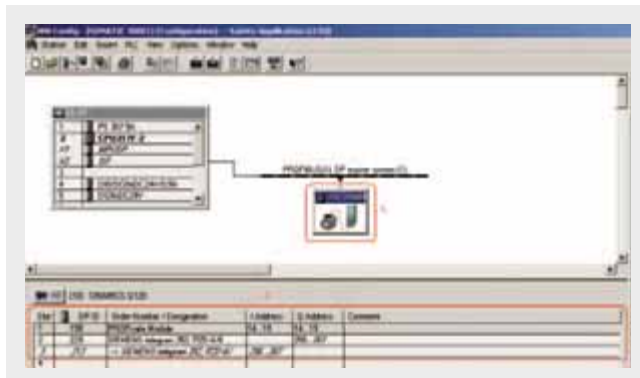
The individual telegram components are selected in the Catalog after pressing the following button 

Settings in the hardware configuration

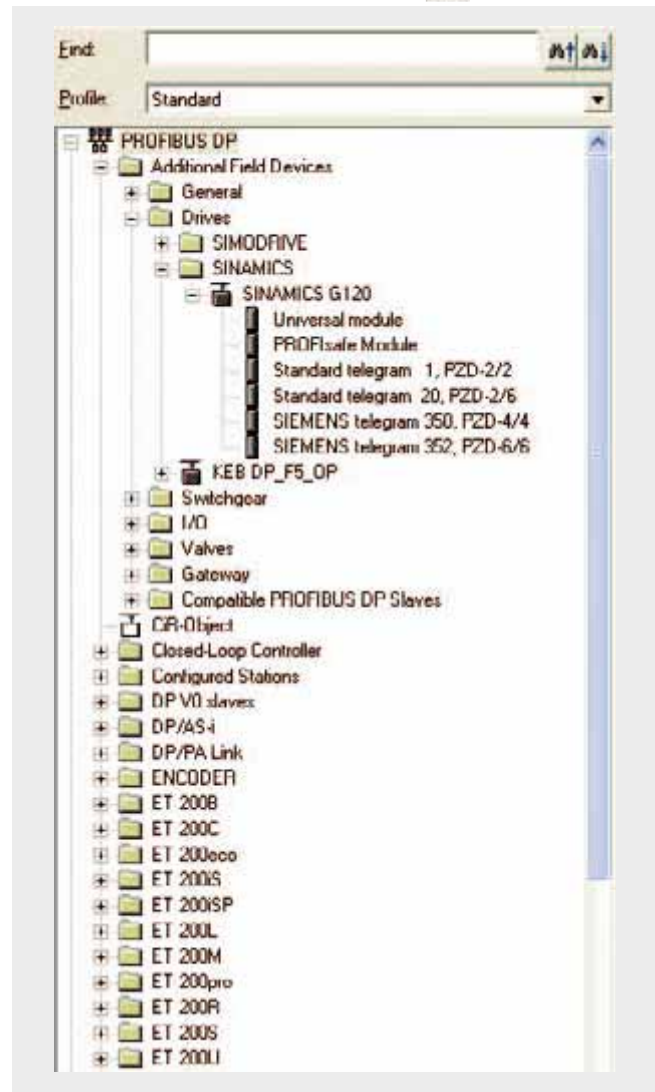


Properties of the SINAMICS G120

The window of the SINAMICS G120 PROFIBUS properties (2) is displayed by clicking once on the SINAMICS G120 icon (1).



A standard telegram is used to establish communications between the CPU and the SINAMICS G120. In this particular function example Siemens Telegram 352 (2.) with a length of 6 words is used to control the SINAMICS G120.



For more detailed information about the different telegram types please refer to *SINAMICS G120 Operating Instructions Control Units CU240S* in the Chapter *Commissioning (software), Commissioning with PROFIBUS DP*.

Siemens telegram 352, PZD 6/6

The standard control (control word, frequency setpoint etc.) of SINAMICS G120 is implemented using the Siemens telegram.

