Failsafe Controllers

SIMATIC Safety Integrated

Two-Hand Control Panel with Integrated
Emergency Stop in Category 4 according to EN 954-1

Functional example no. AS-FE-I-006-V10-EN



safety INTEGRATED



SIEMENS

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.

Aside 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 Safety Functional Examples do not represent customer-specific solutions. They are only intended to provide support for typical applications. You are responsible in ensuring that the described products are correctly used.

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Automation Function

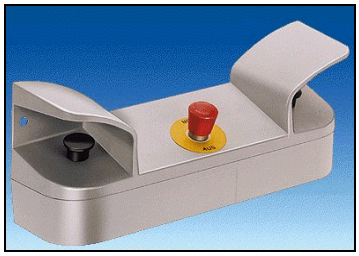
Description of the functionality

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.



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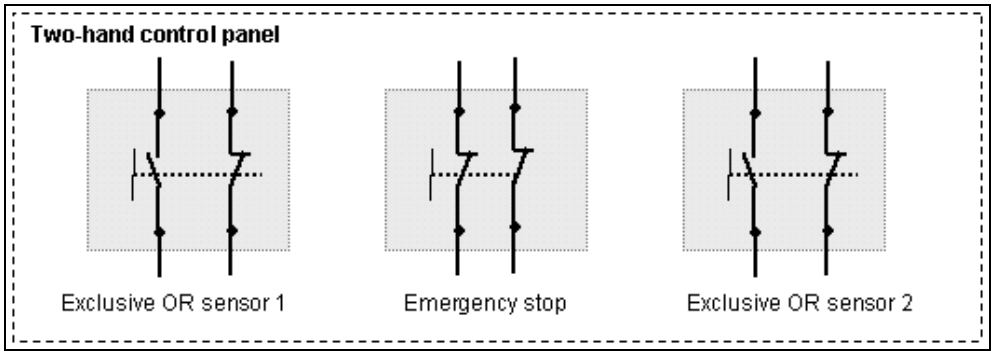
Standards

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 STEP7 (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.

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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://www4.ad.siemens.de/ww/view/de

