Distributed Use of a Safety Light Curtain on a SIMATIC F-CPU, with parallel Muting Using an F-CPU

SIMATIC Safety Integrated for Factory Automation

Application Description • April 2012

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Safety Light Curtain, parallel Muting Using F-CPU

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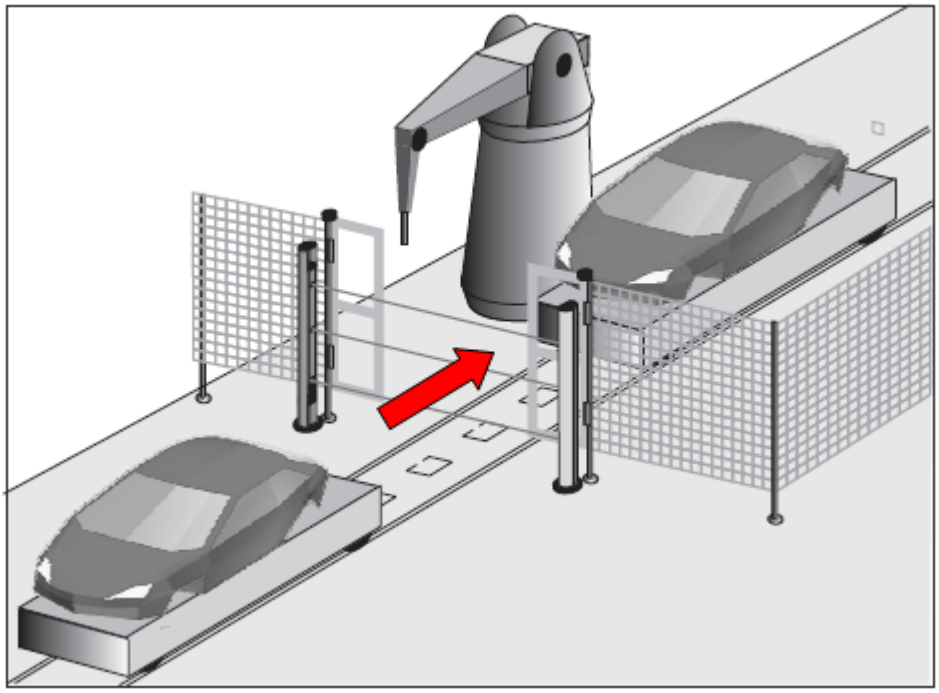
1 Problem

1.1 Starting point

Workpieces are machined in an assembly cell (hazardous area). The assembly cell has an entry via which workpieces are transported into the hazardous area.

Figure 1-1 shows an example of such a situation.

Figure 1-1



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1.2 Problem

Access to the assembly cell is to be protected with a safety light curtain. When the protective field is violated (interruption of the light curtain), a distinction is to be made between the following situations:

- Transport of workpieces: Do not stop the machine
- No transport of workpieces: Stop the machine

For monitoring, a SICK safety light curtain is to be used in conjunction with a fail-safe SIMATIC S7 CPU (F-CPU).

2 Solution

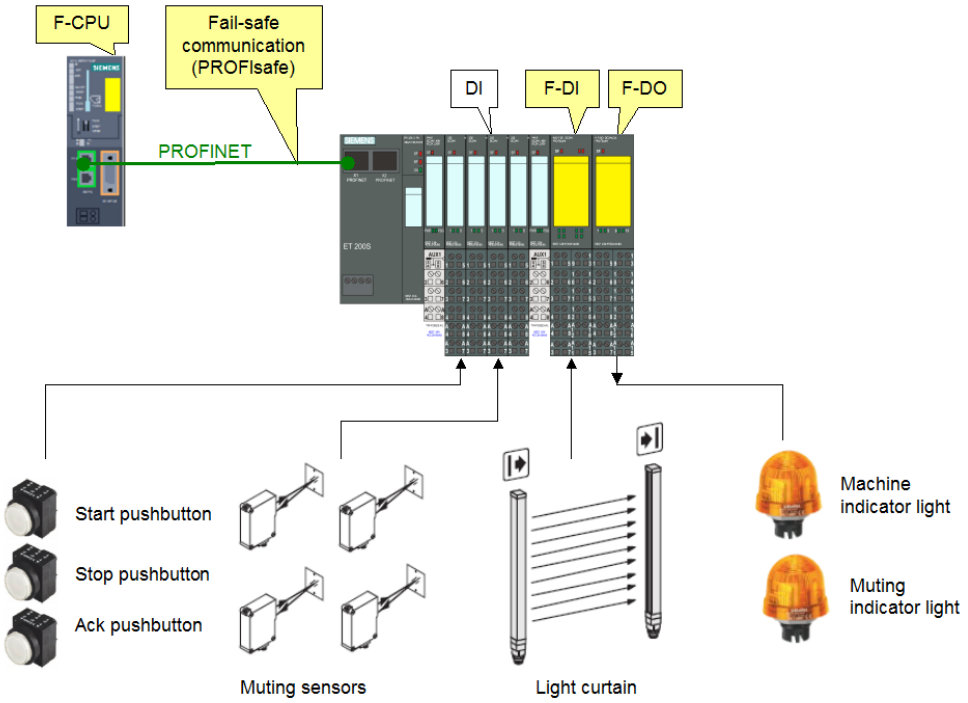
2.1 Overview

2.1.1 Core components

Figure 2-1 schematically shows the most important components of the application example:

- SIMATIC F-CPU (IO controller)
- SIMATIC ET 200S distributed station (IO device) with: DI, F-DI, F-DO
- SICK safety light curtain
- SICK photoelectric retro-reflective sensors as muting sensors

Figure 2-1



Note

In the application example, a machine is simulated by an indicator light that is connected to a fail-safe digital output module (F-DO). In the following, the term “machine” is used in place of this indicator light.

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2.1.2 Core functionality

The following functions are implemented in the application example:

- Switching a machine (indicator light)
- Stop of the machine (indicator light) when the protective field is violated
- Muting via F-CPU
- Reintegration of passivated F-I/O (F-DI, F-DO)

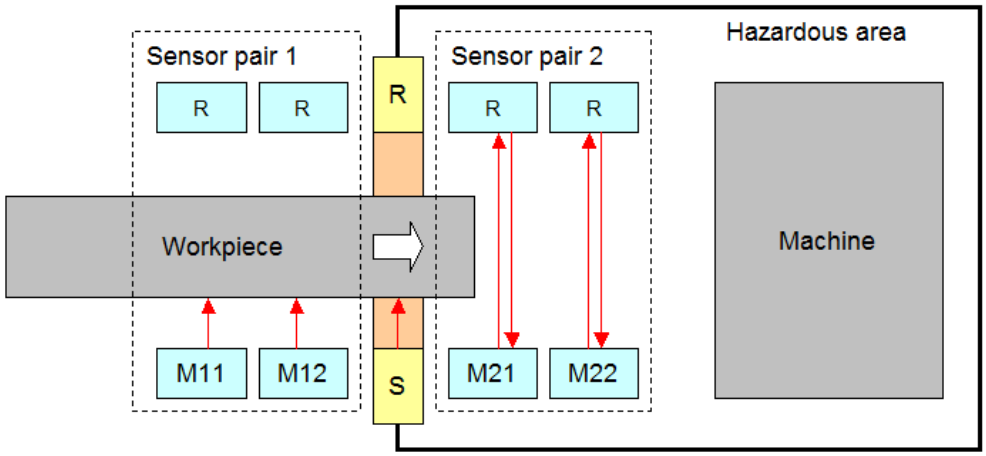
Parallel muting with 4 muting sensors (2 sensor pairs) is implemented in the application example. Photoelectric retro-reflective sensors are used as muting sensors.

For the transport direction of the workpiece, both directions are permitted:

- From sensor pair 1 to sensor pair 2 (“forward”)
- From sensor pair 2 to sensor pair 1 (“backward”)

Figure 2-2 shows the principle for the “forward” direction (top view).

Figure 2-2



Explanations

S: Light curtain sender

R: Light curtain receiver

Silhouetted in orange: Protective field of the light curtain

M: Muting sensor (photoelectric retro-reflective sensor)

R: Reflector of the photoelectric retro-reflective sensor

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2.2 Hardware and software components used

The application example was created with the following components.

2.2.1 Hardware components

Manufactured by Siemens

Table 2-1

Component	Type	Qty.	Order no.
Centralized configuration			
DIN rail	Length: 585 mm	1	6ES7390-1AF85-0AA0
Fail-safe S7 CPU (F-CPU)	CPU 315F-2PN/DP	1	6ES7315-2FJ14-0AB0
Micro Memory Card (MMC)	2 MB	1	6ES7953-8LLxx-0AA0
Distributed configuration			
Standard sectional rail	35 mm, length: 483 mm	1	6ES5710-8MA11
IM of the ET200S	IM151-3 PN HF	1	6ES7151-3BA23-0AB0
Micro Memory Card (MMC)	128 Kbytes	1	6ES7953-8LG20-0AA0
PM-E	PM-E 24..48 VDC 24..230 VAC	2	6ES7138-4CB11-0AB0
DI	2DI 24 VDC HF	4	6ES7131-4BB01-0AA0
F-DI	4/8 F-DI 24 VDC	1	6ES7138-4FA04-0AB0
F-DO	4 F-DO 24 VDC/2A	1	6ES7138-4FB03-0AB0
Terminal module for F-DI, F-DO	30mm, screw-type terminals, AUX1	2	6ES7 193-4CF40-0AA0
Terminal module for PM-E	Screw-type terminals, AUX	2	6ES7 193-4CC20-0AA0
Terminal module for DI	Screw-type terminals, AUX	4	6ES7 193-4CA40-0AA0
Pushbutton for start, acknowledgement (NO)	SIRIUS pushbutton, indicator light	2	3SB2, 3SB3, 3SF5
Pushbutton for stop (NC)		1	
Indicator light for: Machine, muting		2	
Power supplies			
Power supply for SIMATIC	PS307 24V/5A	1	6ES7307-1EA01-0AA0
Power supply for light curtain	PS307 24V/5A	1	6ES7307-1EA01-0AA0

Manufactured by SICK

Table 2-2

Component	Type	Qty.	Part no.
Light curtain			
Safety light curtain SICK C4000 Eco Sender, M12	C40S-0303AA310	1	1027464
Safety light curtain SICK C4000 Eco Receiver, M12	C40E-0303AN310	1	1027465
Connecting cable with connector	DOL-1205-G02M	2	6008899
Muting sensors			
Photoelectric retro-reflective sensor, red-emitting LED, with potentiometer, PNP, M12 connector, 4-pin	WL27-3P2431	4	1027982
Reflector	PL30A	4	1002314
Connecting cable	DOL-1204-G02M	4	6009382

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2.2.2 Software components

Siemens software components

Table 2-3

Component	Type	Order no.
STEP 7 Professional V11	SP2	6ES7822-1A.01-..
STEP 7 Safety Advanced V11	---	6ES7833-1FA11-0YA5

2.2.3 Downloads for the application example

The table contains all downloads of the application example (/2/).

Table 2-4

Download	File name	Contents
Documentation	58793869_LIGHT_CURTAIN_DOKU_V10_en.pdf	Description for the application example
Code	58793869_LIGHT_CURTAIN_CODE_V10.zip	STEP 7 project

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2.3 Advantages

SIMATIC Safety Integrated for Factory Automation

In SIMATIC, standard applications and safety-related applications can be implemented with a single system (hardware and software).

This has the following advantages:

- One controller for both applications
- Uniform engineering for both applications
- One bus system for communication for both applications
- Uniform, centrally accessible diagnostics for both applications
- Easy connection of the safety program to the standard user program

Special instructions are available for programming safety-related applications. Examples: Two-hand monitoring, discrepancy analysis, muting, EMERGENCY STOP, safety door monitoring, feedback loop monitoring.

SICK safety light curtains (/1/)

SICK offers a wide range of safety light curtains:

- Cost-saving complete systems with integrated functions
- Rapid commissioning
- Individual adaptation using CDS user software or customer-specific presettings from the factory
- Can be used with large temperature fluctuations as well as in wet areas
- Reduced engineering and stock-holding costs due to a universal interface
- Integrated PSDI mode with defined PSDI window provides up to 30% higher productivity

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2.4 Required knowledge

The application example shows the principle of how a light curtain can be operated on an F-CPU. It does not describe details. Therefore, basic knowledge of the following topics is required:

- Software for SIMATIC controllers:
  - STEP 7 V11 (/22/)
  - STEP 7 Safety Advanced V11 (/9/)
- SIMATIC S7 modular controllers: S7-300 (/3/)
- SIMATIC ET 200S distributed I/O system (/6/)
- ET 200S IM151-3 PN HF interface module (/16/)
- ET 200S fail-safe engineering (/8/)
- PROFINET industrial communication (/20/)
- SICK C4000 safety light curtain (/1/)
- SICK photoelectric retro-reflective sensor (/1/)

3 Basics

3.1 SICK C4000 Eco safety light curtain

The application example focuses on the use of a safety light curtain in conjunction with SIMATIC Safety Integrated for Factory Automation.

A safety light curtain from SICK is used as an example.

This chapter describes the basics of the SICK C4000 Eco safety light curtain (/1/).

3.1.1 Field of application

The C4000 safety light curtain is electro-sensitive protective equipment. The device is suitable for:

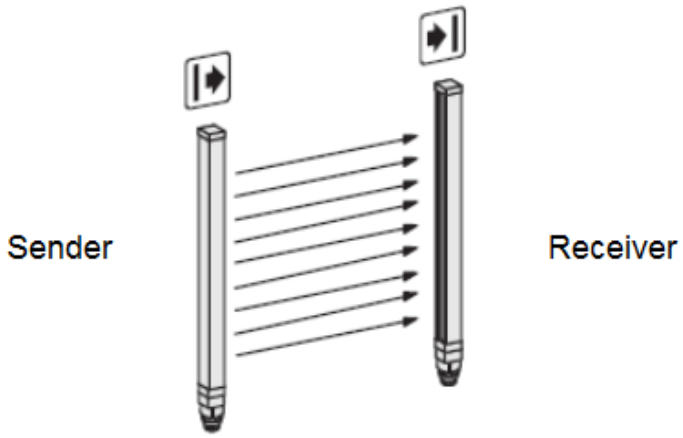
- Hazardous point protection (finger and hand protection)
- Hazardous area protection
- Access protection

3.1.2 Principle of operation

The C4000 safety light curtain consists of a sender and a receiver (Figure 3-1). Between these two units is the protective field, defined by the protective field height and the protective field width.

Sender and receiver automatically synchronize themselves optically. An electrical connection between the two components is not necessary.

Figure 3-1



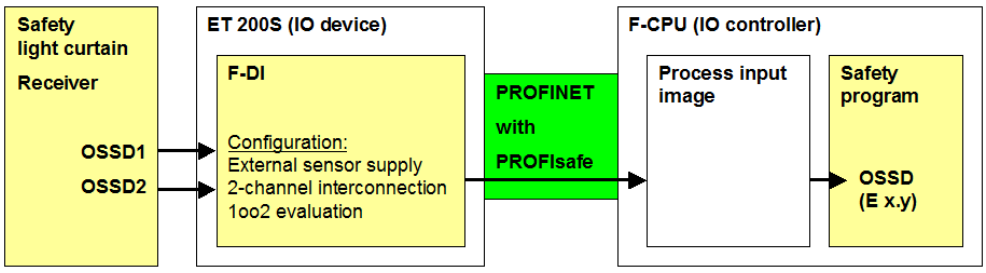
The receiver provides two safety-relevant switching outputs (OSSD1, OSSD2). When the protective field is violated, both switching outputs will switch off (“0” signal).

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3.1.3 Connection of light curtain and SIMATIC F-CPU

The receiver of the light curtain provides the OSSD1 and OSSD2 signals. The signals are connected to a fail-safe digital input module (F-DI) of the ET 200S and evaluated in this module. The F-CPU reads in the result (OSSD) via the process input image. Figure 3-2 shows the principle.

Figure 3-2



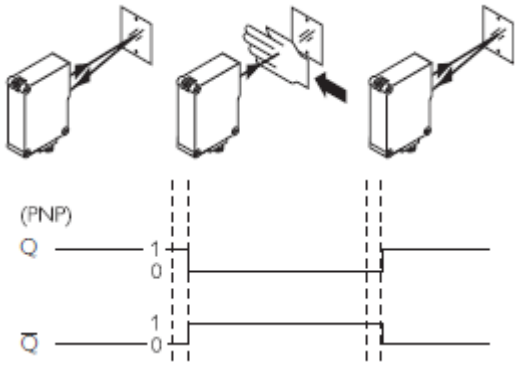
When the protective field is violated (interruption of the light curtain), the F-CPU will read a “0” signal (OSSD) from the F-DI. The safety program in the F-CPU will then cause the stop of the machine.

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3.2 SICK WL27-3 photoelectric retro-reflective sensor

SICK photoelectric retro-reflective sensors of the WL27-3 series are used as muting sensors. Figure 3-3 shows the principle of operation (/1/).

