PSS 4000 Emergency Stop with PITestop Ladder Diagram

PILZ
THE SPIRIT OF SAFETY

Product
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Name: PSS 4000, Blocks, PAS4000, PLC, LD
Manufacturer: Pilz GmbH & Co. KG, Safe Automation

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Validity of Application Note

This present Application Note is valid until a new version of the document is published.
This and other Application Notes can be downloaded in the latest version and for free from www.pilz.com.
For a simple search, use our content document (1002400) or the direct search function in the download area.

Exclusion of liability

We have taken great care in compiling our application note. It contains information about our company and our products. All statements are made in accordance with the current status of technology and to the best of our knowledge and belief.
However, we cannot accept liability for the accuracy and entirety of the information provided, except in the case of gross negligence. In particular it should be noted that statements do not have the legal quality of assurances or assured properties.
We are grateful for any feedback on the contents.

March 2016

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Abbreviations

PAS	**P**ilz **A**utomation **S**uite (software platform)
PSS	Programmable control system (DE: **P**rogrammierbares **S**teuerungs**s**ystem)
PNOZ	Pilz E-STOP Positive-guided (DE: **P**ilz **NO**T-AUS-**Z**wangsgeführt)
POU	**P**rogram **O**rganisation **U**nit
PRG	**Pro**g**r**am
FB	**F**unction **B**lock
FUN	**Fun**ction
LD	**L**adder **D**iagram

1. Useful documentation

Reading the documentation listed below is necessary for understanding this application note. The availability of the indicated tools and safe handling are also presupposed with the user.

1.1. Documentation from Pilz GmbH & Co. KG

No.	Description	Item No.
1	Pilz international homepage, download section	www.pilz.com
2	Operating Manual PSSu H PLC1 FS SN SD	21939-EN-xx
3	Operating Manual PSSu E F 4DI	21310-EN-xx
4	Operating Manual PSSu E F DI OZ 2	21328-EN-xx
5	Operating Manual PSSu E F 4DO 0.5	21316-EN-xx
6	Operating Manual PSSu E S 4DI	21340-EN-xx
7	Operating Manual PSSu E S 4DO 0.5	21346-EN-xx
8	System Description Automation system PSS 4000	1001467-EN-xx
9	Safety Manual Automation system PSS 4000	1001468-EN-xx
10	PAS4000 online help	-
11	Operating Manual PITestop	21136-EN-xx

1.2. Documentation from other sources of information

No.	Description	Item No.
1		
2		
3		
4		

Note

The present example (PSS 4000 Emergency Stop with PITestop) is also available in the programming languages Instruction list, Structured Text and PASmulti

2. Hardware configuration

2.1. Pilz products

No.	Descriptions	Order number	Version	Number
1	PSSu H PLC1 FS SN SD	312 070	002	1
2	PSSu E F 4DI	312 200	-	1
3	PSSu E F DI OZ 2	312 220	-	1
4	PSSu E F 4DO 0.5	312 210	-	2
5	PSSu E S 4DI	312 400	-	1
6	PSSu E S 4DO 0.5	312 405	-	1
7	PSSu BP 1/8 C	312 601	-	6
8	PITes Set1s-5	400 432	-	1
9	PAS4000	-	V1.13.2	1

2.2. Hardware configuration

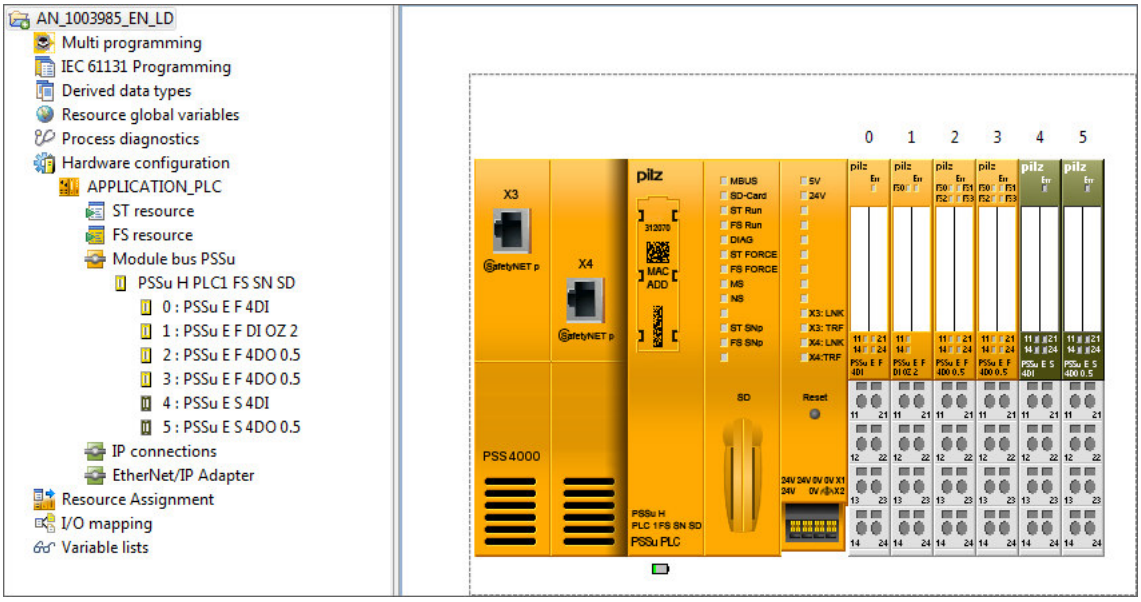


Fig. 1: Hardware configuration

3. Application Task

3.1. Description

The example shows the implementation of an emergency stop application with a PSS 4000 PLC.
The safe control and evaluation of the signals is taken over by two Pilz Function blocks (FS-FB) from the library.

- FS_EmergencyStop
  - CRC EA57

- FS_OutputFBL
  - CRC B3A7

The workflow is divided into the following two main functions:

- Emergency Stop and
- Feedback Loop Monitoring

3.1.1. Emergency stop function

The control system monitors the emergency stop button (S1) via the user program. An instance of the Pilz Function block “*FS_EmergencyStop*” is assigned to them. This FS-FB detects whether the assigned emergency stop button has been operated, as well as detecting incorrect input signals and whether the contact synchronization time has been exceeded, etc.

If the emergency stop button (S1) is operated or an error occurs, the enable output “Enable” on the FS-FB will immediately be reset.
The enable output “Enable” is also reset when the PSS is stopped and when the PSS is switched on. The signal from the enable output “Enable” must be evaluated by the user program and trigger an appropriate reaction.

Based on the diagnostic outputs (“*DiagSwitchError*”, “*DiagInputNotValid*”) it can be determined why “Enable” was reset.
The outputs “*DiagOperated*”, “*DiagReadyForReset*” and “*DiagReadyForTest*” are used as status messages.

A “valid bit” is formed by the system for the respective hardware input to determine whether a process value received from a sensor is valid.
The valid bit is queried in the Function block and indicates whether an error has occurred in the signal transmission between hardware input and processor (such as test clock error, module overheats, etc.).
If the valid bit is FALSE, the process value is invalid and the Pilz function block provides an appropriate diagnostic message. The error signal reset enable.
(*For more information, see “Validity of process data” in PAS4000 online help*)

The way in which the error is reset will depend on the operating mode set on the FS-FB.
In this application example, parameters for FS-FB have been set in such a way that “Reset” (S3) is required in order to reset output parameter “Enable” when:

- the PSS is cold started (PSS switched from off to on),
- warm started (PSS transferring from STOP to RUN) or
- when the emergency stop button (S1) is released.

Although the emergency stop functions are configured to reset themselves, a PSS cold start or the release of an emergency stop button that has been operated may not directly enable a machine to start up without further conditions being met.

Input circuit safety assessment

- If a contact on the emergency stop button is overridden, the Pilz function block will detect this as an error at the next operation.
- A short between the input circuits within a multicore cable will be detected as an error by the programmable control system.
- A short between 24 VDC and an input circuit will be detected as an error by the programmable control system.
- The highest category can only be achieved when the contacts on the E-STOP pushbutton are supplied with test pulses and the E-STOP pushbutton has dual-channel wiring.
- If an operator completely (or even maybe partly) is able to access the dangerous area, a risk analysis should clarify whether an additional, separate “manual reset function” is required.

Switch-off delay of the emergency stop enable signal

The enable output "Enable" of the Pilz Function block “*FS_EmergencyStop*” is passed by means of the Function block "TOF" switch-off-delayed to the Pilz function block “*FS_OutputFBL*” This allows the controlled switch-off of the motor before the safe isolation of the motor contactor is activated. The shutdown delay must be considered at the risk assessment.

