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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

<table>
<thead>
<tr>
<th>DANGER</th>
<th>indicates that death or severe personal injury will result if proper precautions are not taken.</th>
</tr>
</thead>
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<tr>
<td>WARNING</td>
<td>indicates that death or severe personal injury may result if proper precautions are not taken.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>indicates that minor personal injury can result if proper precautions are not taken.</td>
</tr>
<tr>
<td>NOTICE</td>
<td>indicates that property damage can result if proper precautions are not taken.</td>
</tr>
</tbody>
</table>

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

| WARNING | Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed. |

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.
Preface

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens’ products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet [http://www.siemens.com/industrialsecurity].

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet [http://support.automation.siemens.com].
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Introduction to example

1.1 Example Structure and Task Definition

Introduction

These instructions will guide you step-by-step through a specific example for configuring and programming with *STEP 7 Safety Advanced V13*.

You will become acquainted with the basic functions and special features of *STEP 7 Safety Advanced V13*. It should take one or two hours to work through this example, depending on your experience.

In order to understand these Getting Started instructions, you need general knowledge of automation engineering. You also need to be familiar with *STEP 7 Professional V13*.

<table>
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<tr>
<th>WARNING</th>
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<tbody>
<tr>
<td>There is a risk of personal injury or damage to property.</td>
</tr>
<tr>
<td>As a component in plants and systems, the S7-1500 is subject to specific standards and regulations depending on the area of application. Please note the applicable safety and accident prevention regulations, e.g., IEC 60204-1 (General Requirements for Safety of Machinery).</td>
</tr>
<tr>
<td>The example in these Getting Started instructions serves as an introduction to configuring and programming <em>STEP 7 Safety Advanced V13</em>. It does not lead to actual live operation in every case. Before you do this, we strongly recommended that you read the latest version of the &quot;SIMATIC Safety - Configuring and Programming [<a href="http://support.automation.siemens.com/WW/view/en/54110126">http://support.automation.siemens.com/WW/view/en/54110126</a>]*) manual and the manuals of the F-modules in use. The warnings and other notices contained in these manuals must be heeded at all times even if they are not repeated in this Getting Started.</td>
</tr>
<tr>
<td>Serious injury and damage to machines and equipment may result if these regulations are ignored.</td>
</tr>
</tbody>
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Introduction to example

1.1 Example Structure and Task Definition

Production cell with access protection

1 Emergency stop
2 Laser scanner
3 Safety door
4 Control panel with start and acknowledgement pushbuttons

The entry to the production area is monitored with a laser scanner. The service area is secured by a safety door.

Entering the production area or opening the safety door results in a stop or shutdown of the production cell similar to an emergency stop.

The system can only be started when the emergency stop is cancelled, the safety door is closed, and the laser scanner detects no one in the protected area. On-site user acknowledgment is required to restart production after the emergency stop has been activated, the safety door has been opened or the protected area has reacted.
1.2 Procedure

The example in these Getting Started instructions consists of the following chapters:

Configuring

You configure:

- An ET 200SP fail-safe digital input module for connecting an emergency stop switch, the connection of the position switches for monitoring a safety door, and the connection of the laser scanner for monitoring the entry area.
- An ET 200SP fail-safe digital output module for connecting a motor.
- An ET 200SP fail-safe digital input module for user acknowledgment, feedback circuit, and start.

The configuration is described in the section "Configuring (Page 13)".

Programming

Once the configuration is successfully completed, you can program your safety program.

In the Getting Started, a fail-safe block is programmed with an emergency stop, a safety door function, a feedback circuit (as restart protection when there is an incorrect contactor), and a user acknowledgment for reintegration. On completion, the safety program is compiled and downloaded to the F-CPU.

The programming is described in the section "Programming (Page 31)".

Installation on PROFINET IO
Wiring overview for ET 200SP

The Getting Started is based on the following wiring:

The laser scanner is connected to an external sensor supply.

Figure 1-1  Wiring of the F-DI 8x24V DC HF
1.2 Procedure

Figure 1-2  Wiring of the F-DQ 4x24V DC/2A PM HF and the F-DI 8x24V DC HF
1.3 Requirements for configuring and programming

Requirements for the example

You need the following hardware for the Getting Started:

- CPU 1516F-3 PN/DP (6ES7516-3FN00-0AB0)
- SIMATIC Memory Card with at least 4 MB (e.g., 6ES795-8LC01-0AA0)
- S7-1500 load current supply PM 70W 120/230VAC (6EP1332-4BA00)
- An ET 200SP distributed I/O system consisting of:
  - Interface module IM 155-6 PN ST incl. server module (6ES7155-6AU00-0BN0)
  - 1 BaseUnit BU15-P16+A0+2D (6ES7193-6BP00-0DA0)
  - 2 BaseUnits BU15-P16+A0+2B (6ES7193-6BP00-0BA0)
  - 2 fail-safe digital input modules F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)
  - fail-safe digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)
- Emergency stop
- Position switch for monitoring a safety door
- Laser scanner
- 2 contactors which control a drive

The following software packages must be installed on your programming device/PC:

- STEP 7 Professional V13
- STEP 7 Safety Advanced V13

The programming device or PC must be connected to the F-CPU via the PROFINET interface.

Introduction to example

1.4 Additional information

Detailed information on the hardware in use is available at:

2 Configuring

2.1 Introduction

Introduction

WARNING

There is a risk of personal injury or damage to property.
You may come into contact with live electrical wires connected to the mains power supply.
Only wire the S7-1500 and ET 200SP when they are disconnected from the mains power supply.

A detailed Getting Started which explains the installation of a CPU S7-1500 is available on the Internet [http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/_content/EN/content_en.html].

