

# PSS 4000 Light Curtain with PSENopt Instruction List



## Product

Type: FS\_LightCurtain, FS\_OutputFBL  
Name: PSS 4000, Blocks, PAS4000, PLC, IL  
Manufacturer: Pilz GmbH & Co. KG, Safe Automation

## Document

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| 02      | 2010-09-28 | Adjustments for publication on Pilz website,<br>New Function block library, Valid bit | only editorial<br>2 + 3 |
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| 04      | 2011-07-27 | Revision for Pilz Automation Suite  | all                     |
| 05      | 2012-04-20 | Revision of the Application Note  | all                     |
|         |            |   |                         |

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April 2012

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## Abbreviations

|      |   |
|------|---|
| PAS  | <b>P</b> ilz <b>A</b> utomation <b>S</b> uite (software platform)                   |
| PSS  | Programmable control system (DE: <b>P</b> rogrammierbares <b>S</b> teuerungssystem) |
| PNOZ | Pilz E-STOP Positive-guided (DE: <b>P</b> ilz <b>N</b> OT-AUS-Zwangsgeführt)        |
| POU  | <b>P</b> rogram <b>O</b> rganisation <b>U</b> nit                                   |
| PRG  | <b>P</b> rogram   |
| FB   | <b>F</b> unction <b>B</b> lock  |
| FUN  | <b>F</b> unction  |
| IL   | Instruction <b>L</b> ist  |

# 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                      | <a href="http://www.pilz.com">www.pilz.com</a> |
| 2   | Operating Manual PSSu H PLC1 FS SN SD                              | 21939-EN-xx                                    |
| 3   | Operating Manual PSSu E F 4DI                                      | 21 311-xx                                      |
| 4   | Operating Manual PSSu E F DI OZ 2                                  | 21 329-xx                                      |
| 5   | Operating Manual PSSu E F 4DO 0.5                                  | 21 317-xx                                      |
| 6   | Bedienungsanleitung PSSu E S 4DI                                   | 21 340-EN-xx                                   |
| 7   | Bedienungsanleitung PSSu E S 4DO 0.5                               | 21 346-EN-xx                                   |
| 8   | System Description Programmable safety and control system PSS 4000 | 1001 467-EN-xx                                 |
| 9   | Safety Manual Programmable safety and control system PSS 4000      | 1001 468-EN-xx                                 |
| 10  | PAS4000 online help  | -  |
| 11  | Operating Manual PSEN op4F/H-s-.../1                               | 1001 422-EN-xx                                 |

## 1.2. Documentation from other sources of information

| No. | Description | Item No. |
|-----|-------------|----------|
| 1   |             |          |
| 2   |             |          |

### Note

The present example (PSS 4000 Light Curtain with PSENopt) is also available in the programming languages [Structured text](#) and [PASmulti](#).

## 2. Hardware configuration

### 2.1. Pilz products

| No. | Description          | Order number | Version | Number |
|-----|----------------------|--------------|---------|--------|
| 1   | PSSu H PLC1 FS SN SD | 312 070      | 001     | 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   | PSEN op4F-s-14-090/1 | 630 745      | -       | 1      |
| 9   | PAS4000              | -            | v1.5.0  | 1      |

### 2.2. Hardware configuration

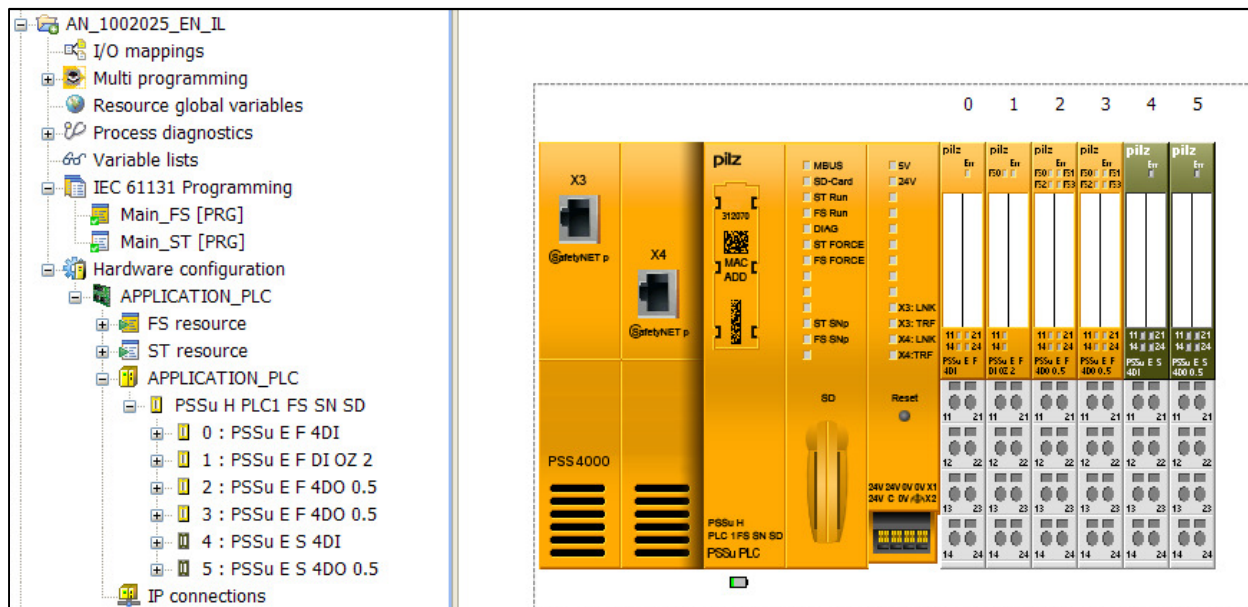


Fig. 1: Hardware configuration

## 3. Application Task

### 3.1. Description

The example shows the implementation of a safety gate 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\_LightCurtain  
CRC 5963
  
- ▶ FS\_OutputFBL  
CRC B3A7

The workflow is divided into the following two main functions:

- ▶ Light Curtain and
- ▶ Feedback Loop Monitoring

#### 3.1.1. Light curtain monitoring function

The control system monitors the light curtain (B1, B2) via the user program. An instance of the Pilz function block *“FS\_LightCurtain”* is assigned to them. This FS-FB detects whether the assigned light curtain has been operated, as well as detecting incorrect input signals and whether the contact synchronization time has been exceeded, etc.

If the light curtain is interrupted 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 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 light curtain are released.

Although the light curtain and the light curtain function are configured to reset themselves, a PSS cold start or the release of the light curtain may not directly enable a machine to start up without further conditions being met.

#### **Input circuit safety assessment**

- ▶ A short between 24 VDC and an input circuit on the PSSu module will be detected as an error by the AOPD; the AOPD outputs are shut down.
- ▶ A short between the input circuits on the PSSu module will be detected as an error by the AOPD; the AOPD outputs are shut down.
- ▶ 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.