3.1.2. Feedback loop monitoring function

The control system monitors the feedback circuits (NC contacts) of the motor contactors KM1 and KM2 via the user program.
An instance of the Pilz function block "*FS_OutputFBL*" is assigned to them.
The FS-FB drives the contactors as well as monitoring the feedback loop.
A 1-signal at input parameter "Input" (delayed "Enable" of emergency stop) of the FS-FB sets the outputs that drive the contactors,
"Output1" and "Output2", to "1"; a 0-signal sets it to "0".
If an error occurs, the outputs "Output1" and "Output2" that drive the contactors on FS-FB will immediately be reset. Both outputs are also reset when the PSS is stopped and when the PSS is switched on.

Based on the diagnostic outputs ("*DiagFeedbackLoopError*", "*DiagFeedbackLoopNotValid*") it can be determined why the outputs were reset.

A "valid bit" is formed by the system for the respective hardware input to determine whether a process value received from a sensor is valid.
The valid bit is queried in the Function block and indicates whether an error has occurred in the signal transmission between hardware input and processor (such as test clock error, module overheats, etc.).
If the valid bit is FALSE, the process value is invalid and the Pilz function block provides an appropriate diagnostic message. The error signal reset enable.
(*For more information, see "Validity of process data" in PAS4000 online help*)

If an error occurs, a new activity has to take place at the input "Input" of the FS-FB once the error has been rectified, so that the outputs "*Output1*" and "*Output2*" will be set again.

Feedback loop monitoring safety assessment

- A short between 24 VDC and a safety output or a feedback loop input will be detected as an error by the programmable control system. The load can be switched off via the second shutdown route.
- The feedback loop contacts must be installed in a single mounting area (control cabinet).
- To achieve a higher level of safety, 2 actuators must be used.

3.2. Function Safety

3.2.1. Safety-related characteristics in accordance with EN ISO 13849-1

No.	Safety function	PL	Safety-related parts of the control system
1	Machine shut down via E-STOP	PL e	Sensor (PITesop S1) Input (PSSu E F 4DI) Logic (PSSu H PLC1 FS SN) Output (PSSu E F DI OZ 2) Actuator (contactors KM1, KM2)

Prerequisites

No.	Description		Identification
1	Common cause failure (CCF)		Requirements are considered to be met (must be tested on implementation)
2	Mission time		20 years
3	Operating interval (electromechanical components)	Sensor	one operations per week
		Actuator	one operations per week
4	Characteristic data of contactors KM1/KM2	$B10_D$	1,300,000

Please note the further requirements of EN ISO 13849-1, e.g. requirements for avoiding systematic faults.

3.2.2. Safety-related characteristics in accordance with EN 62061

No.	Safety-related control function (SRCF)	Safety Integrity Level	Subsystems
1	Machine shut down via E-STOP	SIL 3	Sensor (PITesop S1) Input (PSSu E F 4DI) Logic (PSSu H PLC1 FS SN) Output (PSSu E F DI OZ 2) Actuator (contactors KM1, KM2)

Prerequisites

No.	Description		Identification
1	Common cause failure (CCF)		ß = 2% (must be tested on implementation)
2	Proof test interval		20 years
3	Operating interval (electromechanical components)	Sensor	one operations per week
		Actuator	one operations per week
4	Characteristic data of contactors KM1/KM2	$B10_D$	1,300,000
		Dangerous failure rate	75%

Please note the further requirements of EN 62061, e.g. requirements for systematic safety integrity.

3.3. PAS-Project

To operate a plant with one or more programmable control systems PSS 4000, a project must be created in PAS4000.
A project consists of the hardware configuration and the user program.

3.3.1. IEC 61131 Programming

When programming in accordance with IEC 61131, the user program is structured by three types of program organisation units (POUs):

- Programs (PRG)
- Function blocks (FB)
- Functions (FUN)

The program forms the higher structural level. Functions and function blocks may be called up within a program.
Function blocks and functions undertake specific individual tasks within the program.

Each POU consists of a declaration part and an instruction part.

The variables and type declarations are made in the declaration part, which is shown in text format, irrespective of the programming language.

The instruction part contains the instructions. The instructions can be formulated in one of the IEC 61131 programming languages.

(*For more information about programming with PAS4000, look at PAS4000 online help*)

3.3.1.1. LD-Editor

The program for the cyclic process is created in a POU of the type “Program”.
The Pilz function blocks for emergency stop and feedback loop were added from the library in the declaration part of the program. (Right-click in the declaration part of the POU “Add Library Element”).

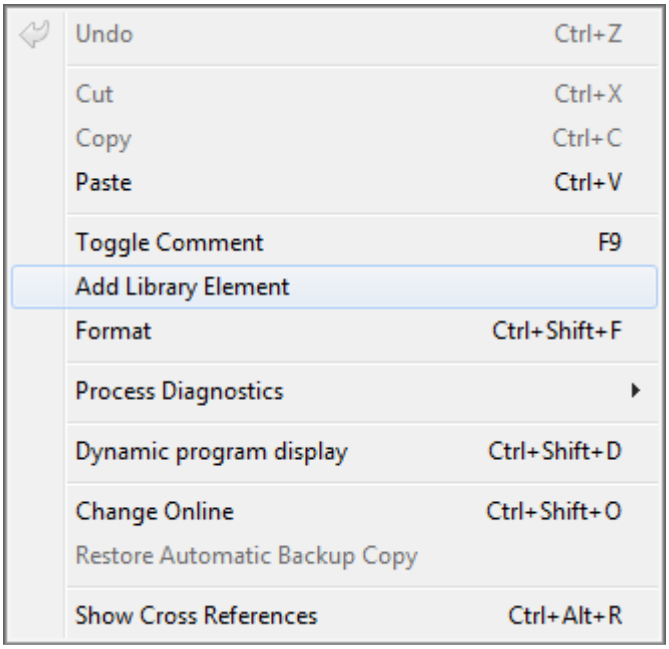


Fig. 2: Add library element

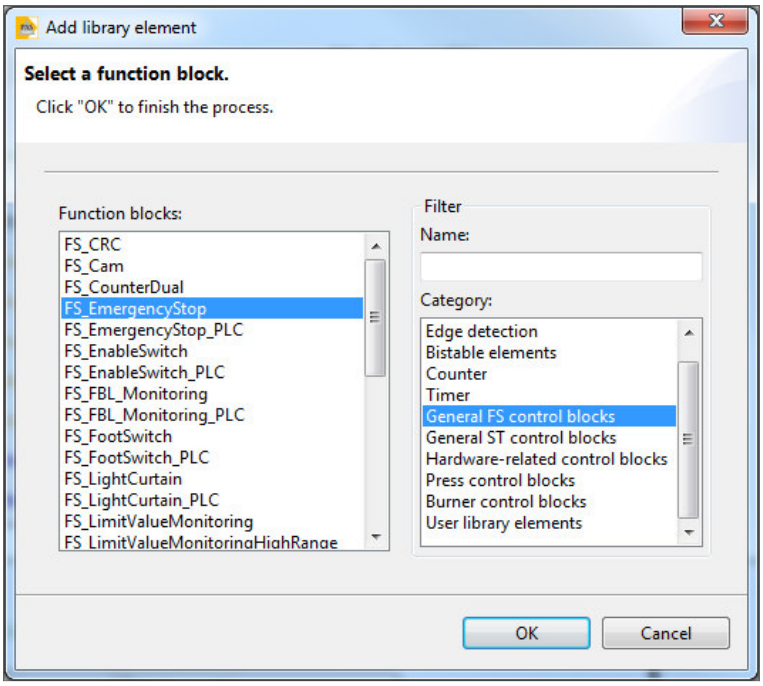


Fig. 3: Selection library element

Use the Palette to add functions to the ladder network by clicking once on the item in the Palette and then once in the ladder network.