Configuring the Hardware

You configure in STEP 7 Professional V13 with the STEP 7 Safety V13 optional package:

- A CPU 1516F-3 PN/DP
- An ET 200SP distributed I/O system consisting of:
  - One interface module IM155-6 PN ST as of firmware V1.1
  - Two ET 200SP fail-safe digital input modules for connecting an emergency stop switch, position switches for monitoring a safety door, the laser scanner, the user acknowledgment, the feedback circuit and start
  - One ET 200SP fail-safe digital output module for connecting a motor
2.2 Step 1: Configuring the CPU 1516F-3 PN/DP

Introduction

In this step, you create a new project, add an F-CPU, and assign parameters for it.
2.2 Step 1: Configuring the CPU 1516F-3 PN/DP

Procedure

1. In the portal view of STEP 7 Professional V13, create a new project with the name "S7_Safety_V13_GS"

2. Add a CPU 1516F-3 PN/DP in the "Devices & networks" portal with "Add new device".
   
   Result: The device view with the CPU 1516F-3 PN/DP opens.

3. In the "Properties" of the F-CPU change to the "Fail-Safe" area.
   
   Here, you can change the following parameters or accept the default setting:
   
   - "Basis for PROFIsafe addresses"
   - "Default F-monitoring time for F-I/O of this interface"

4. Leave the default values unchanged for this example.

Result

The new project has been created and the F-CPU has been configured.
2.3 Step 2: Configuring an ET 200SP distributed I/O system on a PROFINET subnet

Introduction

In this step, you configure the interface module for the ET 200SP distributed I/O system and a PROFINET subnet.

Procedure

1. In the project view, click the "Network view" tab.
2. In the hardware catalog, enter "IM155-6 PN" in the search field, and start the search with [Enter].
3. In the search results, click an interface module with article number 6ES7155-6AU00-0BN0.
4. In the "Information" palette select the firmware version which matches the interface module in the "Version" drop-down list.
5. Drag the interface module with article number 6ES7155-6AU00-0BN0 from the "Catalog" palette to the graphic area of the network view.
6. Starting at the PROFINET interface of the IM155-6 PN ST hold down the mouse button and drag a PROFINET connection to the green PROFINET interface of the F-CPU on the right.

   **Result:** A PROFINET subnet between the F-CPU and the IM155-6 PN ST is created automatically. The IP addresses and the PROFINET device names are also assigned automatically.

Result

The configuration of the interface module for the ET 200SP distributed I/O system and the PROFINET subnet is now complete.
2.4 Step 3: Configuring an F-DI module for connecting an emergency stop switch, position switches, and the laser scanner

Introduction

In this step, you configure a fail-safe digital input module for connecting the emergency stop, the position switches for monitoring the safety door, and the laser scanner for monitoring the entry area.

You will find detailed information on the parameters in the online help.

Procedure

1. In the graphic area of the network view, double-click on the IM155-6 PN ST.

   Result: The IM155-6 PN ST is opened in the device view.

2. In the device view of the ET 200SP, add an F-DI 8x24VDC HF fail-safe digital input module by dragging it from the hardware catalog to slot 1.

3. Select the "I/O addresses" area in the "Properties" tab.

   Leave the "Start address" parameter set to 0 for this example.

4. Change to the "F-parameter" area. Here, you can change the following parameters, if necessary, or apply the default settings:

   - "F-monitoring time"
   - "F-destination address"
   - "Behavior after channel fault"
   - "F-I/O DB-number"

   Leave the settings unchanged for the F-parameters for this example.

5. Switch to the "DI parameter" area.

   Disable the "Short-circuit test" parameter of the sensor supply for channels 2 and 6.
6. In this example, a two-channel emergency stop is to be connected to channels 0 and 4. Make the settings under "Channel parameter" as shown in the figure below. The equivalent 1oo2 evaluation then takes place in the F-module.
7. In this example, the position switches for monitoring a two-channel safety door will be connected to channels 1 and 5.

Make the settings under "Channel parameter" as shown in the figure below.
8. In this example, the laser scanner for monitoring the accessible entry area is to be connected to channels 2 and 6.

Make the settings under "Channel parameter" as shown in the figure below.

9. Disable the unused DI channels 3 and 7 by clearing the "Activated" check box.

Result

The configuration of the fail-safe DI module is now complete.
2.5 Step 4: Configuring an F-DQ module for connecting a motor

Introduction

In this step, you configure a fail-safe digital output module for indirect connection of a motor to channel 0 via two contactors.

You will find detailed information on the parameters in the online help.

Procedure

1. In the device view of the ET 200SP, add an F-DQ 4x24VDC/2A PM HF fail-safe digital output module by dragging it from the hardware catalog to slot 2.

2. Select the "I/O addresses" area in the "Properties" tab.

   Leave the "Start address" parameter set to 6 for this example.

3. Change to the "F-parameter" area. Here, you can change the following parameters or accept the default settings:
   - "F-destination address"
   - "F-monitoring time"
   - "Behavior after channel fault"
   - "F-I/O DB-number"

   Leave the settings unchanged for the F-parameters for this example.

4. Change to the "DO parameter" area.

   Make the settings under "Channel parameter" as shown in the figure below.

   ![DO parameter settings](image)

5. Disable the unused DQ channels 1, 2 and 3 by clearing the "Activated" check box.

Result

The configuration of the fail-safe DQ module is now complete.
2.6 Step 5: Configuring an F-DI module for user acknowledgement, feedback circuit and start

Introduction

In this step, you configure a fail-safe digital input module for connection of a user acknowledgement, a feedback circuit and start.

You will find detailed information on the parameters in the online help.