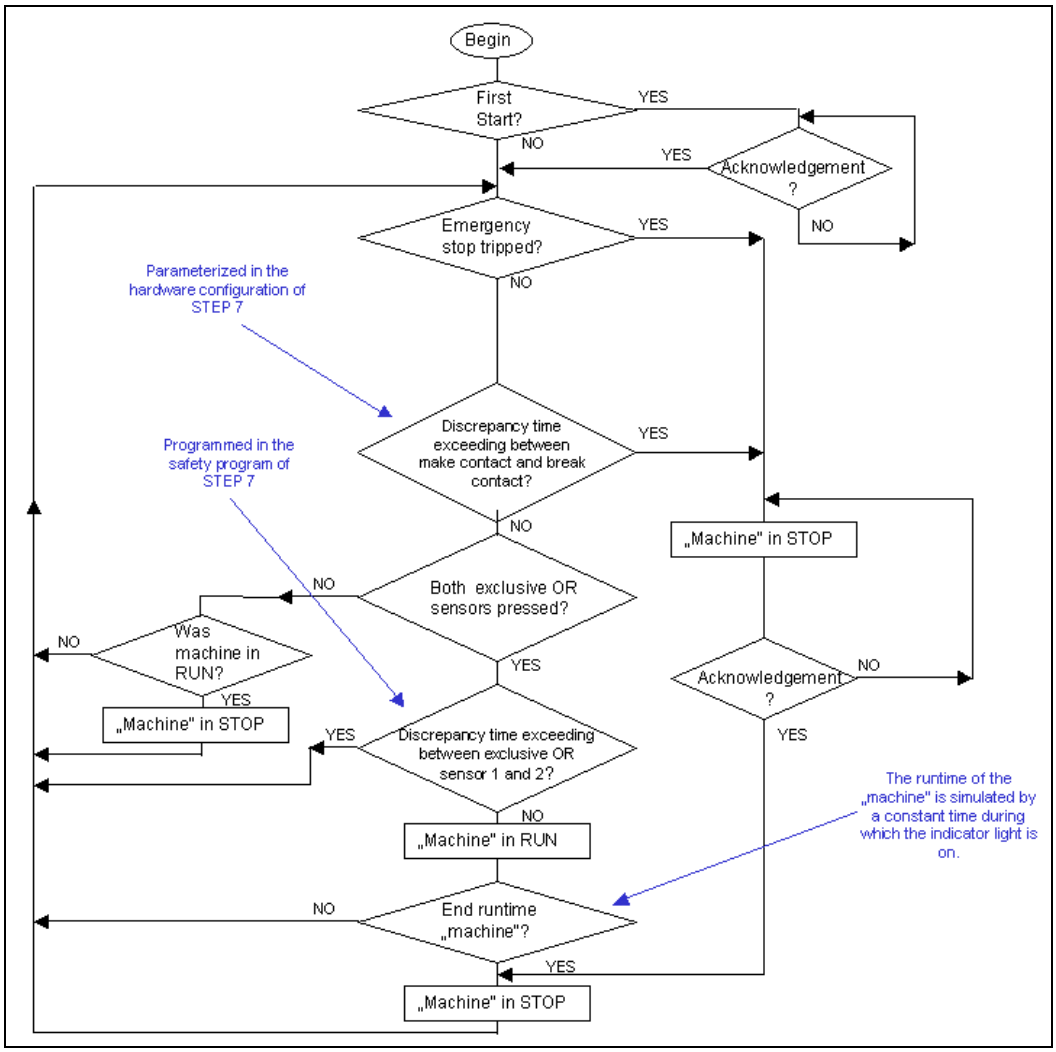
Entry ID **19138505**

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.



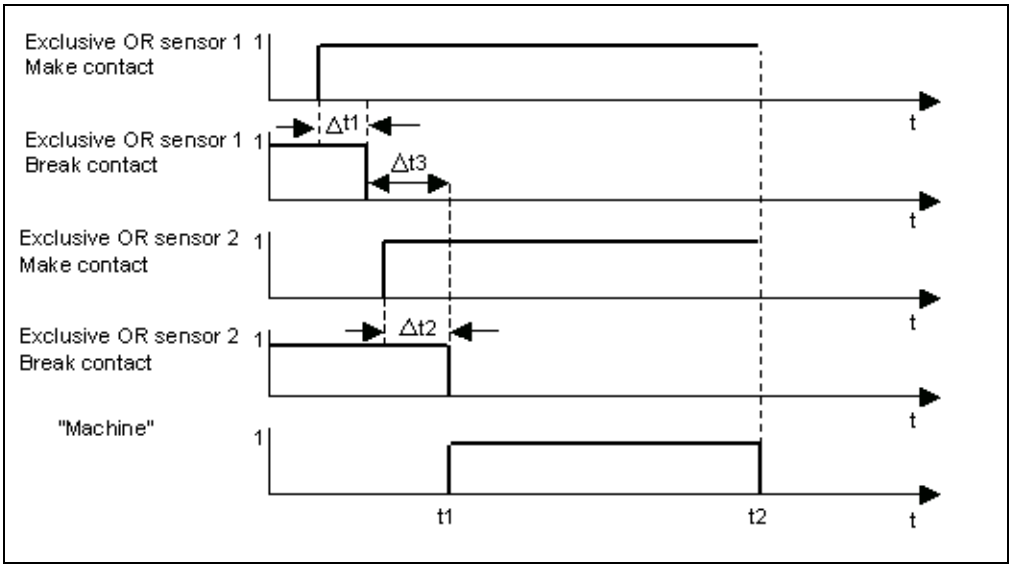
Time sequence

The times listed in the following table are also shown in a timing diagram below.

