Failsafe Controllers

SIMATIC Safety Integrated
Safety Shutdown in the Stop Categories 0 and 1 in Safety Category 4 according to EN 954-1
Preliminary Remarks

The function examples dealing with “Safety Integrated” are fully functional and tested automation configurations based on A&D standard products for simple, fast and inexpensive implementation of automation tasks in safety engineering. Each of these function examples covers a frequently occurring subtask of a typical customer problem in safety engineering.

Apart from a list of all required hardware and software components and a description of the way they are connected to each other, the function examples include the tested and commented code. This ensures that the functionalities described here can be reset in a short period of time and thus also be used as basis for individual expansions.

Important Note

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

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

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1 Warranty, Liability and Support

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If you have questions regarding this function example, please send an e-mail to:

csweb@ad.siemens.de
2 Automation Function

2.1 Description of the functionality

Classification

Three Stop Categories (Stop Category 0, 1 and 2) are defined for the safety shutdown of machines. The Stop Category has to be defined on the basis of the risk assessment of the machine. The standards and regulations are listed in DIN EN 60204-1: 1998.

Stop Category 0

Stopping by immediate shutdown of the energy supply to the machine actuators. This stopping is an uncontrolled stop. Each machine has to be equipped with a stop function of Stop Category 0. The stop of Category 0 must have priority. In this example the shutdown complies with Safety Category 4.

Stop Category 1

Controlled stop during which the energy supply to the machine actuators is maintained to enable the stopping. The energy supply is only interrupted when the stop is reached. In this example the shutdown complies with Safety Category 4.

Stop Category 2

Controlled stop during which the energy supply to the machine actuators is maintained.

Functional example

In this example, safety shutdown in the Stop Categories 0 and 1 is shown. The DS asynchronous motor is hereby switched on and off via a MICROMASTER frequency converter. Apart form the operational stop, the motor can be fail-safe stopped as follows:

Stop Category 0

An NC button simulates a safety door contact. If the safety door is opened during operation ("0" signal of the button) the drive is immediately electrically isolated from the line supply

Stop Category 1

Stop Category 1 is used for an emergency stop. The motor is brought to a standstill. After a parameterized time (after which the motor must be safely in standstill) the motor is taken off the grid.

In addition the conditions listed below apply to the emergency stop:

- Precedence over all other functions and operations
- Resetting may not start a restart (acknowledgement required)
Note

In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. Should you wish to not use the motor holding brake, please change the parameterization of the MICROMASTERS.

Reaction times

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

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

See ID number 19138505

Flowchart

The following flow chart shows the correlation (for a better overview, operational stoppage is not displayed here):
Time sequence for Stop Category 0

The times listed in the following table are also shown in a timing diagram below. The names of the signals correspond to the ones of the S7 program code.

<table>
<thead>
<tr>
<th>Time</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>t1</td>
<td>With the acknowledge signal (negative edge) the contactors K1 and K2 are activated and supply the MICROMASTER with power. This switches the MICROMASTER on.</td>
</tr>
<tr>
<td>t2</td>
<td>With the start signal (positive edge) the output MM of the standard output module &quot;1&quot; signal switches to the MICROMASTER. This starts the motor according to a ramp parameterized in the MICROMASTER.</td>
</tr>
<tr>
<td>T3</td>
<td>During operation the safety door is opened (FDOOR=&quot;0&quot;). The safety door signal is in this example simulated by an (NC) button. The contactors K1 and K2 drop out and electrically isolate MICROMASTER and motor from the line supply; output MM is reset in the program.</td>
</tr>
</tbody>
</table>
Time sequence for Stop Category 1

The times listed in the following table are also shown in a timing diagram below. The names of the signals correspond to the ones of the S7 program code.

