PSS 4000 - Rotational speed monitoring with safe encoder

PILZ
THE SPIRIT OF SAFETY

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Validity of Application Note

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For a simple search, use our content document (1002400) or the direct search function in the download area.

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We are grateful for any feedback on the contents.

August 2015

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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)
POU	**P**rogram **O**rganisation **U**nit
SSM	**S**afe **S**peed **M**onitoring
SDI-M	**S**afe **Di**rection **M**onitoring
SOS-M	**S**afe **O**perating **S**top **M**onitoring
SSR-M	**S**afe **S**peed **R**ange **M**onitoring
SS1	**S**afe **S**top **1**
STO	**S**afe **T**orque **O**ff

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 S 4DI(-T)	21340-EN-xx
5	Operating Manual PSSu E S 4DO 0.5	21346-EN-xx
6	Operating Manual PSSu K F EI	1003303-EN-xx
7	Operating Manual PSEN me2, PSEN me3	1003287-2EN-xx
8	Operating Manual PMCprotego D.48, D.72	1001735-EN-xx
9	Operating Manual PMCtendo SZ	1002405-EN-xx
10	System Description Automation system PSS 4000	1001467-EN-xx
11	Safety Manual Automation system PSS 4000	1001468-EN-xx
12	PAS4000 Online Help	-
13	PASmotion Online Help	-

1.2. Documentation from other sources of information

No.	Description	Item No.
1		
2		

2. Hardware configuration

2.1. Pilz products

No.	Description	Order number	Version	Number
1	PSSu H PLC1 FS SN SD	312070	FW 1.12.0	1
2	PSSu E F 4DI	312200	-	2
3	PSSu E S 4DI	312400	-	1
4	PSSu E S 4DO 0.5	312405	-	1
5	PSSu K F EI	312433	-	1
6	PSSu A Con Set1 C	313114	-	1
7	PSSu BP 1/8C	312601	-	4
8	PSEN me2 / 2AS	570200	-	2
9	PMCprotego D.72/000/0/0/2/208-480V AC	8176426-1	-	1
10	PMCtendo SZ.75/0/2/2/7/F/H/30/00	8177026	-	1
11	Brake resistor 1600W/10R/T/U	8176364	-	1
12	PMCcable FD/D4B6/005/Q25/S1 (Feedback cable EnDat)	8177101	-	1
13	PMCcable M2/C1B3/005/6Q0/S1 (Power cable)	8177211	-	1
14	PNOZ msi b4 Box	773845	-	1
15	MM A MINI-IO-CAB01 1.5M	772200	-	1
16	PAS4000	-	V1.12.0	1
17	PASmotion	-	V1.0.1	1

2.2. Hardware configuration

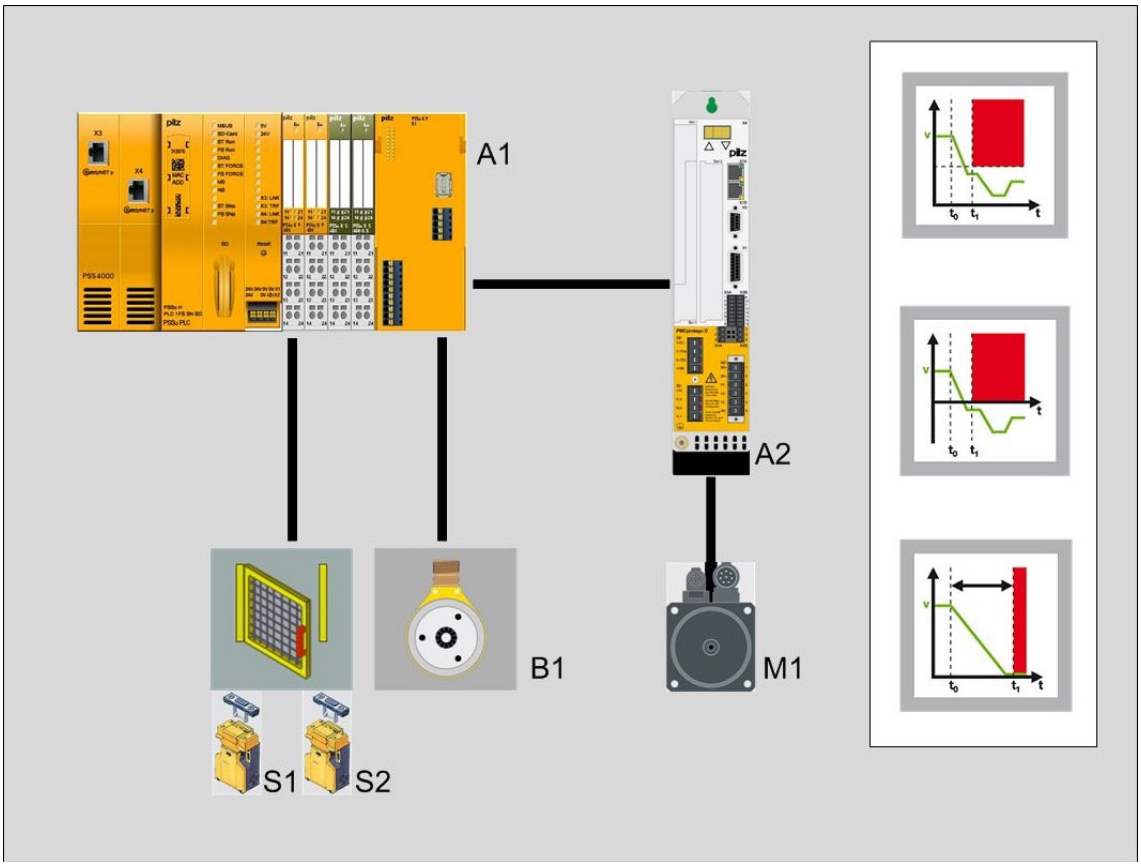


Fig. 1: Hardware configuration

This example illustrates safely monitored speed (rotational speed) and safely monitored direction of rotation with a PSS 4000 PLC and the module PSSu K F EI.
A safe rotary encoder (B1) is used to record the movement of the motor. The rotary encoder is connected to the module PSSu K F EI (A1), which evaluates the signals safely.
Two PSEN me2 (S1, S2) are used to monitor a safety gate.
The motor (M1) is connected to a servo amplifier PMCprotego D (A2). Several Pilz function blocks (FS-FBs) from the PAS4000 Library are used in the PLC program that implements the application:

FS_SafetyGate	Safety Gate Monitoring
FS_EI_SSM0	Communication with the Module PSSu K F EI
FS_EI_SDIM	
FS_EI_SOSM	
FS_EI_SSM1_SSRM	
FS_EI_Basic	

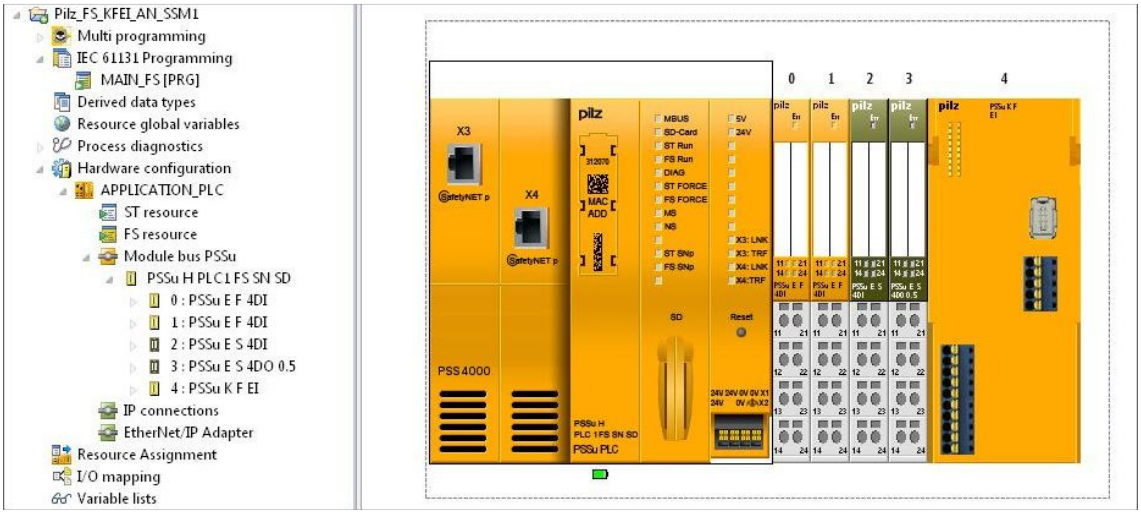


Fig. 2: PSS 4000 Configuration

The module PSSu K F EI is configured as follows:

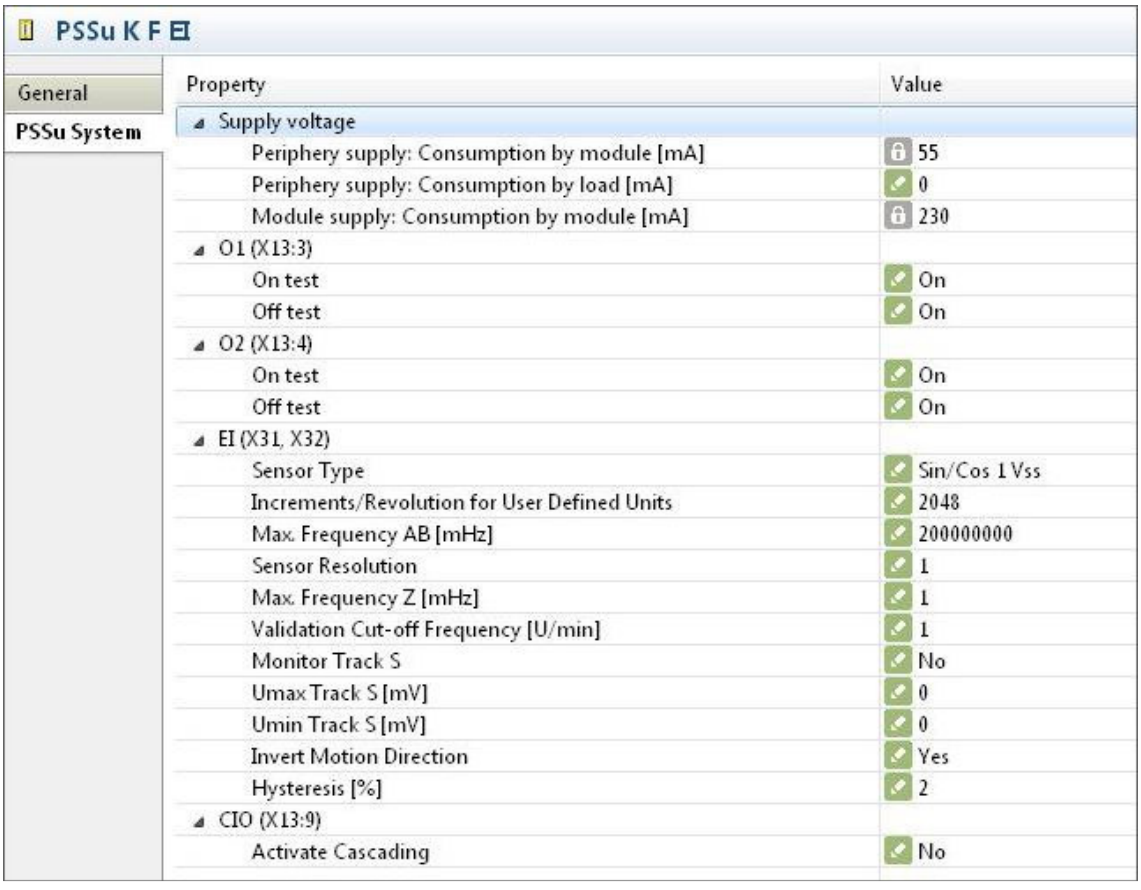


Fig. 3: Configuration of the module PSSu K F EI

Guidelines for the sections EI (X31, X32) and CIO (X13:9)

Sensor type:
The rotary encoder used in this case supplies a Sin/Cos signal 1 Vss.