Time	Explanation	Note
Δt1	Discrepancy time between make contact and break contact at exclusive OR sensor 1	Parameterized in the hardware configuration of STEP 7.
Δt2	Discrepancy time between make contact and break contact at exclusive OR sensor 2	

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Time	Explanation	Note
∆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.
t2	Stop of the “machine”	Possible reasons: • 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)



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Advantage/customer benefit

- 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 STEP7 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	MLFB / Order number	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 Kbytes	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	
Mounting 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	

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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	MLFB / Order number	No.	Manufacturer
SIMATIC STEP 7	V5.3 + SP1	6ES7810-4CC07-0YA5	1	SIEMENS
SIMATIC Distributed Safety	V5.3	6ES7833-1FC01-0YA5	1	

Setup and Wiring

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

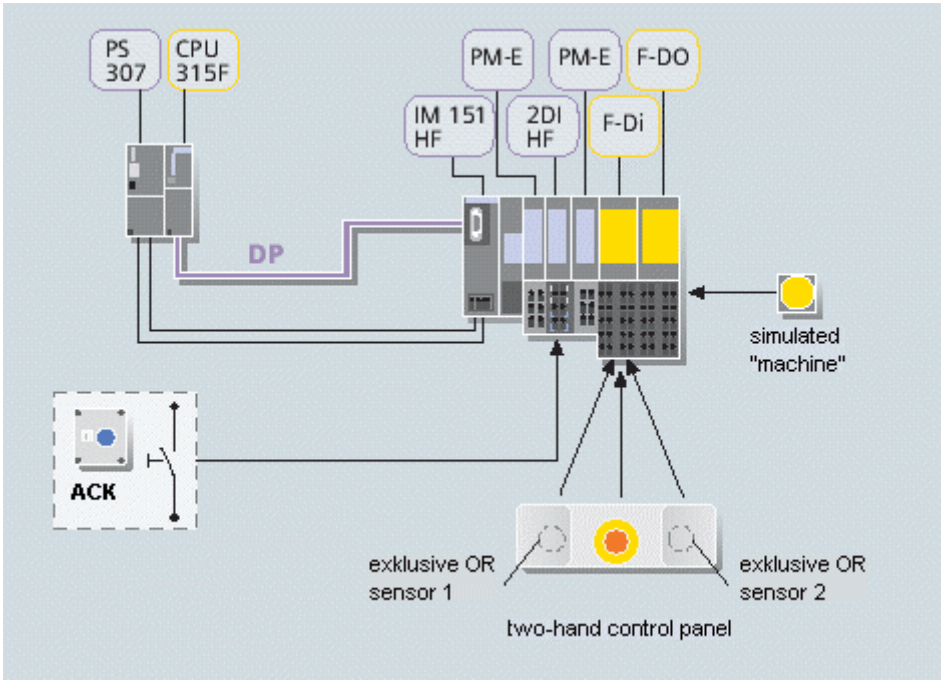
Warning

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 realized 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. Safety Integrated Functional Example 7 provides a detailed description of "Read back".

Overview of the hardware configuration

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.

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Wiring of the hardware components

Prerequisite: The power supplies are supplied with 230V AC.

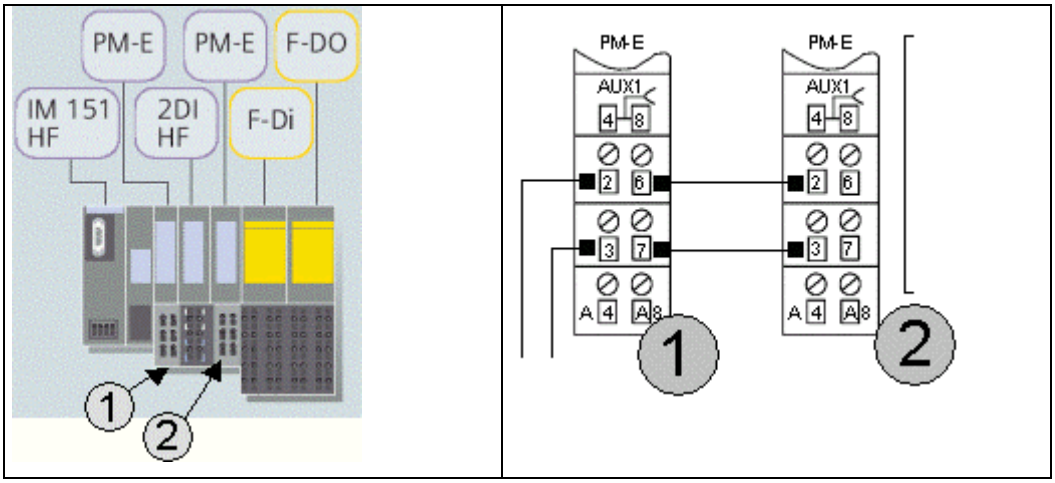
First check the addresses set at the hardware components listed below:

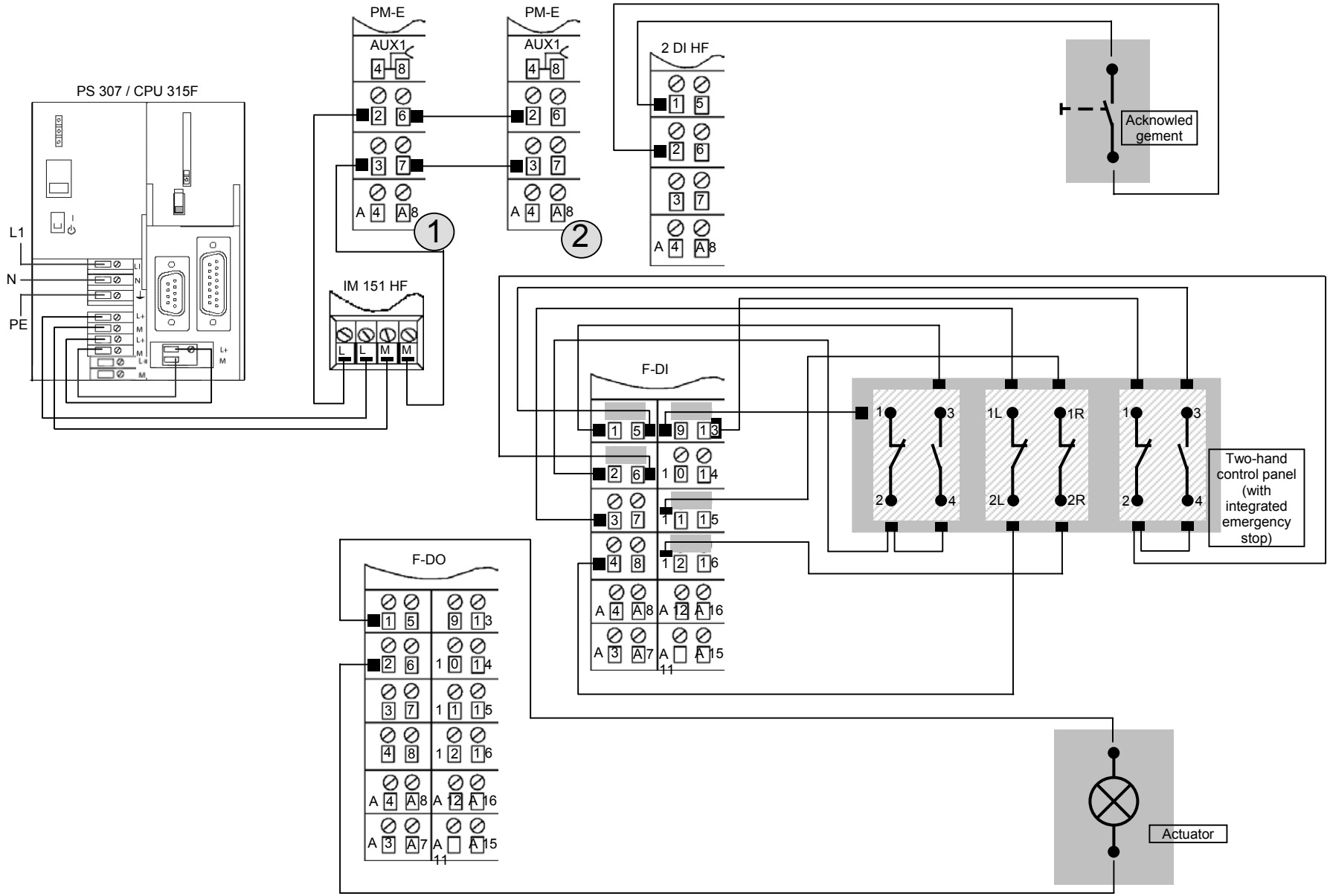
Hardware component	Address to be set	Note
IM 151 High Feature	6 (PROFIBUS address)	Can be changed.
F-DI	Switch position: 1111111110	The PROFIsafe addresses are automatically assigned during configuring the failsafe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure 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 STEP7.
F-DO	Switch position: 1111111101	