<table>
<thead>
<tr>
<th>Time</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>t1</td>
<td>With the acknowledge signal (negative edge) the contactors K1 and K2 are activated and supply the MICROMASTER with power. This switches the MICROMASTER on.</td>
</tr>
<tr>
<td>t2</td>
<td>With the start signal (positive edge) the output MM of the standard output module “1” signal switches to the MICROMASTER. This starts the motor according to a ramp parameterized in the MICROMASTER.</td>
</tr>
<tr>
<td>t3</td>
<td>After activating the emergency stop (ESTP=0”) the output MM of the standard output module is reset. This puts MICROMASTER motor to stop.</td>
</tr>
<tr>
<td>t4-t3</td>
<td>After this time the motor must be in standstill. This time is specified in the safety program as input parameter at a certified function block from the distributed Safety library.</td>
</tr>
<tr>
<td>t4</td>
<td>At motor standstill (parameterized time has elapsed) the contactors K1 and K2 drop out. This isolates the drive from the supply.</td>
</tr>
</tbody>
</table>

Operational stop

If in this example, the (NC) button for the operational stop is pressed, the following procedure has been prepared:

The motor is brought to a standstill by the MICROMASTER. Contactor K1 and K2 continue to supply the MICROMASTER with power. A motor restart is possible without previous acknowledgement.
2.2 Advantage / Customer benefits

- Wiring reduced to a minimum due to use of fail-safe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the fail-safe program with STEP7 engineering tools.
- Only one CPU is required, since fail-safe and standard program parts run on a coexistent basis in the CPU.
- Use of prefabricated (and certified) fail-safe blocks from the Distributed Safety library.

3 Required components

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>MLFB / Order information</th>
<th>No.</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>PS307 5A</td>
<td>6ES73071EA00-0AA0</td>
<td>1</td>
<td>SIEMENS A&amp;D</td>
</tr>
<tr>
<td>S7-CPU, can be used for safety applications</td>
<td>CPU 315F-2DP</td>
<td>6ES7315-6FF01-0AB0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Micro Memory Card</td>
<td>MMC 512 kBytes</td>
<td>6ES7953-8LJ10-0AA0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Interface module for ET 200S</td>
<td>IM 151 High Feature</td>
<td>6ES7151-1BA00-0AB0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Power module for ET 200S</td>
<td>PM-E DC24..48V AC24..230V</td>
<td>6ES7138-4CB10-0AB0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Electronic module for ET 200S</td>
<td>2DI HF DC24V HF</td>
<td>6ES7131-4BB00-0AB0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Electronic module for ET 200S</td>
<td>2DO HF DC24V HF</td>
<td>6ES7132-4BB00-0AB0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Electronic module for ET 200S</td>
<td>4/8 F-DI DC24V</td>
<td>6ES7138-4FA01-0AB0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Electronic module for ET 200S</td>
<td>4 F-DO DC24V/2A</td>
<td>6ES7138-4FB01-0AB0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Terminal module for ET 200S</td>
<td>TM-P15S23-A0</td>
<td>6ES7193-4CD20-0AA0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Terminal module for ET 200S</td>
<td>TM-E15S24-A1</td>
<td>6ES7193-4CA20-0A0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Terminal module for ET 200S</td>
<td>TM-E30C46-A1</td>
<td>6ES7193-4CF50-0AA0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Profile rail</td>
<td>482.6 mm</td>
<td>6ES7390-1AE80-0AA0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Standard mounting rail</td>
<td>35 mm, length:483 mm</td>
<td>6ES5710-8MA11</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Emergency stop</td>
<td>Push button, 1NC</td>
<td>3SB3801-0DG3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Contact (for emergency stop)</td>
<td>1NC, screw-type connection</td>
<td>3SB3420-0C</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Push button</td>
<td>Green, 1NO</td>
<td>3SB3801-0DA3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Push button</td>
<td>Red, 1NC</td>
<td>3SB3801-0DB3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Contactor</td>
<td>AC-3, 3KW/400V, 1NC, DC 24V</td>
<td>3RT1015-2BB42</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Contactor</td>
<td>AC-3, 3KW/400V, 1NO, DC 24V</td>
<td>3RT1015-2BB41</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Excess voltage limiter for plugging onto contactor</td>
<td>RC element AC 24...48V, DC 24...70V</td>
<td>3RT1916-1CB00</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Circuit breaker for motor protection</td>
<td>0.35...0.5A</td>
<td>3RV1011-1JA20</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Frequency inverter</td>
<td>MICROMASTER 410</td>
<td>6SE6410-2BB13-7A0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Operator panel for the frequency inverter</td>
<td>MM410 Operator Panel</td>
<td>6SE6400-0SP00-0AA0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>Low-voltage motor 0.18kW</td>
<td>1LA7063-4AB10-Z</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Note

In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the following hardware components are not necessary: Contactor with auxiliary contact (NO), 1 excess voltage limiter for plugging onto the contactor, option 26 at the motor.