Increments/revolution for user-defined units:
The rotary encoder supplies 2048 increments per revolution. This value is needed for conversion into other physical sizes.

Max. frequency AB:
The data sheet for the rotary encoder lists a maximum frequency of 200 kHz on tracks A and B. Entries are made in mHz. The module PSSu K F EI monitors whether this value is exceeded.

Sensor resolution:
Default value, as only relevant on sensors with track Z.

Max. frequency Z:
Default value, as only relevant on sensors with track Z.

Validation cut-off frequency:
Default value, as only relevant when using proximity switches for tracks A/B.

Monitor track S / Umax track S / Umin track S:
Track S is not monitored in this application.

Invert direction of movement:
Due to the mounting, in this example the direction of movement is inverted internally within the module, in order to monitor the physically correct direction of movement.

Hysteresis:
The stated value of 2% ensures that once the monitoring function SSM1 has reacted, the enable will not be reset until the speed value is 2% below the configured limit value.

Enable cascading:
Cascading is not possible in this example because only one module PSSu K F EI is used.

The configuration of the servo amplifier is not described in this Application Note.

3. Application Task

3.1. Functional description

3.1.1. Plant overview

This application example uses a steel strip finishing plant to show how speed (rotational speed) and direction of rotation can be monitored safely using a PSS 4000 PLC and the module PSSu K F EI.

A steel strip is unwound from a reel and transported onwards via rollers for processing.

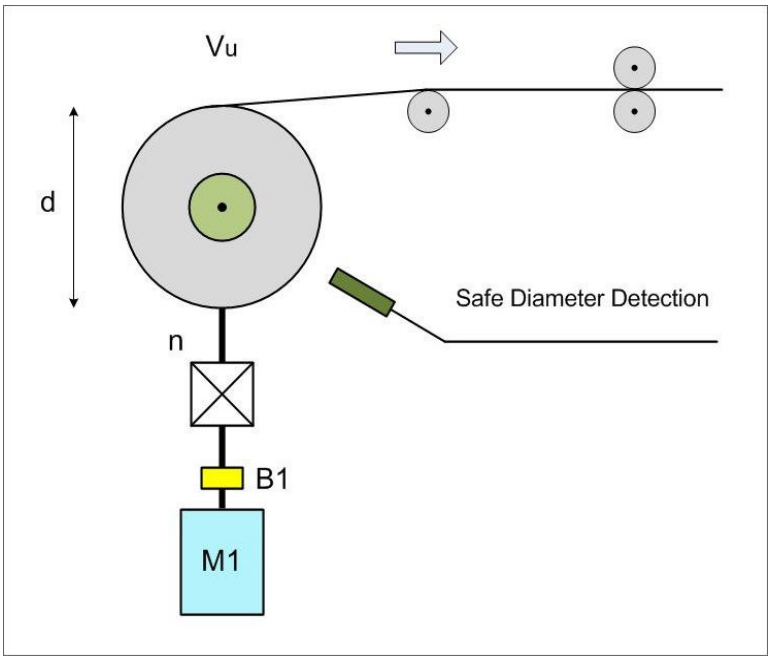


Fig. 4: Steel strip processing application

In automatic mode, safety fences and safety gates protect staff from hazards arising from the transportation of materials.

The risk analysis indicated that interventions to maintain operation are only permitted at reduced material speed and with the correct transport direction, i.e. if a safety gate is opened, the plant must be safely monitored for reduced speed.

The material speed can only be recorded indirectly via the speed of the reel. As a result, the limit value for monitoring the reduced speed should also be set as the rotational speed value.

As the diameter of the coil changes as it unwinds and the material speed is constant, the speed of the reel will change. As a result, the limit value for monitoring the reduced speed must be adjusted, based on the coil diameter.

The coil diameter is recorded safely using the sensors; from this, signals are derived for switching the limit value in 3 steps. The way in which the diameter is recorded safely is not described in this Application Note.

Plant details (example):

Diameter of coil:	500 … 1500 mm
Processing speed:	max. 500 m/min
Reduced speed:	max. 30 m/min

Calculation of limit values for three diameter ranges:

The following applies:	$V_u = d \times \pi \times n$
where:	V_u : Circumferential speed
	d : Diameter
	n : Speed

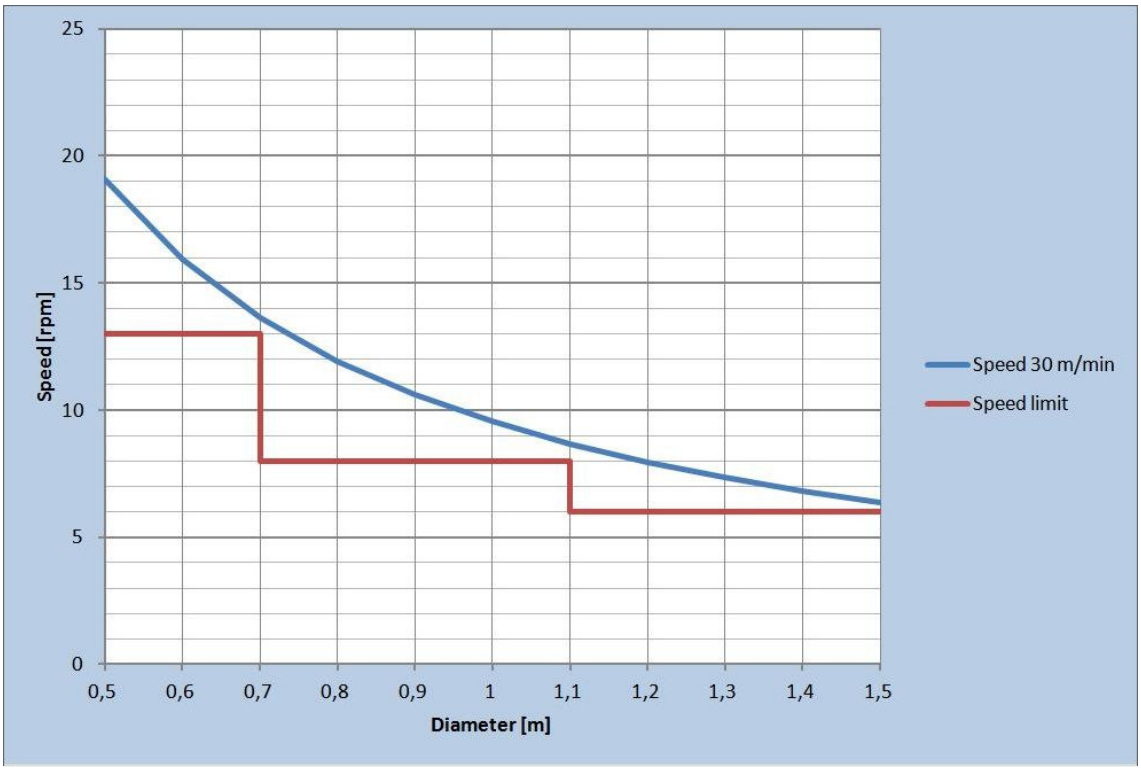


Fig. 5: Speeds and limit values based on coil diameter

A max. permitted reduced speed of 30 m/min produces the following speeds and limit values:

Diameter of – to [mm]	Speed of – to [rpm]	Speed limit value [rpm]
1500 - 1101	6 – 8	6
1100 - 701	8 – 13	8
700 - 500	13 - 19	13

When the limit values are observed, the conveyor speed is reduced to approximately 20 m/min as the diameter decreases.

3.1.2. Safety gate monitoring

The block FS_SafetyGate is used to monitor a safety gate.

The enable signal for safety gate monitoring is used to activate and deactivate the monitoring function SSM1. If the enable is missing (safety gate open or fault on the safety gate), the monitoring function SSM1 is activated, i.e. compliance with the reduced speed is monitored.

Note: "Activate a monitoring function" means that the result of the monitoring function affects the outputs on the module PSSu K F EI. If the monitoring function reacts, outputs O0, O1 and O2 are shut down.

3.1.3. Monitoring rotational speed/speed

The monitoring function SSM1 (Safe Speed Monitoring 1) of the module PSSu K F EI is used to monitor reduced speed when the safety gate is open.

The monitoring function SSM1 is configured via an instance of the Pilz function block FS_EI_SSM1_SSRM.

The speed limit value is adjusted based on the coil diameter. For this purpose, the respective diameter range is detected safely (not described in this Application Note) and is supplied via three SAFEBOOL variables. When switching to another diameter range, a pulse is formed by a task cycle and is used to start the transfer of the respective limit value. Simultaneously a timer is started, which is used to monitor the parameter transfer.

As the parameters are being transferred, the output signals SSM1Enable, SSRMEnable and ParameterTransmissionReady on the block FS_EI_SSM1_SSRM are set to FALSE. The successful transfer of the limit values is displayed on the output ParameterTransmissionReady. In the event of an error (ParameterTransmissionReady = FALSE after time monitoring has elapsed), the module's outputs O0, O1 and O2 are shut down. The output signals SSM1Enable and ParameterTransmissionReady are muted while the timer is running.

The monitoring functions SSM0, SSR-M, SOS-M are deactivated via instances of the Pilz function blocks FS_EI_SSM0, FS_EI_SOSM, FS_EI_SSM1_SSRM. Without deactivation, it would not be possible to put the plant into operation due to one or more missing enables.

It is possible to switch between the limit values without interrupting operation, provided the limit values are not violated when switching.

A value of 50 ms is set for monitoring the time of the switching process. With the present hardware structure and a task cycle time of 10 ms, the transfer of limit values is normally always completed within this time.

3.1.4. Monitoring rotational speed/direction of movement

The monitoring function SDI-M (Safe Direction Monitoring) of the module PSSu K F EI is used for permanent monitoring of the direction of movement.