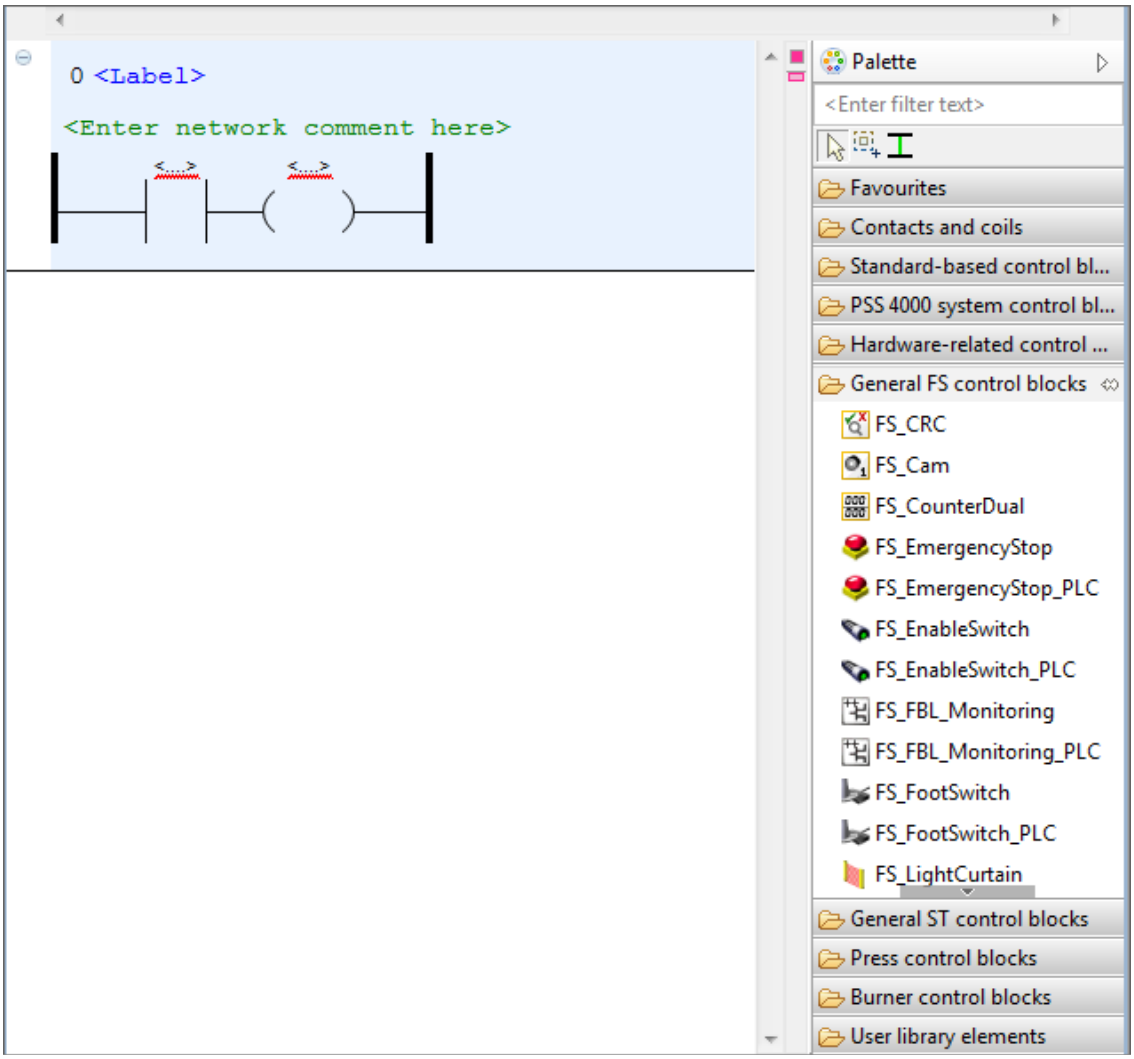


Fig. 4: Edit LD network

Add additional networks by right clicking under the existing network and select ”Add network”.

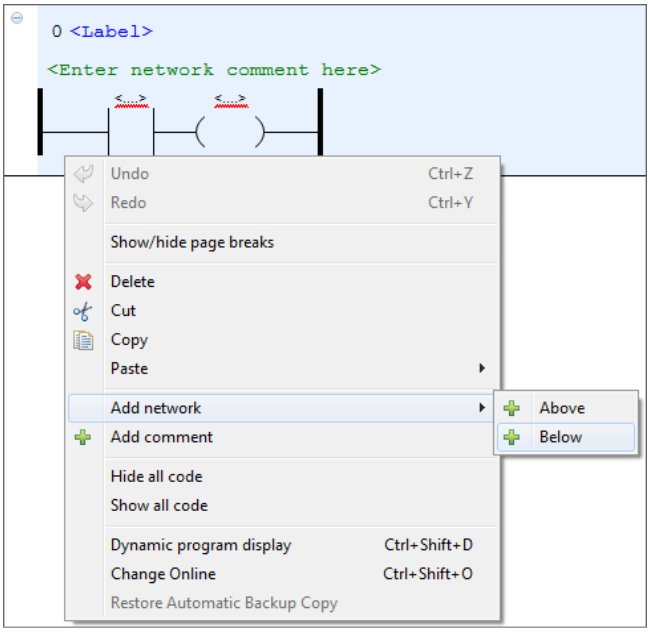


Fig. 5: Add additional ladder network

Invert/Negate existing contacts.coils in the network by right clicking on the contact and selecting “Invert negation”.

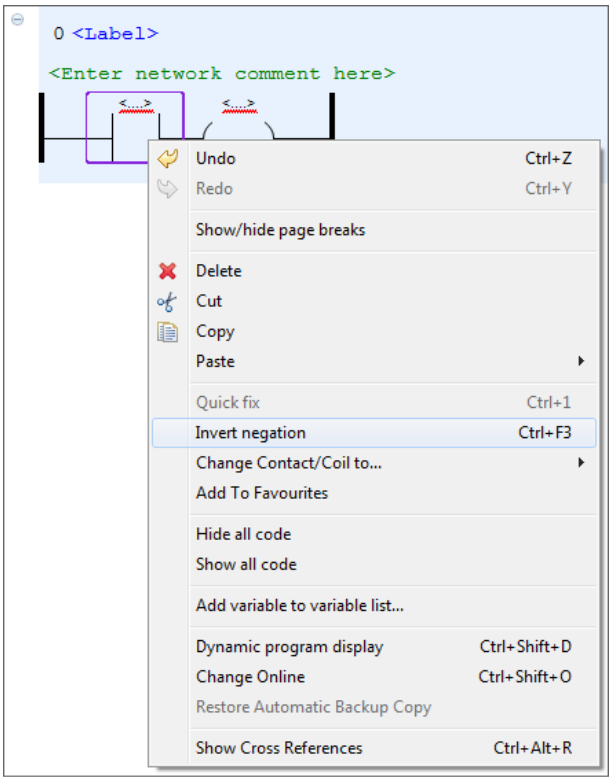


Fig. 6: Invert negation

Failsafe program

Declaration part

```
PROGRAM Main_FS
VAR
      // EStop
      MyEmergencyStop1                          : FS_EmergencyStop;
      MyEStop1_Enable               AT %Q*      : SAFEBOOL;
      MyEStop1_DiagOperated         AT %Q*      : SAFEBOOL;
      MyEStop1_DiagReadyForReset    AT %Q*      : SAFEBOOL;
      MyEStop1_DiagReadyForTest     AT %Q*      : SAFEBOOL;
      MyEStop1_DiagSwitchError      AT %Q*      : SAFEBOOL;
      MyEStop1_DiagInputNotValid    AT %Q*      : SAFEBOOL;

      // Switch-off delay
      MyTOF                                     : TOF;
      MyEStop1_Enable_Delayed                   : SAFEBOOL;
      ET_Time                                   : TIME;

      // FBL
      MyFeedBackLoop1                           : FS_OutputFBL;
      MyFBL1_DiagFblError           AT %Q*      : SAFEBOOL;
      MyFBL1_DiagFblNotValid        AT %Q*      : SAFEBOOL;
END_VAR

VAR CONSTANT
      // Declaration SwitchType 3 (NCNC)
      MyESTOP1_DOUBLE_CH                        : USINT := USINT#3;
END_VAR
```

Instruction part

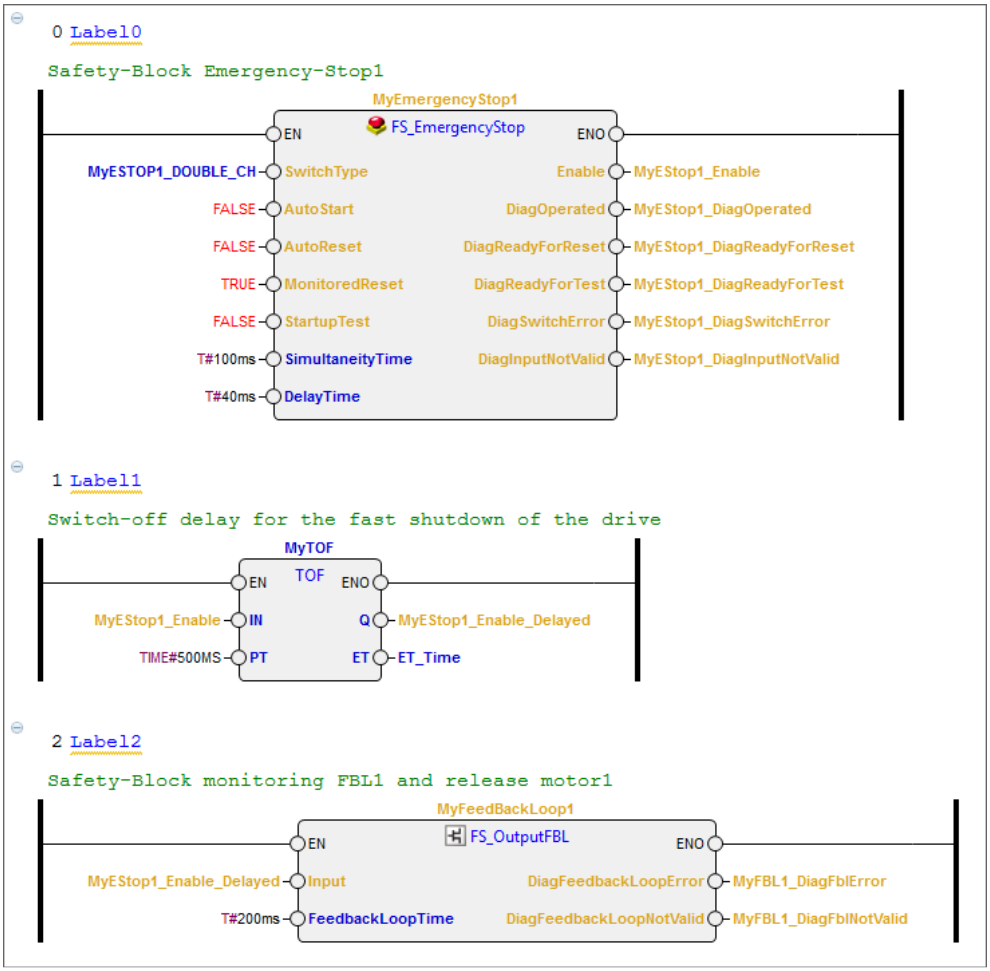


Fig. 7: Instruction part

Standard Program

The signals from the start- and stop switch are imported from a standard module PSSu E S 4DI (1A4). These signals belong to the motor control and thus to the standard control functions of the machine.