Note

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

Configuration software/tools

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>MLFB / Order information</th>
<th>No.</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMATIC STEP 7</td>
<td>V5.3 + SP1</td>
<td>6ES7810-4CC07-0YA5</td>
<td>1</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>SIMATIC Distributed Safety</td>
<td>V5.3</td>
<td>6ES7833-1FC01-0YA5</td>
<td>1</td>
<td>SIEMENS</td>
</tr>
</tbody>
</table>
4 Setup and Wiring

Regarding the use of MICROMASTER 410, please consider the following safety note:

- **Warning**
  - The MICROMASTER carries hazardous voltages and controls potentially dangerous rotating mechanical parts. Non-compliance with warnings or failure to follow the instructions contained in the MICROMASTER manual can result in loss of life, severe personal injury, or serious damage to property.
  - Only adequately qualified personnel may work at this equipment. It is required that this personnel is informed in detail on and familiar with all safety notices, installation, operation and maintenance procedures listed in the MICROMASTER manual. Proper and safe operation of the equipment requires proper handling, installation, operation and maintenance.
  - Risk of electric shock. The DC link capacitors remain charged for 5 minutes after power has been removed. It is thus not permissible to open the equipment until 5 minutes after the power has been removed.
  - Children and not authorized persons must be prevented from accessing or approaching the equipment!
  - The equipment may only be used for the purpose specified by the manufacturer. Unauthorized modifications and the use of spare parts and accessories which are not sold or recommended by the manufacturer of the equipment can cause fires, electric shocks and injuries.
4.1 Overview of the hardware configuration

The arrangement for shutdown in the Stop Categories 0 and 1 consists of a PROFIBUS configuration. A fail-safe S7-CPU is used as DP master, an ET 200S as DP slave.

Overview control circuit

Note
In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the contactor K3 is not necessary:

Note
One 4DI electronic module can be used instead of two 2DI electronic modules. The “high feature” electronic modules can also be replaced by standard modules.
Overview load circuit

Note
In this example we used a motor holding brake. The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding break, the contactor K3 is not necessary:

4.2 Parameterization of the MICROMASTER 410

The parameterization of MICROMASTER 410 is described in the respective instruction manual. To provide better understanding, some points are emphasized in this document:

• Input of the parameters
• Parameters used
Input of the parameters

The inverter parameters can be accessed with the operator panel (OP). Below, it is shown how to set the parameter “Function of digital input 1” (P0701). All other parameters can be set identically. At this point, the procedure during parameterization is described; the parameters are explained under “Parameters used”.

Requirements: The MICROMASTER is supplied with voltage.

<table>
<thead>
<tr>
<th>No.</th>
<th>Press…</th>
<th>Note</th>
<th>Result on the display</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>![P button]</td>
<td>… to be able to access the parameters.</td>
<td>![Display showing “150.00”]</td>
</tr>
<tr>
<td>2</td>
<td>![Arrow up button]</td>
<td>… until P0701 is displayed.</td>
<td>![Display showing “P0701”]</td>
</tr>
<tr>
<td>3</td>
<td>![P button]</td>
<td>… to display the parameter value level.</td>
<td>![Display showing “0000”]</td>
</tr>
<tr>
<td>4</td>
<td>![Arrow up button] or ![Arrow down button]</td>
<td>.. to receive the required value (here: 1)</td>
<td>![Display showing “01”]</td>
</tr>
<tr>
<td>5</td>
<td>![P button]</td>
<td>… to confirm and save the value.</td>
<td>![Display showing “P0701”]</td>
</tr>
</tbody>
</table>

Note

Alternatively, the MICROMASTER can also be parameterized with the “STARTER” software by SIEMENS, which can be downloaded on the Internet (link on page 25) free of charge.
### Parameters used

Below, some characteristic parameters are shown which were used for this example (with the motor used).