Figure 3-3



In the application example, the “Q” signal is evaluated:

- Light beam not interrupted:
  Muting sensor provides “0” signal (sensor inactive)
- Light beam interrupted:
  Muting sensor provides “1” signal (sensor active)

4 Functional Mechanisms

4.1 Functionality of the application example

4.1.1 Overview

See chapter 2.1.2.

4.1.2 Stop the machine

The machine will be stopped when the following events occur:

- The stop pushbutton is pressed.
- An error has occurred:
  - Protective field violation when no muting is active
  - Passivation of F-DI (discrepancy error for OSSD1 and OSSD2, ...)
  - Passivation of F-DO (muting indicator light wire break, ...)
  - Error when muting (*1)

(*1):

Possible causes of errors during muting:

- A monitoring time is not complied with.
- The transported workpiece does not have the required minimum length.

Muting has the following (parameterizable) monitoring times:

- Maximum muting duration
- Discrepancy time for sensor pair 1 (M11, M12)
- Discrepancy time for sensor pair 2 (M21, M22)

4.1.3 Start the machine

The start of the machine depends on how it was previously stopped. Chapter 4.1.2 describes possible causes of a stop of the machine.

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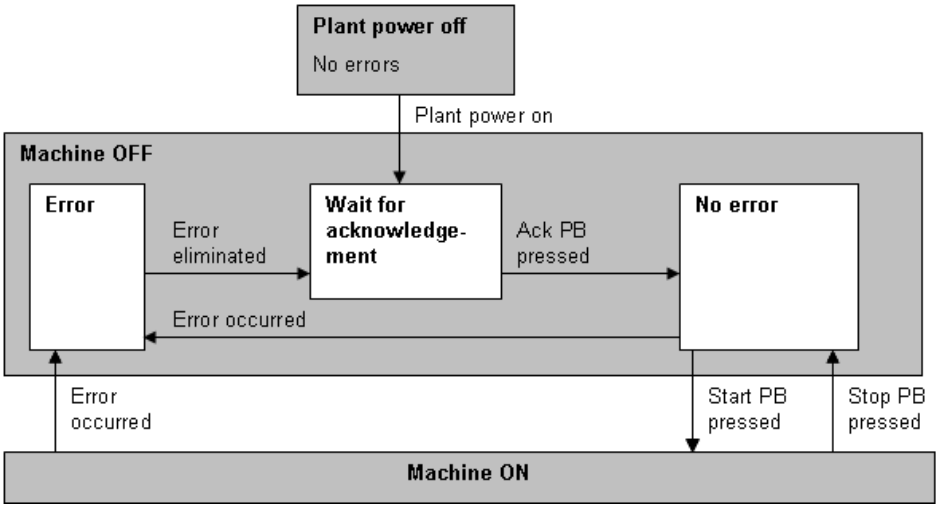
Start after stop pushbutton

The machine will only be restarted when the following conditions are met.

- No muting sensor is active.
- The start pushbutton is pressed and no error has occurred.

Figure 4-1 shows the correlations.

Figure 4-1



Start after error: Protective field violation

The machine will only be restarted when the following conditions are met.

- No muting sensor is active.
- The protective field is unoccupied.
- The acknowledgement pushbutton is pressed.
- The start pushbutton is pressed and no error has occurred.

Figure 4-1 shows the correlations.

Start after error: Passivation of F-DI (discrepancy error for OSSD1 and OSSD2, ...)

The machine will only be restarted when the following conditions are met.

- No muting sensor is active.
- The error on the F-DI has been eliminated.
- The acknowledgement pushbutton is pressed.
- The start pushbutton is pressed and no error has occurred.

Figure 4-1 shows the correlations.

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Start after error: Muting

The machine will only be restarted when the following conditions are met.

- No muting sensor is active.
- The cause of the error during muting has been eliminated.
- The acknowledgement pushbutton is pressed.
- The start pushbutton is pressed and no error has occurred.

Figure 4-1 shows the correlations.

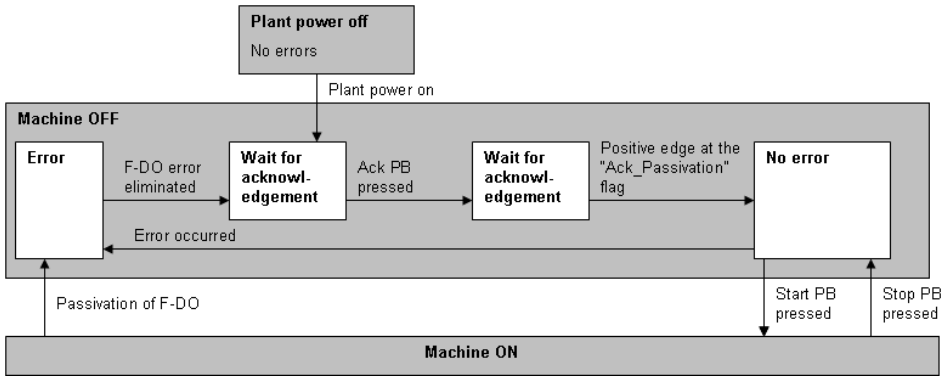
Start after error: Passivation of F-DO (muting indicator light wire break, ...)

The machine will only be restarted when the following conditions are met.

- No muting sensor is active.
- The error on the F-DO has been eliminated.
- The acknowledgement pushbutton is pressed.
- A positive edge is generated at the “Ack_Passivation” flag.
- The start pushbutton is pressed and no error has occurred.

Figure 4-2 shows the correlations.

Figure 4-2



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4.1.4 Operation without muting

The figure below shows the time relationships:

- Start and stop of the machine using pushbuttons
- Stop due to protective field violation
- Start when the protective field is unoccupied again and acknowledgement has been made.

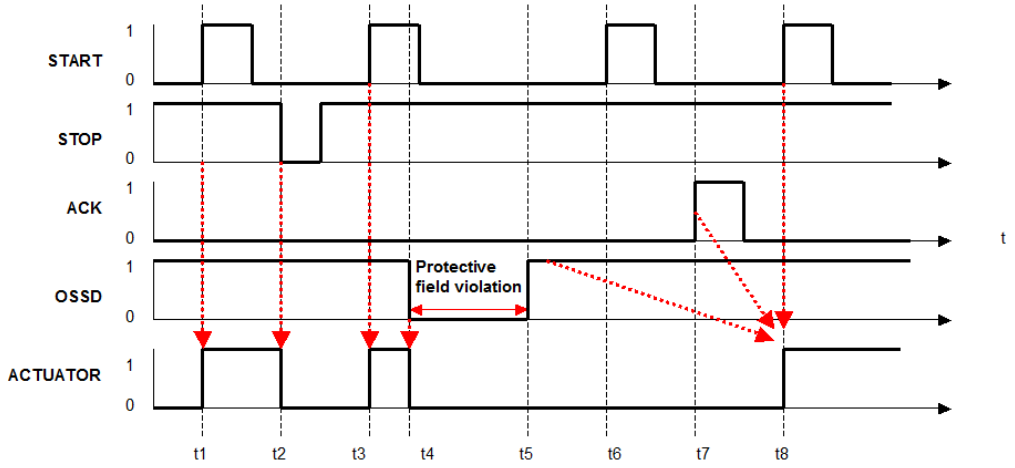
Explanation of the signals shown in Figure 4-3.

Table 4-1

Signal	Hardware	Explanations
START	Start pushbutton	Positive edge: Start the machine
STOP	Stop pushbutton	“0” signal: Stop the machine
ACK	Acknowledgement pushbutton	Positive edge: Acknowledgement
OSSD	Light curtain	“0” signal: Protective field violation
ACTUATOR	Machine (indicator light)	---

Time characteristic of the signals:

Figure 4-3



Explanation of the above times tx:

Table 4-2

Time	Explanations
t1	Start the machine
t2	Stop the machine
t3	Start the machine
t4	Protective field violation: Stop the machine
t5	Protective field unoccupied again
t6	Machine cannot be started due to missing acknowledgement
t7	Acknowledgement
t8	Start the machine

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4.1.5 Operation with muting

Definition of muting

Muting is the intentional suppression of the protective function of light curtains.

Muting can, for example, be used to transport workpieces into the hazardous area monitored by a light curtain without stopping the machine.

Muting is initiated by signals from muting sensors.



DANGER

The position of the muting sensors and correct integration into the production process must ensure that no person enters the hazardous area while muting is active.

Muting

Parallel muting with 4 muting sensors is implemented in the application example. Photoelectric retro-reflective sensors are used as muting sensors.

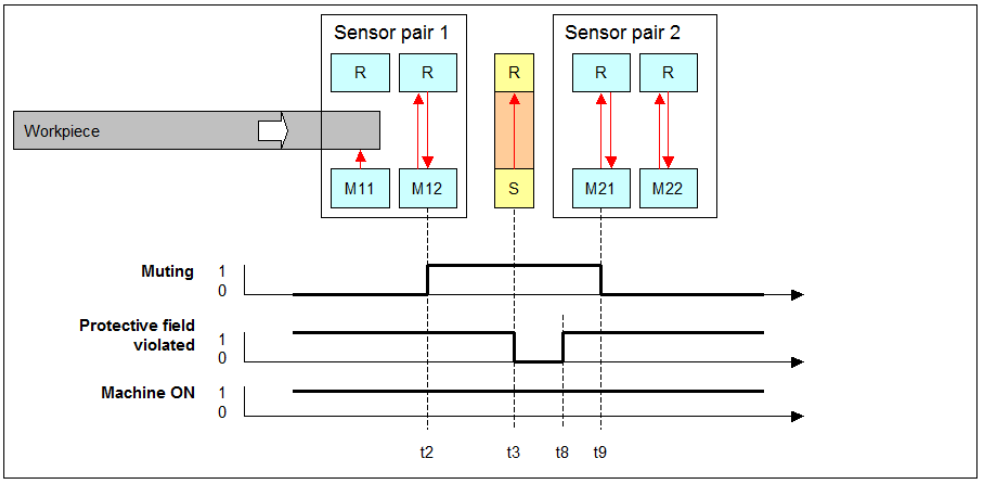
Muting works for both transport directions (parallel muting):

- “forward”: The workpiece is transported from sensor pair 1 to sensor pair 2
- “backward”: The workpiece is transported from sensor pair 2 to sensor pair 1

“forward” transport direction

Figure 4-4 shows the principle for the “forward” transport direction.

Figure 4-4



Muting is initiated when both conditions are met:

- Sensor M12 is activated (light beam is interrupted)
- The two sensors M11 and M12 are activated within a parameterized time (discrepancy time for sensor pair 1).

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If no error has occurred, muting is terminated when:

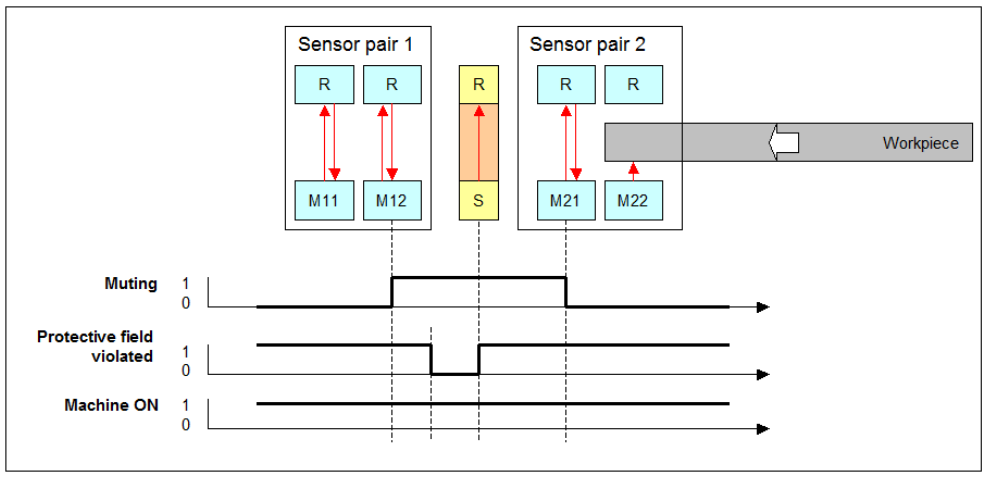
- Sensor M21 is deactivated (light beam no longer interrupted)

Note: Chapter 4.1.6 provides a detailed description of the muting sequence.

“backward” transport direction

Figure 4-5 shows the principle for the “backward” transport direction.

Figure 4-5



Muting is initiated when both applies:

- Sensor M21 is activated (light beam is interrupted)
- The two sensors M21 and M22 are activated within a parameterized time (discrepancy time for sensor pair 2).

If no error has occurred, muting is terminated when:

- Sensor M12 is deactivated (light beam no longer interrupted)

Abnormal termination of muting

If an error has occurred, muting will be terminated and the machine will be stopped.

Errors that may occur during muting:

- Monitoring times are not complied with:
  - Discrepancy time for sensor pair 1 (M11, M12)
  - Discrepancy time for sensor pair 2 (M21, M22)
  - Maximum muting duration
- The muting indicator light fails.
- The workpiece does not have the required minimum length (see next section).

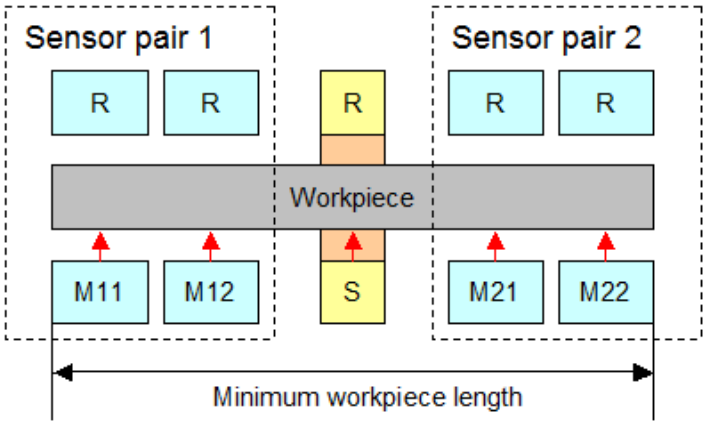
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Correlation: Workpiece length and distance of sensors M11 and M22

For error-free muting, the workpiece must have a minimum length:

- “forward” transport direction: All 4 muting sensors must be active simultaneously before sensor M11 is deactivated.
- “backward” transport direction: All 4 muting sensors must be active simultaneously before sensor M22 is deactivated.

Figure 4-6



4.1.6 Muting sequence

This chapter describes step by step how a workpiece is transported into the hazardous area.

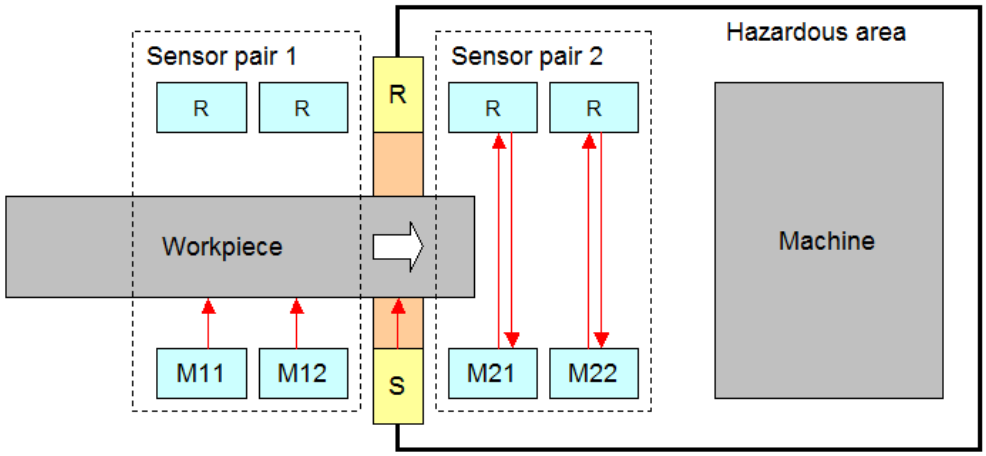
It describes the “forward” transport direction.

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Plant

Figure 4-7 shows the arrangement of muting sensors and light curtain.