Procedure

1. In the device view of the ET 200SP, add an F-DI 8x24VDC HF fail-safe digital input module by dragging it from the hardware catalog to slot 3.
2. Select the "I/O addresses" area in the "Properties" tab.
   Leave the “Start address” parameter set to 11 for this example.
3. Change to the "F-parameter" area. Here, you can change the following parameters, if necessary, or apply the default settings:
   - "F-monitoring time"
   - "F-destination address"
   - "Behavior after channel fault"
   - "F-I/O DB-number"
   Leave the settings unchanged for the F-parameters for this example.
4. Switch to the "DI parameter" area.
   Disable the "Short-circuit test" parameter of the sensor supply for channels 3 and 7.
5. In this example, a feedback circuit is to be connected to channel 0.

Make the settings under "Channel parameter" as shown in the figure below.

Disable channel 4 by clearing the "Activated" check box.

6. In this example, the user acknowledgment is to be connected to channel 1.

Make the settings under "Channel parameter" as shown in the figure below.

Disable channel 5 by clearing the "Activated" check box.
7. In this example, start is to be connected to channel 3. Make the settings under "Channel parameter" as shown in the figure below.

Disable channel 7 by clearing the "Activated" check box.

8. Disable the unused DI channels 2 and 6 by clearing the "Activated" check box.

9. Add a server module by dragging it from the hardware catalog to slot 4.

Result

The configuration of the fail-safe DI module and the ET 200SP is now complete.
2.7 Step 6: Download hardware configuration

Introduction

In this step, you download the hardware configuration to the F-CPU.

Procedure

1. Select the F-CPU in the project tree.
2. In the shortcut menu for the F-CPU, select "Download to device > Hardware configuration". If an online connection to the F-CPU does not yet exist, you are prompted to establish this connection.

   **Result:** The hardware configuration is compiled. The "Load preview" dialog is displayed afterward.

3. Click the "Load" button.

   **Result:** The hardware configuration is downloaded.

4. The "Load results" dialog is then displayed, if applicable. Next click the "Finish" button.

2.8 Step 7: Assign device name

Introduction

In this step, you assign a valid PROFINET device name to the interface module. The device name of the F-CPU has already been assigned during the download of the hardware configuration.

The PROFINET device names are created automatically by *STEP 7 Professional V13*, you only need to assign them.


You will find additional information on configuring PROFINET IO in the online help for *STEP 7 Professional V13* under "Configurations for PROFINET IO".
Procedure

1. Change to the Network view.
2. Select "PN/IE_1" subnet in the network view.
3. Select "Assign device name" from the shortcut menu.

   **Result:** The "Assign PROFINET device name" dialog opens.

4. Select "io_device_1" for the ET200SP in the "PROFINET device name" drop-down list.
5. Select the entry with the type "ET 200SP" in the "Accessible participants in the network" table.
6. You can use the "Flash LED" button to identify the device.
7. Click the "Assign name" button.
2.9 Step 8: Assign PROFIsafe addresses

Result

You have successfully assigned the device name of the IM155-6 PN ST.

2.9 Step 8: Assign PROFIsafe addresses

Introduction

Each F-I/O is uniquely addressed by its PROFIsafe address. The PROFIsafe address consists of an F-source address and an F-destination address.

The uniqueness of the PROFIsafe address is ensured by the combination of F-source address and F-destination address.

The PROFIsafe address must be unique network-wide and CPU-wide (system-wide) for each ET 200SP F-module. This is the case if the following two conditions are met:

- The F-source address ("Basis for PROFIsafe addresses" parameter) of the F-CPU is unique network-wide.
- The F-destination address of the F-module is unique CPU-wide.

Detailed information on PROFIsafe addresses is available in the manual "SIMATIC Safety - Configuring and Programming [http://support.automation.siemens.com/WW/view/en/54110126]" in the section "Configuring".

Detailed information on the assignment of PROFIsafe addresses is available in the manual "SIMATIC Safety - Configuring and Programming [http://support.automation.siemens.com/WW/view/en/54110126]" in the section "Assigning the F-destination address for ET 200SP fail-safe modules".
### Rules for address assignment

The ET200SP is an F-module of the PROFIsafe address type 2. Keep to the following rules when assigning the PROFIsafe addresses:

<table>
<thead>
<tr>
<th>WARNING</th>
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<tbody>
<tr>
<td>F-I/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address (&quot;Basis for PROFIsafe addresses of the assigned F-CPU&quot; parameter) and F-destination address.</td>
</tr>
<tr>
<td>The combination of F-source address and F-destination address for each F-I/O must be unique network-wide* and CPU-wide** (system-wide). In addition, the F-destination address must not be occupied by F-I/O of PROFIsafe address type 1.</td>
</tr>
<tr>
<td>To ensure that addresses are unique across F-CPUs for supported configurations, you need to ensure that the &quot;Basis for PROFIsafe addresses&quot; parameter of all F-CPUs is unique network-wide*. This is achieved by having different settings for the &quot;Basis for PROFIsafe addresses&quot; parameter of the F-CPUs.</td>
</tr>
</tbody>
</table>

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* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet(s). In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/Os assigned to an F-CPU: central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.
2.9 Step 8: Assign PROFIsafe addresses

Procedure

For this example, leave the PROFIsafe addresses assigned automatically by the F-system. The module is ready for the assignment of the F-destination address when all LEDs are lit red. Assign the PROFIsafe addresses as follows:

1. Select the ET 200SP in the network view.
2. Select "Assign F-destination address" from the shortcut menu.
3. Under "Identification", select the method to be used for identifying the F-modules.
   - "by LED flashing"
     This is the default setting. During identification, the STATUS LEDs of the F-modules to be identified flash.
   - "by serial number"
     If you cannot see the F-modules clearly, you can identify them by the serial number of the interface module.

Note

The displayed serial number may have a year number added to it compared with the serial number printed on the interface module. The serial numbers are nevertheless identical.