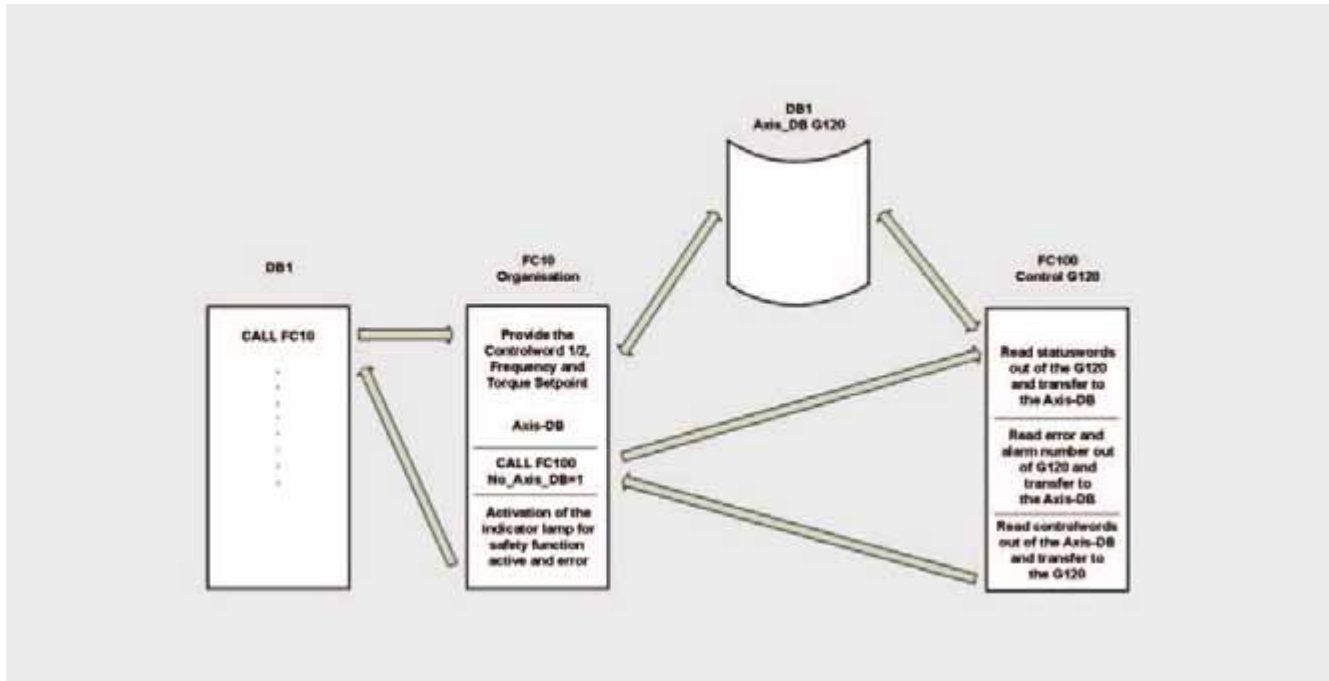
In SINAMICS G120, instead of telegram 352 (fixed assignment of the control/feedback signal words), telegram 999 is used (free assignment of the control/feedback signal words).

In this case, in SINAMICS G120, to start, telegram type 350 should be selected in parameter p922. This pre-assigns the BICO connections. Telegram type 999 (free interconnection via BICO) should then be selected and the following interconnections made:

- p2051[4] = r2131 (error number)
- p2051[5] = r2110 (alarm number)

Functions of the STEP 7 program (without safety program)

Program overview



The STEP 7 program essentially comprises blocks FC10, FC100 and DB1 that are called in the cyclic program (OB1).

DB1, axis_DB

The axis_DB represents the interface between the S7 program and the SINAMICS G120 via FC100.