The monitoring function SDI-M is configured via an instance of the Pilz function block FS_EI_SDIM.

3.1.5. Triggering of safety function SS1

SS1 (Safe Stop 1) is implemented using the outputs O0, O1 and O2 of the module PSSu K F EI and the servo amplifier PMCProtego D.

Should a monitoring function react on the module PSSu K F EI or outputs O0, O1 and O2 be shut down via the block inputs SetO0, SetO1 and SetO2, first the servo amplifier PMCprotego D will be disabled via the output O0 (ENABLE input = FALSE). The servo amplifier brings the motor to 0 speed using the internal emergency braking ramp.

Then, after the configured delay time has elapsed, the safety function STO is triggered in the servo amplifier PMCprotego D via the outputs O1/O2 (inputs STO1-ENABLE = FALSE and STO2-ENABLE = FALSE).

3.1.6. Basic functions, error acknowledgement and restart interlock

Should a monitoring function react on the module PSSu K F EI, causing the outputs O0, O1 and O2 to shut down, or should the module detect an error, a restart interlock is set on the module.

The restart interlock is reset via an instance of the block FS_EI_Basic. Further functions of the block are:

- Driving the outputs O0, O1, O2
- Error acknowledgement
- Output of rotational speed/speed value (current value)
- Output of status and diagnostic messages
- Cascading (not used in this application)

In this example, separate control elements are provided to reset the restart interlock and for the error acknowledgement.

A signal is connected to the inputs for activating outputs O0, O1 and O; this is composed as follows:

- Time monitoring active after change in limit value or parameter transfer complete

Outputs O0, O1 and O2 are shut down if a parameter transfer has not been completed.

When switching the servo amplifier PMCprotego D back on it is important to note that the enable signal ENABLE is set to TRUE no sooner than 100 ms after the signals STO1-ENABLE and STO2-ENABLE. As a result, the control signal for O0 and the reset of the restart interlock are delayed for output O0 by 200 ms via a time element.

3.1.7. Displays and interlock conditions

In this example, the following errors are signalled via indicator lights:

- No enable of SSM1 while reduced speed is monitored (when the safety gate is open)
- No enable of SDIM (positive direction)

Additional messages are signalled via the PAS4000 diagnostic system.

3.2. Configuration of the monitoring functions

A wizard is available in PAS4000 for configuration of the monitoring functions on the module PSSu K F EI. It is called up via the "Monitoring functions" button, which appears in the properties window when selecting the module in the hardware configuration.

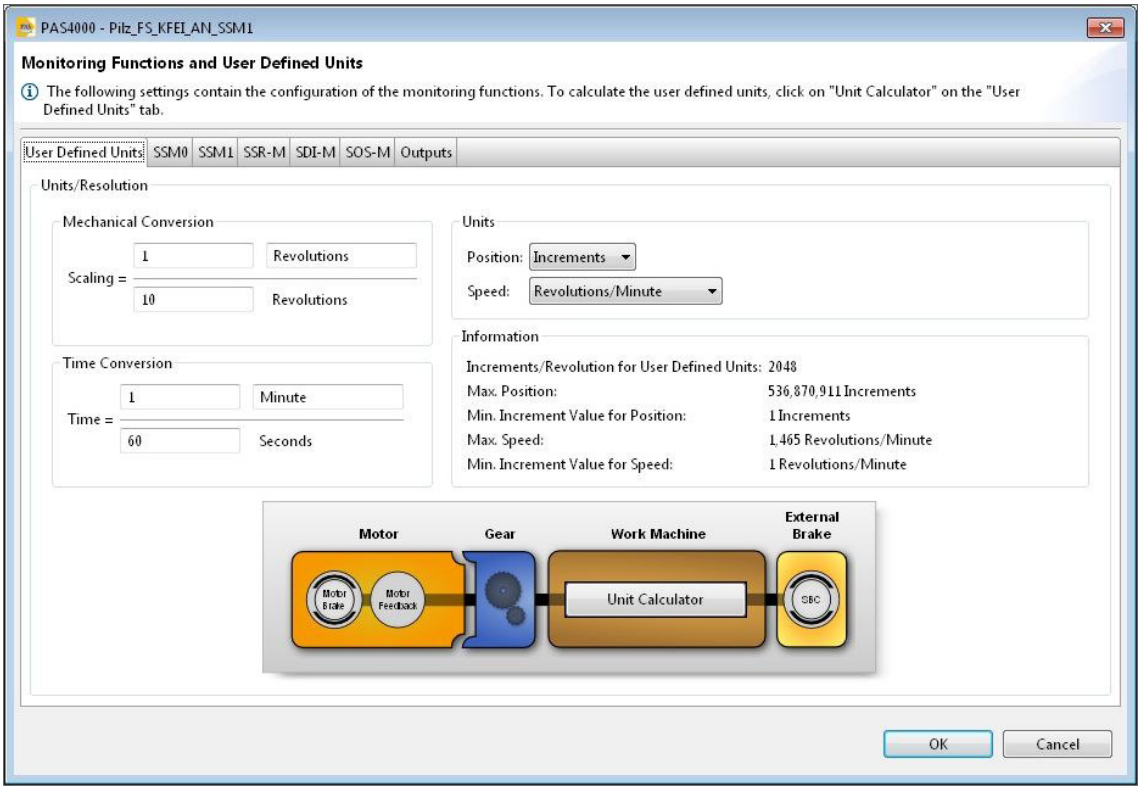


Fig. 6: Configuration of the monitoring functions: User-defined units

The user-defined units are set on the first tab.

Mechanical conversion: Between the motor and plant there is a gear with a transmission ratio of 10:1. As a result, a ratio of 1:10 is entered for scaling (1 revolution on the load corresponds to 10 revolutions on the motor).

Time conversion: As the speed of the plant is stated in m/min, the rotational speed is converted into revolutions/min (1 min corresponds to 60 s).

Units: "Increments" are selected as the position unit, "RPM" is selected as the speed unit.

The result of the calculations can be seen in Fig. 6 under "Information".

The unit calculator is not used in this example.

The monitoring function SSM0 is configured on the second tab. The default value 0 for maximum speed is not changed, as the monitoring function in the PLC program is deactivated.

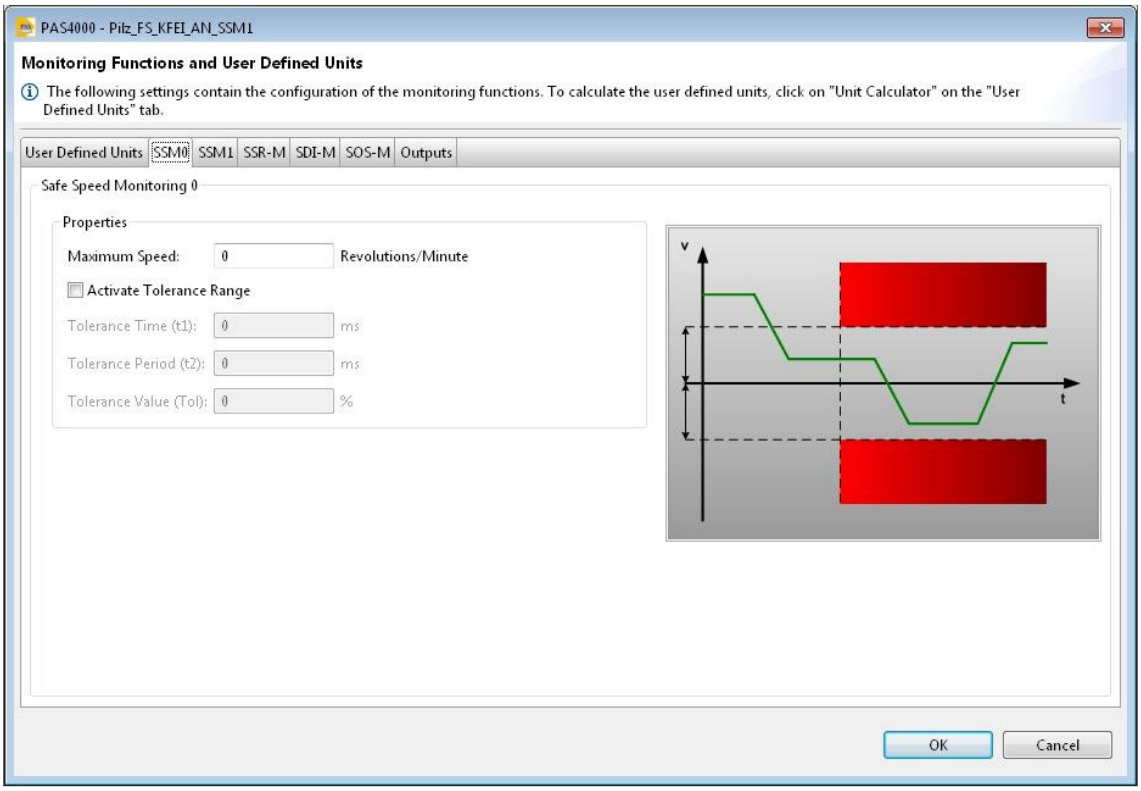


Fig. 7: Configuration of the monitoring functions: SSM0

No entries are made on the tabs SSM1 and SSR-M, as the limit value for safe speed monitoring is specified via the PLC program.