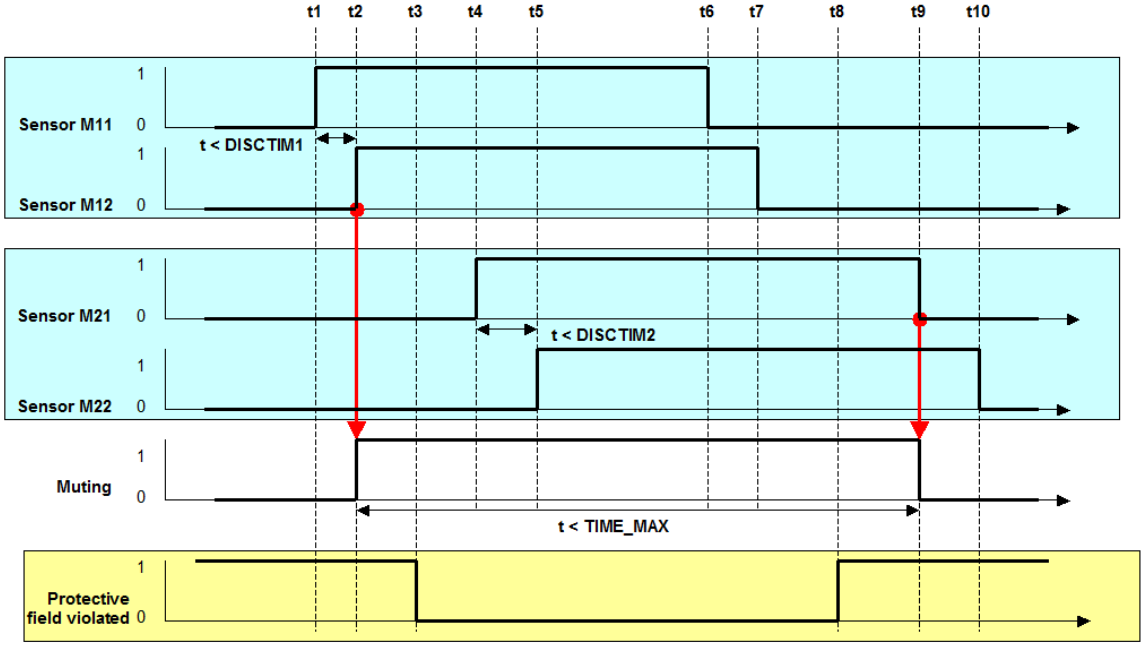
Figure 4-7



Signal characteristics

Figure 4-8 shows the signal characteristics when the workpiece is transported through the plant. Table 4-3 describes the times t1 to t10.

Figure 4-8



Monitoring times:

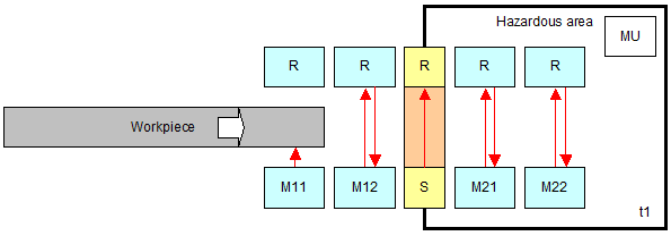
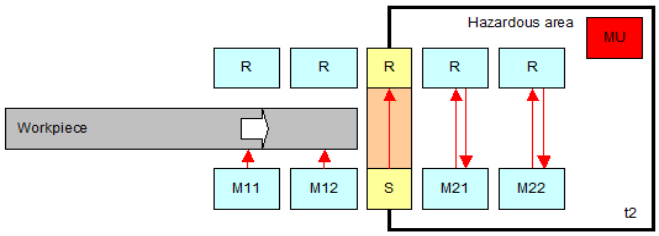
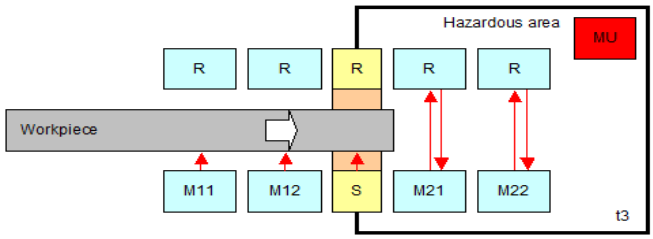
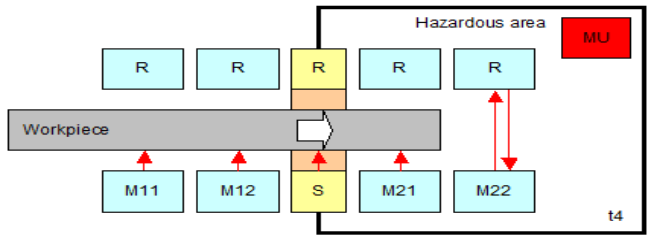
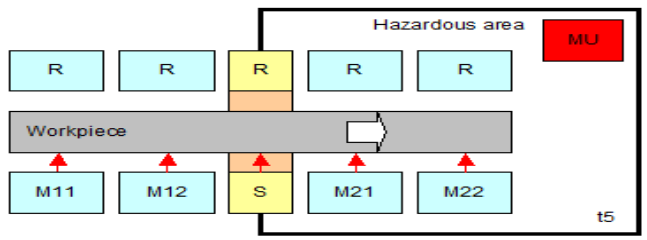
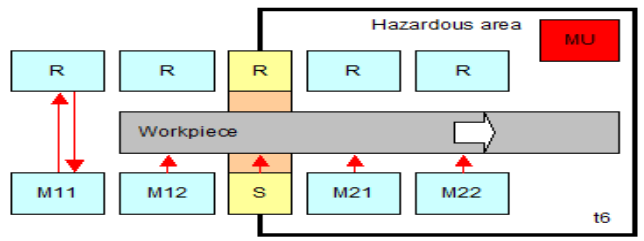
- DISCTIM1: Discrepancy time for sensor pair 1 (M11, M12)
- DISCTIM2: Discrepancy time for sensor pair 2 (M21, M22)
- TIME_MAX: Maximum muting duration

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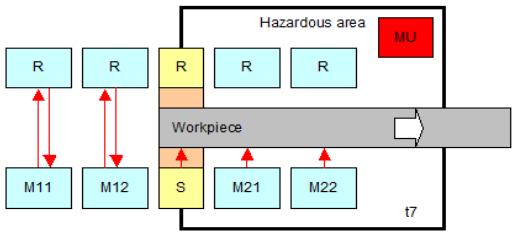
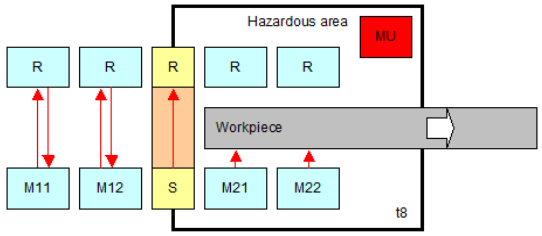
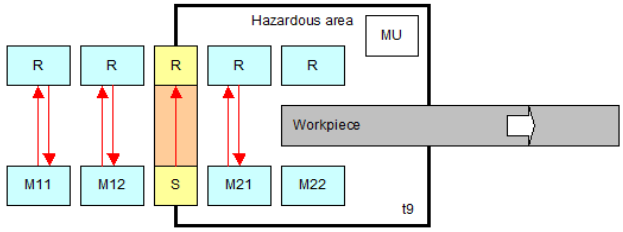
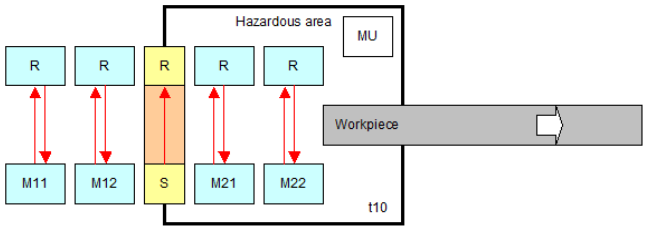
Detailed muting sequence

Table 4-3 shows the transport of the workpiece through the plant at different times.

Table 4-3

tx	Workpiece position	Remarks
t1		Muting starts when both applies: • Sensor M12 is activated • the two sensors M11 and M12 are activated within DISCTIM1
t2		
t3		The workpiece violates the protective field and the machine is not stopped.
t4		Muting is maintained when both applies: • The two sensors M21 and M22 are activated within DISCTIM2 • all four sensors are active simultaneously before M11 is deactivated
t5		
t6		

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tx	Workpiece position	Remarks
t7		
t8		
t9		Muting ends when the following applies: • Sensor M21 is deactivated
t10		

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Explanations

tx: Time x (Figure 4-8)

S: Light curtain sender

R: Light curtain receiver

M: Muting sensor (photoelectric retro-reflective sensor)

R: Reflector of the photoelectric retro-reflective sensor

MU: Muting indicator light (off: white background, on: red background)

Sensor active: Light beam interrupted

Sensor inactive: Light beam not interrupted

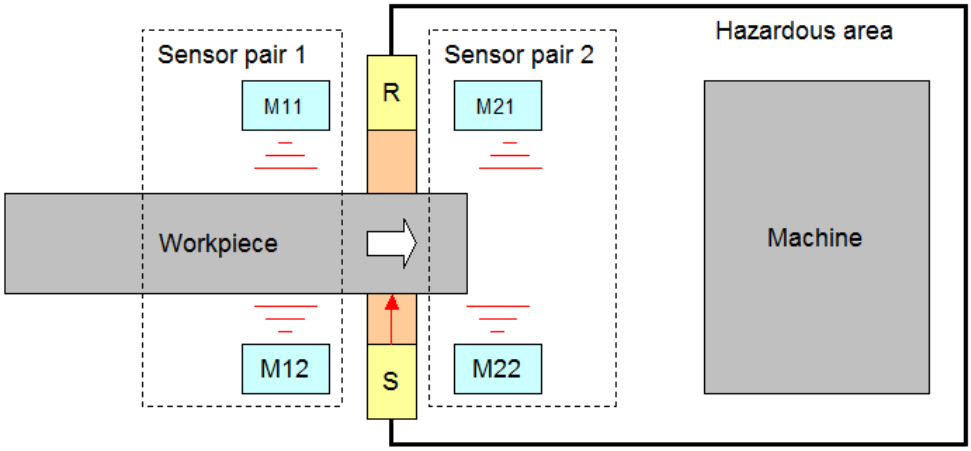
4.1.7 Alternative muting sensor arrangements

In principle, the application example can also be used for other arrangements or other types of muting sensors.

Four opposing muting sensors

Diffuse reflection light scanners or inductive proximity sensors can be used as an alternative to the photoelectric retro-reflective sensors. The two sensors of a sensor pair are then arranged opposite to one another. This offers advantages when there is limited space on the plant.

Figure 4-9



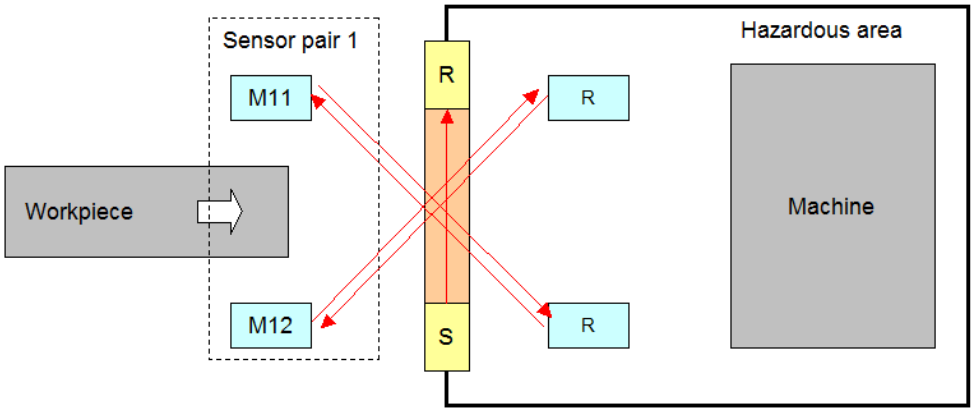
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Two diagonally opposite muting sensors

The application example can also be used for the following arrangement:

- 2 muting sensors (photoelectric retro-reflective sensors) instead of 4
- Arranged diagonally opposite

Figure 4-10



Muting sequence:

- When the two muting sensors M11 and M12 are activated by the workpiece within DISCTIM1 (*1) (switch to “1” signal), muting will start.
- As long as both muting sensors M11 and M12 are activated, muting remains active.
- Muting will only be terminated if one of the two muting sensors M11 and M12 is deactivated (switches to “0” signal).
- Muting must be terminated within TIME_MAX (*2).

(*1): DISCTIM1: Discrepancy time for sensor pair 1 (M11, M12)

(*2): TIME_MAX: Maximum muting duration

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4.1.8 Muting indicator light monitoring

By being permanently illuminated, the indicator light signals to the operating staff that muting has been initiated and therefore the protective function has been bridged.

During muting, the muting indicator light is monitored for wire break. If a wire break is detected, muting will be terminated and the machine will be stopped.

Before the machine can be restarted, the wire break must be corrected and the acknowledgement pushbutton must be pressed.

4.1.9 Reintegration of F-I/O

If an error occurs in a component of the F-I/O, this results in the passivation of this component. Once the error has been eliminated, the passivated component must be reintegrated.

In the application example, reintegration is implemented in different ways:

- F-DI: Reintegration without operator intervention
- F-DO: Reintegration with operator intervention (generation of a positive edge at the Ack_Passivation flag by controlling on the PG/PC)

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4.2 Code description (STEP 7 project)

4.2.1 User program structure

Preliminary remark

The code (STEP 7 project) contains the user program for the F-CPU.

The user program consists of:

- Standard user program
- Safety program

Overview

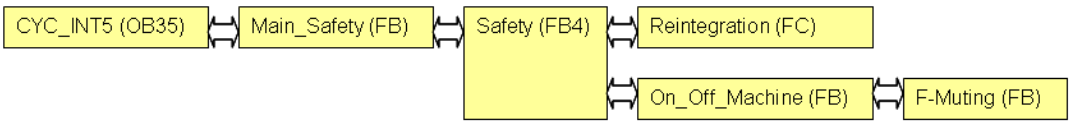
Standard user program:

Figure 4-11



Safety program:

Figure 4-12



Program blocks of the standard user program

Table 4-4

Program block	Function
Main	Calls the block: Start_Stop_Machine
Start_Stop_Machine	Requests the start or stop of the machine

Program blocks of the safety program

Table 4-5

Program block	Function
Safety	Calls the following blocks: • Reintegration • On_Off_Machine
Reintegration	Reintegrates passivated F-I/O
On_Off_Machine	Switches the machine (indicator light) on or off
Muting	Suppresses the protective function of the light curtain (MUTING instruction integrated in STEP 7 V11)

Password for the safety program

A password for the safety program is not used in the code (STEP 7 project) of the application example.

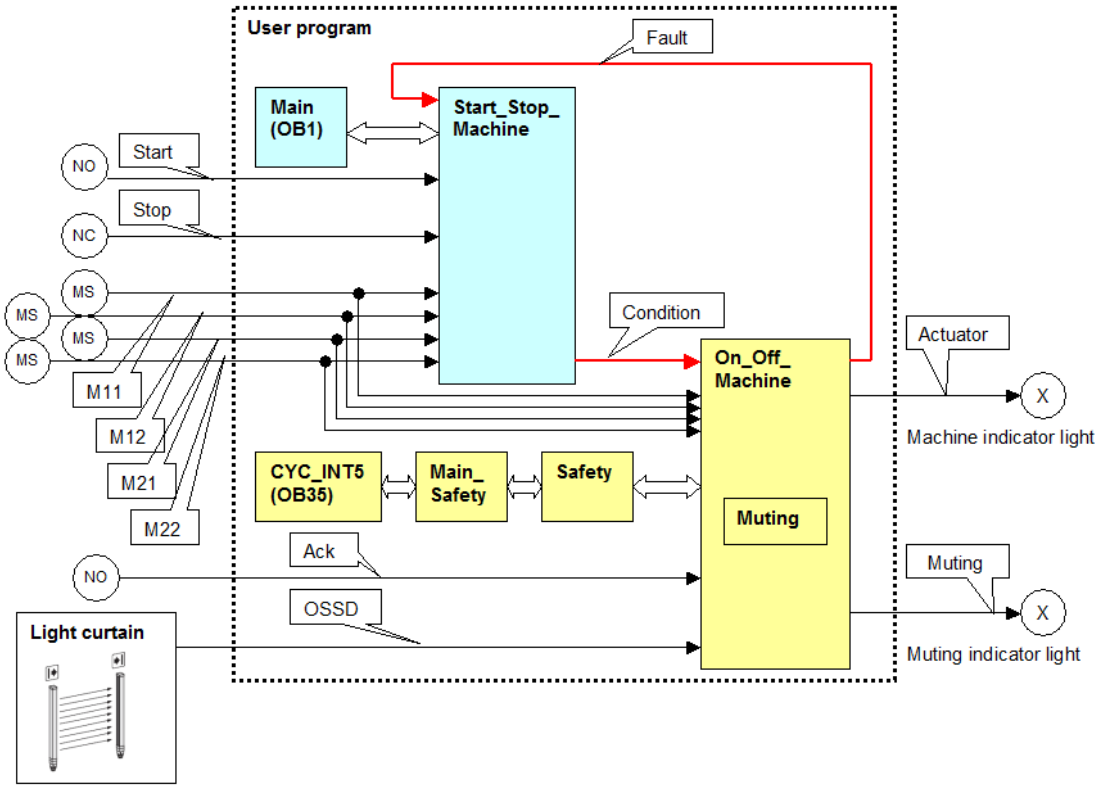
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4.2.2 Function circuit diagram

The figure shows the following correlations:

- Hardware / user program
- Standard user program / safety program

Figure 4-13



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Explanations

Contents of the legends in the figure: Variables of the user program

NO: Pushbutton (NO)

NC: Pushbutton (NC)

MS: Muting sensor, photoelectric retro-reflective sensor
("1": Object interrupts the light beam)

4.2.3 Program block: Start_Stop_Machine

Program

Standard user program

Function

The block generates an enable signal to start the machine. The enable signal is evaluated in the safety program where the machine is started and stopped.

