Safety gate monitoring and guard locking with the safety gate system PSENsgate 2

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Product

Type:	Safety Gate
Name:	PSENsgate 2, PNOZmulti 2
Manufacturer:	Pilz GmbH & Co. KG, Safe Automation

Document

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Release	Date	Changes	Chapter
01	2016-04-xx	Creation	all
02	2016-04-xx	Enhancement	all
03	2016-4-26	Enhancement	all
04	2016-07-07	Correction circuit diagram	3.4.2
05	2023-08-03	Editorial revision	all

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.

The Pilz newsletter is free of charge and keeps you up to date on all the latest issues and trends in safe automation.

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.
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We are grateful for any feedback on the contents.

August 2023

Industrial Security

To secure plants, systems, machines and networks against cyberthreats it is necessary to implement (and continuously maintain) an overall Industrial Security concept that is state of the art.
Perform a risk assessment in accordance with VDI/VDE 2182 or IEC 62443-3-2 and plan the security measures with care. If necessary, seek advice from Pilz Customer Support.

Abbreviations

Abbreviation / term	Description	Source
AN	**A**pplication **N**ote	www.pilz.com > AN content (1002400)
PNOZ	Pilz E-STOP positive-guided (DE: **P**ilz **NO**T-AUS-**Z**wangsgeführt)	www.pilz.com > PNOZ
PNOZmulti 2	**PNOZmulti** Generation **2**	www.pilz.com > PNOZmulti 2
PSS	Programmable control system (DE: **P**rogrammierbares **S**teuerungs**s**ystem)	www.pilz.com > PSS
PSS u2	**PSSu**niversal, **2**nd generation	www.pilz.com > PSS u2
POU	**P**rogram **O**rganisation **U**nit	
NC	**N**ormally **C**losed	
NO	**N**ormally **O**pen	
PL	**P**erformance **L**evel	
SIL	**S**afety **I**ntegrity **L**evel	
SOS	**S**afe **O**perated **S**top	
SOS-M	**S**afe **O**perated **S**top **– M**onitoring	

Definition of Symbols

Information that is particularly important is identified as follows:

CAUTION!

This refers to a hazard that can lead to a less serious or minor injury plus material damage, and also provides information on preventive measures that can be taken.

NOTICE

This describes a situation in which the product or devices could be damaged and also provides information on preventive measures that can be taken.
It also highlights areas within the text that are of particular importance.

INFORMATION

This gives advice on applications and provides information on special features.

Contents

1 Useful documentation

Reading the documentation listed below is necessary for understanding this Application Note. The availability of the software used, and its safe handling are also presupposed for the user.

1.1 Documentation from Pilz GmbH & Co. KG

No.	Description	Item No. /Download
1	Pilz international homepage, download section	www.pilz.com
2	Operating Manual PSEN sg2c	www.pilz.com > Download 1003267
3	Operating Manual PNOZ m B1	www.pilz.com > Download 1003790
4	Operating Manual PNOZ m EF 8DI4DO	www.pilz.com > Download 1002661
5	Operating Manual PNOZ m EF 1MM	www.pilz.com > Download 1003108

1.2 Documentation from other sources of information

No.	Description	Item No. / Download
1		
2		
3		
4		

2 Used hardware and software

2.1 Pilz products

No.	Descriptions	Order number	Version	Number
1	PSEN sg2c	570800	1.0	1
2	PNOZ m B1	772101	1.0	1
3	PNOZ m EF 8DI4DO	772142	1.0	2
4	PNOZ m EF 1MM	772170	2.0	1
5	PNOZmulti Configurator	-	V10.0.0	1