The program code for the evaluation and processing of these signals is not processed within the FS resource (safety-related part) of the control, but in a ST resource in a separate task as independent application (additional POU of type program).

Declaration part

```
PROGRAM Main_ST
VAR
      MyRisingEdge1                          : R_TRIG;
      Start                    AT %I*        : BOOL;
      Stop                     AT %I*        : BOOL;
      Motor1_On                AT %Q*        : BOOL;
      Other_Stop_Conditions    AT %I*        : BOOL;
      FF_Motor1On                            : RS;
      Q_Edge1                                : BOOL;
      Reset_Motor                            : BOOL;
END_VAR
```

Instruction part

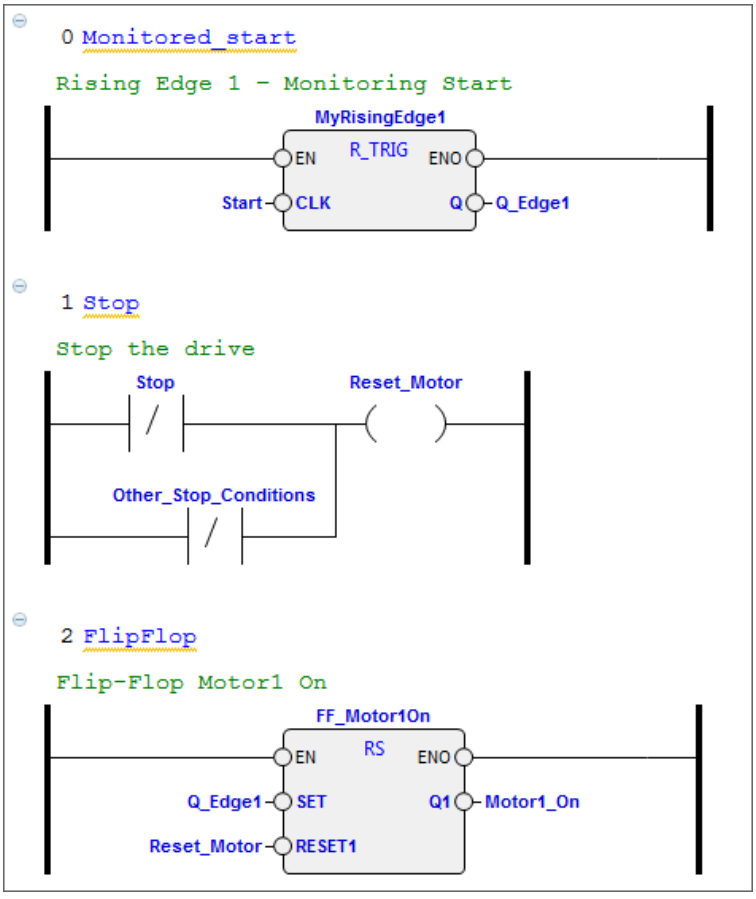


Fig. 8: Instruction part

3.3.2. I/O Mapping

In PAS4000, variables can be created and the user program can be programmed without the need of the mapping to the hardware being present at the beginning of the project.
After identification of the used I/O from the variable declaration, the required hardware can be determined.
The I/O mapping editor forms the connecting between the user program and the hardware and coordinates the available I/O and existing PI-variables.

3.3.2.1. I/O Mapping Editor

The PI variables declared in the user-program can be assigned in the I/O mapping editor to the hardware configuration.

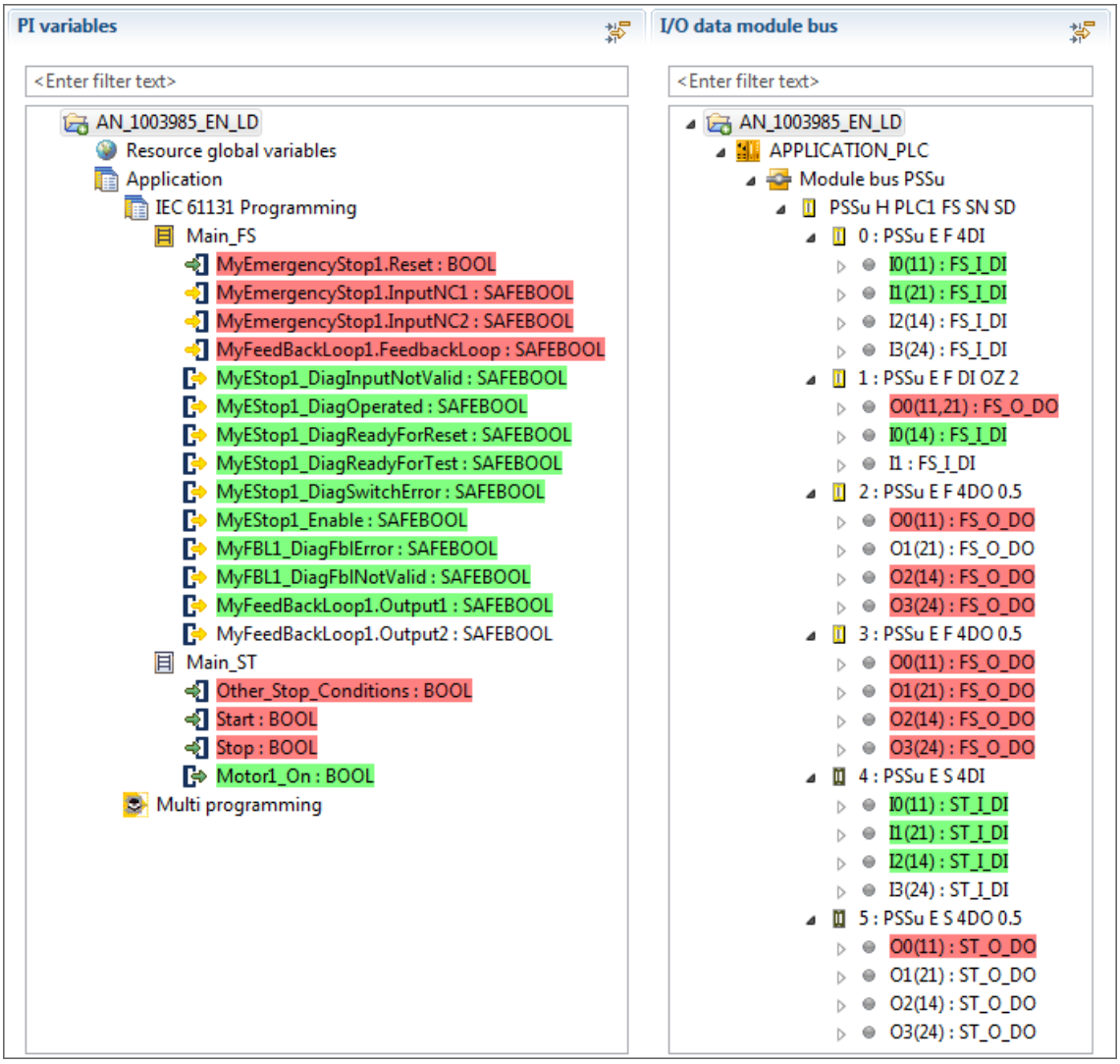


Fig. 9: Mapping Editor – LD-program

3.3.3. Resource Assignment

The resource assignment defines which section of the user program is to be executed on which resource and in which task. The tasks determine the run-time properties of sections of the user program, i.e. the priority with which they are executed.

You can assign the programs automatically to task by drag and drop, then modify the task settings, or create the tasks first and then assign the programs separately.