<table>
<thead>
<tr>
<th>Parameter no.</th>
<th>Parameter name</th>
<th>Value to be set</th>
<th>Note / Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0700</td>
<td>Selection of command source</td>
<td>2 (connecting terminal plate)</td>
<td>There are different options of starting or stopping the motor using the MICROMASTER, e.g., via the keyboard on the OP. In this example, the commands for starting/stopping the motor come from the standard output module (2DO HF) of the ET 200S and are transferred to the terminal connecting plate of the MICROMASTER.</td>
</tr>
<tr>
<td>P0701</td>
<td>Function of digital input 1</td>
<td>1 (ON/OFF1)</td>
<td>The commands for starting/stopping are acquired by digital input 1 on the MICROMASTER. If “1”: Motor starts (ON) If “0”: Motor stops (OFF1)</td>
</tr>
<tr>
<td>P0731</td>
<td>Function of digital output 1</td>
<td>52.C (motor holding brake (MHB) active)</td>
<td>Motor holding brake active (see also P1215)</td>
</tr>
<tr>
<td>P0971</td>
<td>Transfer data from RAM to EEPROM</td>
<td>1 Start RAM-&gt;EEPROM</td>
<td>All values are transferred from RAM to EEPROM.</td>
</tr>
<tr>
<td>P1120</td>
<td>Startup time</td>
<td>6</td>
<td>Time value in seconds required by the motor to accelerate from stop to the highest motor frequency.</td>
</tr>
<tr>
<td>P1121</td>
<td>Ramp-down time</td>
<td>6</td>
<td>Time value in seconds required by the motor for delaying the maximum motor frequency until stop.</td>
</tr>
<tr>
<td>P1215</td>
<td>Holding break enable</td>
<td>1: Motor holding brake enabled</td>
<td>By the value 52.C in P0731, a relay is switched at the points 1 and 2 to control the brake. The relay is located at the terminals 11 and 12 of the MICROMASTER.</td>
</tr>
</tbody>
</table>

**Note**

The parameters are stored in the “as_fe_i_008_v10_code_pstopcat.zip” file. The “STARTER” software by SIEMENS is required to use this file. Chapter 6 “Sample Code” provides information on where to download this software.
Warning

Please note that the parameters stored in the file “as_fe_i_008_v10_code_pstopcat.zip” refer to the motor with holding break used by us for testing. If you use a different motor, the parameters have to be adapted for the MICROMASTER.

For safety reasons, the motor with the prepared parameters does not accelerate to maximum speed.

4.3 Wiring of the hardware components

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

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

<table>
<thead>
<tr>
<th>Hardware component</th>
<th>Address to be set</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM 151 High Feature</td>
<td>6 (PROFIBUS address)</td>
<td>Can be changed.</td>
</tr>
<tr>
<td>F-DI</td>
<td>Switch position: 111111110</td>
<td>The PROFIsafe addresses are automatically assigned during configuring the fail-safe modules in STEP 7. The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP7.</td>
</tr>
<tr>
<td>F-DO</td>
<td>Switch position: 111111101</td>
<td></td>
</tr>
</tbody>
</table>

Note

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

Note

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

In this example we used a motor holding brake (see following page). The parameters for the MICROMASTER used by us, take this motor holding brake into consideration. If you do not want to use the motor holding brake, the contactor K3 is not necessary:
Safety Shutdown in the Stop Categories 0 and 1 in Safety Category 4 according to EN 954-1
The MICROMASTER has to be grounded.

Warning

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

Note

The load circuit looks as follows:

Contactor K3 is responsible for the power supply of the rectifier for the motor brake.