2.2 Hardware configuration

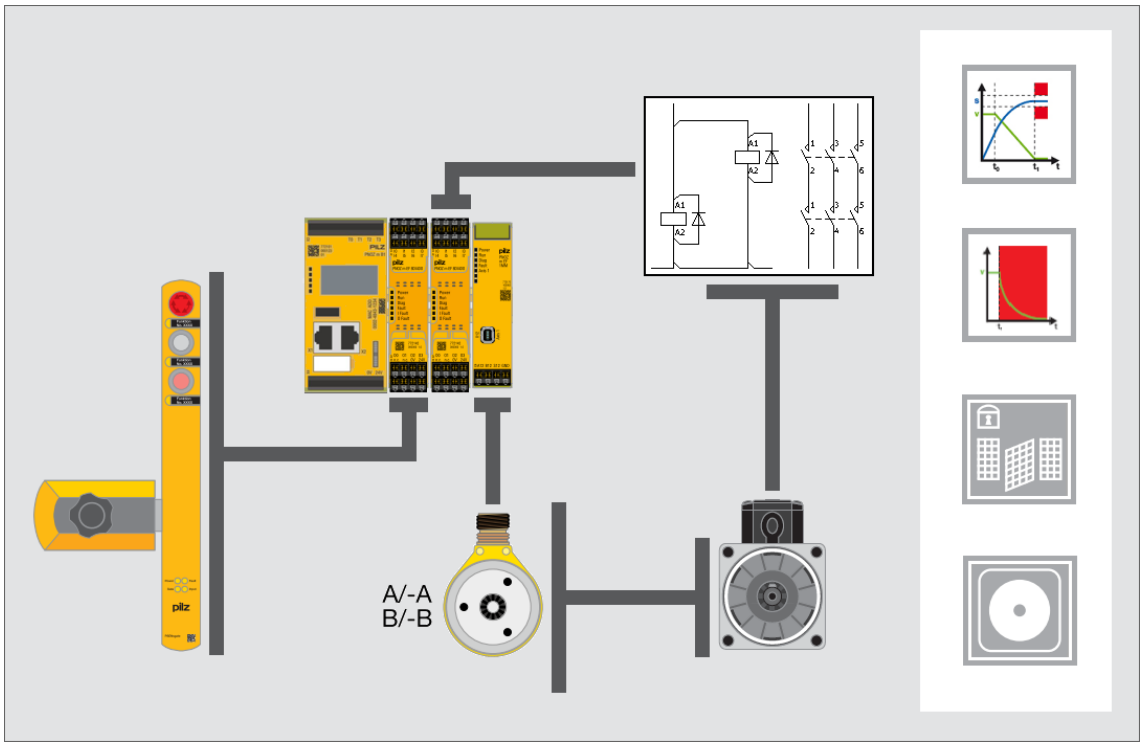


Figure 1: Hardware Configuration

3 Application description

3.1 Description

The example shows the implementation of a PSEN sg2c (S1) for safe monitoring and guard locking of a safety gate.
A PNOZ m B1 (A1) is used for the evaluation and control of the signals.

A machine performs a dangerous movement within a protective housing (guard grid and safety gate).
To ensure that the operator can enter the operating area only when there is no longer any danger, the safety gate is secured by the PSENsgate 2.
A safe rotary encoder (B1) ensures via a PNOZ m EF 1MM (A4) that the safe operating stop is activated before the guard locking of the safety gate can be opened.