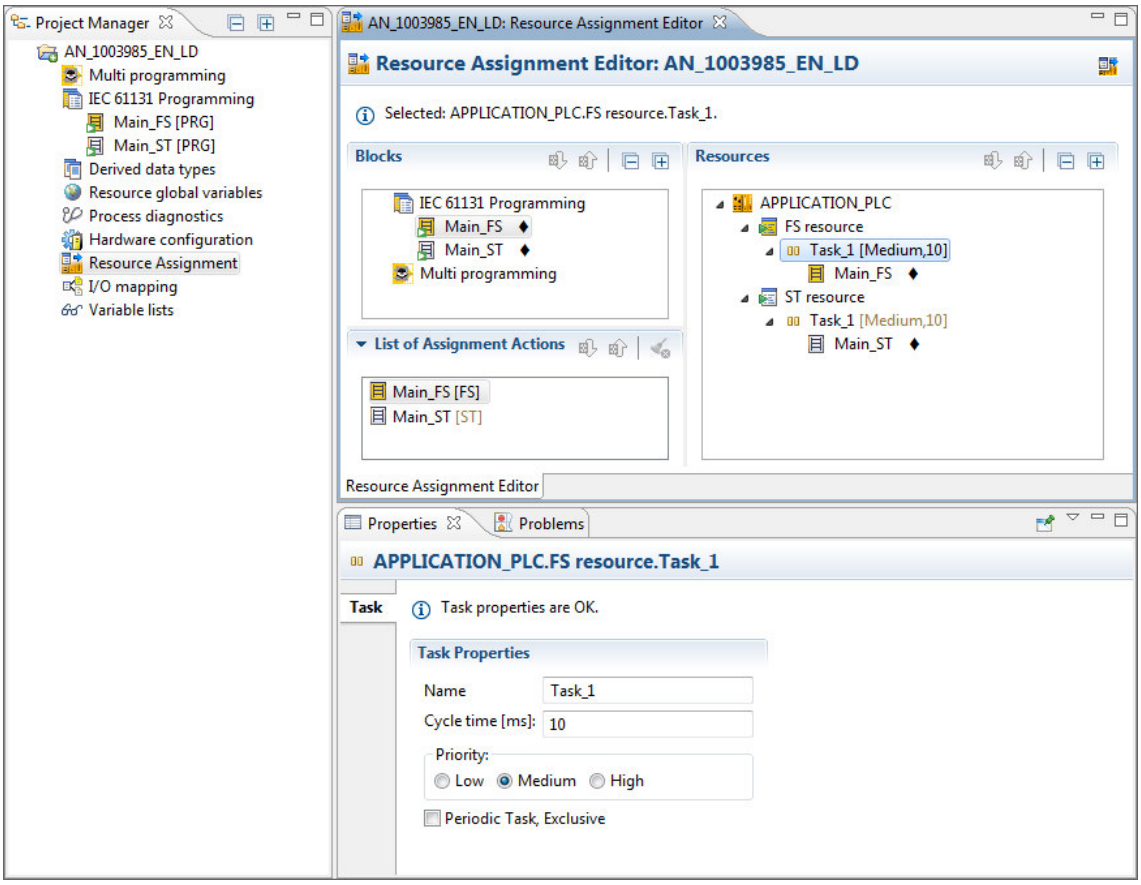


Fig. 10: Resource Assignment

3.3.4. Process PAS Project

- Step 1: In the LD editor, PI variables and the logical sequence will be generated as a program.

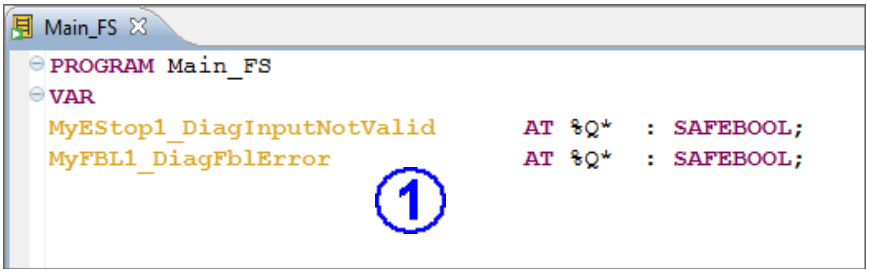


Fig. 11: PI variables

- Step 2: The design of the hardware (control, I/O, sensor, actor) will be created as a circuit diagram. (parallel possible to Step 1)

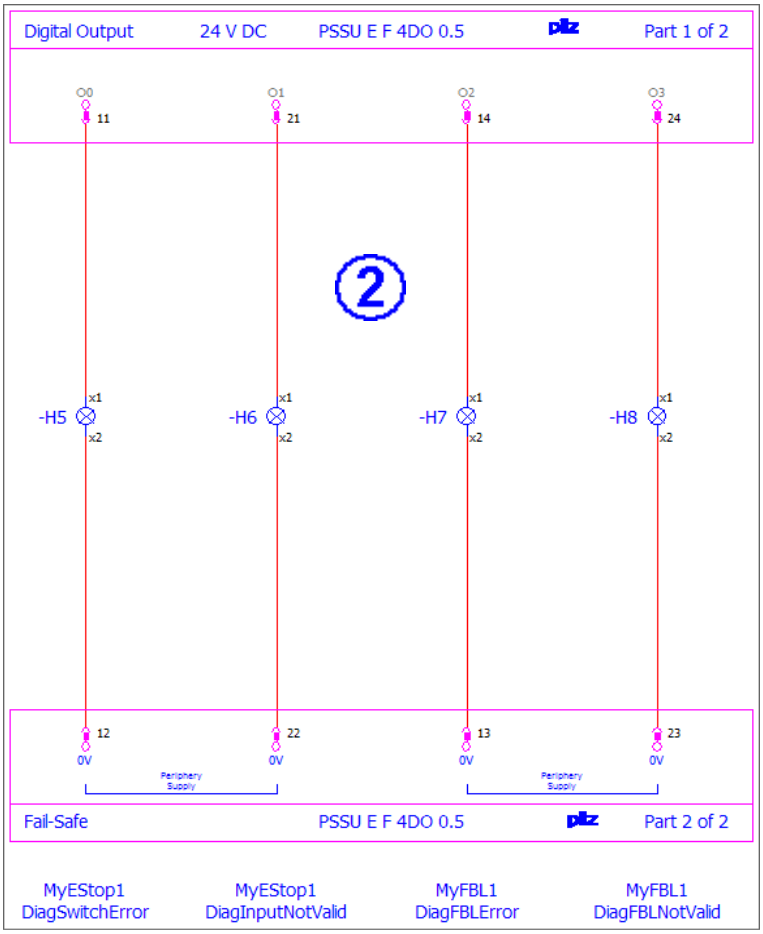


Fig. 12: Circuit diagram (extract)

- Step 3: Based on the PI variable (I/O), the required power of control (PLC, Multi) is selected. The implantation of the I/O modules in the PAS system occurs in the PSSu module editor.

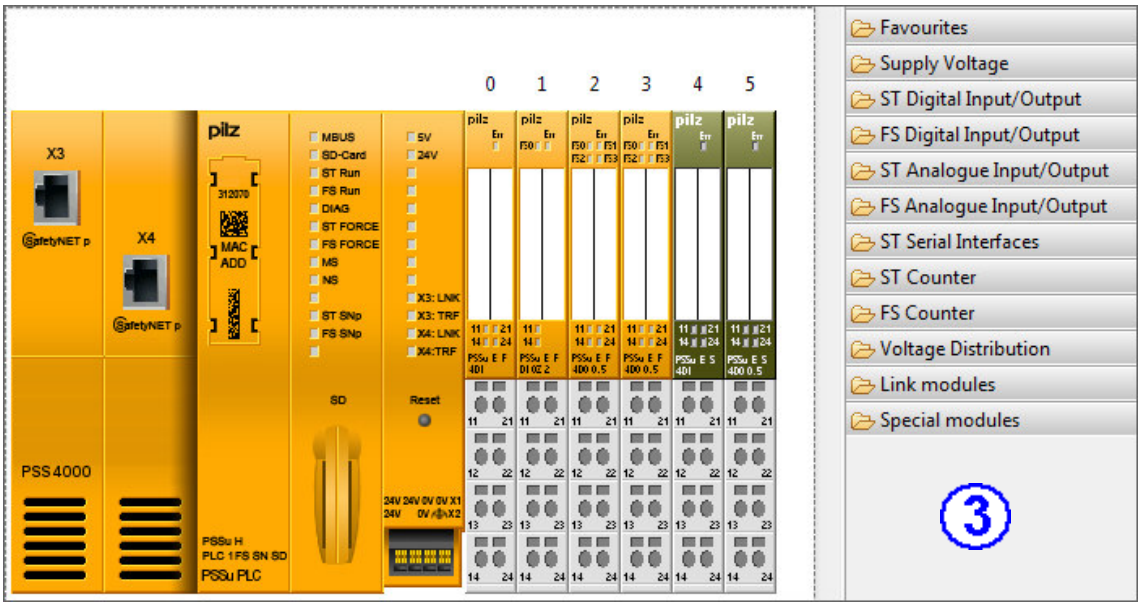


Fig. 13: PSSu Module Editor

- Step 4: Assignment of the PI variables in the I/O Mapping Editor.