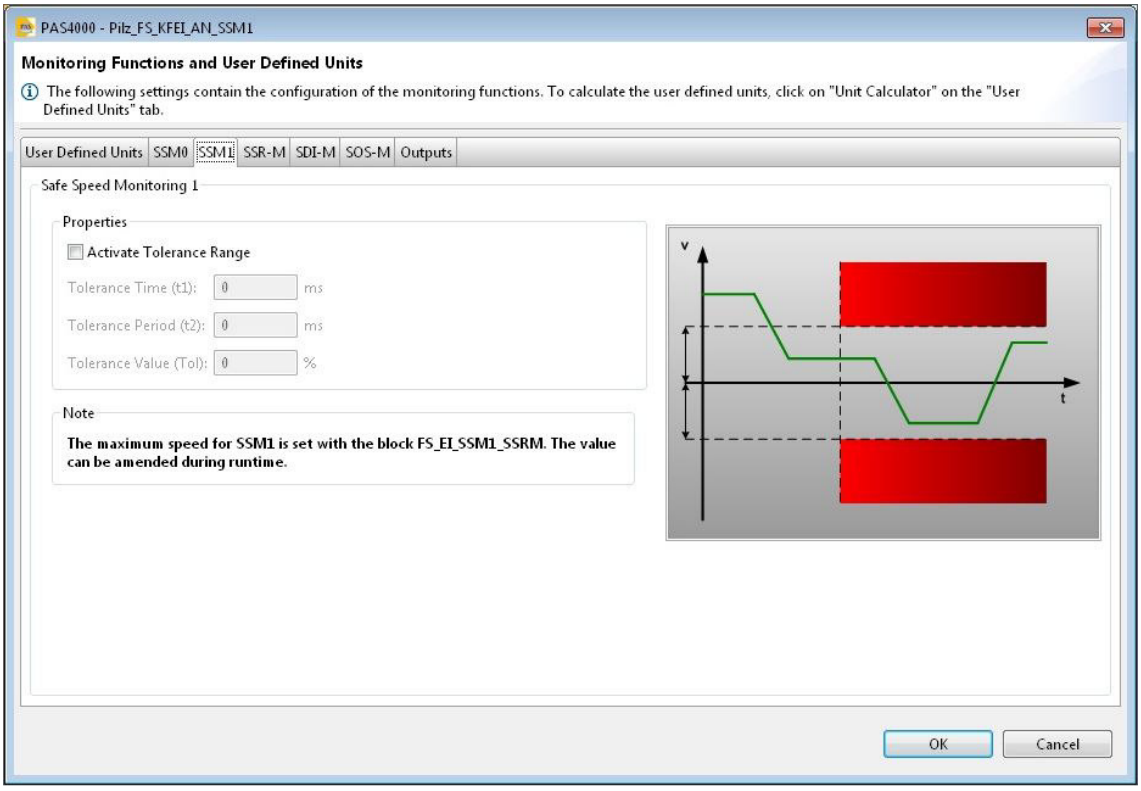


Fig. 8: Configuration of the monitoring functions: SSM1

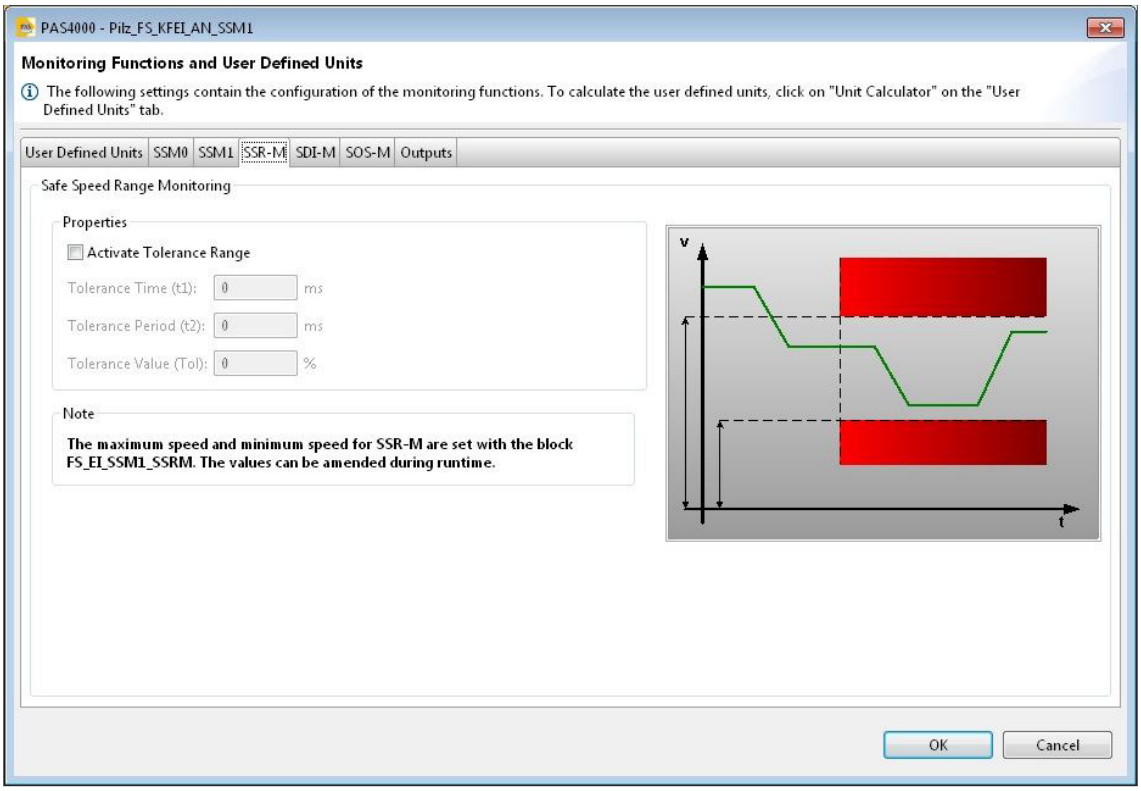


Fig. 9: Configuration of the monitoring functions: SSR-M

On the SDI-M tab, 100 increments are entered as tolerance values for safe direction monitoring in both the positive and negative direction.

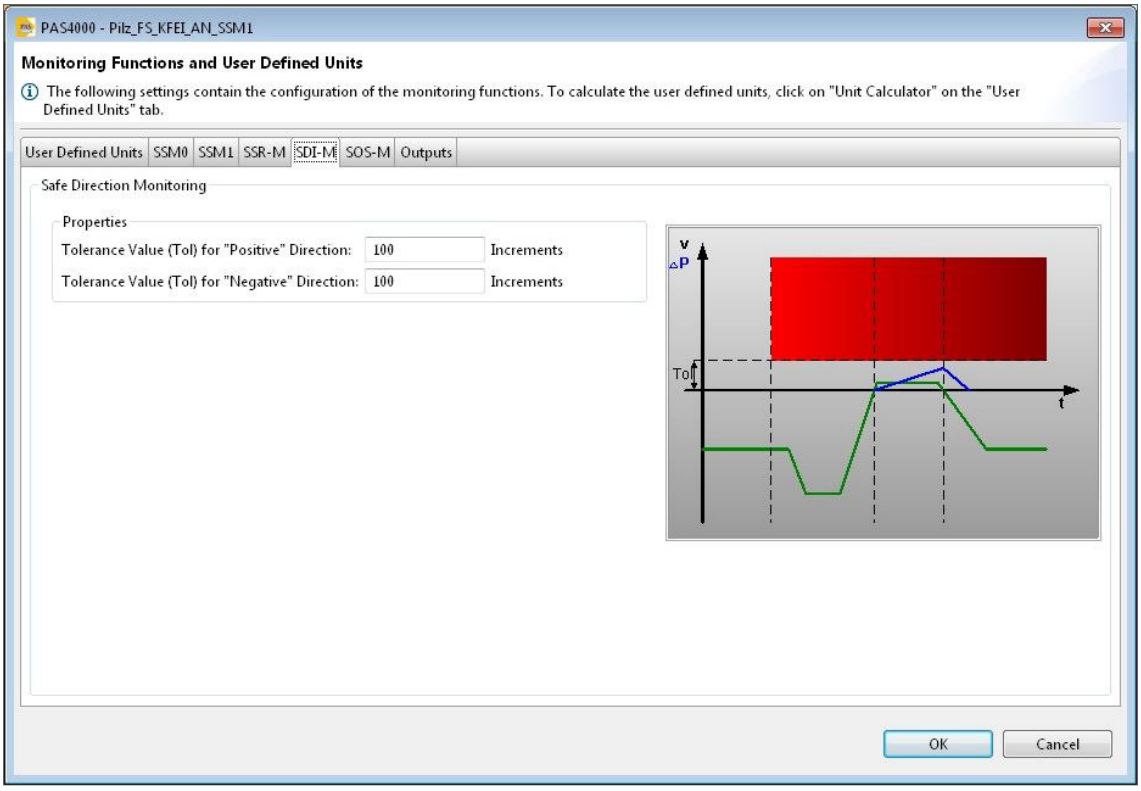


Fig. 10: Configuration of the monitoring functions: SDI-M

As the monitoring function SOS-M is not used in this application, the default values can be adopted on the tab SOS-M.

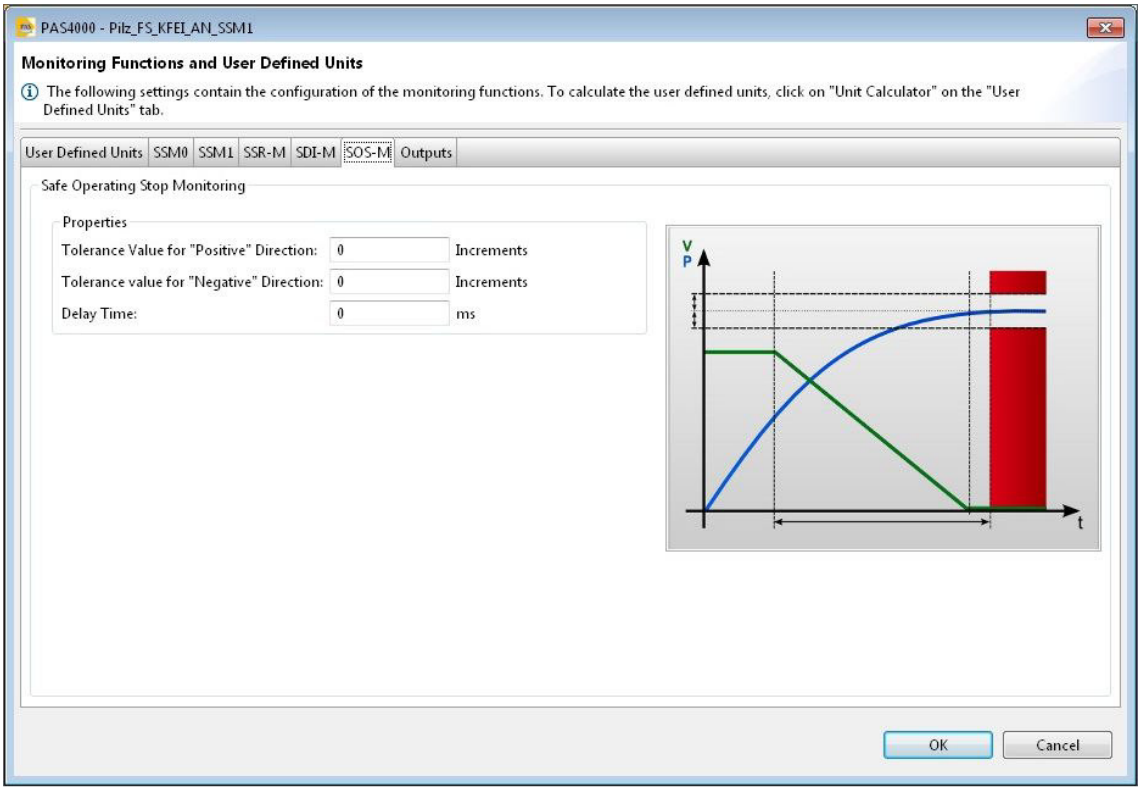


Fig. 11: Configuration of the monitoring functions: SOS-M

The drive of the outputs O0, O1 and O2 is configured on the last tab:

- The default setting is adopted, where the outputs are switched depending on the monitoring result (figures [1], [2], [5]).
- Automatic STO for outputs O1 and O2 is not activated (figures [3], [6]).
- An STO delay time of 1000 ms is specified for outputs O1 and O2 (figures [4], [7]).
- The standstill limit value for automatic STO is irrelevant in this example (figure [8]).