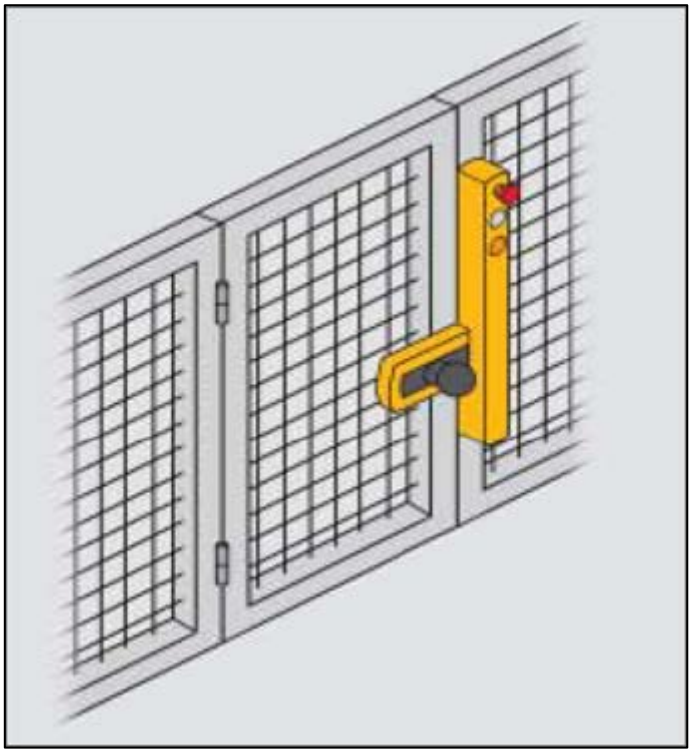


Figure 2: Application with PSENsgate 2

The workflow is divided into the following functions:
- Monitoring Safety Gate
- Monitoring Guard Locking
- Monitoring Safe Operating Stop
- Monitoring Emergency Stop
- Feedbackloop Monitoring

3.1.1 Monitoring of safety gate and guard locking

Open and close of the safety gate is reported the base unit PNOZ m B1 (A1) of the modular safety system PNOZmulti 2 by the safety switch PSEN sg2c (S1) to.

Close guard locking
The safety gate is closed by of a movable bolt.
A locking pin keeps the bolt tongue from being opened unintentionally.
By pressing the integrated button "Activation of guard locking", the locking pin is inserted into the bolt tongue with the safety gate closed.
The OSSD safety outputs of S1 are switching to high signal.
The safety block "Safety gate monitoring" must then be started (reset input "Reset SG").

The contactors KM1 and KM2 energise and the drive can be driven.

Request
If the drive is not at a standstill, operation of the "Access Request" button reports the signal "Request stop" via the output "Stop After Cycle" to the standard controller, which thereby stops the drive depending on the process.

Release guard locking
- The guard locking can be released by operating the integrated button "Access Request" with the safe operating stop of the drive activated.
- The guard lock can also be released in the event of an error (emergency stop pressed) by operating the "Access Request" button. This enables the error rectification in the detection zone.

The planned standstill is reported to the PNOZmulti by the standard controller at the input "Start SOS", whereby the activation of the safe operating stop (SOS) is triggered.

Guard locking mode
After coming to a complete standstill, guard locking magnet is enabled. Depending on the set mode of the PSENsgate 2, the guard locking is opened automatically (unlock mode) or has to be opened manually by pressing the button "Access Request" again (normal mode).
In this example, the normal mode was selected to rule out an uncontrolled release of the guard locking in the event of an error.
(The detailed description of the modes and their switching is described in the operating instructions for the PSENsgate 2)

The OSSD safety outputs (S-Gate Ch.1+Ch.2) switch to low signal as soon as the guard locking is released. They are evaluated by the block "Safety gate".

Shutting down of the OSSD outputs leads to the interruption of the drive enable, whereby the safety outputs of A2 shut down.
The contactors KM1 and KM2 de-energise and the motor (M1) is cut off.

3.1.2 Monitoring of safe operating stop (SOS-M)

The safety system PNOZmulti 2 monitors the standstill position of a drive together with the PNOZ m EF 1MM using the increments of a safe rotary encoder.
The recorded values are evaluated with the blocks "Motion Monitor" and "SOS".
The safety function is started by the signal "Start SOS". As a result, the current position of the rotary encoder is adopted as the set value.
If the movement of the rotary encoder is within the set tolerance window for the position monitoring, the signal "SOS Enable" is output. If the movement exceeds the tolerance window, this switches off the enable of the drive and the safety outputs of A2 shut down.
The contactors KM1 and KM2 are de-energised and the motor (M1) is shut down.