### 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” 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 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 safety 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. Functional 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 when the safety light curtain is interrupted | PL e | Sensor (PSEN op4F-s.../1 A1, A2)<br>Input (PSSu E F 4DI)<br>Logic (PSSu H PLC1 FS SN)<br>Output (PSSu E F DI OZ 2)<br>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   | two operations per hour |
|     |   | Actuator   | two operations per hour |
| 4   | Characteristic data of contactors KM1/KM2         | B10d   | 2,000,000               |

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 (SFCF)                         | Safety Integrity Level | Subsystems   |
|-----|--|------------------------|--|
| 1   | Machine shut down when the safety light curtain is interrupted | SIL 3                  | Sensor (PSEN op4F-s.../1 A1, A2)<br>Input (PSSu E F 4DI)<br>Logic (PSSu H PLC1 FS SN)<br>Output (PSSu E F DI OZ 2)<br>Actuator (contactors KM1, KM2) |

#### Prerequisites

| No. | Description                                       | Identification                                   |                         |
|-----|---|--|-------------------------|
| 1   | Common cause failure (CCF)                        | $\beta = 2\%$ (must be tested on implementation) |                         |
| 2   | Proof test interval                               | 20 years   |                         |
| 3   | Operating interval (electromechanical components) | Sensor   | two operations per hour |
|     |   | Actuator   | two operations per hour |
| 4   | Characteristic data of contactors KM1/KM2         | B10d   | 2,000,000               |
|     |   | Dangerous failure rate                           | 65%                     |

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. IL-Editor

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

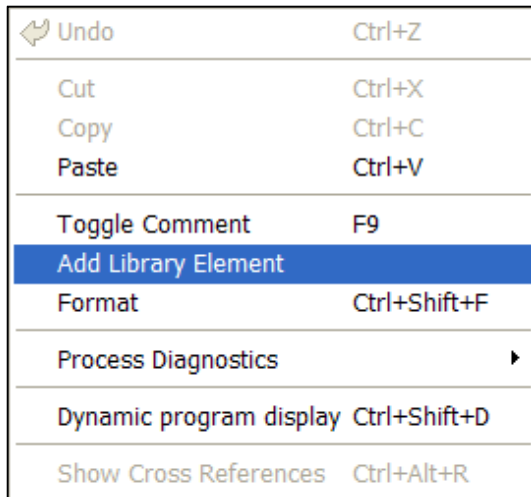


Fig. 2: Add library element

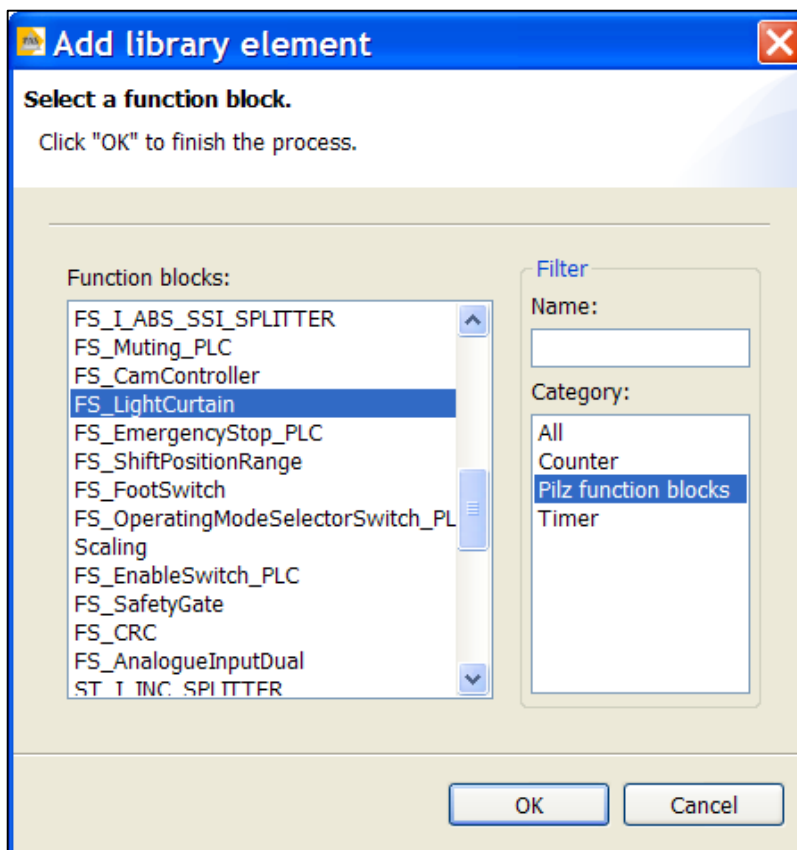


Fig. 3: Selection library element

## Failsafe program

### Declaration part

```
001 PROGRAM Main_FS
002 VAR
003     // My Light Curtain 1
004     MyLightCurtain1                : FS_LightCurtain;
005     MyLCurt1_Enable                AT %Q* : SAFEBOOL;
006     MyLCurt1_DiagOperated          AT %Q* : SAFEBOOL;
007     MyLCurt1_DiagReadyForReset    AT %Q* : SAFEBOOL;
008     MyLCurt1_DiagReadyForTest     AT %Q* : SAFEBOOL;
009     MyLCurt1_DiagSwitchError      AT %Q* : SAFEBOOL;
010     MyLCurt1_DiagInputNotValid    AT %Q* : SAFEBOOL;
011
012     // My FBL
013     MyFeedBackLoop1               : FS_OutputFBL;
014     MyFBL1_DiagFblError           AT %Q* : SAFEBOOL;
015     MyFBL1_DiagFblNotValid       AT %Q* : SAFEBOOL;
016 END_VAR
017
018 VAR CONSTANT
019     // Declaration SwitchType 3 (NCNC)
020     MyLCURT1_DOUBLE_CH             : USINT := USINT#3;
021 END_VAR
```

### Instruction part

```
022     // Safety-Block Light Curtain 1
023     CAL MyLightCurtain1(
024         SwitchType := MyLCURT1_DOUBLE_CH,
025         AutoStart := FALSE,
026         AutoReset := FALSE,
027         MonitoredReset := TRUE,
028         StartupTest := FALSE,
029         SimultaneityTime := T#100ms,
030         DelayTime := T#40ms,
031         Enable => MyLCurt1_Enable,
032         DiagOperated => MyLCurt1_DiagOperated,
033         DiagReadyForReset => MyLCurt1_DiagReadyForReset,
034         DiagReadyForTest => MyLCurt1_DiagReadyForTest,
035         DiagSwitchError => MyLCurt1_DiagSwitchError,
036         DiagInputNotValid => MyLCurt1_DiagInputNotValid
037     )
038
039     // Safety-Block monitoring FBL1 and release motor1
040     CAL MyFeedBackLoop1(
041         Input := MyLCurt1_Enable,
042         FeedbackLoopTime := T#200ms,
043         DiagFeedbackLoopError => MyFBL1_DiagFblError,
044         DiagFeedbackLoopNotValid => MyFBL1_DiagFblNotValid
045     )
046
047     END_PROGRAM
```