4. In the "Assign" column, select all the F-modules to which you want to assign the F-destination address.
   If you select the interface module in the "Assign" column, all F-modules of the station are selected.
5. Click the "Identification" button. Check whether the status LEDs for the F-modules whose F-destination address you want to assign are flashing green.
   If you identify using the serial number, compare the displayed serial number with the serial number of the interface module.
6. Confirm successfully identified F-modules in the "Confirm" column of the table.
7. Use the "Assign F-destination" button to assign the F-destination addresses to the F-modules.
   You must confirm the "Confirm Assignment" dialog within 60 seconds.
8. Close the dialog.

Result

You have successfully assigned the PROFIsafe addresses.
2.10 Summary: Configuring the Hardware

Summary

So far, you have configured the following according to the task definition for the example:

- An F-CPU 1516F-3 PN/DP
- An ET 200SP with:
  - Interface module IM 155-6 PN ST
  - An ET 200SP fail-safe digital input module for connecting an emergency stop, position switches for monitoring a safety door, and the laser scanner for monitoring the accessible production area.
    - Start addresses of the input and output addresses: both 0
    - Channels 0 and 4 for emergency stop
    - Channels 1 and 5 for safety door position switch
    - Channels 2 and 6 for the laser scanner
  - One ET 200SP fail-safe digital output module for connecting a motor
    - Start addresses of the input and output addresses: both 6
    - Channel 0 for indirect switching of motor via two contactors
  - An ET 200SP fail-safe digital input module for user acknowledgment, feedback circuit and start.
    - Start addresses of the input and output addresses: both 11
    - Channel 0 for feedback circuit
    - Channel 1 for user acknowledgment
    - Channel 3 for start
  - Server module

You can now continue with programming the safety program.
3.1 Introduction

In this example, you create a fail-safe block (F-FB). In F-FB you program:

- the safety door function,
- the emergency stop function (safety circuit for shutdown with emergency stop, if the safety door is open, or the protected area monitored by the laser scanner is entered),
- a feedback monitoring circuit (as automatic restart protection in case of a faulty contactor)
- the user acknowledgment for reintegration

You then compile the safety program and download it to the F-CPU.
3.2 The structure of the safety program

Introduction

When you insert the F-CPU, an F-runtime group and the associated F-OB with main safety block (F-FB with instance DB) are created by default.

The first step in programming your safety program is the main safety block. When this block is compiled, additional instructions are added that call the remaining F-blocks of the safety program.

The structure of a safety program

For structuring purposes, a safety program consists of one or two F-runtime groups.

The main safety block is called in the F-CPU by the F-OB assigned to the F-runtime group.

From the main safety block you can call additional F-FBs and F-FCs with safety functions.

This example consists of one F-runtime group. The F-FB "Safety_Interlock" is called from the main safety block of the F-runtime group.


Detailed information on the safety program is available in the manual "SIMATIC Safety - Configuring and Programming" [http://support.automation.siemens.com/WW/view/en/54110126] in the section "Program structure of the safety program (S7-1500)".
Programming

A safety program consists of F-blocks that you create using the FBD or LAD programming language and F-blocks that are automatically added.

In this example, you program using the FBD programming language. Note the following differences compared to programming a standard user program:

- Preconnection of the enable input EN or evaluation of the enable output ENO is not possible.
- Limitations in the instructions
- Limitations in the used data types and operand areas
- Fail-safe signals are shown in yellow in the LAD/FBD Editor.

3.3 The Safety Administration Editor

The Safety Administration Editor supports you in the following tasks:

- Displaying the status of the safety program
- Displaying the F-collective signature
- Displaying the status of the safety mode
- Creating/organizing F-runtime groups
- Displaying information on the F-blocks
- Displaying information about F-compliant PLC data types
- Specifying/changing access protection
- Specifying/changing general settings for the safety program

3.4 Step 9: Specifying the centralized settings for the safety program

Introduction

In this step, you learn how to call the Safety Administration Editor.

Opening the Safety Administration Editor

1. In the project tree of the F-CPU, double-click on "Safety Administration".
   
   **Result:** The Safety Administration Editor opens.
   
   You make central settings for the safety program in the Safety Administration Editor.

2. In the area navigation of the Safety Administration Editors, switch to "F-runtime group".
   
   The automatically created F-runtime group and the F-OB with the associated main safety block are displayed when you create the F-CPU.
   
   Leave the preset blocks for this example.

3. In the area navigation of the Safety Administration Editor, switch to "Settings".
   
   Here you can make the settings for the safety program.
   
   Keep the preassigned settings for this example.

For additional information on the Safety Administration Editor, refer to the "SIMATIC Safety - Configuring and Programming [http://support.automation.siemens.com/WW/view/en/54110126]" manual in the section "Safety Administration Editor".
3.5 Step 10: Create PLC tag table

Introduction
You create symbolic names for each input and output of the F-I/O in the PLC tag table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Data type</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESTOP</td>
<td>Bool</td>
<td>%Q0.0</td>
</tr>
<tr>
<td>Safety_Door_SW1</td>
<td>Bool</td>
<td>%Q0.1</td>
</tr>
<tr>
<td>Laserscanner</td>
<td>Bool</td>
<td>%Q0.2</td>
</tr>
<tr>
<td>Safety_Door_SW2</td>
<td>Bool</td>
<td>%Q0.5</td>
</tr>
<tr>
<td>Safety_Door_SW3</td>
<td>Bool</td>
<td>%Q1.1</td>
</tr>
<tr>
<td>Safety_Door_SW4</td>
<td>Bool</td>
<td>%Q1.5</td>
</tr>
<tr>
<td>Motor_VS</td>
<td>Bool</td>
<td>%Q6.0</td>
</tr>
<tr>
<td>Feedback</td>
<td>Bool</td>
<td>%Q1.0</td>
</tr>
<tr>
<td>Quit</td>
<td>Bool</td>
<td>%Q1.1</td>
</tr>
<tr>
<td>START</td>
<td>Bool</td>
<td>%Q1.3</td>
</tr>
<tr>
<td>Motor</td>
<td>Bool</td>
<td>%Q8.0</td>
</tr>
</tbody>
</table>

Specifying inputs and outputs for the safety program
1. Create a new PLC tag table in the F-CPU project navigation under "PLC tags" with "Add new tag table".
2. Rename the new PLC tag table with the [F2] key as "Safety Program".
3. Double-click the PLC tag table to open it.
4. Assign symbolic names for the inputs and outputs as shown in the figure above.