The block evaluates:

- Start pushbutton
- Stop pushbutton
- Muting sensors (M11, M12, M21, M22)
- “Fault” signal from the safety program (On_Off_Machine)

The block provides to the safety program (On_Off_Machine):

- “Condition” signal

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Parameters of the function block

Figure 4-14

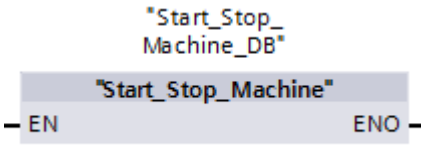


Table 4-6

Parameter	Declaration	Type	Description
---	---	---	---

Implementation

See chapter 4.2.5.

4.2.4 Program block: On_Off_Machine

Program

Safety program

Function

The block implements:

- Start and stop of the machine
- Call of the “MUTING” instruction (chapter 4.2.7)

The block evaluates:

- “Ack” signal from the acknowledgement pushbutton
- “OSSD” signal from the light curtain (collected via F-DI)
- “Condition” signal from the standard user program (Start_Stop_Machine)
- Muting sensors (M11, M12, M21, M22) via the “MUTING” instruction

The block provides to the standard user program:

- “Fault” signal

Parameters of the function block

Figure 4-15

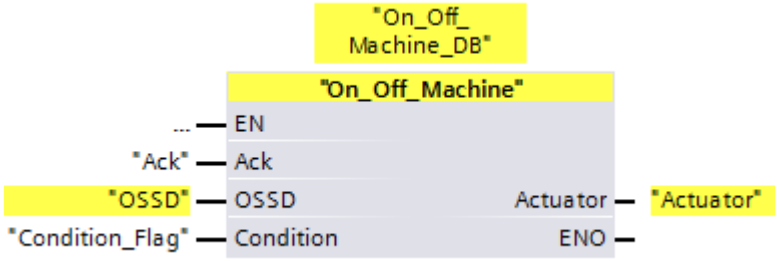


Table 4-7

Parameter	Declaration	Type	Description
Ack	IN	Bool	Signal from the acknowledgement pushbutton. Positive edge: The machine can be started again
OSSD	IN	Bool	Signal from the light curtain. “0” signal: Protective field violated
Condition (*1)	IN	Bool	Signal from the standard user program: Enable signal to start the machine “1” signal: Machine can be started “0” signal: Prevents the machine from starting.
Actuator	OUT	Bool	Signal to the machine indicator light. “1” signal: Start

(*1): “Condition” must be transferred to the safety program via a flag (“Condition_Flag”).

Implementation

See chapter 4.2.5.

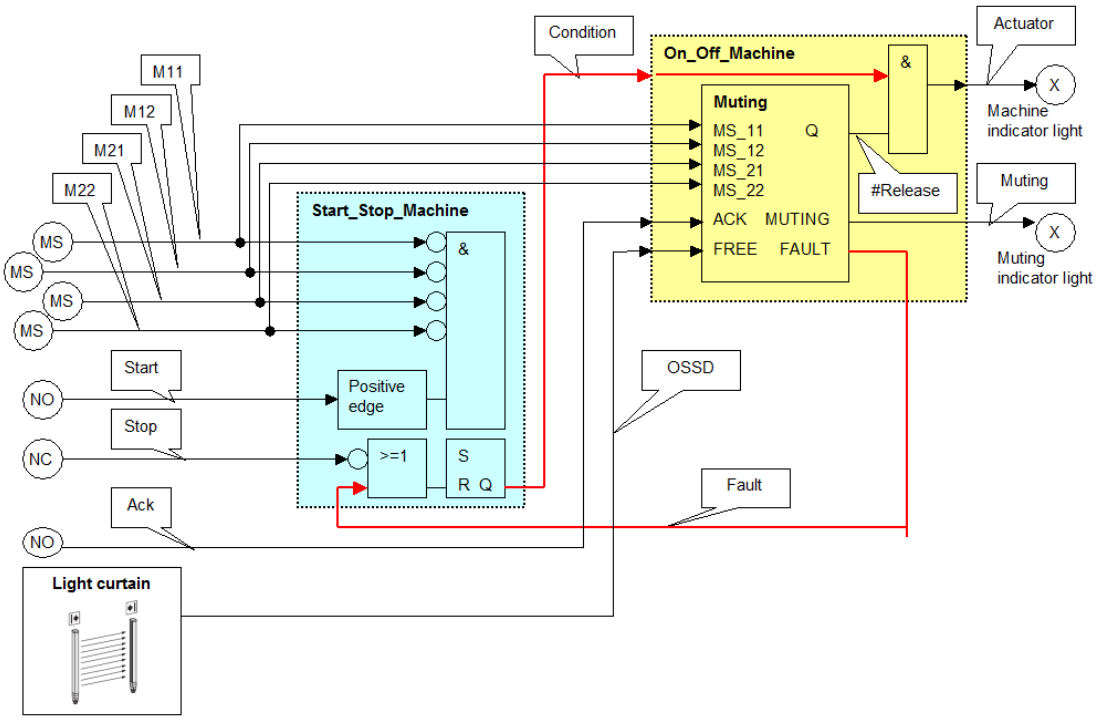
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4.2.5 Interaction: Start_Stop_Machine and On_Off_Machine

Figure 4-16 shows the interaction of the Start_Stop_Machine and On_Off_Machine program blocks.

For the description of the functionality, please refer to chapters 4.1.3 and 4.1.2.

Figure 4-16



Explanations

Contents of the legends in the figure: Variables of the user program

For the flipflop (SR), reset (R) has priority.

NO: Pushbutton (NO)

NC: Pushbutton (NC)

MS: Muting sensor, photoelectric retro-reflective sensor (“1”: Object interrupts the light beam)

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Meaning of the variables:

Table 4-8

Variable	Explanation
Start	Signal from the start pushbutton positive edge: Request to start the machine
Stop	Signal from the stop pushbutton (“0” signal: Stop the machine)
Ack	Signal from the acknowledgement pushbutton positive edge: Machine can be started again
Fault	Signal from the MUTING instruction “1” signal: Prevents the machine from starting (an error has occurred) “0” signal: Machine can be started (no error has occurred)
OSSD	Signal from the light curtain (“0” signal: Protective field violated)
Condition (*1)	Signal from the standard user program: Enable signal to start the machine “1” signal: Machine can be started “0” signal: Prevents the machine from starting.
#Release	Release from the “Muting” instruction: “1” signal: Machine can be started “0” signal: Machine is stopped
Actuator	Signal to the machine indicator light (“1” signal: Start the machine)

(*1): “Condition” must be transferred to the safety program via a flag (“Condition_Flag”).

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4.2.6 Program block: Safety

Program

Safety program

Function

The program block calls the following blocks:

- Reintegration (chapter 4.2.8)
- On_Off_Machine (chapter 4.2.4)

Parameters of the function block

Figure 4-17

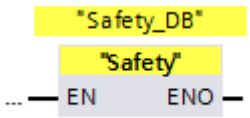


Table 4-9

Parameter	Declaration	Type	Description
---	---	---	---

4.2.7 Instruction: MUTING

Program

Safety program

Function

The MUTING instruction implements parallel muting with two or four muting sensors. Muting is the intentional suppression of the protective function of light curtains.

The instruction is integrated in STEP 7 V11. For a more detailed description of the instruction, please refer to /9/:

Chapter “STEP 7 Safety Advanced V11 Instructions” > Chapter “Instructions” > Chapter “Safety functions” > Chapter “MUTING”

For quick information, the following sections provide a brief description of the transport direction of the workpiece from sensor pair 1 to sensor pair 2.

Switching sequence of the muting sensors

When transporting, the following conditions must be met (*1):

- First sensor pair 1 (MS_11, MS_12) must be activated within DISCTIM1
- then sensor pair 2 (MS_21, MS_22) must be activated within DISCTIM2
- then sensor pair 1 must be deactivated within DISCTIM1
- then sensor pair 2 must be deactivated within DISCTIM2

Additional conditions:

- All 4 muting sensors must have been simultaneously active before the first muting sensor of sensor pair 1 is deactivated again.
- Muting must not exceed TIME_MAX.

(*1): The chronological order of switching the two muting sensors within a sensor pair is not monitored.

Muting operation

Muting starts when the following applies:

- Sensor pair 1 is activated (random sequence of muting sensors)

Muting remains active as long as the following applies:

- Sensor pair 1 is active

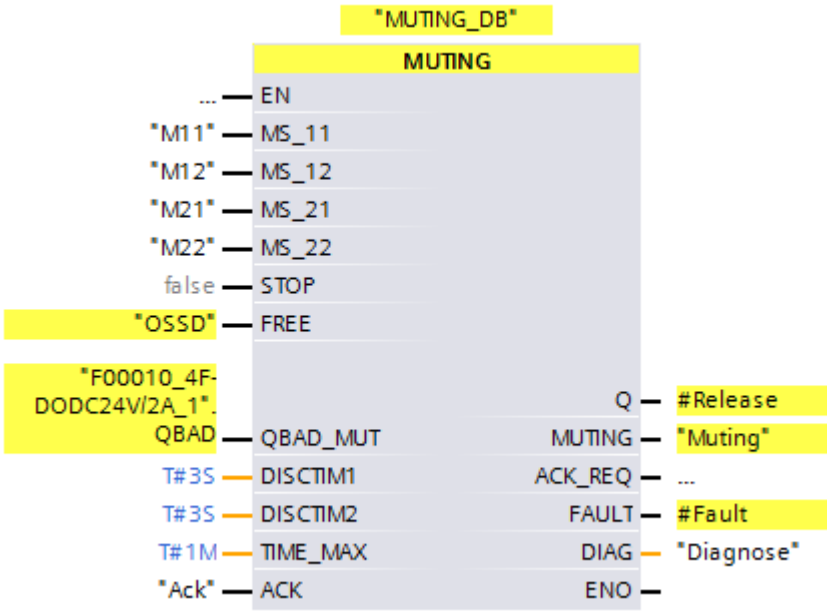
Muting ends (if no error has occurred) when the following applies:

- The first of the two sensors of sensor pair 1 is deactivated

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Parameters of the instruction / block

Figure 4-18



Meaning of the parameters:

Table 4-10

Parameter	Declaration	Type	Description	
MS_11	IN	Bool	Sensor pair 1, muting sensor 1	"1" signal: Sensor active (object detected)
MS_12	IN	Bool	Sensor pair 1, muting sensor 2	
MS_21	IN	Bool	Sensor pair 2, muting sensor 1	
MS_22	IN	Bool	Sensor pair 2, muting sensor 2	
STOP	IN	Bool	"1" signal: Conveyor system stopped	
FREE	IN	Bool	"1" signal: Protective field not violated (light curtain not interrupted)	
QBAD_MUT	IN	Bool	To monitor the muting indicator light: "1" signal: Wire break on the indicator light (example)	
DISCTIM1	IN	Time	Discrepancy time for sensor pair 1 (0 to 3 s): Within this time, MS_11 and MS_12 must be activated.	
DISCTIM2	IN	Time	Discrepancy time for sensor pair 2 (0 to 3 s): Within this time, MS_21 and MS_22 must be activated.	
TIME_MAX	IN	Time	Maximum muting time (0 to 10 min): Maximum time muting may be active.	
ACK	IN	Bool	After FAULT = "1", acknowledgement must be made here (restart interlock)	
Q	OUT	Bool	"1" signal: The machine can be started (release)	
MUTING	OUT	Bool	"1" signal: Muting is active	
ACK_REQ	OUT	Bool	"1" signal: Acknowledgement is required	
FAULT	OUT	Bool	"1" signal: An error has occurred (group error)	
DIAG	OUT	Byte	Error information	

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4.2.8 Program block: Reintegration

Program

Safety program

Function

Components of the F-I/O (F-DI, F-DO) can passivate.

Examples of events that cause passivation:

- Wire break on the F-DO
- Missing power supply on the F-DI

The block reintegrates passivated components. Reintegration is implemented differently in the code (STEP 7 project):

- Reintegration without operator intervention F-DI
- Reintegration with operator intervention (*1): F-DO

(*1): After passivation, a positive edge must be generated at a flag bit (Ack_Passivation) (chapter 7.5).

Parameters of the function block

Figure 4-19

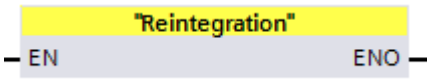


Table 4-11

Parameter	Declaration	Type	Description
---	---	---	---

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5 Configuration of the SIMATIC Components

5.1 Preliminary remark

This chapter describes the most important settings that were made in the application example for the SIMATIC components:

- Settings in the Device Configuration of STEP 7
- Settings in the Safety Administration of STEP 7

Note

It is not necessary to make the settings in the application example, they are already included in the code (STEP 7 project). This chapter is for information only.

For differentiation purposes, the settings are marked:

- “Default”: This value was not changed for the application example.
- “Non-default”: This value was changed for the application example.

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5.2 Device configuration

Actions to open the Device configuration:

- Start TIA Portal
- Open the Project view
- Open the “light_curtain_00” project
- In the Project tree:
  Open the “PLC_1 [CPU 315-F-2 PN/DP]” device > Open the Device configuration

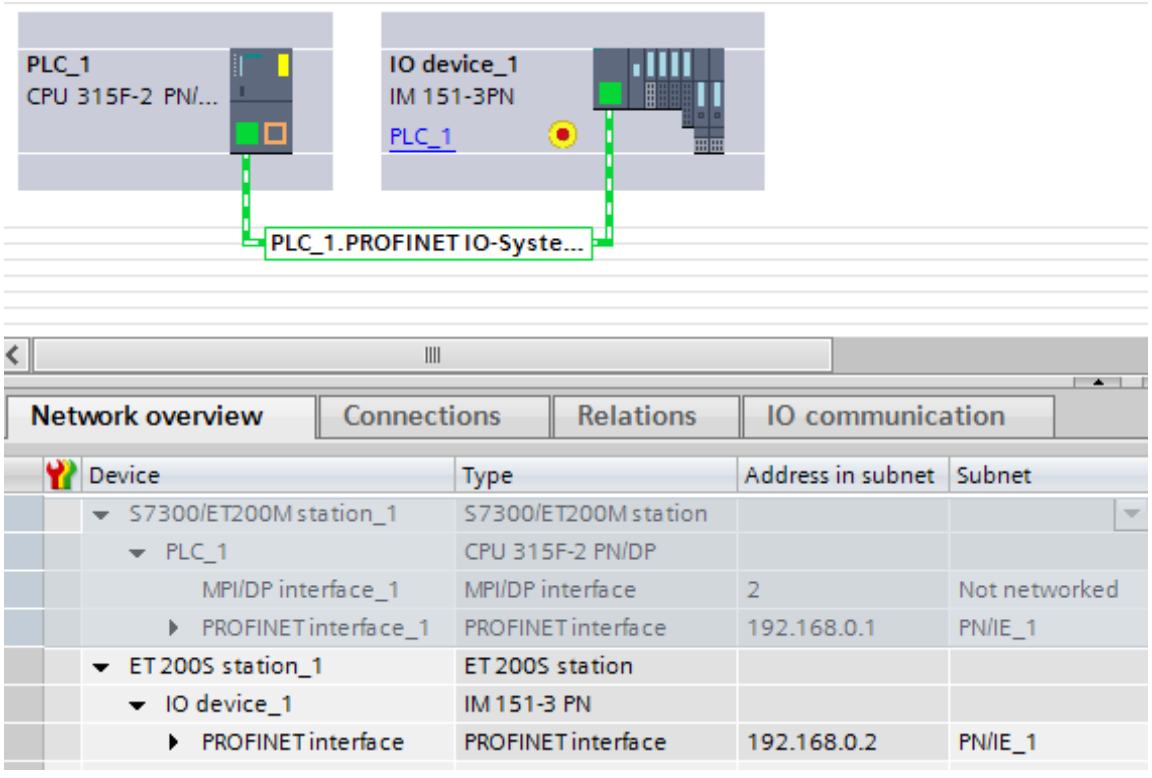
5.2.1 PROFINET network

Actions in the Device configuration:

- In the workspace: Open the Network view
- In the Inspector window: Open the Network overview