Note The DP interface of the CPU 315F has to be connected to 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.

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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).

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Inputs/outputs used

No.	HW 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 1.0	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

Prerequisite: The inputs and outputs have the default values specified under “Inputs/outputs used”.

No.	Instruction	Response	Note
		A 7.0	
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 200S

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:

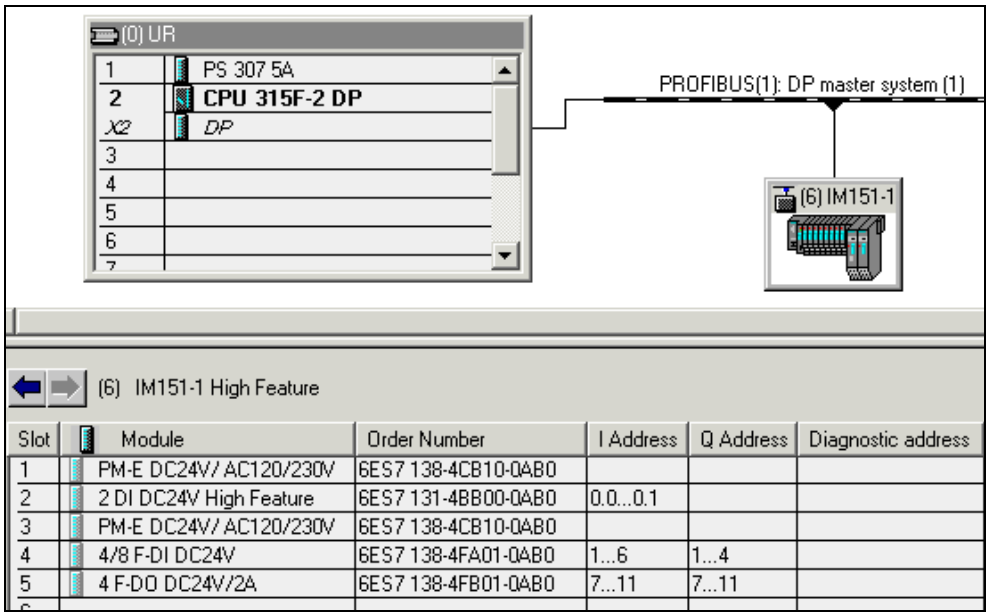
Warning

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.