## 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

```
001 PROGRAM Main_ST
002 VAR
003     MyRisingEdge1           : R_TRIG;
004     Start                   AT %I* : BOOL;
005     Stop                     AT %I* : BOOL;
006     Start_FLR               : BOOL;
007     Set_Motor1              : BOOL;
008     Reset_Motor1            : BOOL;
009     Motor1_On               AT %Q* : BOOL;
010     Other_Stop_Conditions   AT %I* : BOOL;
011     FF_Motor1On            : RS;
012 END_VAR
```

## Instruction part

```
013 // Rising Edge 1 - Monitoring Start
014 CAL MyRisingEdge1(
015     clk := Start,
016     q => Start_FLR
017 )
018
019 // Start Motor1
020 LD Start_FLR
021 // AND Other_Start_Conditions //e.g. Operating Mode
022 ST Set_Motor1
023
024 // Stop Motor1
025 LDN Stop
026 ORN Other_Stop_Conditions //e.g. Enable Signal LCurt1
027 ST Reset_Motor1
028
029 // Flip-Flop Motor1 On
030 CAL FF_Motor1On(
031     set := Set_Motor1,
032     reset1 := Reset_Motor1,
033     q1 => Motor1_On
034 )
035
036 END_PROGRAM
```



### 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.

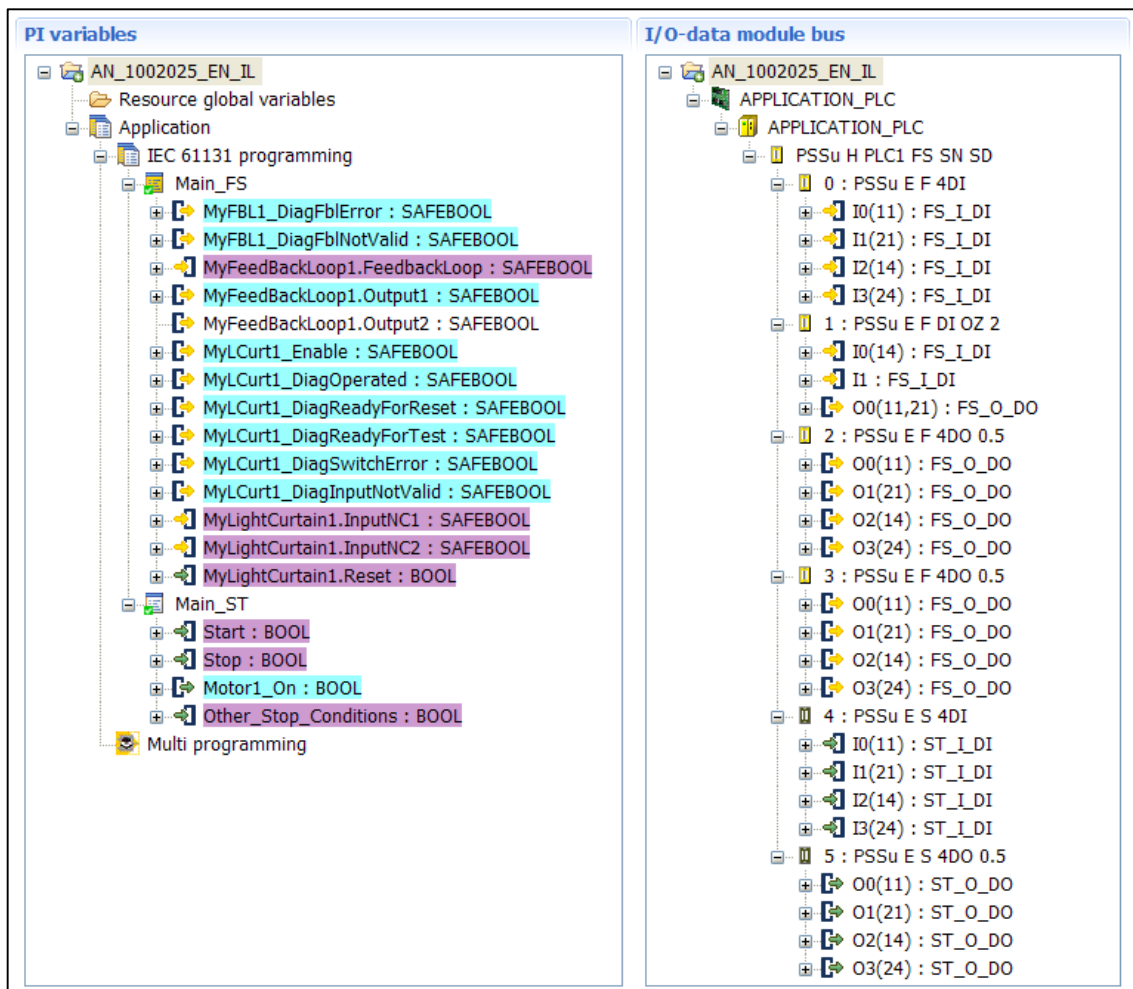


Fig. 4: Mapping Editor – IL-program

### 3.3.3. Process PAS Project

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

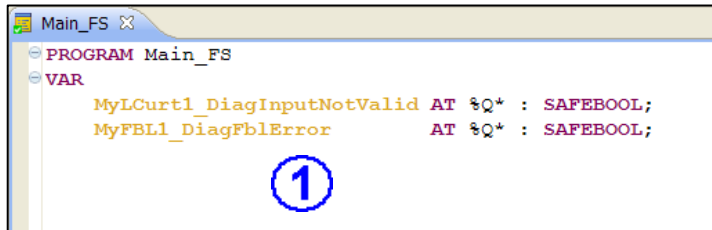


Fig. 5: PI variables

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

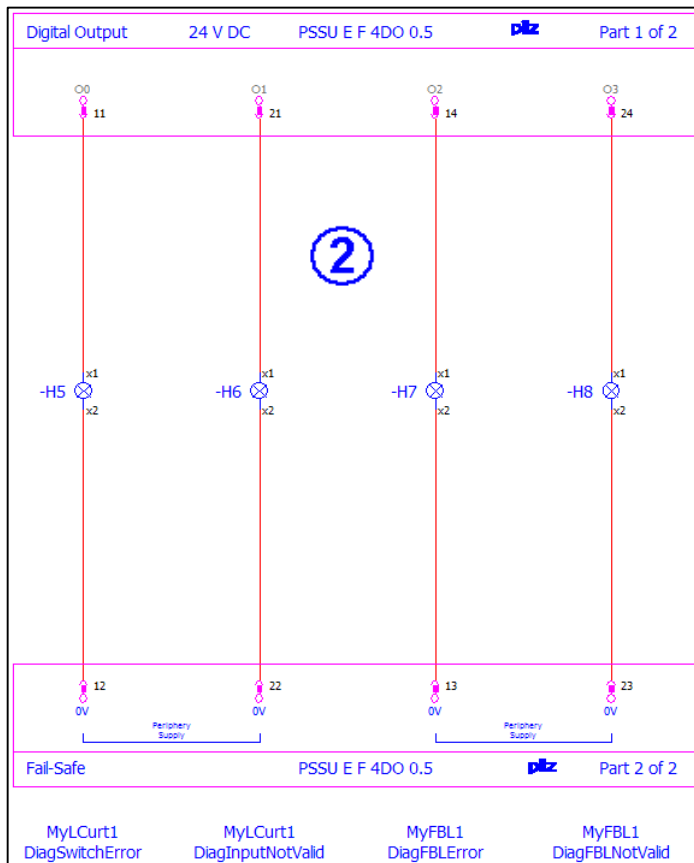


Fig. 6: Circuit diagram (extract)

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

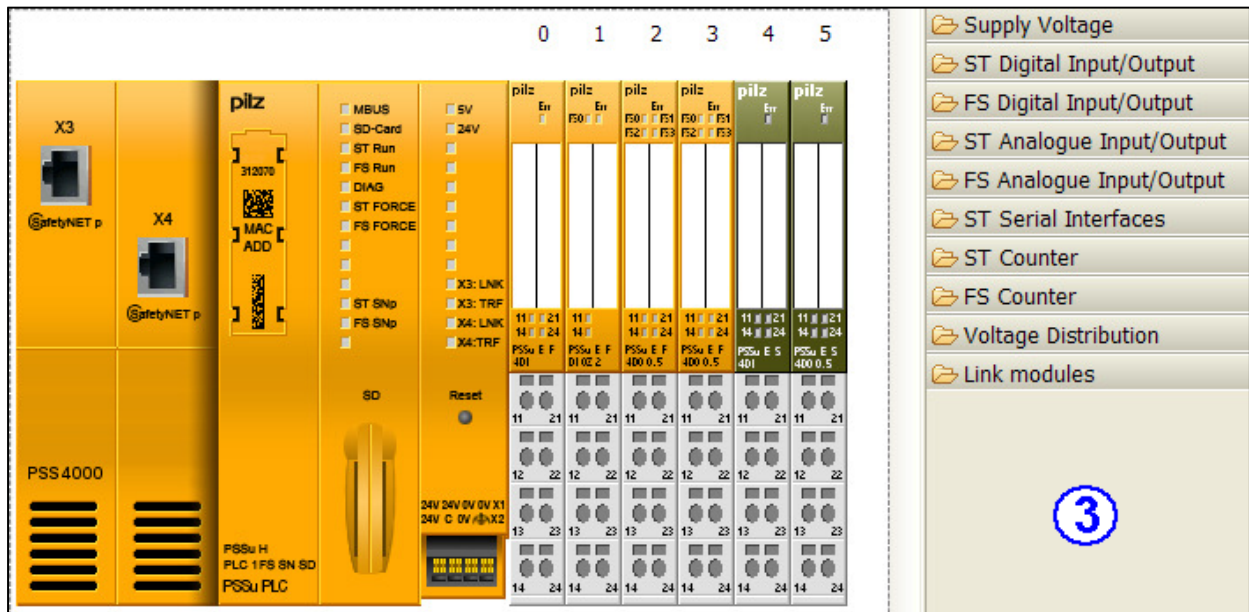


Fig. 7: PSSu Module Editor

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

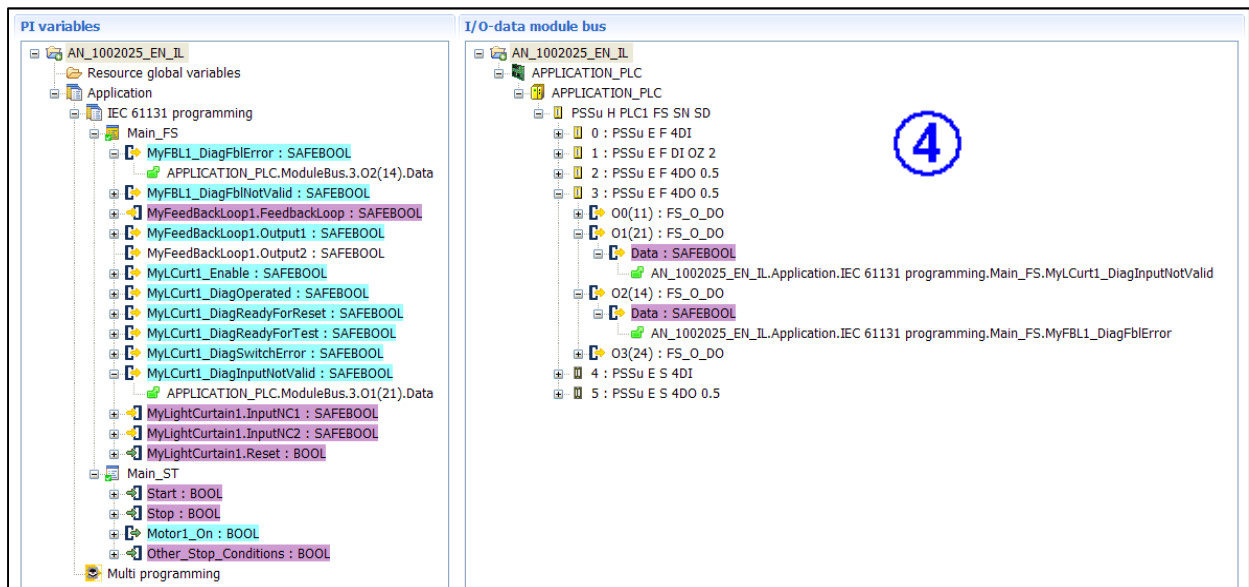


Fig. 8: I/O Mapping Editor

► Overview process PAS Project (Steps 1-4)