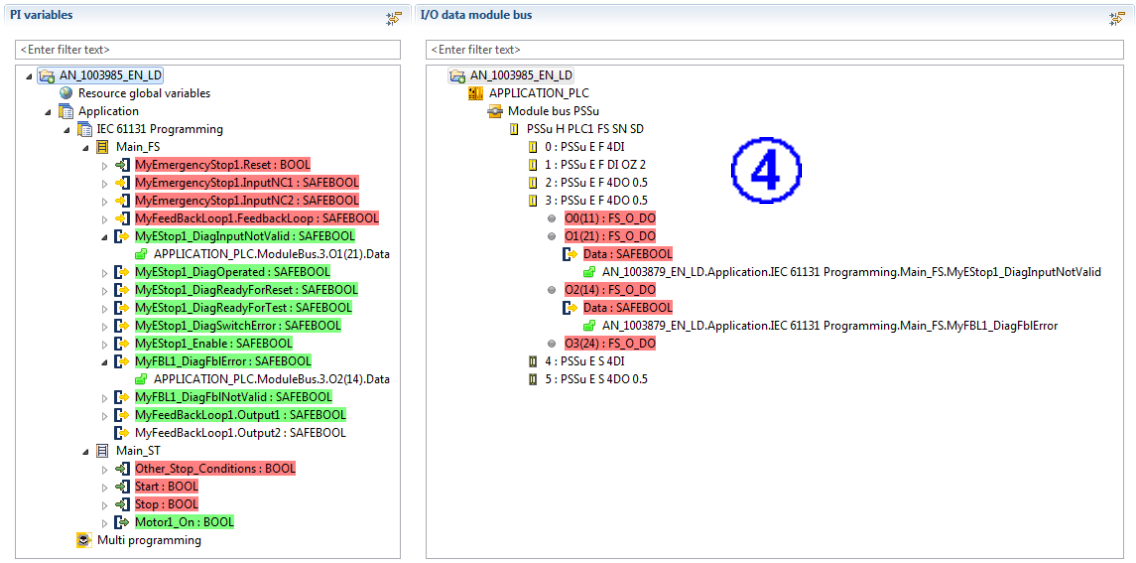


Fig. 14: I/O Mapping Editor

- Overview process of PAS Project (Steps 1-4)

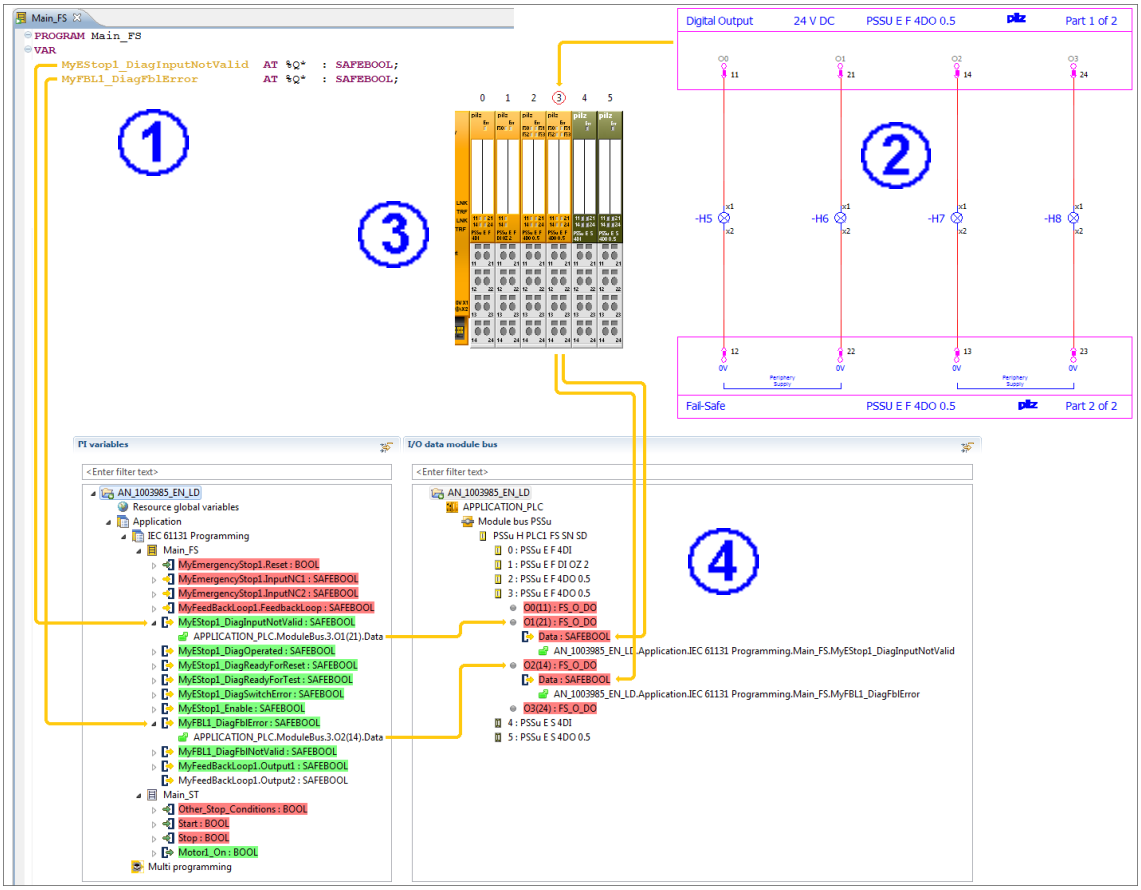
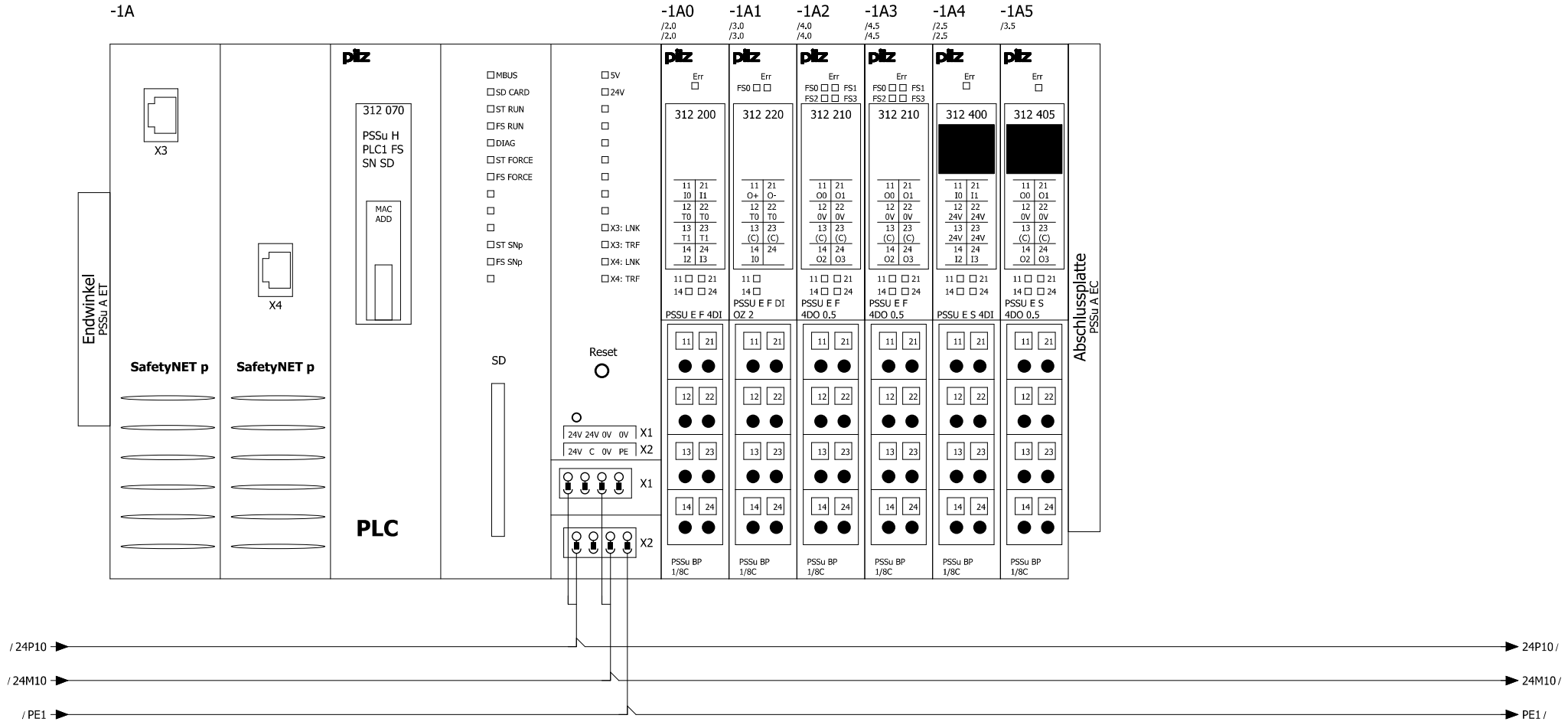