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

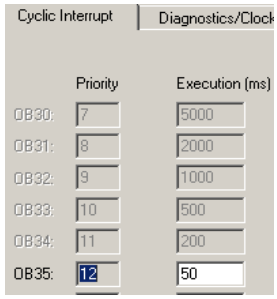
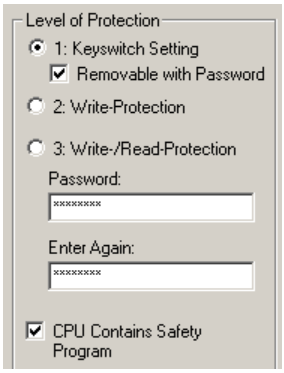
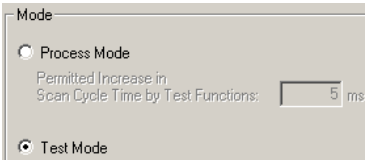
Overview picture



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

Settings of the CPU 315F-2DP

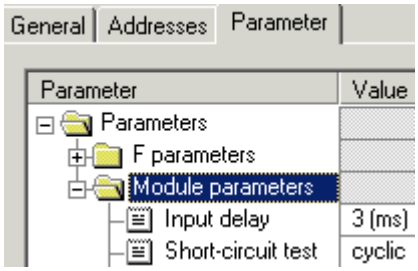
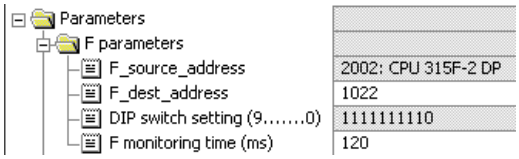
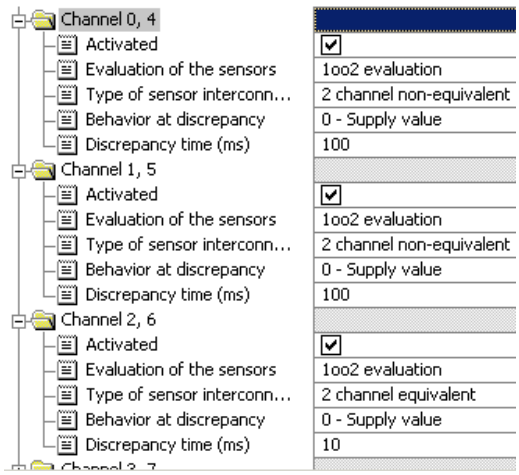
The settings are displayed after double-clicking “CPU 315F-2 DP” (see “Overview picture”).

Screenshot	Note
	Default value: 100 ms. It has to be observed that the F module 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.

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Settings of the failsafe F-DI

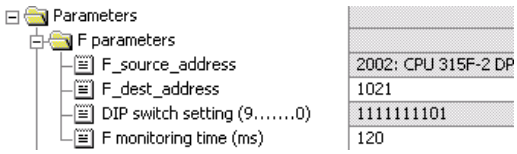
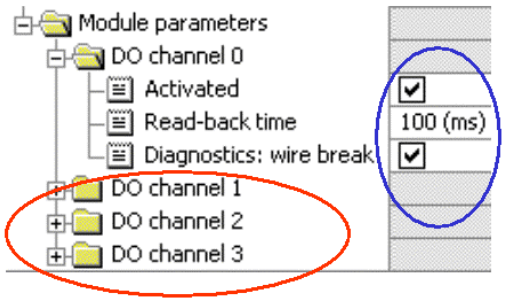
The settings are displayed after double-clicking “4/8 F-DI DC24V” (see “Overview picture”).

Screenshot	Note
	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.
	<u>DIP switch settings</u> This value has to be set on the module (F-DI). <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.
	Also in the “Parameter” tab. During 1oo2 evaluation only the first-mentioned channel (0, 1, 2) is used in each case, the channels 4, 5, 6 cannot be accessed. <u>Channel 0, 4 and channel 1, 5</u> 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. <u>Channel 2, 6</u> Emergency stop <u>All other channels (3, 7)</u> Deactivate

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Settings of the failsafe F-DO

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

Screenshot	Note
	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.
	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.

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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)	approx. 5 ms	Standard and safety program
Max. runtime of the safety program	11 ms	Calculation with the Cotia table. Chapter 2 specifies where to find it.

Sample Code

Preliminary remark

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 password used for the safety-relevant part is **siemens**.

Use of the STEP7 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.