Axis_DB is generated from UDT 1 (Axis_DB_G120)

Principal structure of axis_DB

Address	Symbolic name	Type	Function
Internal data			
DBW0	Basic_Data.Moduleaddress	INT	I/O start address of the SINAMICS G120 (refer to HW Config)
DBB3	Basic_Data.Drivetyp	Byte	Drive type, must be 2
S7 -> SINAMICS G120			
DBW4	Control_signals.STW2	Bool	Control word 2 (for details, refer to the S7 program)
DBW6	Control_signals.STW1	Bool	Control word 1 (for details, refer to the S7 program)
DBW8	Control_signals.Frequency_set	INT	Frequency setpoint in x.x %
DBW10	Control_signals.Torque_set	INT	Torque setpoint in x.x %
SINAMICS G120 -> S7			
DBW14	Status_signals.ZSW2	Bool	Status word 2 (for details, refer to the S7 program)
DBW16	Status_signals.ZSW1	Bool	Status word 1 (for details, refer to the S7 program)
DBW18	Status_signals.Actual_frequency	INT	Frequency actual value in x.x %
DBW20	Status_signals.Actual_current	INT	Current actual value in x.xx A
Fehlermeldungen			
DBW24	Faults.Drive_error_number	INT	Actual error number of the SINAMICS G120
DBW26	Faults.Drive_alarm_number	INT	Actual alarm number of the SINAMICS G120

In this function example the individual data of the DB1 are supplied in FC10.

FC10, organization

This block is called-up in absolute terms in OB1 and in turn calls up FC100.

Principle of the FC10

Network	Function
1	Controls the SINAMICS G120 via the axis-DB, DB1. Calls the SINAMICS G120 control block FC100. This network can be used as template for additional SINAMICS G120 control functions.
2	Controls the signal lamp for "Safety function activated or fault".

FC100, control of SINAMICS G120

SINAMICS G120 is controlled using the FC100 via PROFIBUS.

Only signals from the axis_DB are used to control the block - but no fixed addresses - this is the reason that instances can be used.

This block can be used in the same way for both a standard and a Safety SINAMICS G120.

Formal operands of the FC100

Formal operands	Type	Description
Nr_Axis_DB	IN	Number of the axis-DB generated using UDT1
Internal_Error	OUT	Displays an internal error 0 = no error 1 = incorrect axis-DB type

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Principle structure of the FC100

Network	Function
1	Opens the axis_DB specified using the formal operands Nr_Axis_DB . Generates the internal error message.
2	Reads-in the SINAMICS G120 status words, processes these and saves them in the axis_DB.
3	Resets internal error messages.
4	Converts frequency and torque setpoint from the axis_DB (entered in x.x %) into the SINAMICS G120 format (hex).
5	Enters SINAMICS G120 error and alarm number into the axis_DB.
6	Sends control words from the axis_DB to the SINAMICS G120

SINAMICS G120 - parameterizing the safety functions


Refer to Chapter **SINAMICS G120 configuration** on page 496.

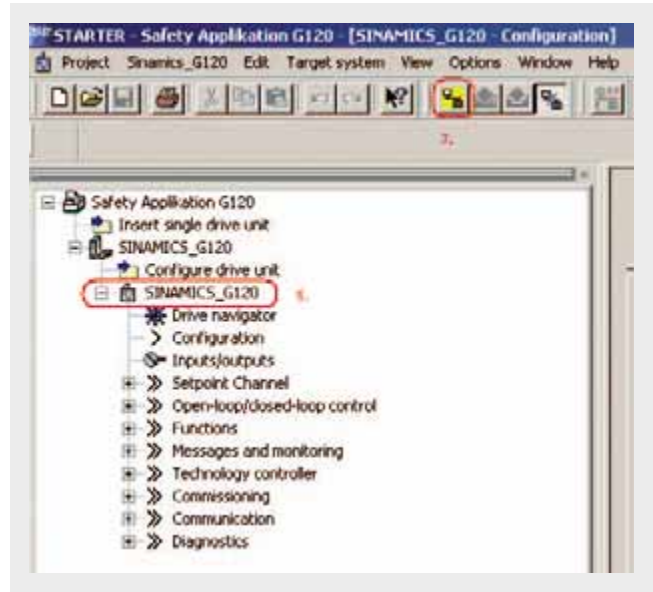
SINAMICS G120 parameterization

In order that the basic SINAMICS G120 functions can be parameterized, the safety functions in the S7-CPU and in the drive inverter itself must already have been commissioned. The reason for this is that during parameterization a motor identification routine is carried-out (the motor and cables are measured) - and if vector control is activated - the controller is optimized. Both of these functions require that the safety functions are in the ready state.