Result

Figure 5-1



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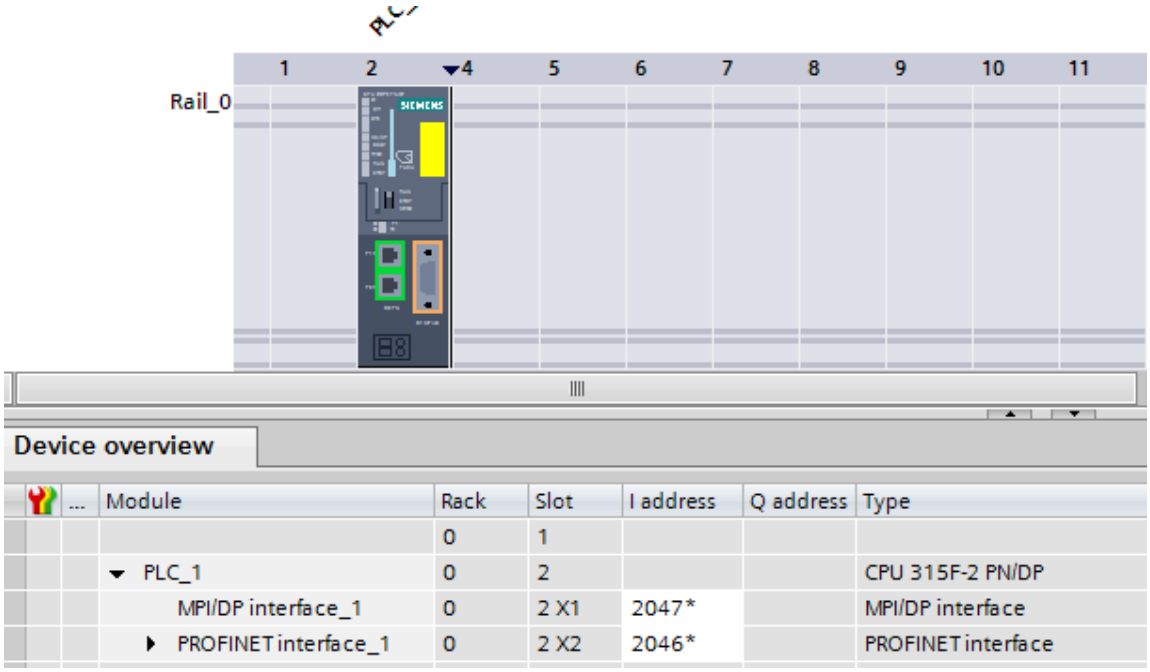
5.2.2 PLC_1

Actions in the Device configuration:

- In the workspace: Open the Device view > Select “PLC_1”

Result:

Figure 5-2



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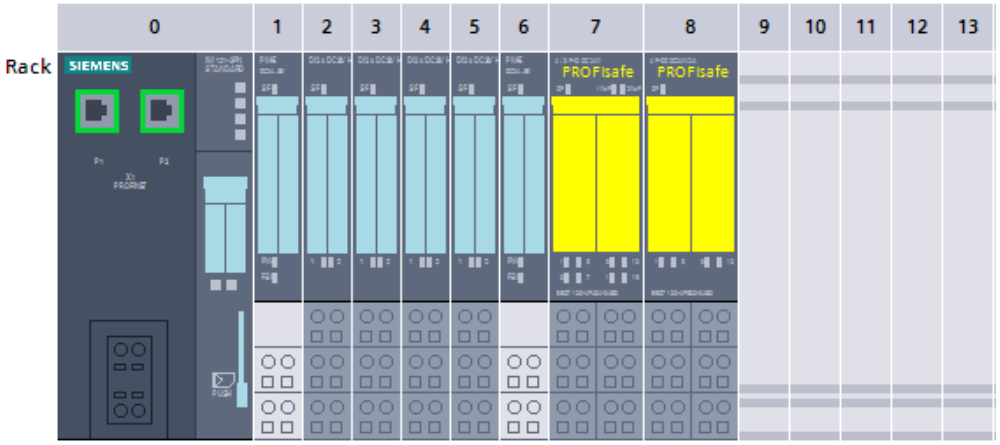
5.2.3 IO device_1

Actions in the Device configuration:

- In the workspace: Open the Device view > Select “IO device_1”

Result

Figure 5-3



Device overview

...	Module	Rack	Slot	I address	Q address	Type
	IO device_1	0	0	2042*		IM 151-3 PN
	PROFINET interface	0	0 X1	2041*		PROFINET interface
	PM-E 24 to 48VDC / 24 to 2...	0	1	2038*		PM-E 24 to 48VDC / 24 to 230VAC
	2DI x 24VDC HF_1	0	2	0.0...0.1		2DI x 24VDC HF
	2DI x 24VDC HF_2	0	3	1.0...1.1		2DI x 24VDC HF
	2DI x 24VDC HF_3	0	4	2.0...2.1		2DI x 24VDC HF
	2DI x 24VDC HF_4	0	5	3.0...3.1		2DI x 24VDC HF
	PM-E 24 to 48VDC / 24 to 2...	0	6	2037*		PM-E 24 to 48VDC / 24 to 230VAC
	4/8 F-DI DC24V_1	0	7	4...9	4...7	4/8 F-DI DC24V
	4 F-DO DC24V/2A_1	0	8	10...14	10...14	4 F-DO DC24V/2A

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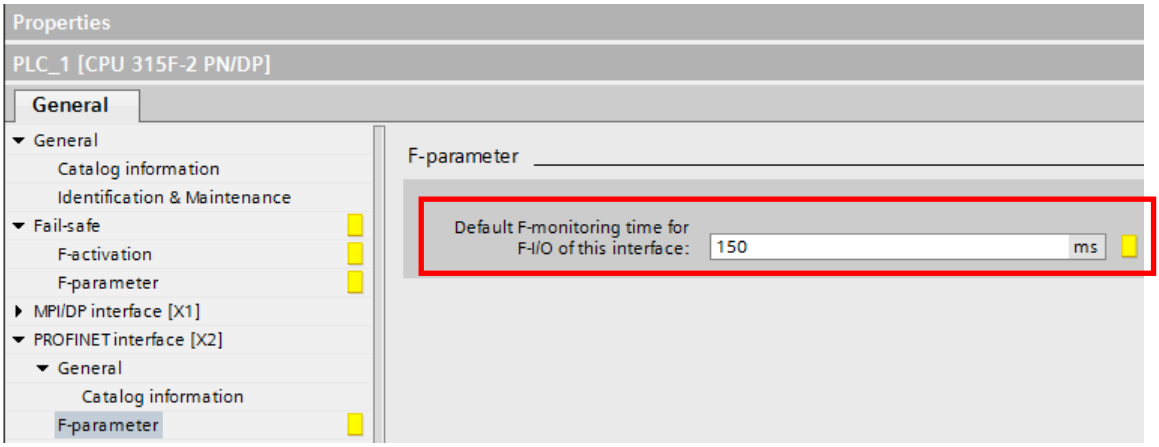
5.2.4 F-CPU

Actions in the Device configuration:

- In the workspace:
  - Open the Device view > Select “PLC_1” > Select the F-CPU
- In the Inspector window:
  - Select the “Properties” tab
  - Open “PROFINET interface (X2)”
  - Select “F-parameter” (see result)

Result

Figure 5-4



F-monitoring time for F-I/O of this interface: 150 ms (default)

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5.2.5 F-DI

Actions in the Device configuration:

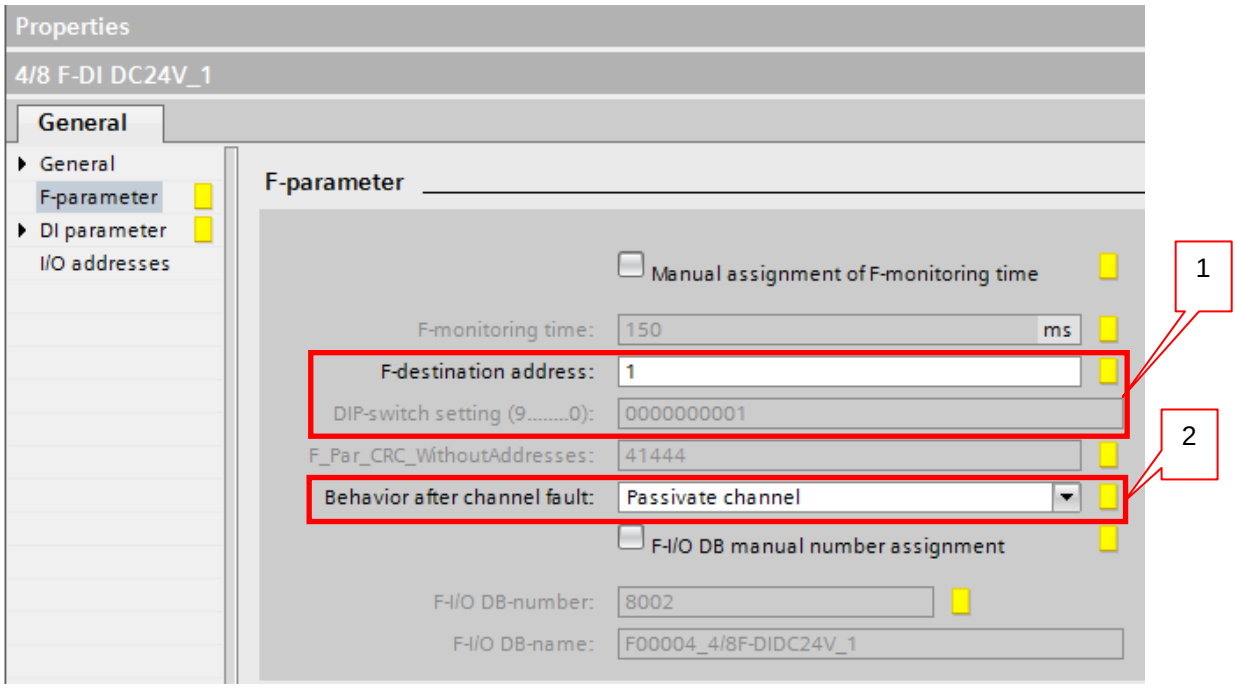
- In the workspace:
  - Open the Device view > Select “IO device_1”
  - Select the “4/8 F-DI DC24V_1” module

In the Inspector window:

- Select the “Properties” tab
- Select “F-parameter”
  (see result 1)
- Select “DI parameter”
  (see result 2)
- Select: “DI parameter” > “Channel 0, 4”
  (see result 3)
- Select: “DI parameter” > “Channel 1, 5”
  (see result 4)
- Select: “DI parameter” > “Channel 2, 6”
  (see result 4)
- Select: “DI parameter” > “Channel 3, 7”
  (see result 4)

Result 1

Figure 5-5



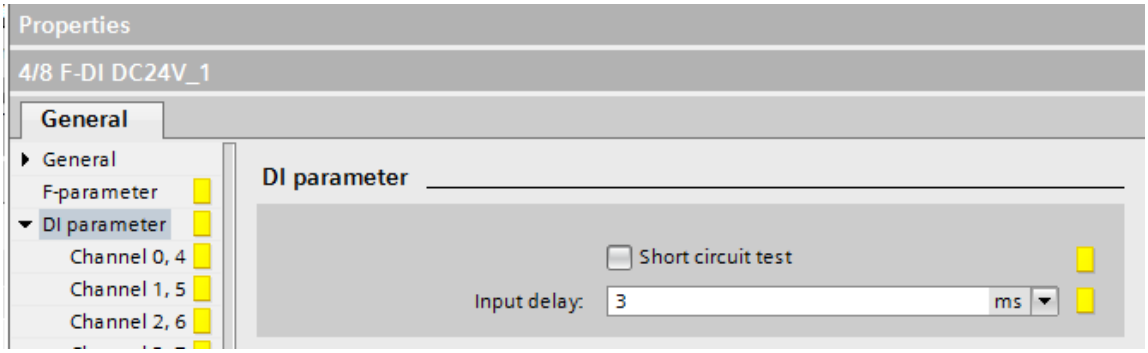
(1): On the F-DI, the F-destination address is set on the address switch.

(2): Behavior after channel fault: Passivate channel (default).

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Result 2

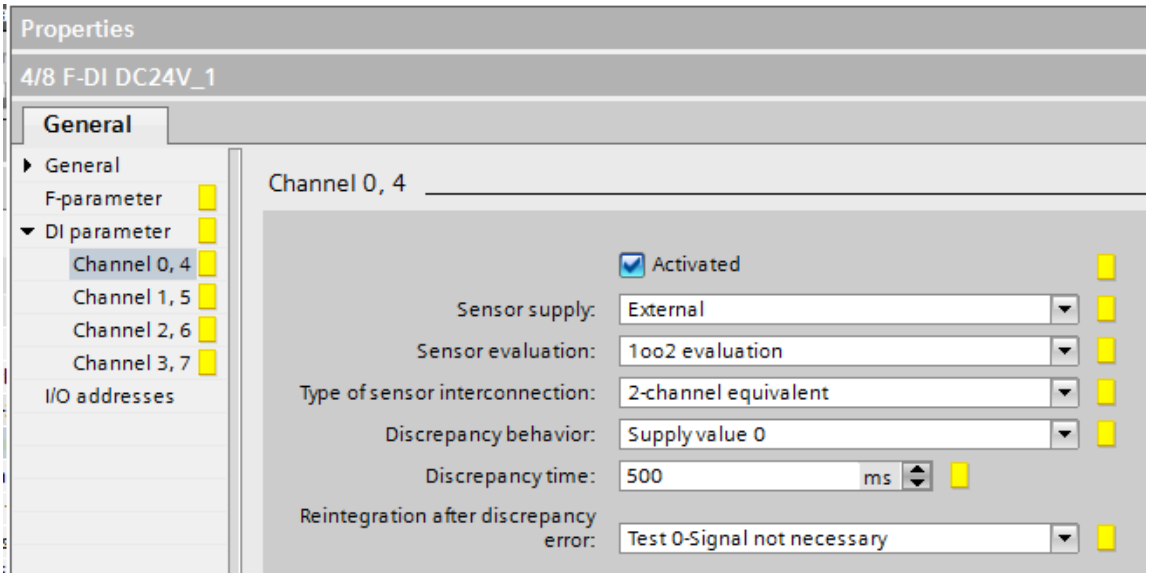
Figure 5-6



Due to external sensor supply, short circuit test must be deactivated (non-default).

Result 3

Figure 5-7



Settings:

- External sensor supply (non-default)
- Sensor evaluation: 1oo2 (default)
- Type of sensor interconnection: 2-channel equivalent (default)

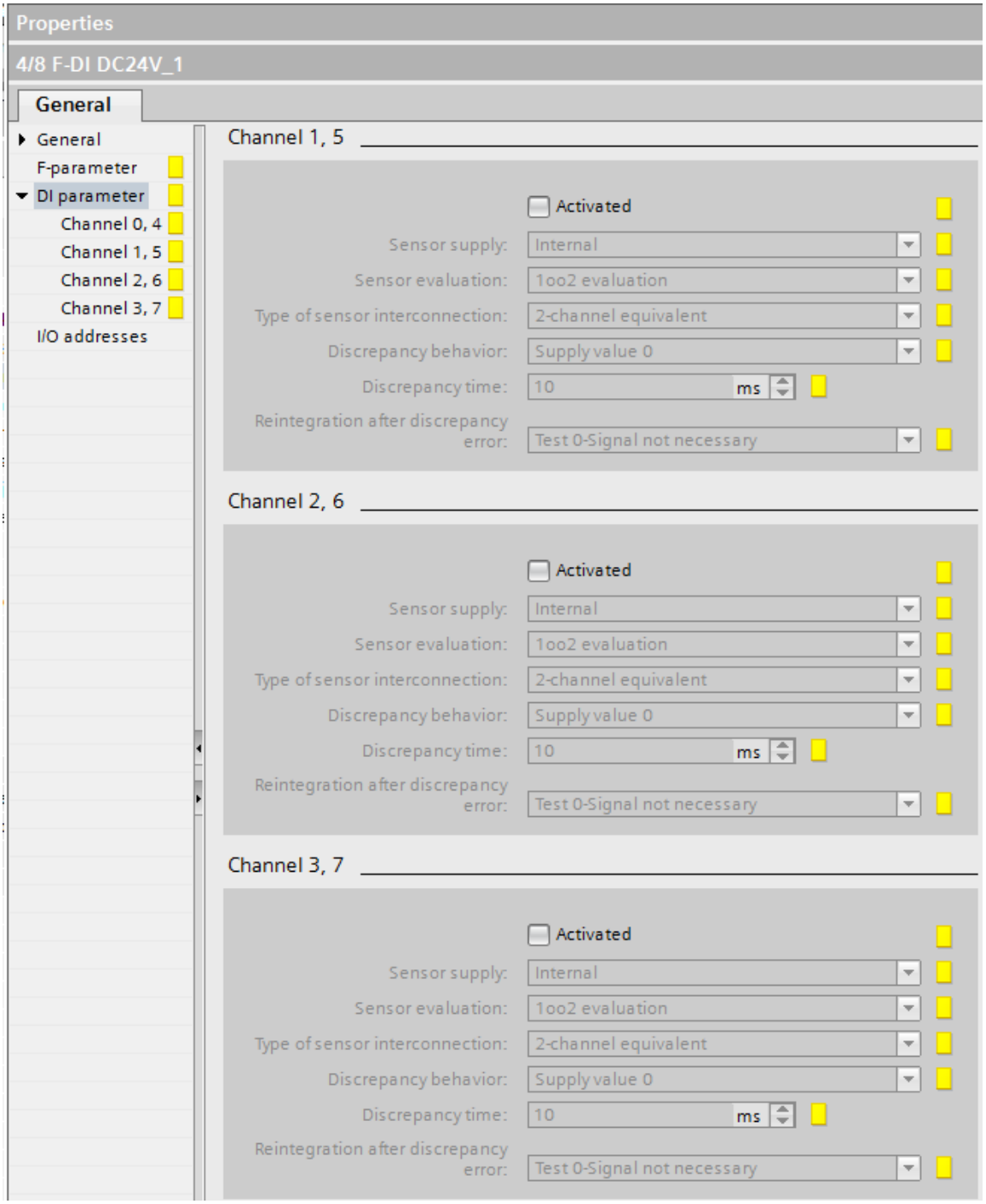
Channel assignment:

- Channel 0: OSSD1 of light curtain
- Channel 1: OSSD2 of light curtain

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Result 4

Figure 5-8



The remaining channels are deactivated (non-default).