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Download

- 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 to the S7-CPU
- Switch to the SIMATIC Manager
- Select the “Blocks” folder
- Menu “Options“ -> Edit safety program
- Click the ”Download” button.

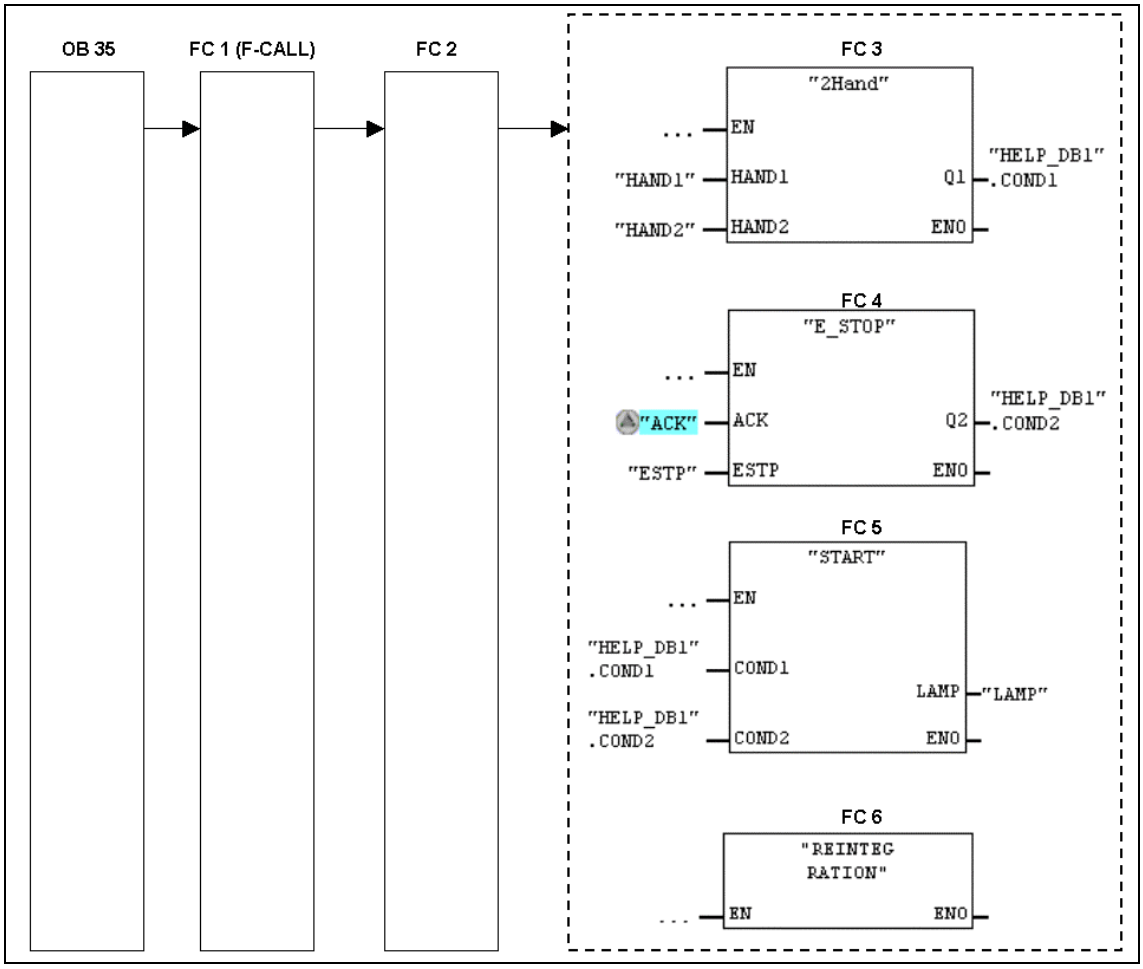
The sample code with the listed configurations enables the following:

- 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 flow

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 program sequence of the failsafe program is shown below:



F-CALL (FC 1)

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 FC 2).