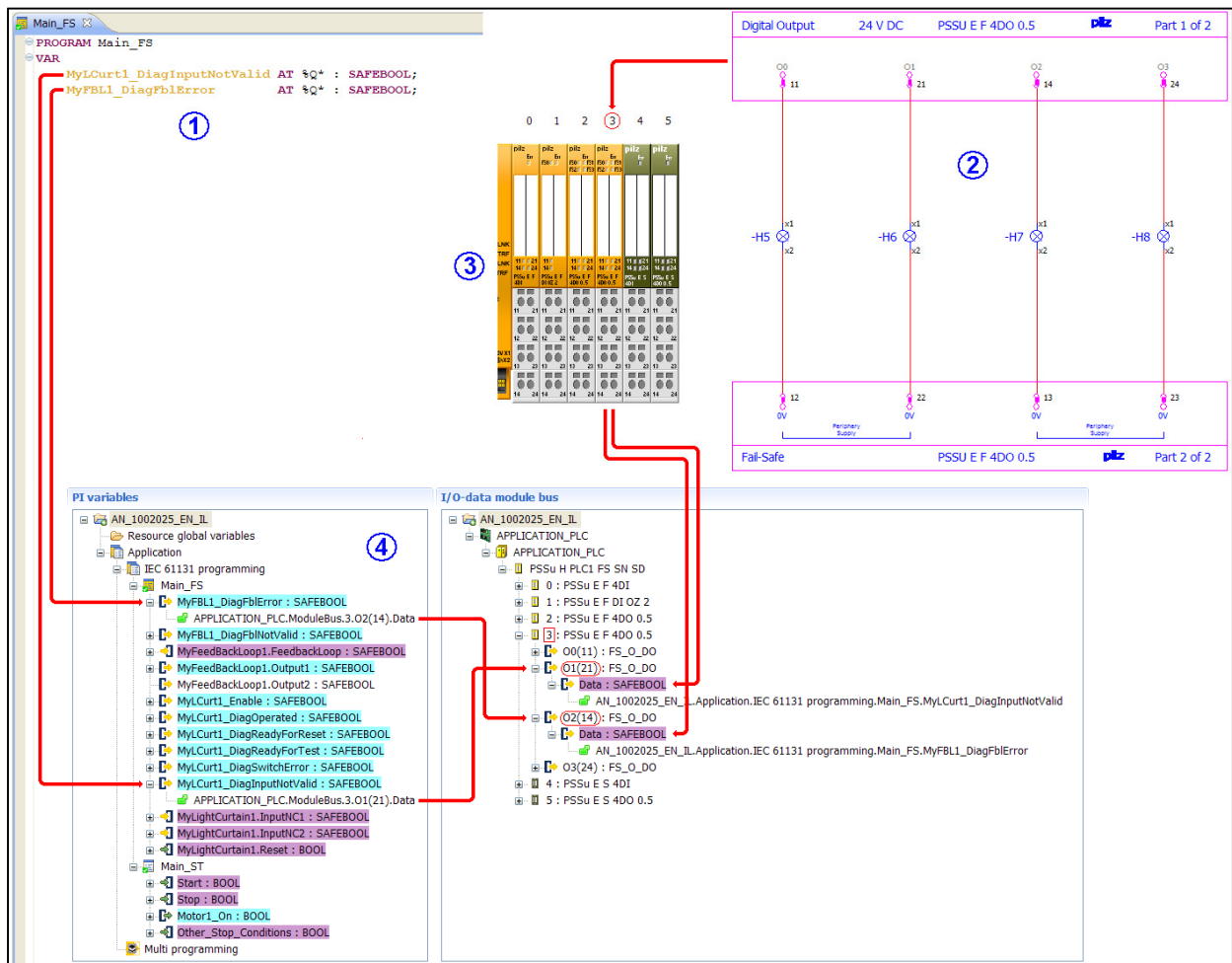
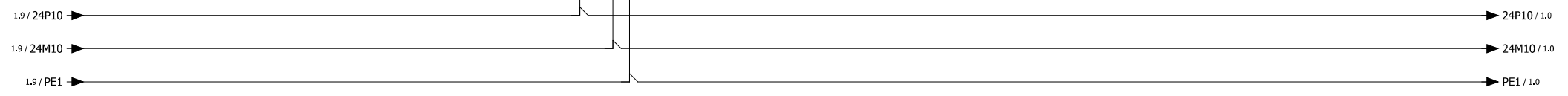
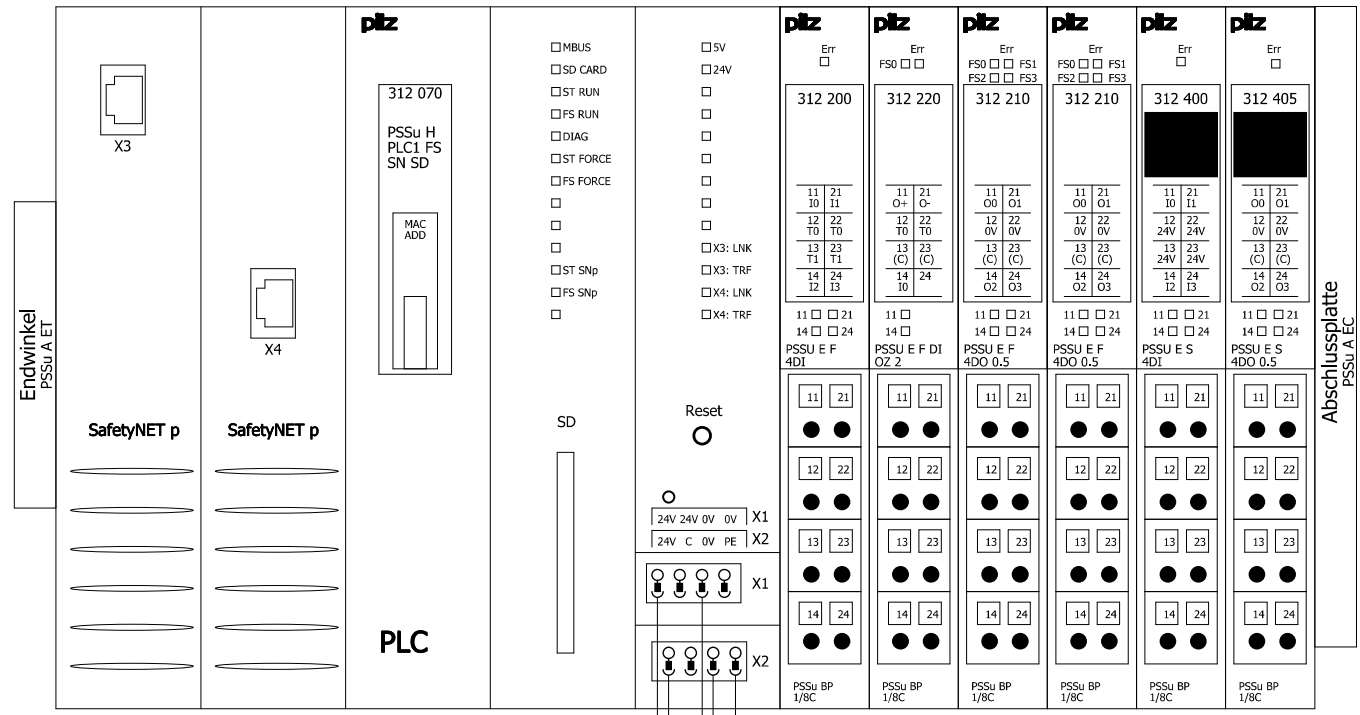