Result
In the next steps of the Getting Started, you can now assign symbolic names to the inputs and outputs of the instructions simply using drag-and-drop from the detail view of the "Safety Program" PLC tag table.
3.6  Step 11: Creating an F-FB

Introduction

In this step, you create an F-FB in which you program the safety functions for this example in the next steps.

Procedure

1. Go to the "Program blocks" folder of the F-CPU and double-click "Add new block".
   Result: The "Add new block" dialog opens.
2. Under "Name" enter "Safety_Interlock" for the name of the F-FB.
3. Click the "Function block" button on the left.
4. Select the "Create F-block" option.
5. Choose "FBD" as the language for the F-FB.
6. Close the dialog box with "OK".
Result

The F-FB "Safety_Interlock" is created in the "Program blocks" folder and opens automatically in the LAD/FBD Editor.

You can now continue with programming the safety functions in the next step.
3.7 Step 12: Programming the safety door function

Introduction

In this step, you program the safety door function for this example. You will find detailed information on the "SFDOOR" instruction in the online help.

![Diagram of SFDOOR instruction]

Procedure

1. Create the following static tag of data type BOOL in the interface of the "Safety Interlock" F-FB:

<table>
<thead>
<tr>
<th>Name</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN_Safety_Door</td>
<td>Bool</td>
</tr>
</tbody>
</table>

2. Insert the "SFDOOR" instruction from the "Safety functions" subfolder of the "Instructions" task card into network 1.

3. Click "OK" to confirm the "Call options" dialog.

4. Supply the inputs and outputs as shown in the figure above.

5. Insert one "Invert RLO" each at the inputs QBAD_IN1" and "QBAD_IN2" from the "Instructions" task card.

Result

The programming of the safety door function is now complete.
3.8  Step 13: Programming the emergency stop function

Introduction

In this step, you program the emergency stop function for this example.

An emergency stop is executed:

- when the emergency stop is activated
- when the safety doors open
- when the protected area of the laser scanner is entered

You will find detailed information on the "ESTOP1" instruction in the online help.

Procedure

1. Create the following static tag of data type BOOL in the interface of the "Safety Interlock" F-FB:

2. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card in network 2.

3. Insert a third input at the "AND logic operation" instruction by clicking on the yellow star.

4. Supply the inputs of the instruction as shown in the figure above.

5. Insert the "ESTOP1" instruction from the "Safety functions" subfolder of the "Instructions" task card into network 2.

6. Click "OK" to confirm the "Call options" dialog.

7. Supply the inputs and outputs of the instruction as shown in the figure above.

8. Connect the output of the "AND logic operation" instruction to the "E_STOP" input of the "ESTOP1" instruction.

Result

The programming of the emergency stop function is now complete.
3.9 Step 14: Programming the feedback monitoring

Introduction

In this step, you program the feedback circuit monitoring for this example.

You will find detailed information on the "FDBACK" instruction in the online help.

Procedure

1. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card in network 3.
2. Supply the inputs of the instruction as shown in the figure above.
3. Insert the "FDBACK" instruction from the "Safety functions" subfolder of the "Instructions" task card into network 3.
4. Click "OK" to confirm the "Call options" dialog.
5. Supply the inputs and outputs of the instruction as shown in the figure above.
6. Insert a "Negate RLO" at the "QBAD_FIO" input from the "Instructions" task card.
7. Connect the output of the "AND logic operation" instruction to the "ON" input of the "FDBACK" instruction.

Result

The programming of the feedback monitoring is now complete.
### 3.10 Step 15: Programming the User Acknowledgment for Reintegration of the F-I/O

#### Introduction

In this step, you program the user acknowledgement for reintegration of the F-I/O for this example.

In your safety program, you must provide a user acknowledgment for the reintegration for the F-I/O. In this example, this is the "Quit" input.

You can use the ACK_GL instruction to reintegrate all F-I/O of an F-runtime group.

---

#### Note

A user acknowledgment with a positive edge at the ACK_GL instruction is required for a reintegration of the F-I/O (i.e., for switching from fail-safe values (0) to process data) after a fault is corrected:

- After every communication error
- After F-I/O faults or channel faults when parameter ACK_NEC = true in the F-I/O DBs

You will find detailed information on the "ACK_GL" instruction in the online help.

If you use the option of user acknowledgment by means of an acknowledgment key and there is a communication error / F-I/O fault / channel fault on the F-module to which the acknowledgment key is connected (F-DI 8x24VDC HF on slot 3), acknowledgment for reintegration of this F-module is not possible.

This "block" can only be removed by a STOP/RUN transition of the F-CPU.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system in order to acknowledge reintegration of the F-module to which the acknowledgment key is connected. You can find more information on this in the manual "SIMATIC Safety - Configuring and Programming [http://support.automation.siemens.com/WW/view/en/54110126]", section "Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO Controller".