Fig. 15: Process PAS Project



PSSu E F 4DI
312 200

PSSu E S 4DI 0.5
312 400

PSSu E S 4DI 0.5
312 400

PSSu E F DI OZ 2
312 220

PSSu E S 4DO 0.5
312 405

PSSu E S 4DO 0.5
312 405

PSSu BP 1/8C
312 601

PSSu BP 1/8C
312 601

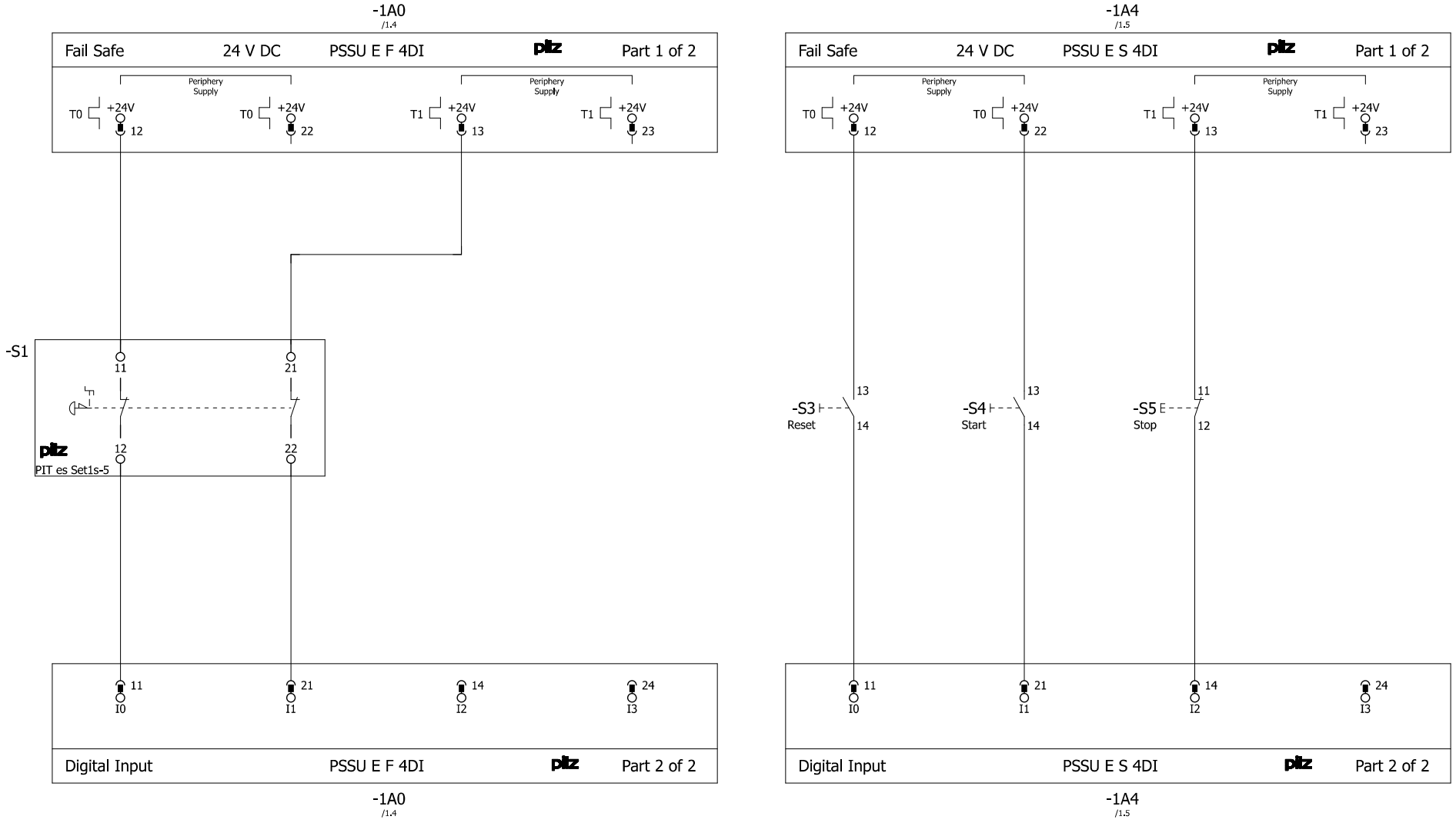
PSSu BP 1/8C
312 601

PSSu BP 1/8C
312 601

PSSu BP 1/8C
312 601

PSSu BP 1/8C
312 601

Revision	15.03.2016	Date	24.02.2016	EN ISO 13849-1	PL e	PILZ Pilz GmbH & Co.KG Felix-Wankel-Str.2 73760 Ostfildern	PSS 4000 - Emergency Stop with PITestop
Name	Pilz	Name	Pilz				Power supply PSS 4000
				EN 62061:	SIL 3		Mounting place + AN_1003985_01
		Dep.	CS				Page: 1 / 4



MyEmergencyStop1 InputNC1	MyEmergencyStop1 InputNC2	Spare	Spare

MyEmergencyStop1 Reset	Start	Stop	Spare

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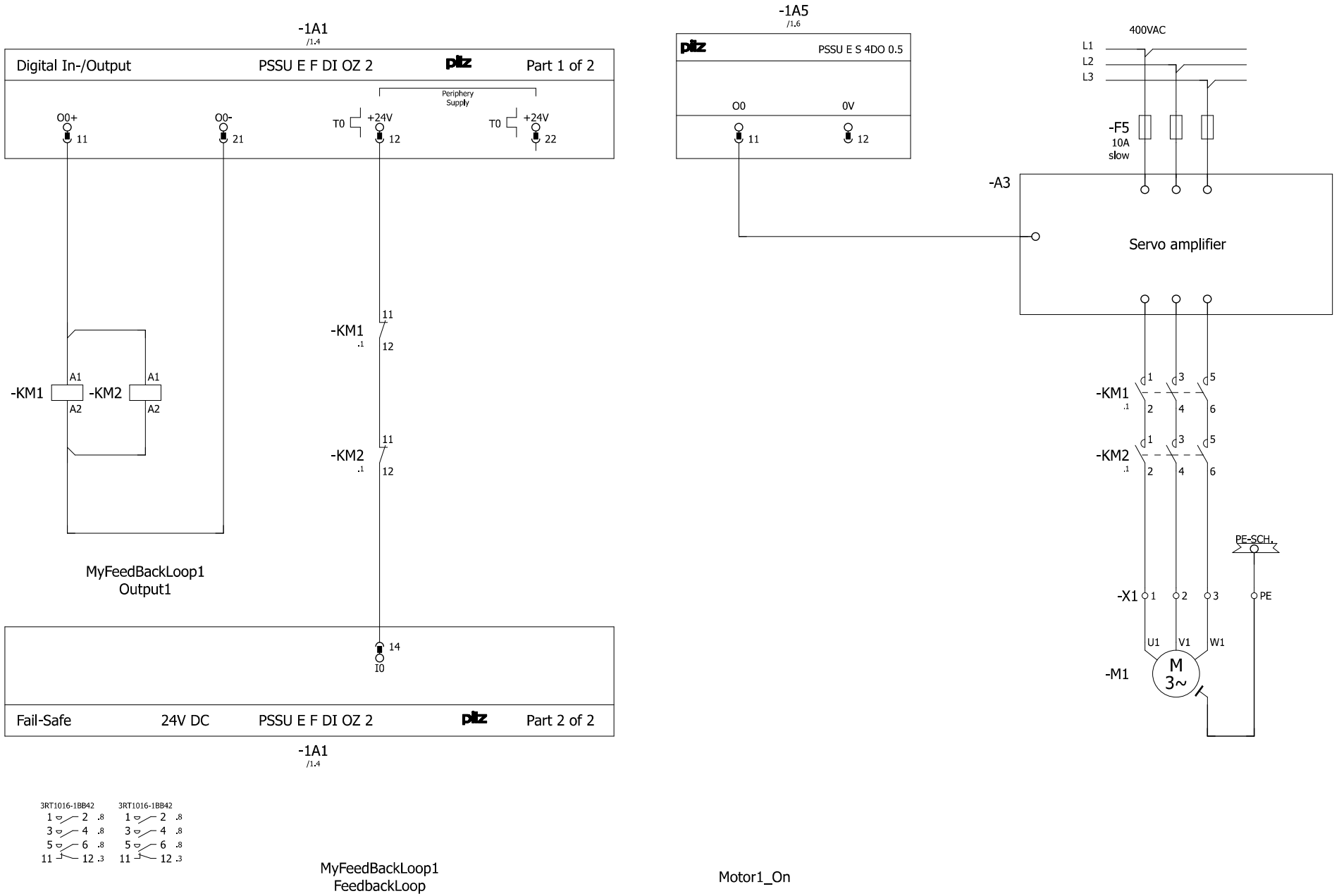
Name	Pilz	Name	Pilz				
				EN 62061:	SIL 3		Inputs
		Dep.	CS				