Fig. 9: Process PAS Project

-1A -1A0 -1A1 -1A2 -1A3 -1A4 -1A5



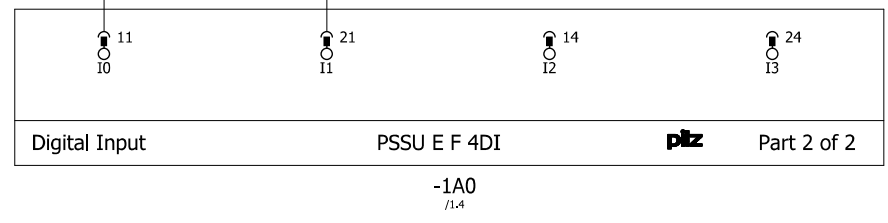
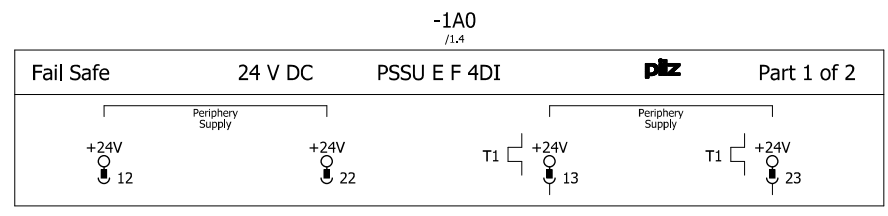
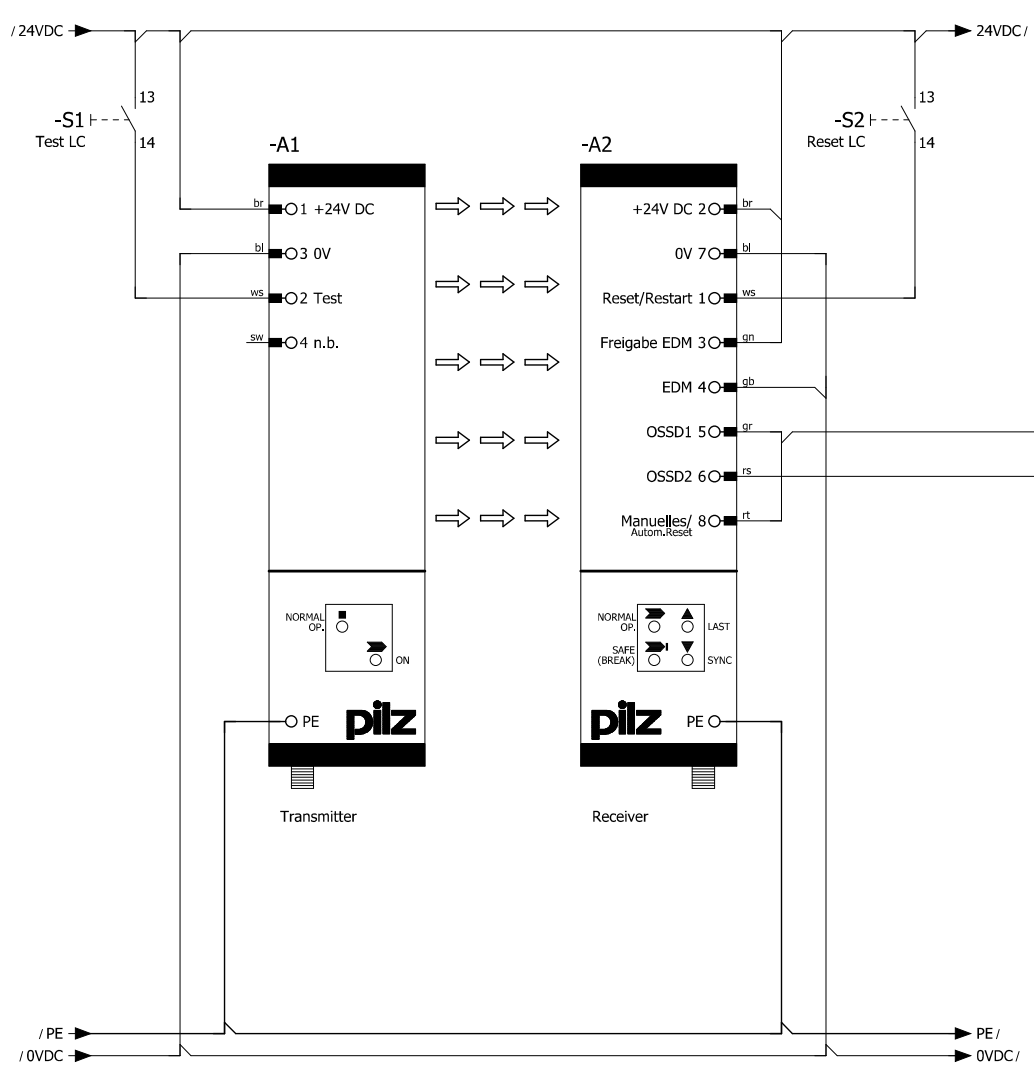
- PSSu E F 4DI 312 200
- PSSu E S 4DI 0.5 312 400
- PSSu E S 4DI 0.5 312 400
- PSSu E F DI OZ 2 312 220
- PSSu E S 4DO 0.5 312 405
- PSSu E S 4DO 0.5 312 405
- PSSu BP 1/8C 312 601
- PSSu BP 1/8C 312 601
- PSSu BP 1/8C 312 601
- PSSu BP 1/8C 312 601
- PSSu BP 1/8C 312 601
- PSSu BP 1/8C 312 601

|          |            |      |            |
|----------|------------|------|------------|
| Revision | 08.03.2012 | Date | 19.01.2005 |
| Name     | RDS        | Name | RDS        |
|          |            | Dep. | CS         |