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5.2.6 F-DO

Actions in the Device configuration:

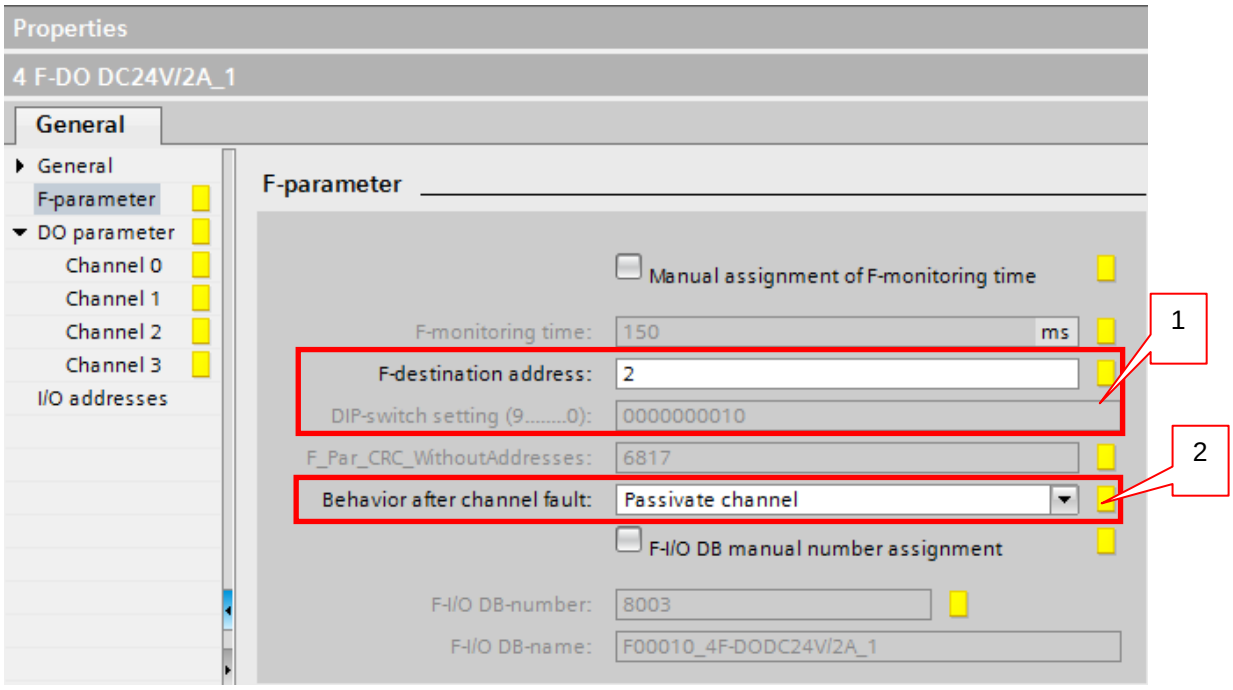
- In the workspace:
  - Open the Device view > Select “IO device_1”
  - Select the “4 F-DO DC24V/2A_1_1” module

In the Inspector window:

- Select the “Properties” tab
- Select “F-parameter” (see result 1)
- Select “DO parameter” (see result 2)

Result 1

Figure 5-9



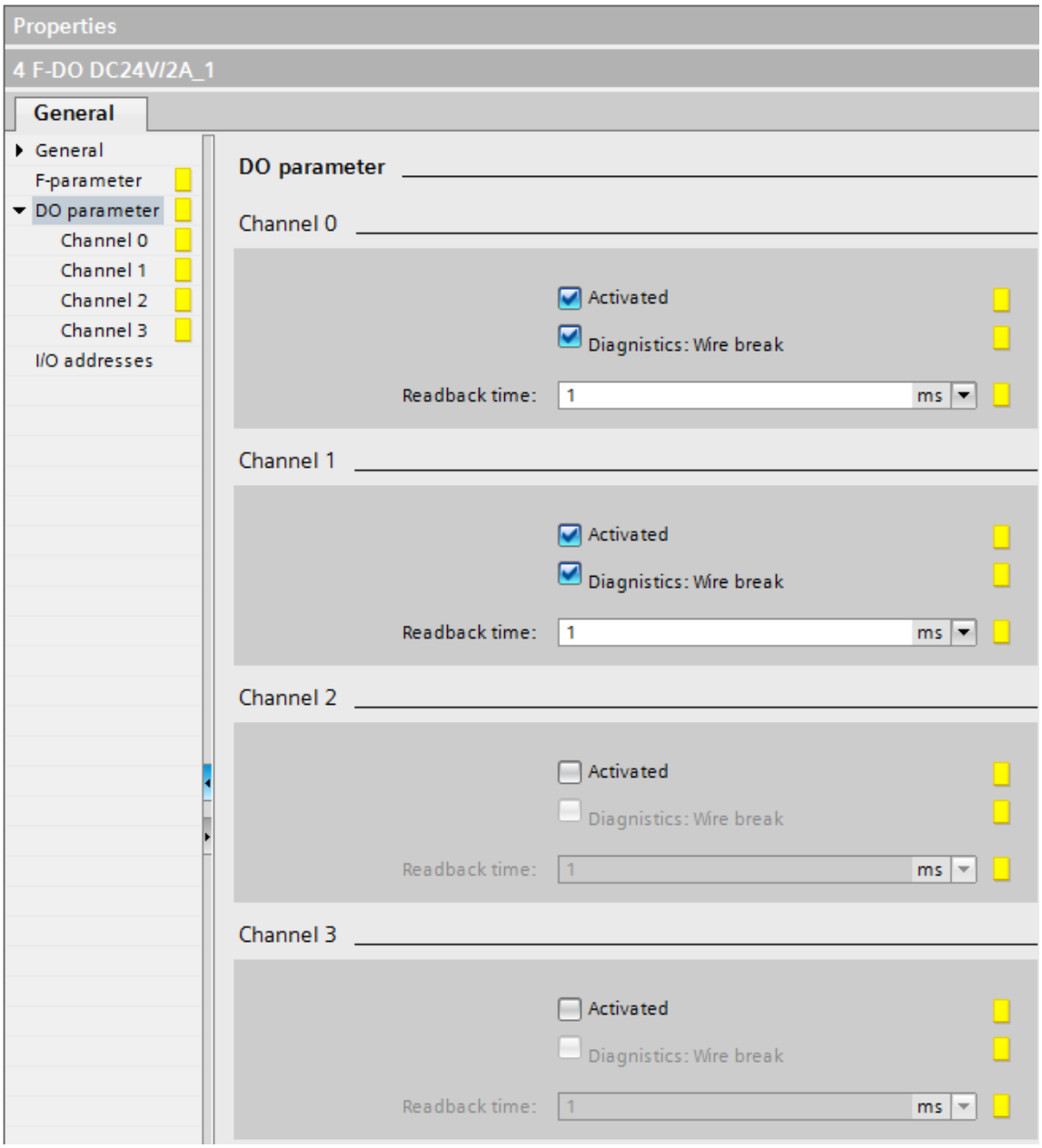
(1): On the F-DO, the F-destination address is set on the address switch.

(2): Behavior after channel fault: Passivate channel (default).

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Result 2

Figure 5-10



Settings:

- Channel 0 and channel 1:
  - Activated (default)
  - Diagnostics: Wire break (default)
- All other channels: Not activated (non-default)

Channel assignment:

- Channel 0: Machine indicator light
- Channel 1: Muting indicator light

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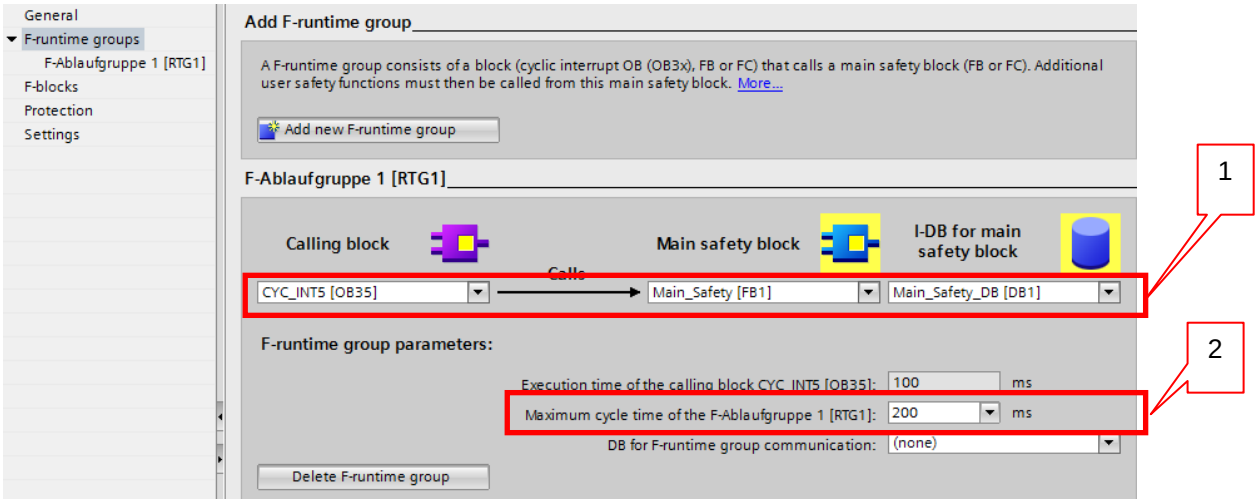
5.3 Safety Administration

Open the Safety Administration as follows:

- Start TIA Portal
- Open the Project view
- Open the “light_curtain_00” project
- In the Project tree:
  - Open the “PLC_1 [CPU 315-F-2 PN/DP]” device
  - Open the Safety Administration
- In the workspace, select “F-runtime groups”

Result

Figure 5-11



(1): F-runtime group 1 (default)

(2): Monitoring time for F-runtime group 1 (default)

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6 Installation and Commissioning

6.1 Overview of the steps

The following steps are necessary to install the application example:

- Load the download to the PG/PC:
  - Code (STEP 7 project) for the F-CPU
- Install the hardware:
  - SIMATIC components
  - SICK safety light curtain
- Create a defined initial state:
  - F-CPU
  - IM151-3 PN HF
- Assign the device names
- Download the code (Step 7 project) to the F-CPU

The following chapters describe the steps.

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6.2 Loading the downloads to the PG/PC

The downloads for the application example are listed in chapter 2.2.3.

To install the code (STEP 7 project) on the PG/PC, the following actions are necessary:

- Download the “58793869_LIGHT_CURTAIN_CODE_V10.zip” file to any directory on the PG/PC.
- Unzip the file.

6.3 Installing the hardware

For the necessary hardware components, please refer to chapter 2.2.1.

NOTICE

Follow the installation guidelines for PROFINET (/4/), SICK light curtain and photoelectric retro-reflective sensor (/1/), SIMATIC S7-300 (/3/) and SIMATIC ET 200S (/16/).

Refer to the relevant manuals.

6.3.1 Installation

The table shows the procedure to install the hardware.

Table 6-1

No.	Hardware	Action
		Centralized configuration
1.	F-CPU and MMC	Delete the SIMATIC Micro Memory Card (MMC) for the F-CPU and insert the MMC into the F-CPU.
2.	S7-300 mounting rail	Mount the following devices on the mounting rail: • Power supply for SIMATIC • Power supply for light curtain • F-CPU
		ET 200S distributed configuration
3.	IM and MMC of ET 200S	Delete the SIMATIC Micro Memory Card (MMC) for the IM and insert the MMC into the IM.
4.	F-DI	Set the PROFIsafe address on the address switch. (*1)
5.	F-DO	Set the PROFIsafe address on the address switch. (*1)
6.	Standard sectional rail	Assemble the modules in the described order: • IM151-3 PN interface module • Terminal modules for power module and electronic modules • Terminating module Insert the modules into the terminal modules in the order shown in Figure 6-1.
7.	DI 1 and DI 2	Wire the 3 pushbuttons (start, stop, acknowledgement).
8.	DI 3 and DI 4	Wire the 4 muting sensors (M11, M12, M21, M22).
9.	F-DI	Wire the light curtain (receiver).
10.	F-DO	Wire the 2 indicator lights (muting, machine).
11.	PROFINET cable	Connect: • F-CPU to IM 151-3 PN • F-CPU to PG/PC.
12.	Power supply for SIMATIC	Complete all connections for the SIMATIC components.
13.	Power supply for light curtain	Complete all connections for the light curtain.

(*1):

The PROFIsafe addresses are automatically assigned when configuring the fail-safe modules in STEP 7:

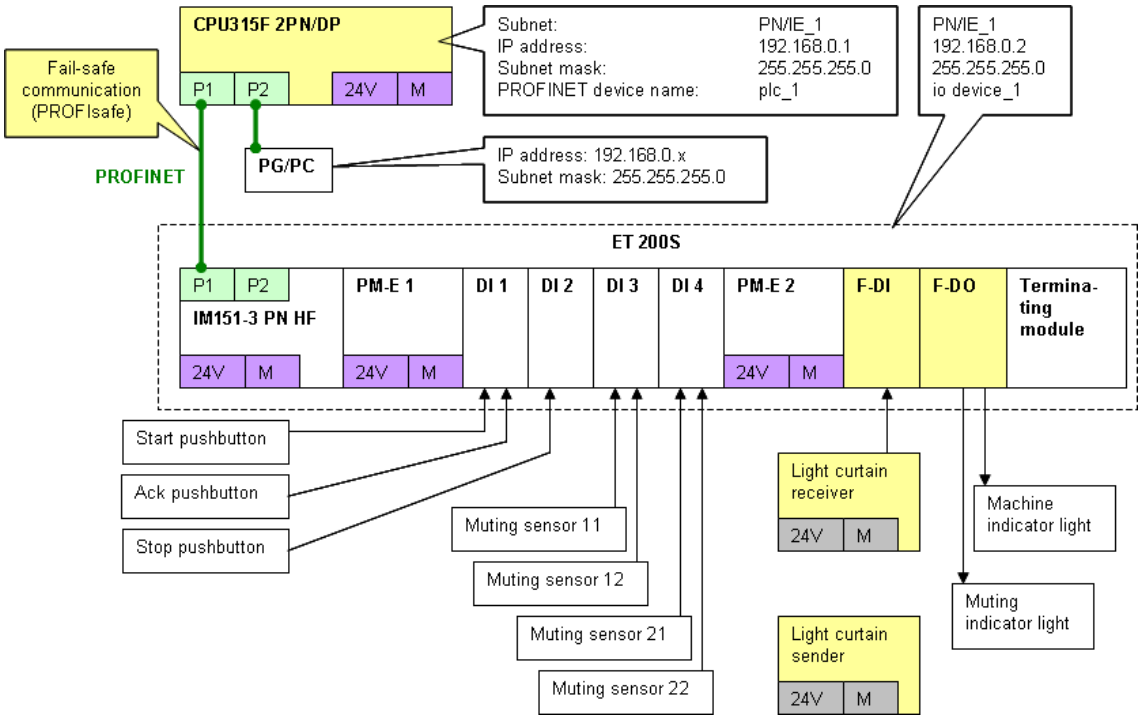
- F-DI: See chapter 5.2.5
- F-DO: See chapter 5.2.6

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6.3.2 Overview of the configuration

Figure 6-1 schematically shows the configuration of the application example.

Figure 6-1



Explanations

Px: Port x of the PROFINET interface

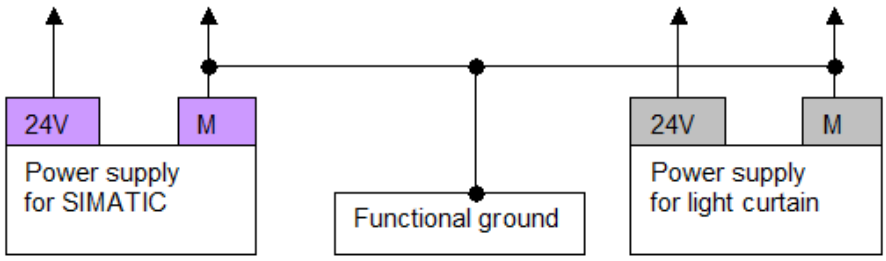
24V / M: Power supply terminal

Note on the power supply

A separate power supply can be used for the safety light curtain, to improve the availability (EMC, voltage fluctuation, ...).