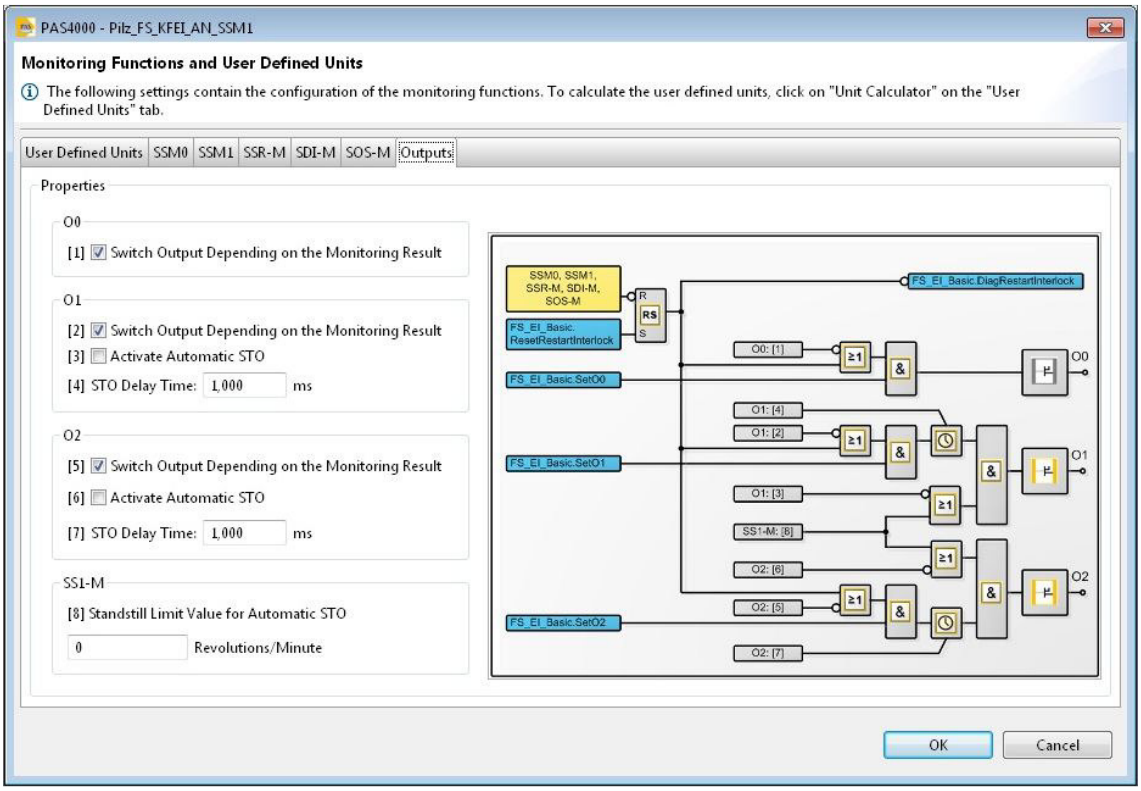


Fig. 12: Configuration of the monitoring functions: SS1-M / STO

3.3. Safety assessment

3.3.1. Safety assessment for safety gate monitoring

The safety control system monitors the input circuits on the 2-channel safety gate monitoring device for short circuit and shorts between contacts. The contacts are provided with test pulses for this purpose.

The function block FS_SafetyGate monitors the switching of the safety gate contacts for simultaneity. A reset is required after the safety gate is closed.

3.3.2. Safety assessment for rotary encoder and module PSSu K F EI

An error in the PSSu K F EI module does not lead to the loss of the safety function.

Open circuits on any individual track of the rotary encoder are detected by the module PSSu K F EI and lead to a shutdown of the outputs O0, O1 and O2.

Outputs O1 and O2 are monitored by the module PSSu K F EI through cyclical output tests. If a defective output or a short circuit is detected, outputs O0, O1 and O2 are shut down.

Errors that occur when transferring limit values are detected by the block FS_EI_SSM1_SSRM and lead to a shutdown of the outputs O0, O1 and O2. Depending on the system structure it can take up to 500 ms to transfer parameters (monitoring time of block FS_EI_SSM1_SSRM to error message "DiagParameterError"). In this application the parameters are transferred more quickly, so that any error when transferring parameters will result in a shutdown just 50 ms after the parameter transfer is started.

The diameter-dependent speed limit values for the monitored reduced speed were determined before the PLC program was created and were stored in the program as a constant. As a result, a parameter error due to a miscalculation at runtime is excluded. A parameter value outside the permitted value range is detected by the module PSSu K F EI.

Forced dynamisation must be performed: The safe sensor for speed detection (B1) must be moved so that a signal changes on all the connected tracks within an 8 hour period.

Common cause failure (CCF), which can cause the encoder system to fail, e.g. due to a shearpin breakage and slippage, must be excluded by suitable (e.g. design) measures or will require further measures for detection.

3.3.3. Safety assessment for motor control

An error in the PMCprotego D does not lead to the loss of the safety function.
Hazardous situations must not be allowed to arise due to SS1 braking ramps and stopping times.
The best possible mechanics at the drive (overdimensioning) are assumed (fault exclusion for broken shearpin).

The operator must ensure that the function of the safe pulse disabler is tested periodically, after 8 hours at the latest, by triggering safety functions SS1 or STO:

- By restarting after safety functions SS1 or STO have been triggered as a condition of operation
- By restarting after safety function SS1 has been triggered by the operator. ----------

3.4. Functional safety

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

No.	Safety function	PL	Safety-related parts of the control system
1	The plant is stopped if the permitted reduced speed is exceeded while the safety gate is open. (SSM)	PL d	Input (Safe encoder) Input (PSENme 2/2AS) Input (PSSu K F EI) Logic (PSSu E F 4DI) Logic (PSSu K F EI) Logic (PSSu H PLC1 FS SN) Output (PSSu K F EI) Actuator (PMCprotego D)
2	The plant is stopped if the plant's direction of movement is outside the permitted tolerance. (SDI)	PL d	Input (safe encoder) Input (PSSu K F EI) Logic (PSSu K F EI) Logic (PSSu H PLC1 FS SN) Output (PSSu K F EI) Actuator (PMCprotego D)

Prerequisites

No.	Description		Identification
1	Common cause failure (CCF):		Requirements are considered to be met (must be tested on implementation)
2	Mission time:	general	20 years
		Sensor B1	10 years
3	Characteristic data of the sensor B1	PFHd	4,345 *10^{-9} 1/h
		PL	e
4	Operating interval (electromechanical components):	Sensor	1 operation all 2 hours for safety gate

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

CAUTION

The calculation of the performance level is only valid when used with a PMCtendo motor.

3.4.2. Safety-related characteristics in accordance with EN 62061

No.	Safety-related control function (SRCF)	Safety Integrity Level	Subsystems
1	The plant is stopped if the permitted reduced speed is exceeded while the safety gate is open. (SSM)	SIL 2	Input (safe encoder) Input (PSENme 2/2AS) Input (PSSu K F EI) Logic (PSSu E F 4DI) Logic (PSSu K F EI) Logic (PSSu H PLC1 FS SN) Output (PSSu K F EI) Actuator (PMCprotego D)
2	The plant is stopped if the plant's direction of movement is outside the permitted tolerance. (SDI)	SIL 2	Input (safe encoder) Input (PSSu K F EI) Logic (PSSu K F EI) Logic (PSSu H PLC1 FS SN) Output (PSSu K F EI) Actuator (PMCprotego D)

Prerequisites

No.	Description		Identification
1	Common cause failure (CCF):		ß = 2 % (must be tested on implementation)
2	Proof-Test Intervall:	general	20 years
		Sensor B1	10 years
3	Characteristic data of the sensor B1	PFHd	4,345 *10^{-9} 1/h
		SIL	3
4	Operating interval (electromechanical components):	Sensor	1 operation all 2 hours for safety gate

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

CAUTION
The calculation of the safety integrity level is only valid when used with a PMCtendo motor.

3.5. PAS project

3.5.1. Program in the FS resource

3.5.1.1. Declaration part

```
PROGRAM MAIN_FS
VAR
//--Diameter ranges and switching of limit value---------------------------
        DiameterRange1                          : SAFEBOOL;
        DiameterRange2                          : SAFEBOOL;
        DiameterRange3                          : SAFEBOOL;
        SpeedRange1_RTrig                       : R_TRIG;
        SpeedRange2_RTrig                       : R_TRIG;
        SpeedRange3_RTrig                       : R_TRIG;
        SpeedRange1_REdge                       : SAFEBOOL;
        SpeedRange2_REdge                       : SAFEBOOL;
        SpeedRange3_REdge                       : SAFEBOOL;
        TimerChangeSpeedRange                   : TP;
        StartTimerChangeSpeedRange              : SAFEBOOL;
        TimerChangeSpeedRangeRunning            : SAFEBOOL;

//--Safety Gate------------------------------------------------------------
        SafetyGate                              : FS_SafetyGate;
        SafetyGateEnable                        : SAFEBOOL;

//--Enable for set the outputs of the module PSSu K F EI-------------------
        EnableOutputs                           : SAFEBOOL;
        TimerEnableServo                        : TON;

//-- Speed monitoring functions PSSu K F EI ----------------------------
        KFEI_SSM0                               : FS_EI_SSM0;
        SSM0Enable                              : SAFEBOOL;

        KFEI_SOSM                               : FS_EI_SOSM;
        SOSMSet                                 : SAFEBOOL;
        SOSMEnable                              : SAFEBOOL;

        KFEI_SDIM                               : FS_EI_SDIM;
        SDIMSet                         AT %I*  : SAFEBOOL;
        PosEnable                               : SAFEBOOL;
        NegEnable                               : SAFEBOOL;

        KFEI_SSM1_SSRM                          : FS_EI_SSM1_SSRM;
        MaximumSpeed                            : SAFEUDINT;
        SSM1Enable                              : SAFEBOOL;
        SSRMEnable                              : SAFEBOOL;
        ParameterTransmissionReady              : SAFEBOOL;
        DiagParameterError                      : SAFEBOOL;

        KFEI_Basic                              : FS_EI_Basic;
        ResetRestartInterlock           AT %I*  : SAFEBOOL;
        ResetError                      AT %I*  : BOOL;
        SpeedValid                              : SAFEBOOL;
        SpeedValue                              : SAFEUDINT;
        StateCascading                          : BOOL;
        StateSTO_Timer1                         : SAFEBOOL;
        StateSTO_Timer2                         : SAFEBOOL;
        AutomaticSTO                            : SAFEBOOL;
        DiagRestartInterlock                    : SAFEBOOL;
        DiagEncoderMissing                      : BOOL;
        DiagModuleError                         : BOOL;

//--Messages---------------------------------------------------------------
        SSM1Error                       AT %Q*  : BOOL;
        SDIMError                       AT %Q*  : BOOL;
        SSM1Error_SR                            : SR;
        SDIMError_SR                            : SR;
END_VAR
```

```
VAR CONSTANT
//--Speed limit values ------------------------------------------------------
       MaxSpeed1                          : SAFEUDINT := UDINT#6;   // rpm
       MaxSpeed2                          : SAFEUDINT := UDINT#8;   // rpm
       MaxSpeed3                          : SAFEUDINT := UDINT#13; // rpm
END_VAR
```