EN ISO 13849-1:2006 PL e  
 EN 62061:2005 SIL 3



PSS 4000 - Light curtain with PSENopt  
 Power supply PSS 4000



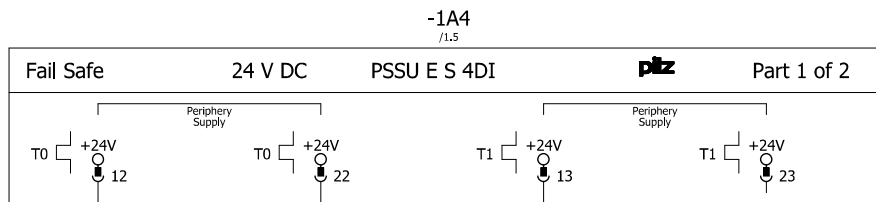
MyLightCurtain1 InputNC1      MyLightCurtain1 InputNC2      Spare      Spare

|          |            |      |            |
|----------|------------|------|------------|
| Revision | 08.03.2012 | Date | 19.01.2005 |
| Name     | RDS        | Name | RDS        |
|          |            | Dep. | CS         |

|                     |       |
|---------------------|-------|
| EN ISO 13849-1:2006 | PL e  |
| EN 62061:2005       | SIL 3 |

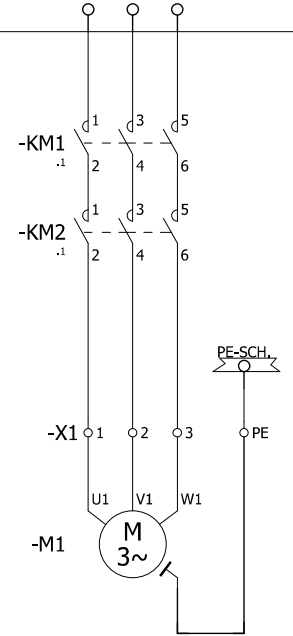
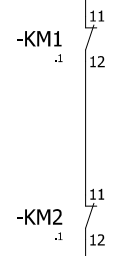
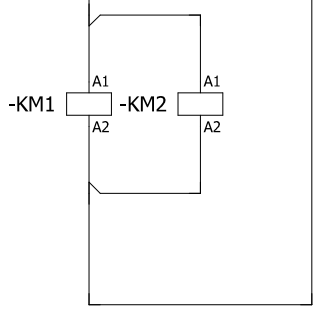
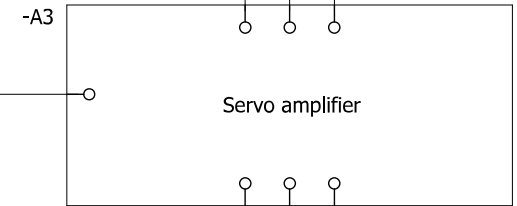
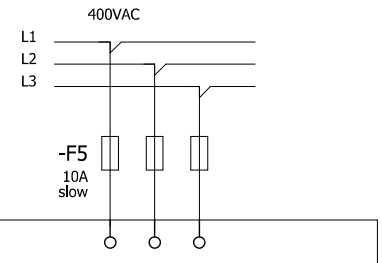
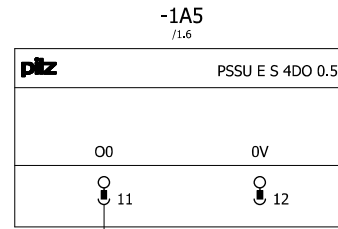
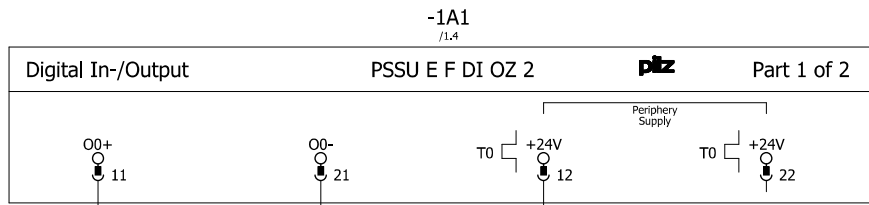
**pilz** Pilz GmbH & Co. KG  
Felix-Wankel-Str. 2  
73760 Ostfildern

PSS 4000 - Light curtain with PSENopt  
Inputs

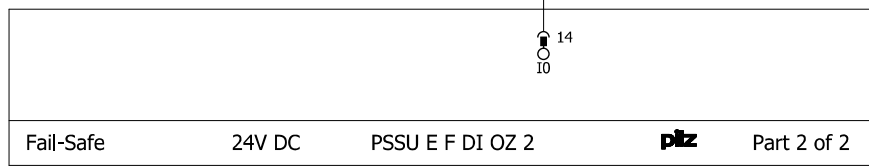


-1A4  
/1.5

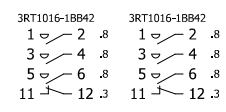
MyLightCurtain1      Start      Stop      Spare  
Reset