Note

Please note that, in this example, contactor K3 – unlike K1 and K2 – features a make contact. If you do not want to use the motor holding break, the contactor K3 is not necessary:
4.4 Function test

The inputs and outputs used can be checked with regard to functionality, if:

- the hardware components are wired
- the S7 project was loaded to the F CPU
- the MICROMASTER was supplied with the respective parameters.

Inputs/outputs used

<table>
<thead>
<tr>
<th>No.</th>
<th>HW component</th>
<th>Address</th>
<th>Button</th>
<th>Signal (default value)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Push button (NO)</td>
<td>E 0.0</td>
<td>START</td>
<td>“0”</td>
<td>Start request</td>
</tr>
<tr>
<td>2</td>
<td>Push button (NC)</td>
<td>E 0.1</td>
<td>STOP</td>
<td>“1”</td>
<td>Operational stop</td>
</tr>
<tr>
<td>3</td>
<td>Push button (NO)</td>
<td>E 1.0</td>
<td>ACK</td>
<td>“0”</td>
<td>Acknowledgement</td>
</tr>
<tr>
<td>4</td>
<td>Push button (NC)</td>
<td>E 3.1</td>
<td>FDOOR</td>
<td>“1”</td>
<td>Simulated safety door contact</td>
</tr>
<tr>
<td>5</td>
<td>Contactor auxiliary contact (NC)</td>
<td>E 1.1</td>
<td>K1_HELP</td>
<td>“1”</td>
<td>Contactor K1</td>
</tr>
<tr>
<td>6</td>
<td>Contactor auxiliary contact (NC)</td>
<td>E 2.0</td>
<td>K2_HELP</td>
<td>“1”</td>
<td>Contactor K2</td>
</tr>
<tr>
<td>7</td>
<td>Emergency stop push button (NC)</td>
<td>E 3.0</td>
<td>ESTP</td>
<td>“1”</td>
<td>Emergency stop</td>
</tr>
<tr>
<td>8</td>
<td>Micromaster</td>
<td>A 0.0</td>
<td>MM</td>
<td>“0”</td>
<td>Control MICROMASTER</td>
</tr>
<tr>
<td>9</td>
<td>Magnet coil contactor</td>
<td>A 9.0</td>
<td>K1_K2</td>
<td>“0”</td>
<td>From A 9.0 to K1 and K2</td>
</tr>
</tbody>
</table>

Testing inputs and outputs

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructions</th>
<th>Response A 9.0</th>
<th>MICROMASTER</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Press the push button E 1.0 and release it.</td>
<td>“1”</td>
<td>Supplied with voltage via K1 and K2</td>
<td>In stop</td>
</tr>
<tr>
<td>2</td>
<td>Press the push button E 0.0 and release it.</td>
<td>“1”</td>
<td>ON</td>
<td>Accelerates</td>
</tr>
<tr>
<td>3</td>
<td>Wait until the motor has accelerated.</td>
<td>“1”</td>
<td>ON</td>
<td>Runs</td>
</tr>
<tr>
<td>4</td>
<td>Press the emergency stop push button E 3.0</td>
<td>“0” (delayed)</td>
<td>After stopping the motor, K1 and K2 drop out and the MICROMASTER is electrically isolated from the line supply (stop category 1).</td>
<td>Decelerates to stop</td>
</tr>
<tr>
<td>5</td>
<td>Unlock the emergency stop button and repeat no 1 to 3.</td>
<td>“1”</td>
<td>Supplied with voltage via K1 and K2</td>
<td>Accelerates</td>
</tr>
<tr>
<td>6</td>
<td>Press the push button E 3.1 and release it.</td>
<td>“0”</td>
<td>By drop-out of K1 and K2, MICROMASTER and motor are electrically isolated from the line supply immediately (stop category 0).</td>
<td></td>
</tr>
</tbody>
</table>

Note

After an emergency stop, a signal from the simulated safety door, and an initial start an acknowledgement is required before restarting.
4.5 Important hardware component settings

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

⚠️ Warning
The settings shown below contribute to meet the requirements of Safety Category 4 in Stop Category 0. Changes at the settings may cause loss of the safety function.