3.5.1.2. Instruction part

```
//-- Safety Gate ---------------------------------------------------------
SafetyGate(
       SwitchType                 := USINT#3,
       AutoStart                  := TRUE,
       AutoReset                  := FALSE,
       MonitoredReset             := TRUE,
       StartupTest                := FALSE,
       SimultaneityTime           := T#1000ms,
       DelayTime                  := T#30ms,
       Enable                     => SafetyGateEnable
       );

//-- Recording of diameter change ----------------------------------------
// Pulse edge evaluation of safe signals for recording diameter; so:
// - Pulse for change of speed limit value (FS_EI_SS1M_SSRM)
// - Timer is started (50 ms) to monitor the transfer of parameters
SpeedRange1_RTrig(
       CLK := DiameterRange1 AND NOT DiameterRange2 AND NOT DiameterRange3
              AND SpeedValid,
       Q   => SpeedRange1_REdge
       );
SpeedRange2_RTrig(
       CLK := DiameterRange2 AND NOT DiameterRange1 AND NOT DiameterRange3
              AND SpeedValid,
       Q   => SpeedRange2_REdge
       );
SpeedRange3_RTrig(
       CLK := DiameterRange3 AND NOT DiameterRange1 AND NOT DiameterRange2
              AND SpeedValid,
       Q   => SpeedRange3_REdge
       );

StartTimerChangeSpeedRange := SpeedRange1_REdge OR SpeedRange2_REdge OR
                              SpeedRange3_REdge;

TimerChangeSpeedRange(
       IN := StartTimerChangeSpeedRange,
       PT := T#50ms,
       Q  => TimerChangeSpeedRangeRunning
       );

//-- Enable for setting the outputs of the module PSSu K F EI ------------
// Parameter transfer is running (monitoring timer is running) or is complete.
EnableOutputs := TimerChangeSpeedRangeRunning OR ParameterTransmissionReady;

//-- Selection of speed limit values -------------------------------------
IF SpeedRange1_REdge THEN                   // Diameter range 1
       MaximumSpeed        := MaxSpeed1;    // MaximumSpeed limit value for SSM1

ELSIF SpeedRange2_REdge THEN                // Diameter range 2
       MaximumSpeed        := MaxSpeed2;    // MaximumSpeed limit value for SSM1

       ELSIF SpeedRange3_REdge THEN         // Diameter range 3
              MaximumSpeed := MaxSpeed3;    // MaximumSpeed limit value for SSM1

ELSE
       MaximumSpeed        := MaximumSpeed; // Limit value unchanged;

END_IF;
```

```
//-- Monitoring functions PSSu K F EI ------------------------------------
// Safe Speed Monitoring 1 and Safe Speed Range Monitoring
KFEI_SSM1_SSRM(
        SSM1DeactivateSS1M          := SafetyGateEnable, // SSM1 activated, if S-Gate open
        MaximumSpeed                := MaximumSpeed,
        SSRMDeactivateSS1M          := TRUE,             // SSRM deactivated
        MinimumSpeed                := UDINT#0,
        SetParameter                := StartTimerChangeSpeedRange,
        SSM1Enable                  => SSM1Enable,
        SSRMEnable                  => SSRMEnable,
        ParameterTransmissionReady  => ParameterTransmissionReady,
        DiagParameterError          => DiagParameterError
        );

// Safe Speed Monitoring 0
KFEI_SSM0(
        DeactivateSS1M              := TRUE,          // SSM0 deactivated
        Enable                      => SSM0Enable
        );

// Safe Operating Stop Monitoring
KFEI_SOSM(
        DeactivateSS1M              := TRUE,          // SOSM deactivated
        Set                         := SOSMSet,
        Enable                      => SOSMEnable
        );

// Safe Direction Monitoring
KFEI_SDIM(
        PosDeactivateSS1M           := FALSE,         // SDI pos. direction activated
        NegDeactivateSS1M           := TRUE,          // SDI neg. direction deactivated
        Set                         := SDIMSet,
        PosEnable                   => PosEnable,
        NegEnable                   => NegEnable
        );

// Base functions of the module PSSu K F EI
KFEI_Basic(
        ActivateCascading           := FALSE,
        SetO0                       := TimerEnableServo.Q,
        SetO1                       := EnableOutputs,
        SetO2                       := EnableOutputs,
        ResetRestartInterlock       := ResetRestartInterlock,
        ResetError                  := ResetError,
        SpeedValid                  => SpeedValid,
        SpeedValue                  => SpeedValue,
        StateCascading              => StateCascading,
        StateSTO_Timer1             => StateSTO_Timer1,
        StateSTO_Timer2             => StateSTO_Timer2,
        AutomaticSTO                => AutomaticSTO,
        DiagRestartInterlock        => DiagRestartInterlock,
        DiagEncoderMissing          => DiagEncoderMissing,
        DiagModuleError             => DiagModuleError
        );

// Switch-on delay for the HW enable of the servo amplifier
TimerEnableServo(
        IN := EnableOutputs AND NOT DiagRestartInterlock,
        PT := T#200ms
        );

//-- Messages ------------------------------------------------------------
SSM1Error_SR(                   // Shutdown via SDIM
        SET1  := NOT SafetyGateEnable AND NOT TimerChangeSpeedRangeRunning AND
                 ParameterTransmissionReady AND NOT DiagParameterError AND NOT
                 SSM1Enable AND SpeedValid,
        RESET := ResetRestartInterlock,
        Q1    => SSM1Error
        );
SDIMError_SR(                   // Shutdown via SDIM
        SET1  := NOT TimerChangeSpeedRangeRunning AND NOT PosEnable AND SpeedValid,
        RESET := ResetRestartInterlock,
        Q1    => SDIMError
        );
END_PROGRAM
```

3.5.1.3. Resource assignment

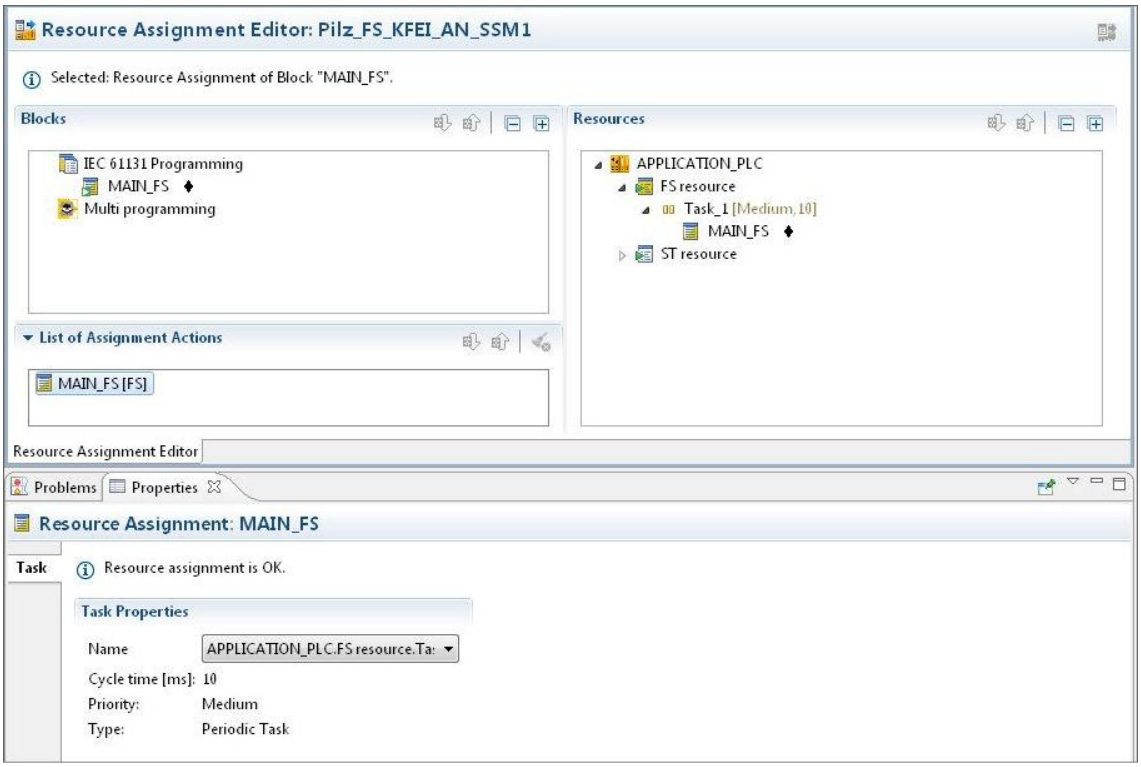
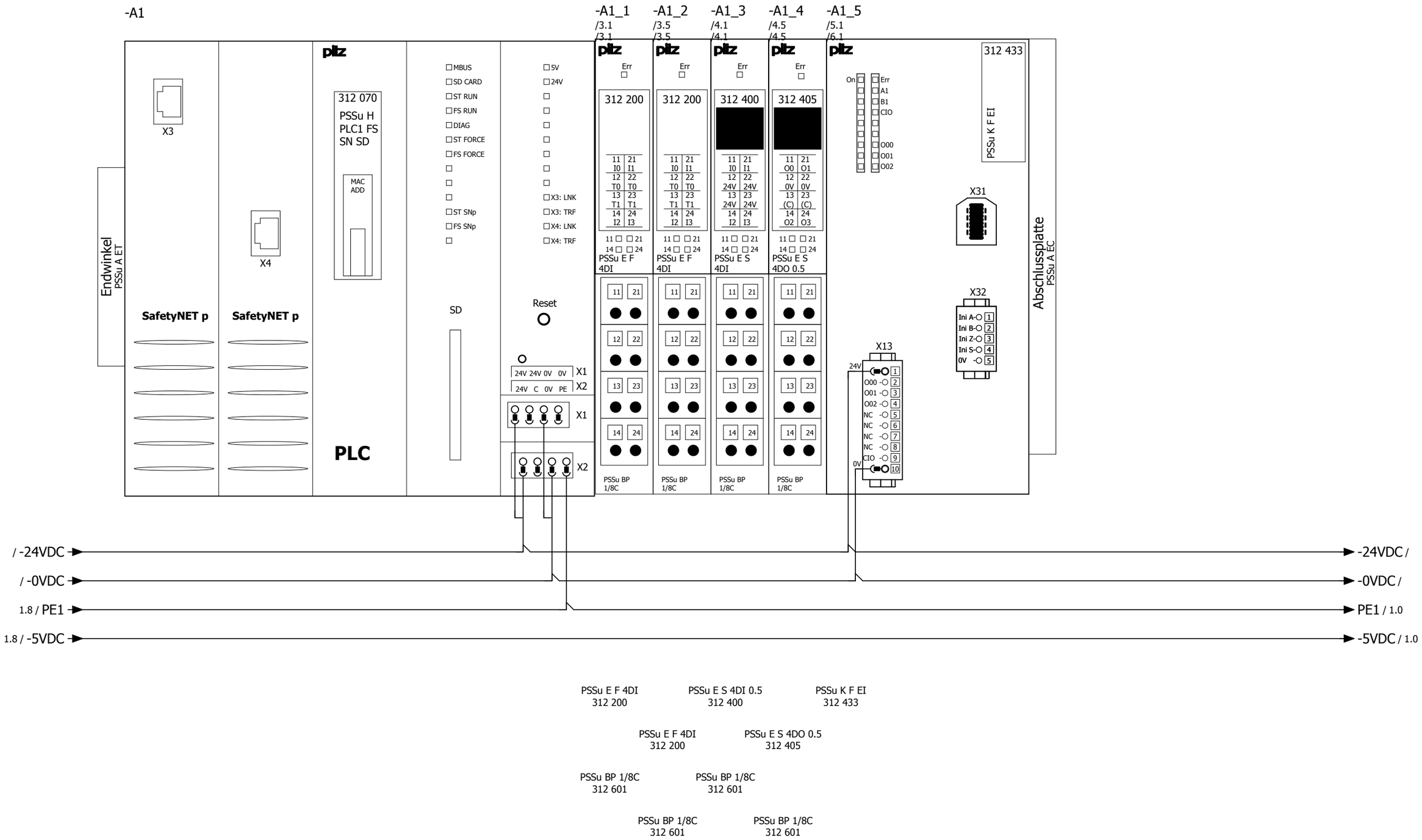