---

#### Procedure

1. Insert the "ACK_GL" instruction from the "Safety functions" subfolder of the "Instructions" task card into network 4.
2. Click "OK" to confirm the "Call options" dialog.
3. Supply the input as shown in the figure above.
Result

The programming of the user acknowledgment is now complete.

3.11 Step 16: Programming of the main safety block

Introduction

In this step, you program the main safety block for this example. The main safety block was created automatically when the F-CPU was created.

Procedure

1. Double-click in the project navigation to open the main safety block "Main_Safety".
2. Use drag-and-drop to insert the F-FB "Safety_Interlock" into network 1 of the main safety block.
3. Click "OK" to confirm the "Call options" dialog.

Result

The F-FB "Safety_Interlock" is now called cyclically in the main safety block.

You have now programmed the functionality according to the task definition of the example. You can now proceed with the next steps to compile the safety program and then download the safety program along with the hardware configuration to the F-CPU.
Introduction

In this step, you compile the safety program.

A consistency check is performed on the execution-relevant F-blocks when the safety program is compiled, that is, the safety program is checked for errors. Any error messages are output in the "Compile" tab. After a successful consistency check, the additionally required F-system blocks are generated automatically and added to the F-runtime group to generate an executable safety program.

Procedure

1. Select the F-CPU in the project tree.
2. In the shortcut menu for the F-CPU, select "Compile > Software (only changes)".

   Result: The safety program is compiled.

Result

After successful compilation, you always have a consistent safety program that is ready for approval.
3.13 Step 18: Download the safety program to the F-CPU

Introduction
In this step, you download the safety program to the F-CPU.

Procedure
1. Select the F-CPU in the project tree.
2. In the shortcut menu for the F-CPU, select "Download to device > Software (only changes)". If an online connection to the F-CPU does not yet exist, you are prompted to establish this connection.
   
   **Result:** The "Load preview" dialog is displayed.

3. Click the "Load" button.

   **Note**
   To download the entire safety program, the F-CPU must be in STOP mode.

   **Result:** The safety program is downloaded and the "Load results" dialog is displayed.

4. Check in the dialog if the F-collective signatures are identical online and offline.
   If so, the download operation was successful. If not, repeat the download operation.
5. Click the "Finish" button.

6. Switch the F-CPU from STOP to RUN mode.

The display of the F-CPU shows you the current status of the safety mode in the "Overview > Fail-safe" menu item.

---

**Note**

Once a safety program has been created, you need to perform a full function test according to your automation task (see SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

---

**Result**

You have now finished creating the safety program according to the task definition of the example. In the following appendix, we show you how easy it is to set up access protection for your safety program and the F-CPU.
Setting up access protection

Introduction

It is essential to provide access protection in production mode for the access to the SIMATIC Safety F-system.

No access protection is initially necessary for test purposes, commissioning, etc. That is, you can execute all offline and online actions without access protection, i.e., without password prompt.

In this step, you set up access protection for the safety program and the F-CPU.

For additional information, refer to the "Access protection" chapter in the SIMATIC Safety - Configuring and Programming manual.

Procedure

To set up access protection for productive operation, follow these steps:

1. In the area navigation of the Safety Administration Editors, switch to "Access protection".
2. Under "Offline safety program protection" click "Set up". Enter the password in the dialog that appears, and enter it again to confirm.
3. Close the dialog with "OK".

   Result: You have set up access protection for the safety program.

4. Under "F-CPU access protection", click the link "Go to the "Protection" area of the F-CPU".

   Result: You switch to the device view of the F-CPU.
5. Under "Protection", select the "Full access (no protection)" option. Under "Access permission", enter a password. Then enter the password again to confirm.

6. Select the F-CPU in the project tree.

7. In the shortcut menu for the F-CPU, select "Download to device > Hardware and software (only changes)".

   **Result:** You have set up access protection for the F-CPU and the safety program.

---

**Result**

You can only make changes to the safety program offline on your programming device/PC if you enter the password from Step 2.

You cannot overwrite the safety program in the F-CPU until you enter the password from Step 4.

As the next step, acceptance testing of the system may be necessary for productive operation. For additional information regarding acceptance testing, refer to the "System Acceptance Test" chapter in the "SIMATIC Safety - Configuring and Programming [http://support.automation siemens.com/WW/view/en/54110126]" manual.
## Typical configuring and programming errors and their causes

### Errors, causes and remedy measures

<table>
<thead>
<tr>
<th>Type</th>
<th>Error</th>
<th>Possible causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration error</td>
<td>F-blocks cannot be downloaded to the F-CPU.</td>
<td>F-CPU parameter &quot;F-activation&quot; is not activated in the &quot;Fail-Safe&quot; area.</td>
</tr>
<tr>
<td>Configuration error</td>
<td>DIAG-LED flashes red and all channel error LEDs on the F-module are lit</td>
<td>The PROFIsafe address does not match the PROFIsafe address in the hardware configuration.</td>
</tr>
<tr>
<td>Configuration error</td>
<td>The DIAG-LED on the F-module flashes red and TIMEOUT error in the DIAG byte of the F-I/O DB</td>
<td>Monitoring time of the F-module ≤ max. cycle time of the F-runtime group.</td>
</tr>
</tbody>
</table>
| Configuration error| The DIAG-LED on the F-module flashes red and CRC error in the DIAG byte of the F-I/O DB | • Loaded safety program is not consistent with the loaded hardware configuration.  
• Safety program is inconsistent.  
• PIQ/PII of the F-module is being overwritten by the standard user program. |
| Configuration error| The DIAG-LED on the F-DI module flashes red, channel error LED is lit and F-module signals discrepancy | Sensor connection does not match parameter assignment, for example:  
• Only one switching contact is connected to a channel with 1oo2 evaluation  
• A sensor with nonequivalent contacts is connected to a channel set to "two-channel equivalent". |
| Programming error  | F-CPU changes to STOP                                               | • Main safety block is being called more than once in the cyclic program.  
• Operands of F-DBs are being written to in the standard user program.  
• Undeclared TEMP variables are being used in the safety program.  
• Bit memory that is modified during processing of the main safety block, e.g., clock memory, is being read-accessed in the safety program.  
• Overflow with mathematical functions.  
• F-monitoring time set too low. The F-monitoring time must be greater than the max. runtime (see section "Monitoring and response times" in the manual "SIMATIC Safety - Configuring and Programming [http://support.automation.siemens.com/WW/view/en/54110126]"). |
Glossary

Access protection

→ Fail-safe systems must be protected against dangerous, unauthorized access. Access protection for F-systems is implemented by assigning two passwords (one for the → F-CPU, and one for the → safety program).