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

Overview picture

The PROFIBUS address at IM 151 HF is set using DIP switches.
Settings of the CPU 315F-2DP

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

<table>
<thead>
<tr>
<th>Screenshot</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Screenshot" /></td>
<td>Default value: 100 ms. It has to be observed that the F module monitoring time must be larger than the call time of OB 35.</td>
</tr>
</tbody>
</table>

Level of Protection

- **1:** Keypad Setting
- **2:** Removable with Password
- **3:** Write-Protection
- **4:** Write-/Read-Protection

Password:

Enter Again:

- **CPU Contains Safety Program**

Available in the “Protection” tab.

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

Password used here: siemens

Set mode: “Test Mode”

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

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

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

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The two-channel emergency stop push button is supplied with power via the module. Category 4 is reached due to the fact that a cross-circuit detection is possible. This requires that the short circuit test is activated.</td>
</tr>
<tr>
<td></td>
<td><strong>DIL switch settings</strong></td>
</tr>
<tr>
<td></td>
<td>This value has to be set on the module (F-DI).</td>
</tr>
<tr>
<td></td>
<td><strong>F monitoring time</strong></td>
</tr>
<tr>
<td></td>
<td>It has to be observed that the F monitoring time must be larger than the call time of OB 35.</td>
</tr>
<tr>
<td></td>
<td>Also in the “Parameter” tab.</td>
</tr>
<tr>
<td></td>
<td>A two-channel connection of the emergency stop push button to channel 0 is performed. At channel 1 the simulated safety contact NC is read in.</td>
</tr>
<tr>
<td></td>
<td>All other channels are to be deactivated.</td>
</tr>
</tbody>
</table>

**Warning**

Monitoring a safety door of safety category 4 is performed with two sensors (see Safety Function Examples no. 2, 3 and 4). The connected single button simulates only one signal, which is assigned to a safety door for better clarity.
Safety Shutdown in the Stop Categories 0 and 1 in Safety Category 4 according to EN 954-1

Settings of the failsafe F-DO

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

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Note</th>
</tr>
</thead>
</table>
| DIL switch settings  
This value has to be set on the module (F-DO). |
| F monitoring time  
It has to be observed that the F monitoring time must be larger than the call time of OB 35. |
| Activate used channel 0 for the switching of the line contactors K1 und K2, deactivate channels which are not used. |
| The read-back time defines the duration of the switch-off procedure for the respective channel. If the respective channel switches high capacity loads, the read back time should be set sufficiently large. We recommend setting the read back time as small as possible, however large enough so that the output channel does not become passive. |

5 Basic Performance Data

Load and main memory (without program code)

<table>
<thead>
<tr>
<th>Total</th>
<th>S7 standard blocks</th>
<th>F blocks (fail-safe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Memory</td>
<td>approx. 37.5 k</td>
<td>approx. 0.2 k</td>
</tr>
<tr>
<td>Main Memory</td>
<td>approx. 28.2 k</td>
<td>approx. 0.09 k</td>
</tr>
</tbody>
</table>

Load and main memory (with program code)

<table>
<thead>
<tr>
<th>Total</th>
<th>S7 standard blocks</th>
<th>F blocks (fail-safe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Memory</td>
<td>approx. 47.1 k</td>
<td>approx. 1.0 k</td>
</tr>
<tr>
<td>Main Memory</td>
<td>approx. 31.5</td>
<td>approx. 0.4 k</td>
</tr>
</tbody>
</table>

Cycle time

| Total cycle time (typical) | approx. 4 ms | Standard and safety program |
| Max. runtime of the safety program | 7 ms | Calculation with the Cotia table. Chapter 2 specifies where to find it. |
6 Sample Code

Preliminary Remarks
Enclosed, we offer you the STEP 7 project as sample code with which you can reset the functionality described here.

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

Password
In all cases, the password used for the safety-relevant part is siemens.

Use of the STEP 7 project
Using a MICROMASTER, a motor can be started via a push button (NO). There are two options of stopping the motor:
1. Operational via a button NC.
2. Fail-safe via (NC) button, simulating a safety door contact (stop category 0).
3. Fail-safe via an emergency stop button in stop category 1.