Fig. 13: FS resource assignment

3.5.2. I/O mapping

The following I/O mappings are to be performed for the module PSSu K F EI (PI Variables <-> Module Bus):

Fig. 14: I/O mappings of the module PSSu K F EI



PSSu E F 4DI
312 200

PSSu E S 4DI 0.5
312 400

PSSu K F EI
312 433

PSSu E F 4DI
312 200

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

Revision	10.08.2015	Date	12.06.2015	EN ISO 13849-1:2008	PL d	Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	PSSu H PLC1 With PSSu K F EI	Mounting place + AN_1003746_01
Name	CS-SAT	Name	CS-SAT					
				EN 62061:2005	SIL 2			Page: 1 / 6
		Dep.	CS					

/ -L1
/ -L2
/ -L3
/ -PE
/ -N
/ -24VDC
/ -0VDC

-L1 /
-L2 /
-L3 /
-PE /
-N /
-24VDC /
-0VDC /

-F1 1 3 5 / 2 4 6
-K1 /2.6 1 3 5 / 2 4 6

Evtl. sep. Versorgung

-STO2_ENABLE / 6.3
-STO1_ENABLE / 6.2
-ENABLE / 6.1

-K1 A1 A2
-S3 13 14

-A2

-X0 L1 L2 L3 PE PE
Power

-X9B 1 2
BR +24V BRGND
Brake Supply

-X4 1 2 3 4 5 6 7 8
+24V +24V XGND XGND STO2-ENABLE STO2-STATUS STO1-ENABLE STO1-STATUS
24V/STO

-X3 1 8 13 14 15 16
ENABLE +24V AGND BTB/RTO BTB/RTO DGND
I/O

pilz
PMCprotego D.72/...
8176426-1

Motor | External brake resistor
-X8 U2 V2 W2 PE +RB -RB +DC -DC

Brake
BR+ BR-
-X9A 1 2

PE

Encoder
SUB-D 15pol.
-X1

Resolver
SUB-D 9pol.
-X2

Ethernet
RJ45 8pol.
-X7A

Ethernet
RJ45 8pol.
-X7B

PC/CAN
SUB-D 9pol.
-X6

-W1_1
-W1_2

optional
ext. brake resistor

-FB1 1 2
-FB2 1 2
-RBE x1 x2

-W1
PMCcable M2/C1B3/005/6Q0/S1

-W2
PMCcable FD/D4B6/005/Q25/S1

-M1
-X1 Shield U1 V1 W1
U1 V1 W1
M 3~
PE

B+ B-
+ -

PE

-X2 Shield
EnDat 2.2

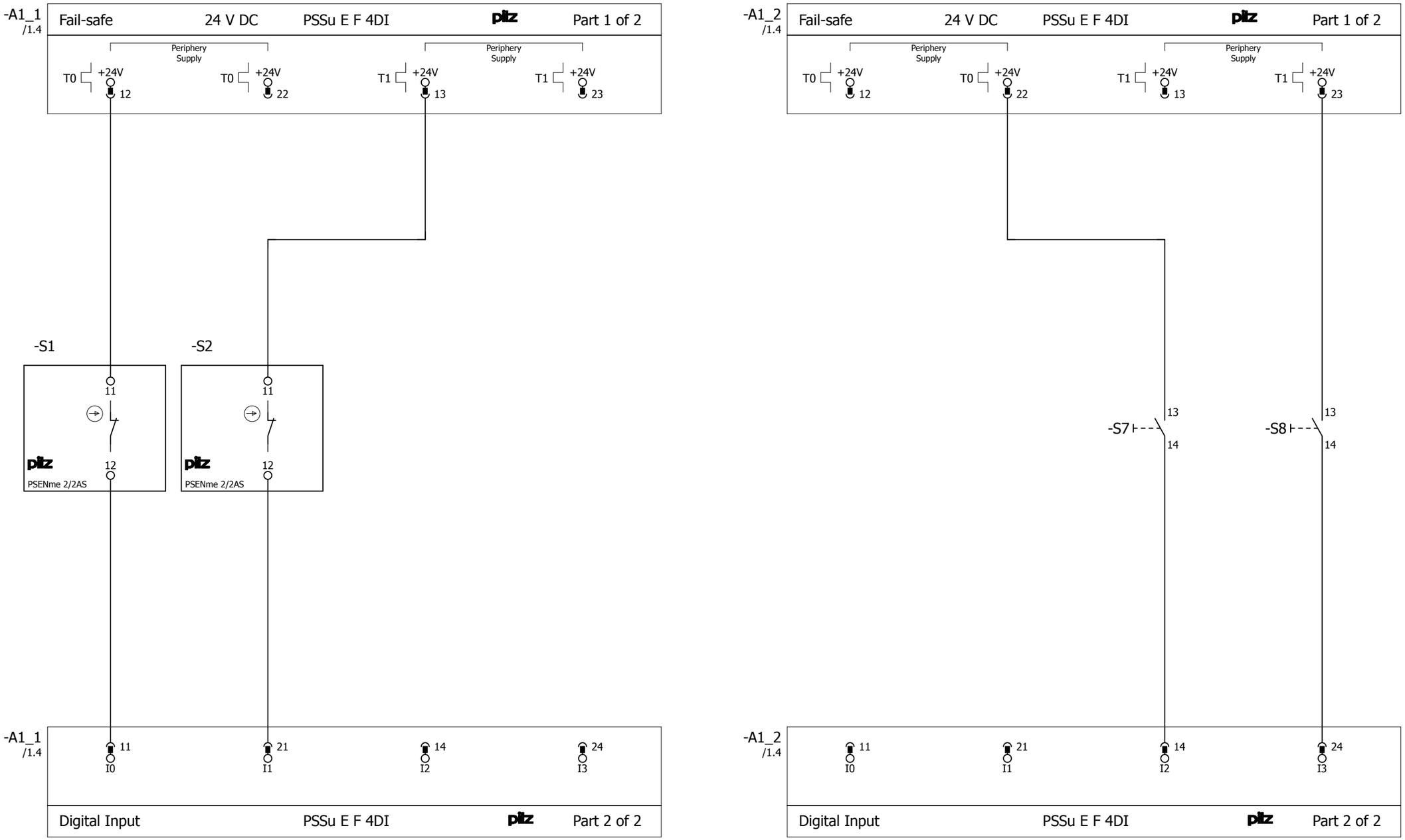
PMCtendo SZ.75/..