Both power supplies require the same ground.

Figure 6-2

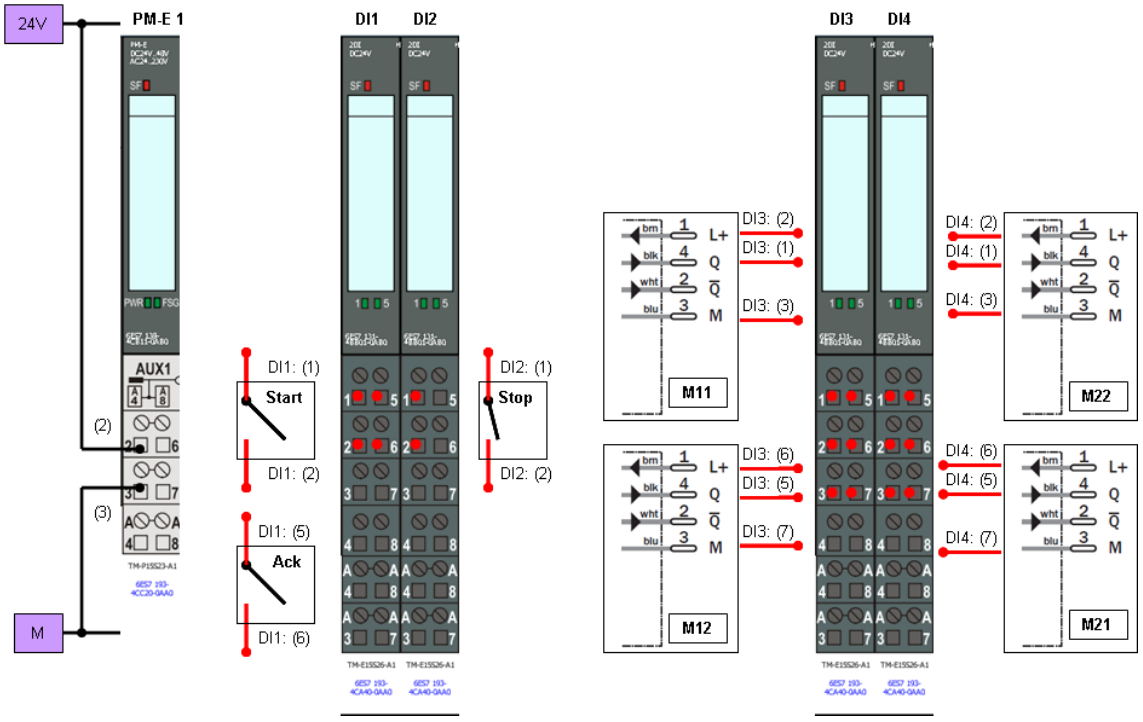


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6.3.3 Wiring: DI

The figure schematically shows the wiring.

Figure 6-3

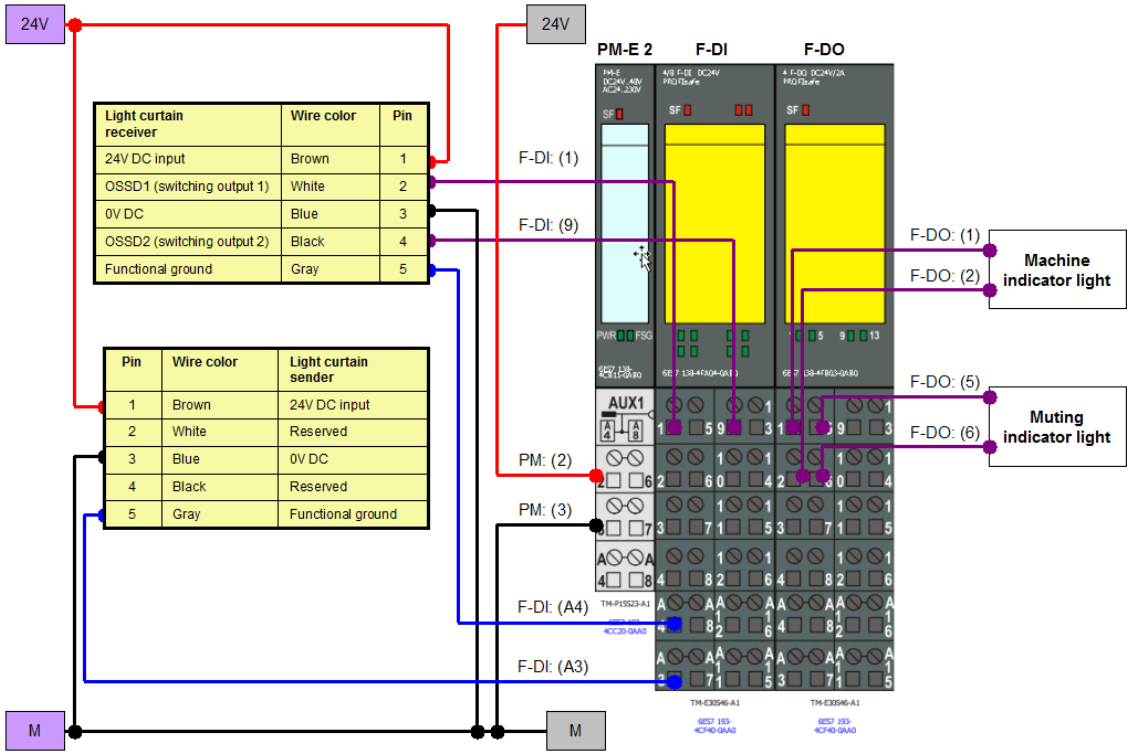


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6.3.4 Wiring: Light curtain, F-DI, F-DO

The figure schematically shows the wiring.

Figure 6-4



Light curtain receiver	Wire color	Pin
24V DC input	Brown	1
OSSD1 (switching output 1)	White	2
0V DC	Blue	3
OSSD2 (switching output 2)	Black	4
Functional ground	Gray	5

Pin	Wire color	Light curtain sender
1	Brown	24V DC input
2	White	Reserved
3	Blue	0V DC
4	Black	Reserved
5	Gray	Functional ground

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6.4 Setting the F-CPU to the initial state

In the “initial state”, the F-CPU has the following properties:

- The F-CPU has the factory setting.
- The SIMATIC Micro Memory Card (MMC) of the F-CPU has been deleted.

Prerequisite:

- The PG/PC is connected to the F-CPU via the PROFINET interface.
- STEP 7 V11 is installed on the PG/PC.

Resetting the F-CPU to factory settings

Prerequisite:

- No MMC is inserted in the F-CPU.
- The F-CPU has an IP address.
- The F-CPU is in STOP mode
  (mode selector switch is set to STOP).

Procedure:

- In the Project tree, select the F-CPU
- In the toolbar, select the “Go online” button
- Open “Online & diagnostics” of the F-CPU
- Select:
  “Functions” >
  “Reset to factory settings”
- Select the “Reset” button

Result:

- RAM, internal load memory and operand areas have been deleted.
- All parameters have been reset to their default values.
- Diagnostic buffer has been deleted and the time of day has been reset.
- IP address and PROFINET device name have been deleted.

Display for the F-CPU in “Accessible devices”:

Table 6-2

Device	Device type	Type	Address	MAC address
Accessible device	S7-300	ISO	---	00-1B-1B-17-4C-3D (example)

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Deleting the MMC of the F-CPU

Procedure:

- Insert the MMC into the programming device
- In the Project tree:
  - Open: “SIMATIC Card Reader” > “Internal prommer”
  - Select “Micro Memory Card”
- In the “Project” menu, select:
  “SIMATIC Card Reader” >
  “Format memory card”

Inserting the deleted MMC into the F-CPU

Prerequisite:

- The F-CPU is in STOP mode
  (mode selector switch is set to STOP).

Procedure:

- Switch off the power supply of the F-CPU
- Insert the MMC into the F-CPU
- Switch the power supply of the F-CPU back on

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6.5 Setting the IM151-3 PN HF to the initial state

In the “initial state”, the IM151-3 PN HF has the following properties:

- The IM has the factory setting.
- The SIMATIC Micro Memory Card (MMC) of the IM has been deleted.

Resetting the IM to factory settings

Prerequisite:

- No MMC is inserted in the IM (the IM has no IP address)
- The F-CPU is in the “initial state” (chapter 6.4).

Procedure:

- In the Project tree, select the F-CPU
- In the toolbar, select the “Accessible devices” button
- In the “Accessible devices” window:
  - Select the row with “IM151-3”
  - Select the “Show” button
- In the Project tree, the “Online access” folder opens:
  - Open “Online & diagnostics”
  - Select:
    “Functions” >
    “Reset to factory settings”
  - Select the “Reset” button

Result:

- The PROFINET device name has been deleted.
- The IP address has been deleted.

Display for the IM in “Accessible devices”:

Table 6-3

Device	Device type	Type	Address	MAC address
Accessible device	IM151-3	ISO	---	00-0E-8C-FA-A3-1E (example)

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Deleting the MMC of the IM

Procedure:

- Insert the MMC into the programming device
- In the Project tree:
  - Open: “SIMATIC Card Reader” > “Internal prommer”
  - Select “Micro Memory Card”
- In the “Project” menu, select:
  “SIMATIC Card Reader” >
  “Format memory card”

Inserting the deleted MMC into the IM

Procedure:

- Switch off the power supply of the IM
- Insert the MMC into the IM
- Switch the power supply of the IM back on

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6.6 Assigning the device names

Procedure

Open the Device configuration:

- Start TIA Portal
- Open the Project view
- Open the “light_curtain_00” project
- In the Project tree:
  - Open the following device: “PLC_1[CPU 315F-2 PN/DP]”
  - Open the Device configuration

Actions in the Device configuration:

- In the workspace, select: “Network view”
- Select subnet “PN/IE_1”
- Right-click
- Select “Assign device name”

Result:

- The “Assign PROFINET device name” window opens

F-CPU device

Actions in the “Assign PROFINET device name” window:

- Select the “Accessible devices in the network” button
- In the “PROFINET device name” drop-down list, select “plc_1”
- In the table, select the “S7-300” row
- Select the “Assign name” button
- Select the “Accessible devices in the network” button

IM device

Actions in the “Assign PROFINET device name” window:

- Select the “Accessible devices in the network” button
- In the “PROFINET device name” drop-down list, select “io device_1”
- In the table, select the “IM151-3” row
- Select the “Assign name” button
- Select the “Accessible devices in the network” button

Result

Display for the IM in “Accessible devices”:

Table 6-4

Device	Device type	Type	Address	MAC address
io device_1	IM151-3	ISO	---	00-0E-8C-FA-A3-1E (example)
plc_1	S7-300	ISO	---	00-1B-1B-17-C-3D (example)

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6.7 Downloading the code (STEP 7 project) to the F-CPU

Prerequisite:

- F-CPU and IM have been set to the initial state (chapters 6.4 and 6.5)
- The PG/PC is connected to the F-CPU via the PROFINET interface.

Procedure:

- Start TIA Portal
- Open the Project view
- Open the “light_curtain_00” project
- In the Project tree:
  - Select “PLC_1 [CPU 315F-2 PN/DP]”
  - Right-click and select:
    “Download to device” >
    “all”
- In the “Extended download to device” window:
  - Check the “Show all accessible devices” option
  - In the “Accessible devices in target subnet” table,
    select the “S7-300” row
  - Select the “Load” button
- In the “Load preview” window:
  Select the “Load” button
- In the “Load results” window:
  Select the “Finish” button
- Set the F-CPU to RUN (mode selector switch to the RUN position)

Result:

Display for the IM in “Accessible devices”:

Table 6-5

Device	Device type	Type	Address	MAC address
plc_1	S7-300	PN/IE	192.168.0.1	00-1B-1B-17-C-3D (example)
io device_1	IM151-3	PN/IE	192.168.0.2	00-0E-8C-FA-A3-1E (example)

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7 Operation of the Application Example

Prerequisite:

- Hardware and software have been installed as described in chapter 6

The chapter describes the following actions:

- Creating the initial state of the setup
- Operation: Without muting
- Operation: With muting
- Operation: Muting indicator light wire break

7.1 Creating the initial state of the setup

Prerequisite:

- The power supply is switched off (power off)
- Set the F-CPU to STOP (mode selector switch to STOP)
- No object in the sensing area of the light curtain
- No object in the sensing area of the muting sensors

Procedure:

- Switch on the power supplies for the SIMATIC controller and the SICK light curtain.
- Set the F-CPU to RUN (mode selector switch to RUN)

Result:

- Machine indicator light: Off
- Muting indicator light: Off
- Light curtain receiver: Green LED on
- Muting sensor: Green LED on, yellow LED on

For a description of the indicators on the light curtain and the muting sensor, please refer to chapter 7.7.

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7.2 Operation: Without muting

Prerequisite:

- The setup is in the initial state (chapter 7.1).

The actions in the table are used to switch the machine (indicator light) on and off. Muting is not activated.

Table 7-1

No.	Action	Explanation	Indicator light		Light curtain
			Machine	Muting	Receiver display
1	Press the acknowledgement pushbutton	Acknowledgement necessary after power on	Off	Off	Protective field unoccupied
2	Press the start pushbutton	---	On	Off	Protective field unoccupied
3	Press the stop pushbutton	---	Off	Off	Protective field unoccupied
4	Press the start pushbutton	---	On	Off	Protective field unoccupied
5	Set object in protective field of light curtain	Protective field violated	Off	Off	Protective field violated
6	Press the start pushbutton	---	Off	Off	Protective field violated
7	Remove object from protective field of light curtain	Restart interlock	Off	Off	Protective field unoccupied
8	Press the start pushbutton	Restart interlock	Off	Off	Protective field unoccupied
9	Press the acknowledgement pushbutton	---	Off	Off	Protective field unoccupied
10	Press the start pushbutton	---	On	Off	Protective field unoccupied

For a description of the indicators on the light curtain and the muting sensor, please refer to chapter 7.7.

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7.3 Operation: With muting

Prerequisite:

- The setup is in the initial state (chapter 7.1).

The actions in the table are used to simulate the transport of a workpiece (object) into the hazardous area.

Note

During operation, the monitoring times parameterized in the code (STEP 7 project) must be complied with:

- Discrepancy time for sensor pair 1 (M11, M12): 3 seconds (DISCTIM1)
- Discrepancy time for sensor pair 2 (M21, M22): 3 seconds (DISCTIM2)
- Maximum muting duration: 1 minute (TIME_MAX)

Table 7-2

No.	Action	Explanation	Indicator light		Light curtain
			Machine	Muting	Receiver display
1	Press the acknowledgement pushbutton	Acknowledgement necessary after power on	Off	Off	Protective field unoccupied
2	Press the start pushbutton	---	On	Off	Protective field unoccupied
3	M11: Interrupt light beam with object	Both sensors must be activated within the discrepancy time DISCTIM1.	On	Off	Protective field unoccupied
4	M12: Interrupt light beam with object		On	On	Protective field unoccupied
5	Set object in protective field of light curtain	---	On	On	Protective field violated
6	M21: Interrupt light beam with object	Both sensors must be activated within the discrepancy time DISCTIM2.	On	On	Protective field violated
7	M22: Interrupt light beam with object		On	On	Protective field violated
8	M11: Remove object from light beam	Both sensors must be deactivated within the discrepancy time DISCTIM1.	On	On	Protective field violated
9	M12: Remove object from light beam		On	On	Protective field violated
10	Remove object from protective field of light curtain	---	On	On	Protective field unoccupied
11	M21: Remove object from light beam	Both sensors must be deactivated within the discrepancy time DISCTIM2.	On	Off	Protective field unoccupied
12	M22: Remove object from light beam		On	Off	Protective field unoccupied

For a description of the indicators on the light curtain and the muting sensor, please refer to chapter 7.7.

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7.4 Operation: Muting indicator light wire break

Prerequisite:

- The setup is in the initial state (chapter 7.1).

The actions in the table are used to simulate the failure of the indicator light for muting (muting indicator light).

Table 7-3

No.	Action	Explanation	Indicator light		Light curtain
			Machine	Muting	Receiver display
1	Press the acknowledgement pushbutton	Acknowledgement necessary after power on	Off	Off	Protective field unoccupied
2	Press the start pushbutton	---	On	Off	Protective field unoccupied
3	M11: Interrupt light beam with object	Both sensors must be activated within the discrepancy time DISCTIM1.	On	On	Protective field unoccupied
4	M12: Interrupt light beam with object		On	On	Protective field unoccupied
5	Disconnect a terminal to the muting indicator light	Indicator for F-DO and IM: • SF LED: On (red)	Off	Off	Protective field unoccupied
6	Reconnect to muting indicator light	---	Off	Off	Protective field unoccupied
7	Wait until F-DO no longer detects an error.	Indicator for IM: • SF LED: Off Indicator for F-DO: • SF LED: Flashes (red)	Off	Off	Protective field unoccupied
8	Operation on the PG/PC (*1): Modify the “Ack_Passivation” flag from “0” to “1”	Indicator for F-DO: • SF LED: Off	Off	Off	Protective field unoccupied
9	M11 and M12: Remove object from light beam	--	Off	Off	Protective field unoccupied
10	Press the acknowledgement pushbutton	---	Off	Off	Protective field unoccupied
11	Press the start pushbutton	---	On	Off	Protective field unoccupied

(*1):

Using Watch_Table_1 included in the code (STEP 7 project) (chapter 7.5).