Automatically generated F-blocks

→ F-blocks that are automatically generated and, if necessary, opened when the → safety program is compiled, in order to generate an executable safety program from the safety program programmed by the user.

Category

Category in accordance with ISO 13849-1:2006 or EN ISO 13849-1:2008
With SIMATIC Safety, use in → safety mode up to category 4 is possible.

Channel fault

Channel-related fault, such as a wire break or short-circuit.

collective F-signatures

The collective F-signatures uniquely identify a particular state of the → safety program and the safety-related parameters of the F-CPU and F-I/O. They are important for the on-site acceptance test of the safety program, e.g., by → experts.

CPU-wide

"CPU-wide" means all F-I/Os assigned to an F-CPU: central F-I/O of this F-CPU as well as F-I/Os for which the F-CPU is DP master/IO controller. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

CRC

Cyclic Redundancy Check → CRC signature

CRC signature

The validity of the process data in the → safety message frame, the correctness of the assigned address relationships, and the safety-related parameters are validated by means of a CRC signature contained in the safety message frame.
Depassivation

→ Reintegration

Discrepancy analysis

Discrepancy analysis for equivalence or nonequivalence is used for fail-safe inputs to
determine errors based on the time characteristic of two signals with the same functionality.
The discrepancy analysis is initiated when different levels are detected in two associated
input signals (for nonequivalence testing, when identical levels are detected). On expiration
of an assignable period (→ discrepancy time), a check is made to determine whether the
difference in levels has disappeared (for nonequivalence testing, whether the identicalness
of the levels has disappeared). If not, there is a discrepancy error. The discrepancy analysis
is performed between the two input signals of the 1oo2 sensor evaluation (→ sensor
evaluation) in the fail-safe input.

Discrepancy time

Assignable time for the → discrepancy analysis. If the discrepancy time is set too high, the
fault detection time and → fault reaction time are prolonged unnecessarily. If the discrepancy
time is set too low, availability is decreased unnecessarily because a discrepancy error is
detected when, in reality, no error exists.

Fail-safe modules

ET 200MP, ET 200SP, ET 200S, ET 200pro, ET 200iSP modules that can be used for
safety-related operation (→ safety mode) in the ET 200MP, ET 200SP, ET 200S, ET 200pro
or ET 200iSP distributed I/O systems. These modules are equipped with integrated → safety
functions. They operate in accordance with IEC 61784-1: 2010 (fieldbus profiles) and the →
PROFIsafe bus profile.

Fail-safe systems

Fail-safe systems (F-systems) are systems that remain in a safe state or immediately switch
to another safe state as soon as particular failures occur.

F-blocks

The following fail-safe blocks are designated as F-blocks:

- those created by the user in LAD or FBD
- those created by the user as → F-DBs
- those selected by the user from a global library
- those added automatically in the → safety program (→ F-SBs, → automatically generated
  F-blocks, → F-shared DB, → F-I/O DBs; instance DBs of F-FBs)

All F-blocks are shown in yellow in the project tree.
**F-CPU**

An F-CPU is a central processing unit with fail-safe capability that is approved for use in SIMATIC Safety and in which a → safety program can run in addition to the → standard user program.

**F-DBs**

Optional fail-safe data blocks that can be read-/write-accessed from anywhere within the safety program (exception: DBs for F-runtime group communication).

**F-FBs**

Fail-safe function blocks (with instance DBs), in which the user programs the → safety program in FBD or LAD.

**F-FCs**

Fail-safe FCs, in which the user programs the → safety program in → FBD or → LAD.

**F-I/O**

Collective name for fail-safe inputs and outputs available in SIMATIC S7 for integration in SIMATIC Safety, among others. The following are available:

- → ET 200eco fail-safe I/O module
- → S7-300 fail-safe signal modules
- → Fail-safe modules for S7-1200
- → Fail-safe modules for ET 200MP
- → Fail-safe modules for ET 200SP
- → Fail-safe modules for ET 200S
- → Fail-safe modules for ET 200pro
- → Fail-safe modules for ET 200iSP
- → Fail-safe DP standard slaves
- → Fail-safe standard I/O devices
**F-I/O DB**

Fail-safe data block for F-CPU to an → F-I/O in *STEP 7 Safety*. An F-I/O DB is automatically created for each F-I/O when the F-I/O is configured in the hardware and network editor. The F-I/O DB contains tags that the user can or must evaluate or write in the safety program as follows:

- For reintegration of the F-I/O after communication errors
- For reintegration of F-I/O after F-I/O or channel faults
- If F-I/O are to be passivated as a result of particular safety program statuses (for example, group passivation)
- For reassignment of parameters for fail-safe DP standard slaves/standard I/O devices or enabling HART communication for the F-I/O with the corresponding functionality
- In order to evaluate whether fail-safe values or process data are output

**F-I/O faults**

Module-related F-I/O fault, such as a communication error or parameter assignment error

**F-modules**

→ Fail-safe modules

**F-OB**

The F-OB calls the main safety block of an F-runtime group in S7-1200/1500 F-CPU.