-M2
M 1~
1 2
PE

1 2 /2.1
3 4 /2.1
5 6 /2.1

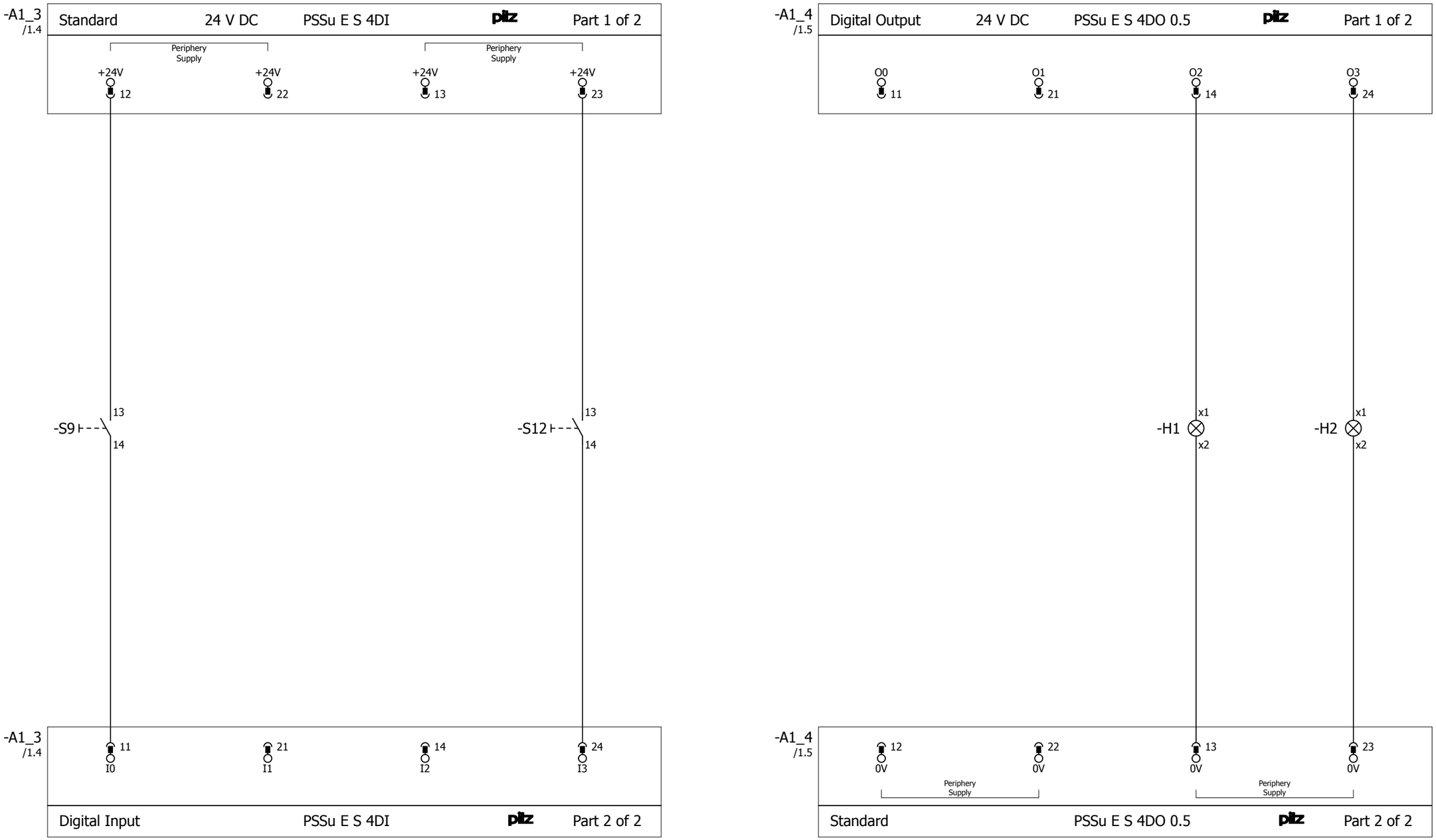
Fan Motor 1

Revision	10.08.2015	Date	12.06.2015	EN ISO 13849-1:2008	PL d	PILZ Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	PMC Protego D
Name	CS-SAT	Name	CS-SAT				Mounting place + AN_1003746_01
				EN 62061:2005	SIL 2		Page: 2 / 6
		Dep.	CS				

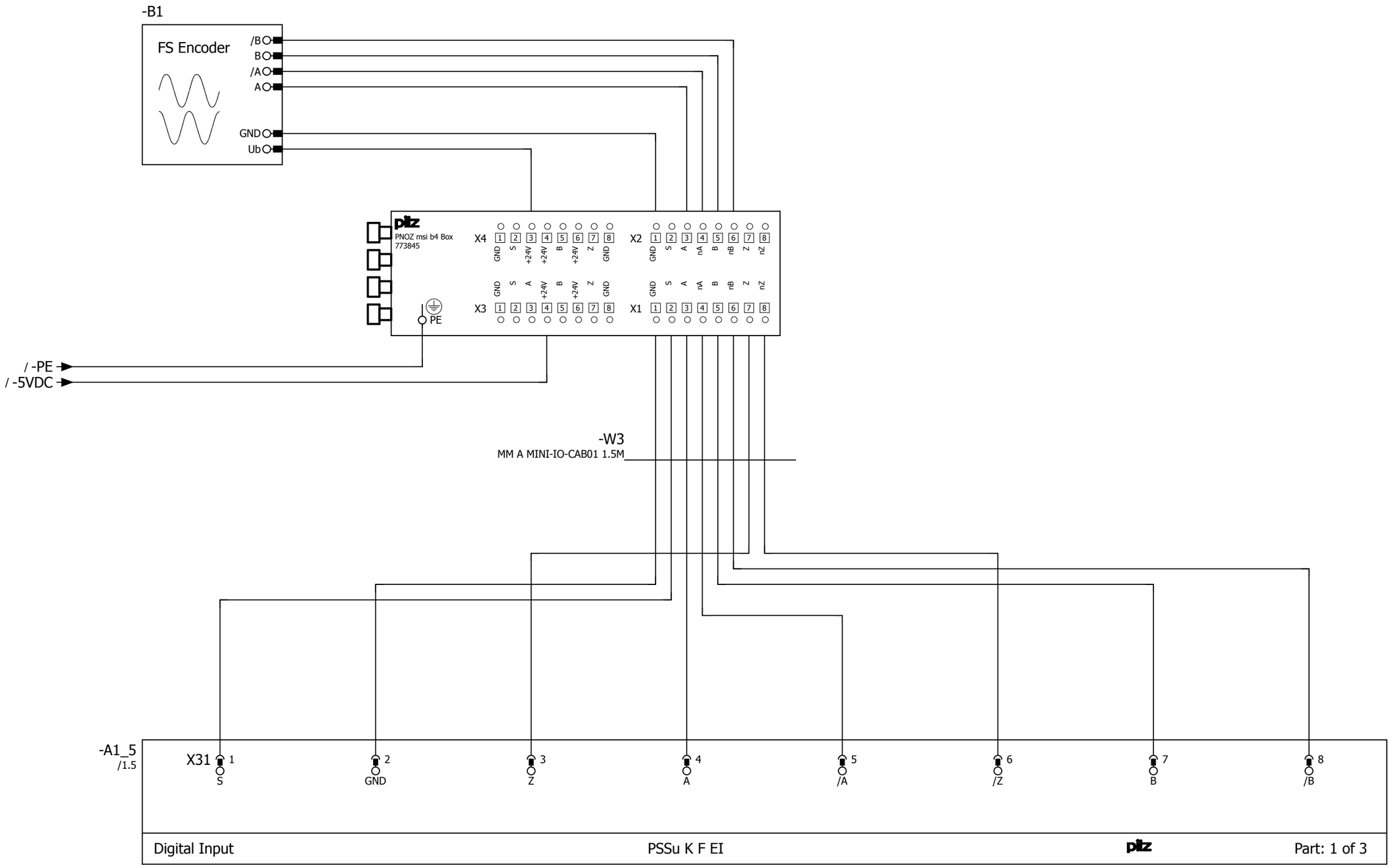


SafetyGate1 Input1	SafetyGate1 Input2	Spare	Spare	Spare	Spare	SDIM Set	Reset Restart Interlock

Revision	10.08.2015	Date	12.06.2015	EN ISO 13849-1:2008	PL d	PILZ Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	FS IN - SGate	Mounting place + AN_1003746_01
Name	CS-SAT	Name	CS-SAT					
				EN 62061:2005	SIL 2			Page: 3 / 6
		Dep.	CS					



SafetyGate1 Reset | Spare | Spare | KFEI Reset Error | Spare | Spare | SSM1 Error | SDIM Error


-B1
FS Encoder
/B
B
/A
A
GND
Ub
PNOZ msi b4 Box
773845
X4
X2
X3
X1
GND
S
A
+24V
nA
B
nB
Z
nZ
PE
/ -PE
/ -5VDC
-W3
MM A MINI-IO-CAB01 1.5M
-A1_5
/1.5
X31
1 S
2 GND
3 Z
4 A
5 /A
6 /Z
7 B
8 /B
Digital Input
PSSu K F EI
Part: 1 of 3

-A1_5
/1.5

Digital Output | PSSu K F EI | pilz | Part: 3 of 3

	O00	O01	O02	NC	NC	NC	NC	CIO
X13	2	3	4	5	6	7	8	9
	2.5 / -ENABLE	2.5 / -STO1_ENABLE	2.4 / -STO2_ENABLE					
	Enable	STO1-ENABLE	STO2-ENABLE	Spare	Spare	Spare	Spare	Spare

Revision	10.08.2015	Date	12.06.2015	EN ISO 13849-1:2008	PL d	K F EI - Enable	Mounting place + AN_1003746_01
Name	CS-SAT	Name	CS-SAT				
				EN 62061:2005	SIL 2		Page: 6 / 6
		Dep.	CS				

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D-73760 Ostfildern

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Recommended printer settings

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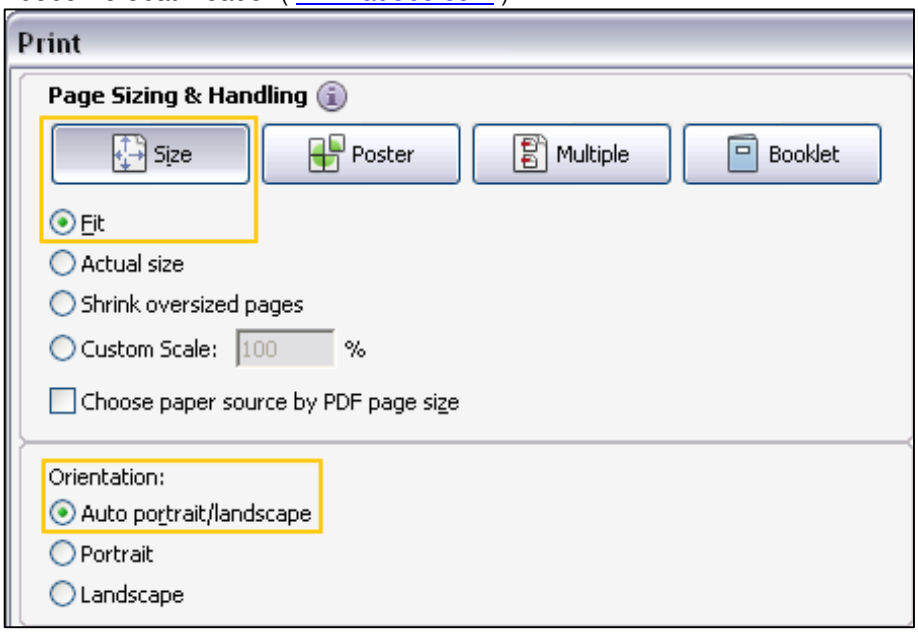
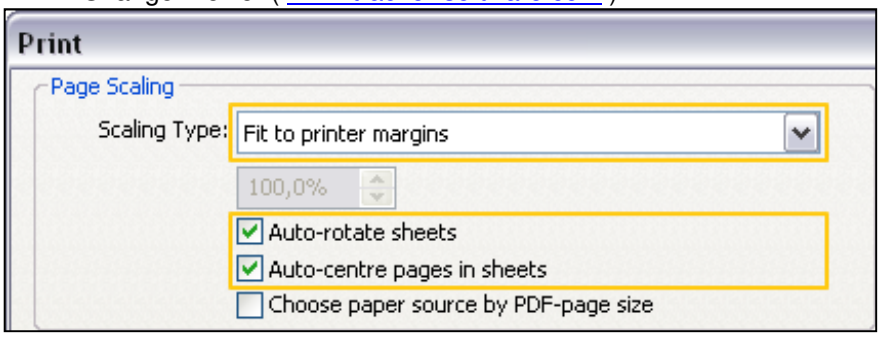


PDF-XChange Viewer (www.tracker-software.com)



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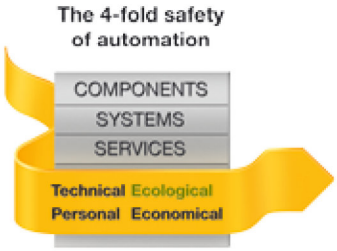

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