3.1.3 Monitoring of emergency stop

Operation of the emergency stop button integrated in PSENsgate 2 is evaluated by the block "Emergency stop".
Upon operation, the enable of the drive is interrupted and the safety outputs of A2 shut down.
The contactors KM1 and KM2 de-energise and the motor (M1) is cut off.

3.1.4 Feedback loop monitoring function

The positive-guided N/C contacts of the contactor KM1 and KM2 are monitored via the feedbackloop input "FBL1/FBL2" of A2.

3.1.5 Reset of the safety functions

The reset of the error depends on the operating mode set in the FS block.
Parameters are set for the FS blocks in this application example such that:
- upon restart (PNOZmulti switched off/on),
- upon start-up (PNOZmulti transferring from STOP to RUN) or
- after the reset in the safe state (safety gate closed etc.) a reset by the respective "Reset" (S2, S3, S4) must be performed so that the output parameter "Enable" is set again.

Even if the safety functions emergency stop, safety gate and safe operating stop are configured to reset themselves, a PNOZmulti restart or a reset in the safe state (e.g. closing of the safety gate) can still not directly result in start-up of the machine without additional conditions.

3.1.6 General guidelines

Enable start conditions
The enable of the drive can be started if:
- no emergency stop is operated and
- the contactors KM1 and KM2 are de-energised

AND EITHER

- the inputs (X2-3) and (X2-4) at PSENsgate 2 are HIGH
- the safety gate is closed and
- the bolt latch is within the response range and
- the locking pin is inserted in the bolt latch (guard locking) and
- the escape or auxiliary release pin is in the correct position

OR

- SOS enable is activated

Settings
- The jumpers between PNOZ m B1, PNOZ m EF 8DI4DO and PNOZ m EF 1MM must be set.

Escape release
The PSENsgate 2 comes with the option of manually unlocking of a guard lock to leave the danger zone without assistance from the escape side (within the danger zone).

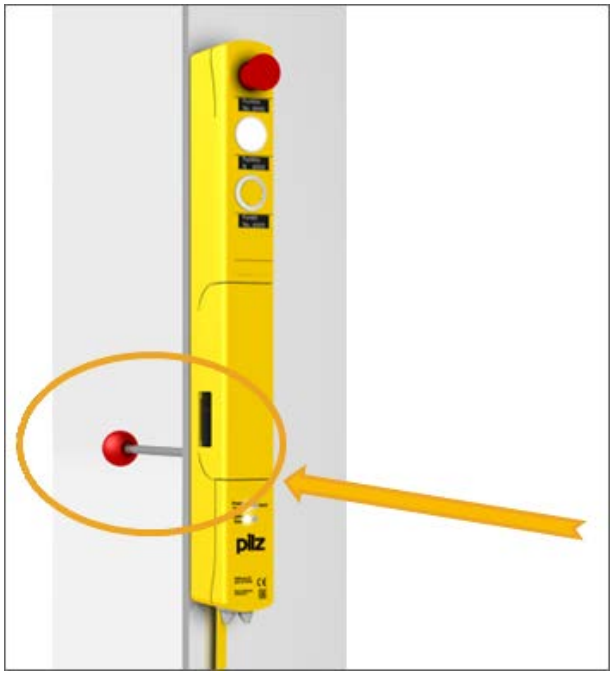


Figure 3: Escape release

3.1.7 Safety assessment

PSENsgate 2

The safety switch meets the following safety requirements

- Safe guard locking (only for revolving gates and swing gates)
- Safe interlocking (position monitoring)
- Detection of broken bolt tongue and broken guard locking element
- 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.
- If position is exceeded during the safe operating stop or when operating the emergency stop, a separation of the power supply to the motor is enforced. Hereby, the drive may not produce a torque and thus also not a brake torque.
  As a result, more dangers can arise that need to be considered.
  Such as:
  - increased duration up to the stop (overrun),
  - uncontrolled descent (e.g. with vertical axes),
  - change in position by mass, pressure or voltage,
  - etc.