FC “2H_and_ESTP” (FC 2)

FC 2 ensures the modular setup of the safety program.

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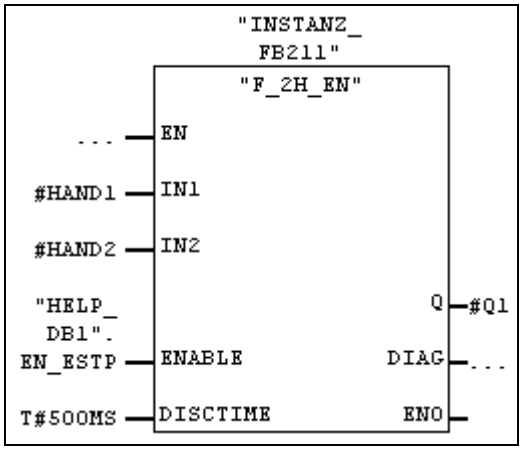
The “two-hand control” functionality is basically implemented in the function blocks FC3, FC4 and FC5, FC6 called by FC2.

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	Ditto	
Output parameter	**Assignment**	**Function**
HELP_DB1.COND1	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.

Conside the following scenario:

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1. Both exclusive OR sensors are pressed and will be pressed all along.
2. The emergency stop is pressed.
3. The emergency stop is unlocked.
4. An acknowledgement is done.

Eve 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: • 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.
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

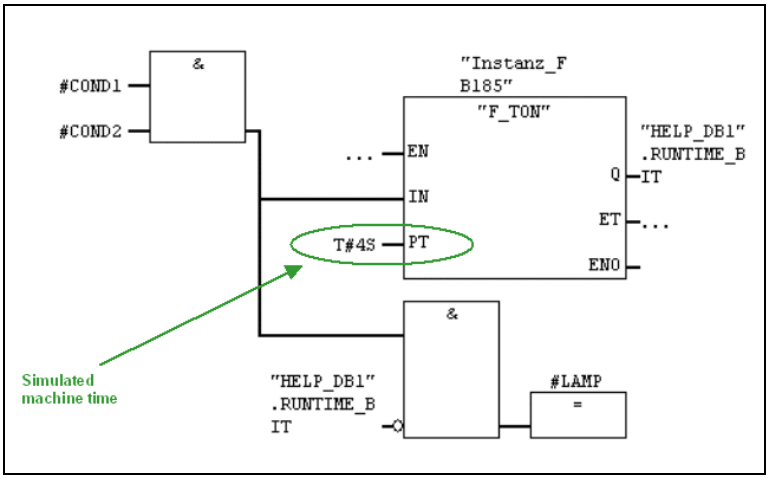
FC “START” (FC 5)

Input parameter	Assignment	Function
HELP_DB1.COND1	Bit from F-DB	Condition for the start of the “machine” from FC3
HELP_DB1.COND2	Ditto	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.

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Note

The bits from DB “HELP_DB1” (DB1) mentioned here and used in the STEP 7 program are only used for buffering.

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FC “REINTEGRATION” (FC 6)

Network 4 of FC 2 calls FC 6 where the reintegration is realized 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.

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Evaluation/Feedback

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From: Name: Office: Location: Telephone: E-mail:	If you find typographical errors while reading this document, please use this form to let us know. We would also appreciate any ideas and suggestions for improvements.

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Evaluation of the documentation

Very good ❑ **Good** ❑

Not so good ❑ **Because:**

.....

Subject well chosen ❑ **Wrong subject** ❑

Scope sufficient ❑ **Too detailed** ❑ **Too superficial** ❑

Easy to understand ❑ **Partly easy to understand** ❑ **Impossible to understand** ❑

Good presentation ❑ **Average presentation** ❑**Poor presentation** ❑

Often used ❑ **Rarely used** ❑ **Used once and never again** ❑

Time saving using this documentation in comparison with previous documentation:

No saving ❑ **approx. 5%** ❑ **approx. 10%** ❑ **other.....%**

Suggestions: .....