MyFeedBackLoop1  
Output1



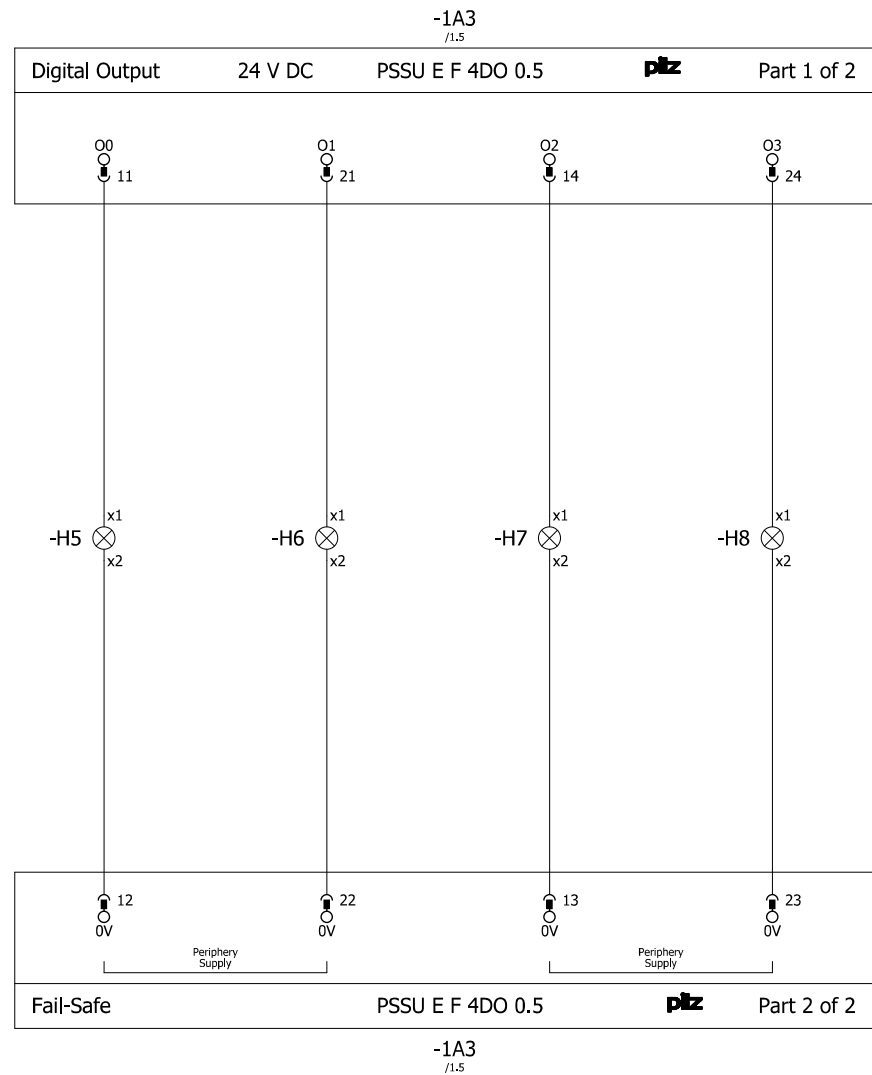
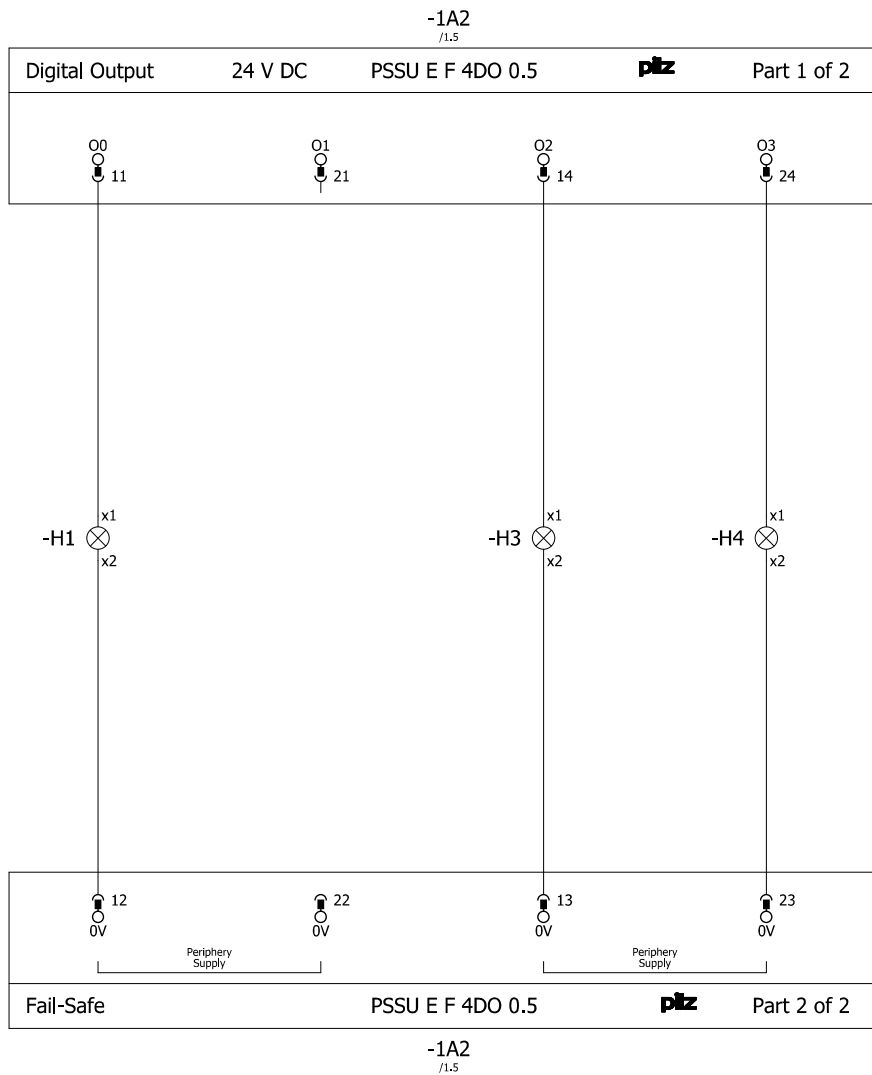
-1A1  
/1.4



MyFeedBackLoop1  
FeedbackLoop

Motor1\_On





MyLCurt1  
DiagOperated

Spare

MyLCurt1  
DiagReadyForReset

MyLCurt1  
DiagReadyForTest

MyLCurt1  
DiagSwitchError

MyLCurt1  
DiagInputNotValid

MyFBL1  
DiagFBLError

MyFBL1  
DiagFBLNotValid

|          |            |      |            |
|----------|------------|------|------------|
| Revision | 08.03.2012 | Date | 19.01.2005 |
| Name     | RDS        | Name | RDS        |
|          |            | Dep. | CS         |

EN ISO 13849-1:2006    PL e  
EN 62061:2005        SIL 3



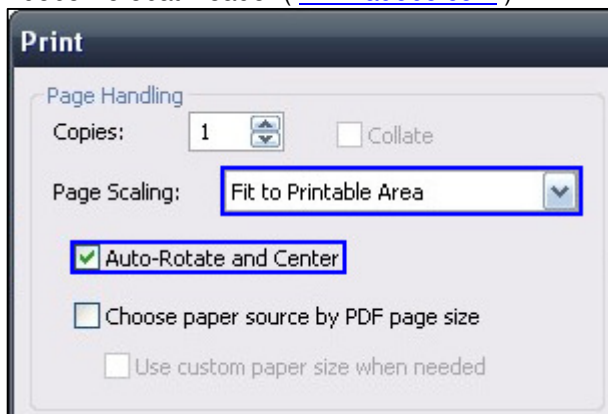
PSS 4000 - Light curtain with PSENopt  
Status/Error message

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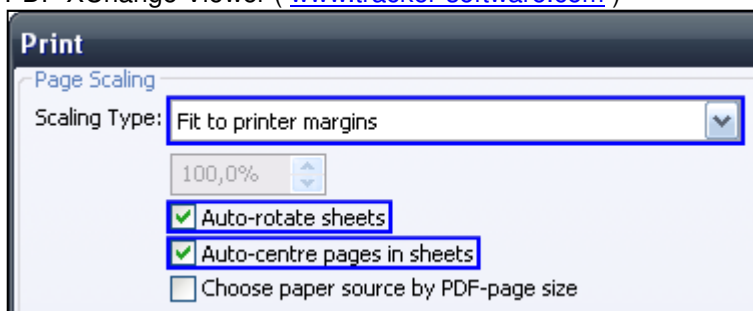
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## Recommended printer settings

Adobe Acrobat Reader ( [www.adobe.com](http://www.adobe.com) )



PDF-XChange Viewer ( [www.tracker-software.com](http://www.tracker-software.com) )





► ...  
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