Download
To call the corresponding project file, open the "as_fe_i_008_v10_code_csstopcat.zip" file offered as a separate download (on the HTML page) and extract it into a user defined directory.

For downloading the project into the F-CPU please proceed as follows:
- First load the hardware configuration to the S7-CPU
- Switch to the SIMATIC Manager
- Select the "Blocks" container.
- Menu "Options" -> Edit safety program.
- Click the "Download" button.

The sample code with the listed configurations enables the following:
- A motor is turned off via a push button (NC) simulating a safety door contact according to Stop Category 0.
- A motor is turned off via an emergency stop push button (NC/NC) according to Stop Category 1.
Note: If you want to use the parameter settings used by us for the MICROMASTER ("as_fe_i_008_v10_code_pstopcat.zip"), you need the SIEMENS software “STARTER”, which you can download free of charge via the internet. The link is listed below.

Link: [www.siemens.de/automation/service&support](http://www.siemens.de/automation/service&support)

Subsequently click the “Download” link and enter “Starter” as keyword.

Older projects (*.mcp) can be converted into a current project and further edited. Select the Starter project in the displayed window and confirm by clicking OK. The project is converted and possible errors are displayed in the detail display.

Program procedure

The standard user program consists of two networks of OB 1:

**Network 1**

```
"K1_HL1P" & "FEEDBACK"
"K2_HL1P" & 
```

The memory bit “FEEDBACK” evaluates the readback signals of the contactors K1 and K2. “FEEDBACK” is used as input parameter of FB “F_FDBACK” in the safety program. FB “F_FDBACK” is a certified block from the Distributed Safety library for the monitoring of the readback signals.

The information of the memory bit FEEDBACK is read as memory bit FEEDBACK1 in the safety program. This allocation occurs in the cyclic interrupt OB 35 for the following reason:

If you want to read data from the standard user program (flags or PII of standard I/O) in the safety program (here: FEEDBACK), which can be changed by the standard user program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate flags (here: FEEDBACK1). Data from the standard user program have to be written to these memory bits immediately before calling the F runtime group. Only these memory bits may then be accessed in the safety program.

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

Note: If the above section is not observed the F-CPU may go to STOP mode.
In network 2 the signal for operational starting (START) and the stopping (Stop) are given. The output of the standard output module MM is set/reset. This output is connected with the MICROMASTER. With MM="1" the MICROMASTER receives the request of starting up the motor; with MM="0" the MICROMASTER sets the motor to standstill.

As long as there is a "1" signal at the R input of the flip-flop, MM="0" remains true, even if the start button is pressed, as the reset function at this flip-flop type has priority.

The fail-safe program has the following program sequence:
At an acknowledgement (negative edge of ACK) both #Q_ESTP and #Q_FDOOR remain “1” (precondition: emergency stop button unlocked and simulated safety door contact FDOOR="1"). In network 2 the contactors K1 and K2 are activated and supply the MICROMASTER with power.

If the safety door is opened during operation (simulated with FDOOR), then FDOOR becomes 0" and Q_FDOOR="0", which in network 2 causes an immediate drop-out of contactor K1 and K2. The drive is immediately isolated from the supply (stop category 0).

If the emergency stop button is pressed during running operation (ESTP="0"), #Q_ESTP is reset after the time parameterized at PT has elapsed. This time must be set so that after it has elapsed, the motor is in standstill. Only then is the drive isolated from the supply in network 2 (stop category 1).

Network 2
FB “Safety_PRG” (FB1, DB1) calls FB “F_FDBACK” (FB216, DB216). FB 216 is a certified block from the Distributed Safety library; this block is available from version 5.3.
Note

Before inserting the F application block F_FDBACK you have to copy the F application block F_TOF from the block container F-Application Blocks\Blocks of the F library Distributed Safety (V1) into the block container of your S7 program, if it is not available in this container (has already been done in this example project).

Warning

When using the F application block F_FDBACK it is required that the F application block F_TOF has the number FB 186 and that the number is not changed!