Mounting place + AN_1003985_01



Revision	15.03.2016	Date	24.02.2016	EN ISO 13849-1	PL e	PILZ Pilz GmbH & Co.KG Felix-Wankel-Str.2 73760 Ostfildern	PSS 4000 - Emergency Stop with PITestop
Name	Pilz	Name	Pilz				Drive
				EN 62061:	SIL 3		
		Dep.	CS				

Mounting place
+ AN_1003985_01

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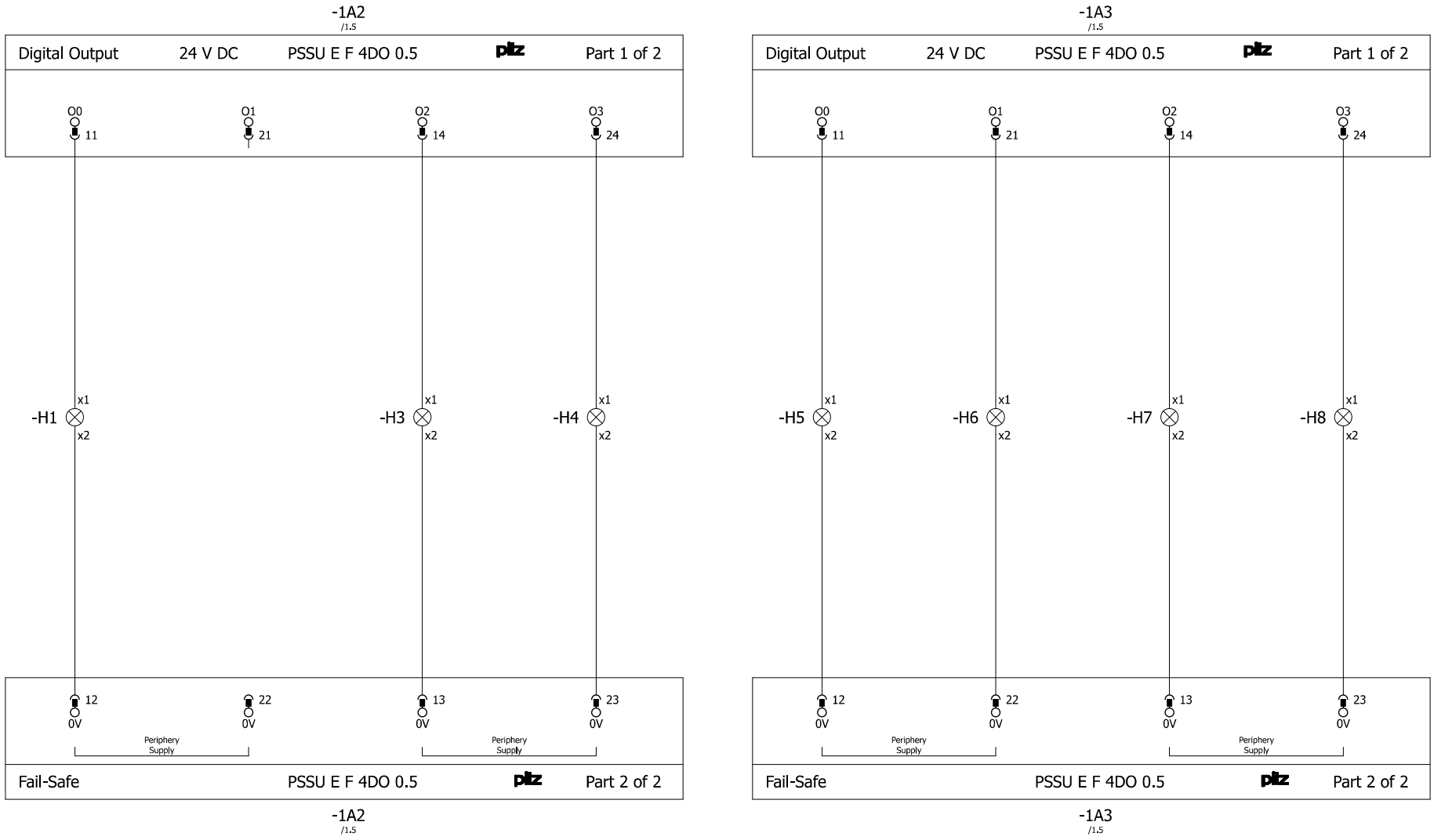

MyEStop1 DiagOperated	Spare	MyEStop1 DiagReadyForReset	MyEStop1 DiagReadyForTest	MyEStop1 DiagSwitchError	MyEStop1 DiagInputNotValid	MyFBL1 DiagFBLError	MyFBL1 DiagFBLNotValid

Revision	15.03.2016	Date	24.02.2016	EN ISO 13849-1 PL e	Pilz GmbH & Co.KG Felix-Wankel-Str.2 73760 Ostfildern	PSS 4000 - Emergency Stop with PITestop	Mounting place + AN_1003985_01
Name	Pilz	Name	Pilz				
				EN 62061: SIL 3		Status/Error message	Page: 4 / 4
		Dep.	CS				

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Es konnten keine Einträge für ein Abbildungsverzeichnis gefunden werden.

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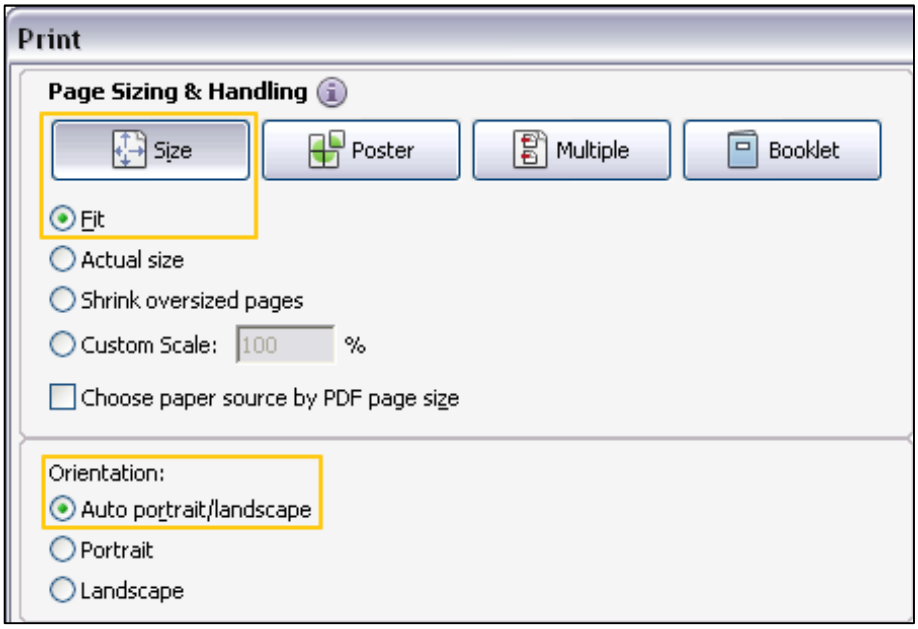
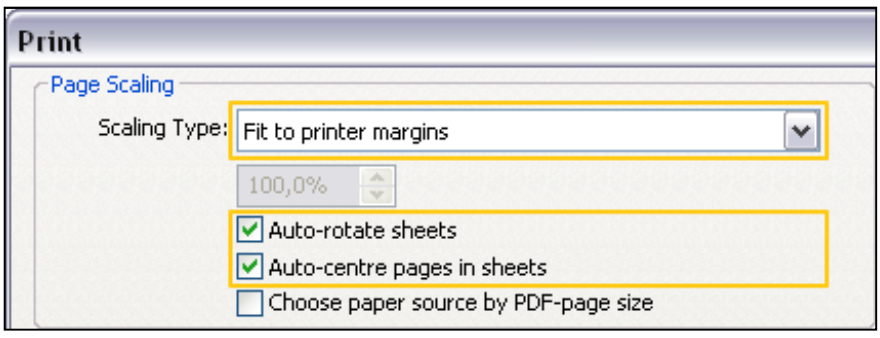
Recommended printer settings

Adobe Acrobat Reader (www.adobe.com)



PDF-XChange Viewer (www.tracker-software.com)



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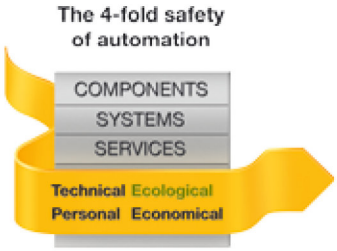

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