- Starting from the main path of the SIMATIC Manager, start the STARTER parameterizing software by double clicking on the **SINAMICS_G120** icon



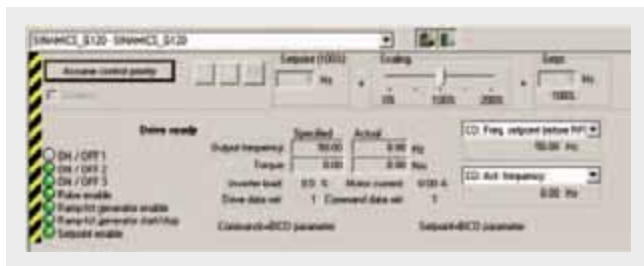
- Then, in the Project Navigator of the STARTER parameterizing software select the object "SINAMICS_G120" (1.) and press button  (2.) to establish an online connection to the drive inverter.



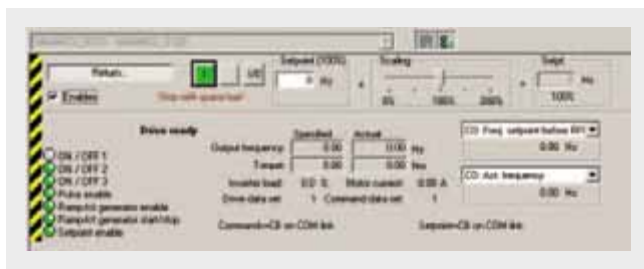
- The screen form with the actual configuration is opened by double clicking on **Configuration** in the Project Navigator.
- "The quick commissioning Wizard is started after pressing the **Wizard...** button.
- Enter the appropriate values into all of the screen forms.
- In the screen form **Drive functions**, select for **Motor identification**, the **function Ident. of al param. in standstill incl. the saturation curve (3)**.
- In the screen form **Calculation of the motor data**, select **Restore factory setting and calculate motor data**.
- In the screen form **Summary** do not activate the function **RAM -> ROM**, but instead press the **Finish** button.
- After completing the quick commissioning, alarm **A0541** (Motor data-identification active) is displayed. Please carefully note that when starting the motor identification routine current flows in the motor. For hanging (suspended) axes the load must always be supported.

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5.2

- To start the motor data identification routine, in the Project Navigator select the menu item **Commissioning** and activate by double clicking on **Control panel**.

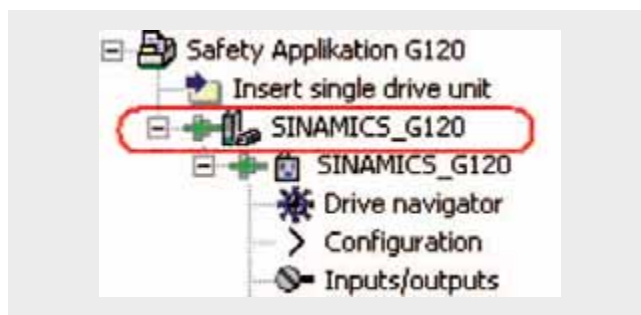


- Press **Assume control priority** and carefully note the security/safety information and instructions. Then activate **Enables**.



- The motor data identification routine is started by pressing the **1** button. Do not exit the STARTER software and go to another task as otherwise the motor data identification routine will be interrupted for safety reasons.

- Please wait until the **0** button changes back to the **1** button.
- Return the control priority to the S7 control by pressing the **Return...** button.
- Finally, you only have to save the SINAMICS G120 configured software in the ROM memory of the drive inverter. To do this in the Project Navigator select the menu item **SINAMICS_G120**.



- In the function bar press the **Download** button.
- Please wait until the download operation has been completed.

Ex. No.

5.2

Warranty, Liability and Support

Warranty, Liability and Support

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