The acknowledgement signal ACK is responsible for the acknowledgement after exceeding the feedback time FDB_TIME (at FB 216).

Output Q is set to 1 as soon as input ON = 1. It is required that readback input FEEDBACK = 1 and no readback error must be stored. In this example, this causes contactor K1 and K2 to pick up, which supplies the MICROMASTER with power.

A readback error ERROR = 1 is detected if the signal state of the readback input FEEDBACK (to output Q) does not follow the signal state of the input ON within the maximum tolerable feedback FDB_TIME time.

To ensure that no readback error is detected and that no acknowledgement is required in a passivation of the failsafe I/O modules controlled by output Q you have to supply the input QBAD_FIO with the variable QBAD of the corresponding failsafe I/O module DB.

F_GLOBDB.VKE1 applies a "1" signal at the input ACK_NEC. This requires acknowledgement at the input ACK in case of an error (ERROR="1").

Note

The F-Global-DB (F_GLOBDB) provides the variables "VKE0" or "VKE1". This can be used in the safety program for supplying parameters at block calls if the Boolean constants "0" and "1" are required.

Network 3

**FC "REINTEGRATION" (FC 2)**

Network 3 of FB 1 calls FC 2 where the reintegration is realized in case of a passivation of F-DI or F-DO. For R-DO, a REINT memory bit has been prepared, which reintegrates the module with a positive edge.

Warning

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

A passivation is indicated via LED “SF” lighting up on the module. The reintegration of an F module may take approx. one minute.
Operating instructions

Prerequisite:

- Hardware configuration and safety program are in the S7-CPU
- Emergency stop unlocked
- No passivation of the F-DI/F-DO

The tables below demonstrate the function principle:

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructions</th>
<th>Result / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Press the acknowledgement push button (NO) and release it.</td>
<td>Necessary prior to the first start. Contactor K1 and K2 pick up and supply the MICROMASTER with power.</td>
</tr>
<tr>
<td>2</td>
<td>Press the start push button (NO) and release it.</td>
<td>The output MM of the digital output module is set. The MICROMASTER receives the signal for starting the motor. The MICROMASTER starts the motor up according to its parameterization.</td>
</tr>
<tr>
<td>3</td>
<td>Press the button (NC) which simulates the safety door contact and release it.</td>
<td>Contactors K1 and K2 drop out: MICROMASTER and motor are isolated from the supply (stop category 0).</td>
</tr>
<tr>
<td>4</td>
<td>Repeat No. 1 and 2</td>
<td>The output MM of the digital output module is reset. The MICROMASTER receives the signal for stopping the motor. The MICROMASTER brings the motor to standstill according to its parameterization. Contactors K1 and K2 drop out and isolate the drive from the supply.</td>
</tr>
<tr>
<td>5</td>
<td>Press the emergency stop push button.</td>
<td></td>
</tr>
</tbody>
</table>

Note

After an emergency stop, a signal from the simulated safety door, and an initial start an acknowledgement is required before restarting.

Alternative

The Distributed Safety library offers a Stop Category function block FB “F_ESTOP1” (FB 215). With this block you can realize an emergency stop in the Stop Categories 0 and 1.
Evaluation/Feedback

A&D AS CS3 KM
D-90327 Nürnberg-Moorenbrunn

Fax.: 0911 895 – 15 2407
Mail: csweb@ad.siemens.com

If you find typographical errors while reading this document, please use this form to let us know. We would also appreciate any ideas and suggestions for improvements.

Evaluation of the documentation

Very good □ Good □
Not so good □ Because:

Subject well chosen □ Wrong subject □
Scope sufficient □ Too detailed □ Too superficial □
Easy to understand □ Partly easy to understand □ Impossible to understand □
Good presentation □ Average presentation □ Poor presentation □
Often used □ Rarely used □ Used once and never again □

Time saving using this documentation in comparison with previous documentation:
No saving □ approx. 5% □ approx. 10% □ other..........%

Suggestions: ..............................................................................................................................................

A&D AS CS3 KM
D-90327 Nürnberg-Moorenbrunn

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