For a description of the indicators on the light curtain and the muting sensor, please refer to chapter 7.7.

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7.5 Watch table

The “Watch_Table_1” table can be used to

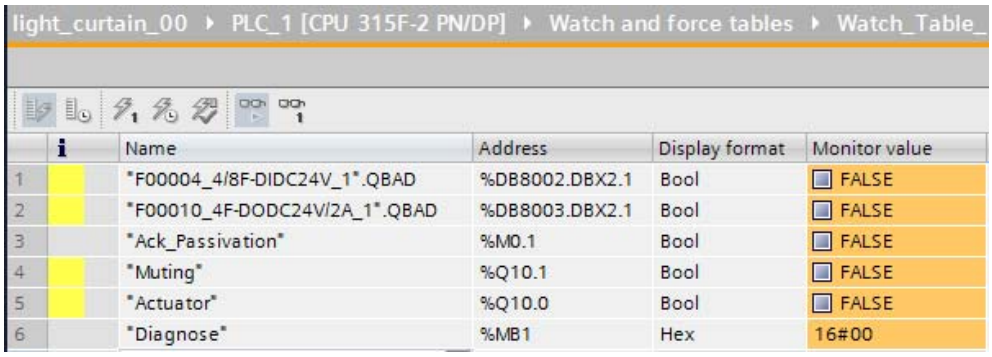
- show if a component of the F-I/O is passivated (F-DI, F-DO)
- reintegrate the passivated F-DO:
  Positive edge at “Ack_Passivation” (Modify variable)

Open the table as follows:

- Open the Project tree
- Open “PLC_1 [CPU 315F-2 PN/DP]”
- Open “Watch and force tables”
- Open the “Watch_Table_1” table
- Select “Go online”
- Select “Monitor all”

Result

Figure 7-1



	i	Name	Address	Display format	Monitor value
1		"F00004_4/8F-DIDC24V_1".QBAD	%DB8002.DBX2.1	Bool	FALSE
2		"F00010_4F-DODC24V/2A_1".QBAD	%DB8003.DBX2.1	Bool	FALSE
3		"Ack_Passivation"	%M0.1	Bool	FALSE
4		"Muting"	%Q10.1	Bool	FALSE
5		"Actuator"	%Q10.0	Bool	FALSE
6		"Diagnose"	%MB1	Hex	16#00

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7.6 PLC tag

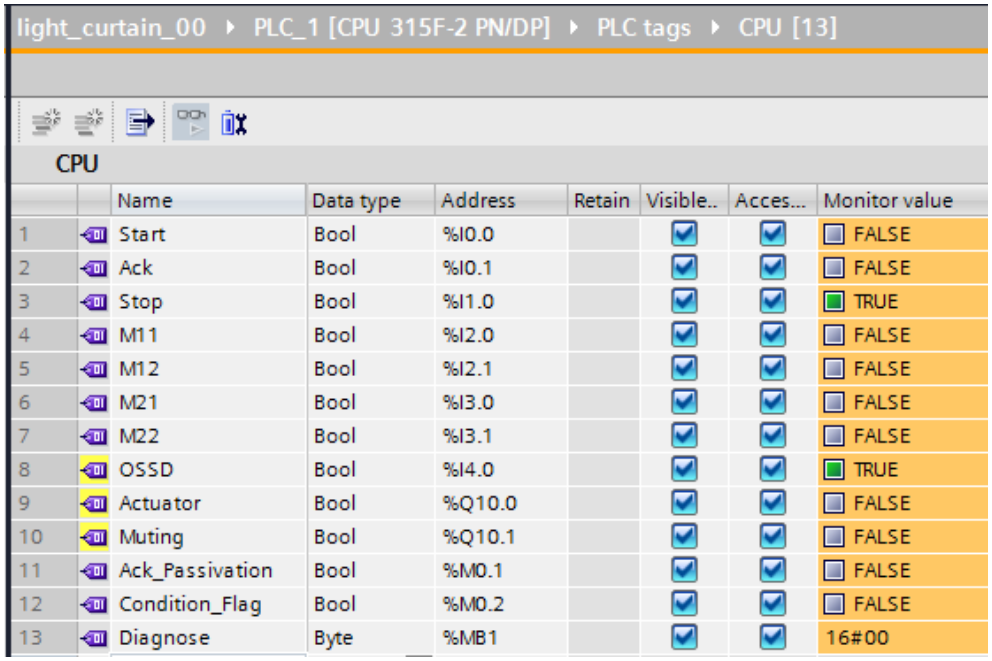
The “CPU” table contains all symbols of the STEP 7 project. The table can also be used for test purposes.

Open the tables as follows:

- Open the Project tree
- Open “PLC_1 [CPU 315F-2 PN/DP]”
- Open “PLC tags”
- Open the “CPU” table
- Select “Go online”
- Select “Monitor all”

Result

Figure 7-2



	Name	Data type	Address	Retain	Visible..	Acces...	Monitor value
1	Start	Bool	%I0.0		☑	☑	FALSE
2	Ack	Bool	%I0.1		☑	☑	FALSE
3	Stop	Bool	%I1.0		☑	☑	TRUE
4	M11	Bool	%I2.0		☑	☑	FALSE
5	M12	Bool	%I2.1		☑	☑	FALSE
6	M21	Bool	%I3.0		☑	☑	FALSE
7	M22	Bool	%I3.1		☑	☑	FALSE
8	OSSD	Bool	%I4.0		☑	☑	TRUE
9	Actuator	Bool	%Q10.0		☑	☑	FALSE
10	Muting	Bool	%Q10.1		☑	☑	FALSE
11	Ack_Passivation	Bool	%M0.1		☑	☑	FALSE
12	Condition_Flag	Bool	%M0.2		☑	☑	FALSE
13	Diagnose	Byte	%MB1		☑	☑	16#00

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7.7 Indicators on light curtain and muting sensor

Note: This chapter describes only indicators that are important for the application example.

Light curtain receiver (/1/)

Figure 7-3

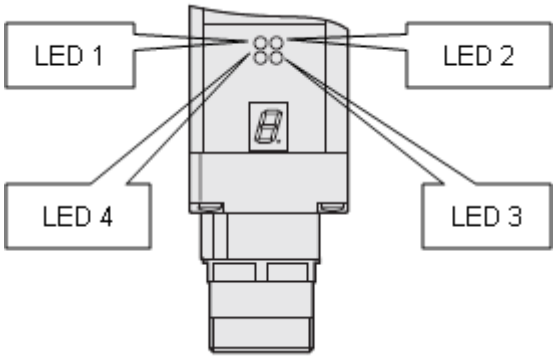


Table 7-4

LED	Color	Meaning	
LED 1	Orange	On:	Cleaning or realignment required
LED 2	Red	On:	Object in the protective field (protective field violated)
LED 3	Green	On:	No object in the protective field (protective field unoccupied)
LED 4	Yellow	Flashes:	Reset required

Muting sensor (/1/)

Figure 7-4



Table 7-5

LED	Color	Meaning	
LED 1	Green	On:	Operating voltage active
LED 2	Yellow	On: Off:	Light beam not interrupted (sensor inactive) Light beam interrupted (sensor active)

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8 Evaluation according to IEC 62061 and ISO 13849

8.1 Information on the standards

Overview

For an overview of IEC 62061, please refer to the following Safety Functional Example:

Practical Application of IEC 62061 Illustrated Using an Application Example with SIMATIC S7 Distributed Safety (/11/)

For an overview of ISO 13849-1, please refer to the following book:

Funktionale Sicherheit von Maschinen und Anlagen.
Umsetzung der europäischen Maschinenrichtlinie in der Praxis (/12/).

Calculations

Support for the calculations for the standards is provided by:

Safety Evaluation Tool (SET) (/15/)

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8.2 Safety function

The following considerations are based on the following safety function (example):

"When the protective field of the light curtain is violated and when there is no muting, the machine must be stopped."

The application example does not consider the entire safety function:

Table 8-1

Tasks of a safety function		
Detect	**Evaluate**	**React**
Is considered	Is considered	Is not considered

In the following, the above-listed tasks of a safety function are evaluated according to the two standards IEC 62061 and ISO 13849-1.

9 Safety Function

Chapter 8.2 describes the safety function.

This chapter considers only parts of the safety function:

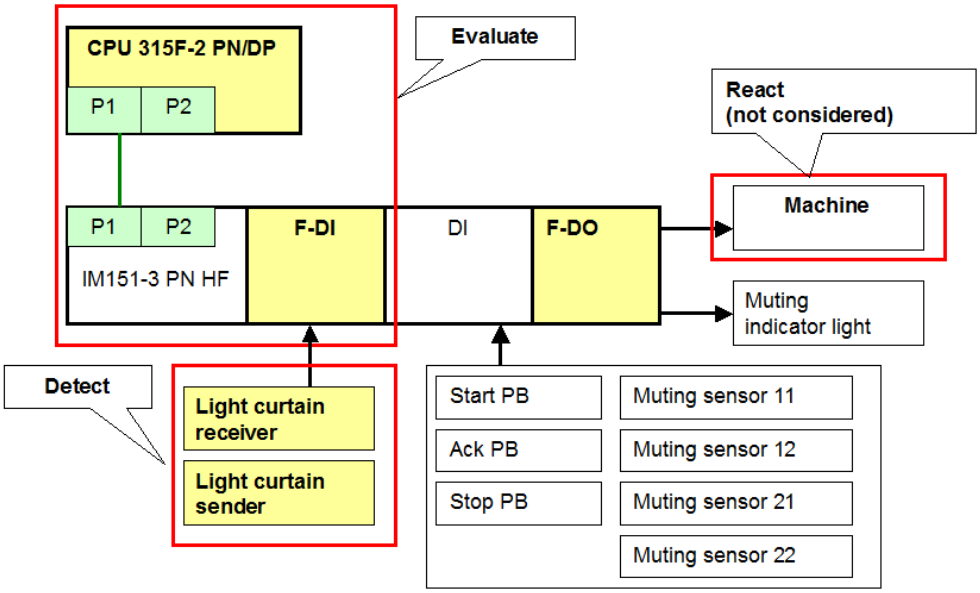
- Detect with SICK safety light curtain
- Evaluate with SIMATIC F-PLC

Therefore, the safety function is not evaluated in the application example.

9.1 Mapping of the safety function

Figure 9-1 schematically shows the mapping of the safety function to the hardware of the application example.

Figure 9-1



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9.2 Assessment of Detect

Component involved:

- Safety light curtain

9.2.1 Evaluation according to IEC 62061

Result:

Table 9-1

Result		Reason
SILCL	3	Specified by the manufacturer, SICK AG
PFH_D	$1.5 * 10^{-8}$	

9.2.2 Evaluation according to ISO 13849-1

Result:

Table 9-2

Result		Reason
PL	e	Specified by the manufacturer, SICK AG
Average probability of a dangerous failure per hour	$1.5 * 10^{-8}$	

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9.3 Assessment of Evaluate

Components involved:

- SIMATIC Safety Integrated for Factory Automation
- Safety-related SIMATIC controllers

9.3.1 Evaluation according to IEC 62061

Result:

Table 9-3

Result		Reason
SILCL	3	Specified by the manufacturer, SIEMENS AG
PFH_D	$2.1 * 10^{-9}$	The values for the calculation can be found in the following table.

Values to calculate the PFH_D:

Table 9-4

Parameter	Component	Value	Definition
PFHD (F-CPU)	CPU 315F-2 PN/DP	$1 * 10^{-9}$	Siemens AG
PFHD (F-I/O)	F-DI of the ET 200S (SILCL 3)	$1 * 10^{-10}$	
P_{TE} (F-communication)	Fail-safe communication PROFIsafe: F-CPU and ET 200S	$1 * 10^{-9}$	

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9.3.2 Evaluation according to ISO 13849-1

Result:

Table 9-5

Result		Reason
PL	e	Specified by the manufacturer, SIEMENS AG
Average probability of a dangerous failure per hour	$2.1 * 10^{-9}$	

9.4 Assessment of React

In the application example, switching off is only used for test purposes and therefore not assessed at this point.

If safety-related switching off is to be performed, special arrangements must be made for diagnostics (for example, read back) when switching via contactors.

An application example exists that deals with read back (/7/). An assessment is made in this application example.

10 Glossary

Table 10-1

Abbreviation / term in the document	Meaning
“1“ signal	Signal has the TRUE logic state
CDS	Tool to configure and diagnose the SICK S3000 safety light curtain.
DI	Digital input module (standard module)
F-CPU	Fail-safe S7 CPU
F-DI	Fail-safe digital input module
F-DO	Fail-safe digital output module
IM of the ET 200S	Interface module of the ET 200S
M12	Muting sensor 12
MMC	SIMATIC Micro Memory Card
OSSD	Output signal switching device: Signal output of the protective device that is used to stop the dangerous movement.
PG/PC	Programming device / personal computer
Power off	The power supply for SIMATIC and the power supply for the light curtain are switched off.
Power on	The power supply for SIMATIC and the power supply for the light curtain are switched on.
PROFIsafe address	Each fail-safe component has its own PROFIsafe address. Safety mode requires that the PROFIsafe address be configured in the hardware configuration and set on the component. Depending on the component, this is done via the address switch or configuration.
Sensor pair 1	Muting sensor M11 and muting sensor M12
Sensor pair 2	Muting sensor M21 and muting sensor M22
User program	User program = safety program + standard user program The term “safety program” refers to the fail-safe part of the user program and is used instead of “fail-safe user program”, “F-program”, etc. For differentiation purposes, the non-safety-related part of the user program is referred to as the “standard user program”.

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11 References

Notes with reference (/x/) in the document:

Table 11-1

	Topic	Link / source
/1/	SICK safety light curtain C4000 Micro, C4000 Basic Plus, C4000 basic, C4000 Eco Operating Instructions	www.sick.com
	SICK: SENSIK WL27-3 photoelectric retro-reflective sensor, Operating Instructions	
/2/	Reference to the document	http://support.automation.siemens.com/WW/view/en/58793869
/3/	SIMATIC S7-300, CPU 31xC and CPU 31x: Installation / Operating Instructions	http://support.automation.siemens.com/WW/view/en/13008499
/4/	PROFINET / System Manual	http://support.automation.siemens.com/WW/view/en/19292127
/6/	SIMATIC Distributed I/O System ET 200S Operating Instructions	http://support.automation.siemens.com/WW/view/en/1144348
/7/	Integration of the Readback Signal in an Application of Category 4 according to EN 954-1: 1996 (with evaluation according to EN 62061 and EN ISO 13849-1: 2006)	http://support.automation.siemens.com/WW/view/en/21331098
/8/	SIMATIC Distributed I/O System Fail-Safe Engineering ET 200S Distributed I/O System	http://support.automation.siemens.com/WW/view/en/34474892
/9/	SIMATIC Industrial Software SIMATIC Safety – Configuring and Programming	http://support.automation.siemens.com/WW/view/en/54110126
/11/	Practical Application of IEC 62061 Illustrated Using an Application Example with SIMATIC S7 Distributed Safety	http://support.automation.siemens.com/WW/view/en/23996473
/12/	Funktionale Sicherheit von Maschinen und Anlagen. Umsetzung der europäischen Maschinenrichtlinie in der Praxis.	ISBN-13: 978-3-89578-281-7, ISBN-10: 3-89578-281-5
/15/	Safety Evaluation Tool	http://www.industry.siemens.com/topics/global/en/safety-integrated/machine-safety/safety-evaluation-tool/Pages/Default.aspx
/16/	SIMATIC ET 200S distributed I/O Interface module IM151-3 PN HIGH FEATURE (6ES7151-3BA23-0AB0)	http://support.automation.siemens.com/WW/view/en/30609285
/18/	System Description: Safety Engineering in SIMATIC S7	http://support.automation.siemens.com/WW/view/en/12490443
/20/	PROFINET with STEP 7 V11 Function Manual	http://support.automation.siemens.com/WW/view/en/49948856
/21/	SIMATIC Safety Getting Started	http://support.automation.siemens.com/WW/view/en/49972838
/22/	STEP 7 Professional V11	http://support.automation.siemens.com/WW/view/en/57185407

Notes without reference (/x/) in the document:

Table 11-2

Topic	Link / source
Siemens Industry Online Support	http://support.automation.siemens.com

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12 History

Version	Date	Modification
V1.0	04/2012	First edition
	23.05.12	Note on the power supply changed (Chapter 6.3.2)

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