**F-runtime group**

The → safety program consists of one or two F-runtime groups. An F-runtime group is a logical construct of several associated → F-blocks. It is generated internally by the F-system. An F-runtime group consists of the following F-blocks:

→ Main safety block, F-OB (S7-1200, S7-1500), if applicable → F-FBs/ → F-FCs, if applicable → F-DBs, → F-I/O DBs, F-blocks of global libraries, instance DBs, → F-SBs, and → automatically generated F-blocks.

**F-runtime group information DB**

The F-runtime group information DB provides key information on the corresponding → F-runtime group and on the → safety program as a whole.

**F-systems**

→ Fail-safe systems
Main safety block

"Introductory F-block" for fail-safe programming of the → safety program in STEP 7 Safety. The main safety block is an → F-FB or → F-FC that the user assigns to the calling F-OB (S7-1200, S7-1500) or block (OB, FC, FB) (S7-300, S7-400) of an → F-runtime group.

The main safety block contains the safety program and any calls of other → F-FBs/F-FCs for program structuring.

Network-wide

A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet(s). In PROFIBUS, a network includes all nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all nodes accessible via RT_Class_1/2/32 (Ethernet/WLAN/Bluetooth, Layer 2) and if applicable RT_Class_UDP (IP, Layer 3).

Passivation

When passivation occurs in an → F-I/O with inputs, the → F-system provides the safety program with fail-safe values (0) instead of the process data pending at the fail-safe inputs in the PII.

When passivation occurs in an F-I/O with outputs, the F-system transfers fail-safe values (0) to the fail-safe outputs instead of the output values in the PIQ provided by the safety program.

PL

Performance Level (PL) according to ISO 13849-1: 2006 or in accordance with EN ISO 13849-1: 2008

With SIMATIC Safety, use up to Performance Level (PL) e is possible in → safety mode.

PROFIsafe

Safety-related bus profile of PROFIBUS DP/PA and PROFINET IO for communication between the → safety program and the → F-I/O in an → F-system. See IEC 61784-3-3:2010.
Glossary

PROFIsafe address

The PROFIsafe address (code name in accordance with IEC 61784-3-3: 2010) is used to uniquely identify the source and destination. The PROFIsafe address consists of an F-source address and an F-destination address. Each F-I/O therefore has two addresses, an F-source address and an F-destination.

The F-source address is automatically assigned and is displayed for fail-safe DP standard slaves/IO standard devices and ET 200SP F-modules. The F-source address for F-modules ET 200S, ET 200eco, ET 200pro, ET 200iSP and F-SMs S7-300 is always 1. With the F-modules ET 200SP/ET 200MP, the F-source address is the basis of the PROFIsafe addresses of the assigned F-CPU.

You need to configure the F-destination address in the hardware and network editor. You configure the F-destination address for the ET 200S, ET 200eco, ET 200pro, ET 200iSP and F-SMs S7-300 F-modules with a switch. For ET 200SP F-modules and ET 200MP F-modules, assign the F-destination address in the hardware and network editor. With S7-1200 F-modules, the F-destination address is automatically assigned by the F-system.

Program signature

→ F-collective signature

Proof test interval

Time period after which a component must be put into fail-free state. That is, it is replaced by an unused component or it is proven to be completely error-free.

Reintegration

The switchover from fail-safe values (0) to process data (reintegration of an F-I/O) takes place automatically or following user acknowledgment in the F-I/O DB. The reintegration method depends on the following:

- The reason for passivation of the F-I/O/channels of the F-I/O
- A parameter assignment in the F-I/O DB or in the configuration itself (for example, ET 200MP F-modules on an F-CPU S7-1500 and S7-1200 F-modules on an F-CPU S7-1200)

Following reintegration for an F-I/O module with inputs, the process data pending at the inputs in the PII are provided again for the safety program. For an F-I/O with outputs, the F-system again transfers the output values provided in the PIQ in the safety program to the fail-safe outputs.

SAE

→ Safety Administration Editor
Safe state

The basic principle of the safety concept in fail-safe systems is the existence of a safe state for all process variables. For digital F-I/O that conform to IEC 61508:2010, this is always the value "0".

Safety Administration Editor

The Safety Administration Editor provides support for the main tasks of your safety program.

Safety function

Mechanism integrated in the F-CPU and F-I/O that allows them to be used in fail-safe systems.

According to IEC 61508:2010, a function that is implemented by a safety device in order to maintain the system in the safe state or bring the system to a safe state in the event of a specific fault. (fault reaction function -> user safety function)

Safety message frame

In safety mode, data are transferred in a safety frame between the F-CPU and F-I/O, or between the F-CPU in safety-related CPU-CPU communication.

Safety mode

1. Operating mode of F-I/O in which safety-related communication can take place using safety message frames.

2. Operating mode of the safety program. In safety mode of the safety program, all safety mechanisms for error detection and error reaction are activated. In safety mode, the safety program cannot be modified during operation. Safety mode can be deactivated by the user (deactivated safety mode).

Safety program

Safety-related user program

Safety protocol

Safety message frame

Safety-related communication

Safety-related communication is used to exchange fail-safe data.
Sensor evaluation

There are two types of sensor evaluation:

- 1oo1 evaluation – sensor signal is read once
- 1oo2 evaluation - sensor signal is read twice by the same → F-I/O and compared internally

Signature

→ collective F-signatures

SIL

Safety Integrity Level (SIL) according to IEC 61508:2010. The higher the Safety Integrity Level is, the more stringent the measures for avoiding and controlling system faults and random hardware failures.

With SIMATIC Safety, up to Safety Integrity Level SIL3 is possible in safety mode.

Standard user program

Non-safety-related user program