General wiring guidelines

- The safety level PL e (Cat. 4)/SIL CL 3 can be achieved when
  - The safety outputs use 2-channel processing and
  - The solenoid is operated 2-channel via safe relay outputs, suitable for PL e (Cat. 4)/SIL CL 3 applications.
    Wiring errors should be excluded using appropriate measures. The potential solutions are the protected cable layout or the use of pulsed semiconductor outputs.
- The power supply must meet the regulations for extra low voltages with protective separation (SELV, PELV).
- The inputs and outputs of the safety switch must have a protective separation to voltages over 60 V AC.
- The supply voltage has to be at the safety switch terminals within the indicated tolerances.
- the supply voltage of the safety switch must be secured with a fuse of type quick between 2 A and 10 A.
- The electrical installation must be performed in accordance with IEC/EN 60204.
- The assured release distance (S_{aO}) can be influenced by external influences (e.g.: temperature, dirt, EMC)

INFORMATION

Safety relays with universal power supply or in AC device versions have internal potential isolation and are not suitable as evaluation devices. Only safety relays with a 24 V DC supply voltage are suitable.

PNOZ m B1

The relay conforms to the following safety criteria:

- The circuit is redundant with built-in self-monitoring.
- The safety function remains effective in the case of a component failure.

General installation guidelines

- The unit should be installed in a control cabinet with a protection type of at least IP54.
- Install the system vertically on to a horizontal mounting rail. The venting slots must face upward and downward. Other mounting positions could damage the safety system.
- Use the locking elements on the rear of the unit to attach it to a mounting rail.
- In environments exposed to heavy vibration, the unit should be secured using a fixing element (e.g. retaining bracket or end angle).
- Open the locking slide before lifting the unit from the mounting rail.
- To comply with EMC requirements, the mounting rail must have a low impedance connection to the control cabinet housing.

General wiring guidelines

- Use copper wiring with a temperature stability of 75 °C.
- Sufficient fuse protection must be provided on all output contacts with inductive loads.
- The safety system and input circuits must always be supplied by a single power supply.
  The power supply must meet the regulations for extra low voltages with protective separation (SELV, PELV).
- Test pulse outputs are used to detect shorts between the inputs. Shorts between inputs are detected if the inputs are connected to different test pulses (test pulse 0 ... test pulse 3). Shorts between inputs of the same module with the same test pulses will not be detected.
- Test pulse outputs must exclusively be used to activate the inputs. They must not be used to drive loads.
  Do not route the test pulse lines together with actuator cables within an unprotected multicore cable.
- The maximum permitted total current of the test pulse outputs is 640 mA.

PNOZ m EF 8DI4DO

The relay conforms to the following safety criteria:

- The circuit is redundant with built-in self-monitoring.
- The safety function remains effective in the case of a component failure.
- The safety outputs are tested periodically using a disconnection test.

General installation guidelines

- The unit should be installed in a control cabinet with a protection type of at least IP54.
- Fit the safety system to a horizontal mounting rail. The venting slots must face upward and downward. Other mounting positions could damage the safety system.
- Use the locking elements on the rear of the unit to attach it to a mounting rail.
- In environments exposed to heavy vibration, the unit should be secured using a fixing element (e.g. retaining bracket or end angle).
- Open the locking slide before lifting the unit from the mounting rail.
- To comply with EMC requirements, the mounting rail must have a low impedance connection to the control cabinet housing.
- The ambient temperature of the PNOZmulti units in the control cabinet must not exceed the figure stated in the technical details, otherwise air conditioning will be required.

General wiring guidelines

The wiring is defined in the circuit diagram of the PNOZmulti Configurator.
Please note:

- Use copper wire that can withstand 75° C.

PNOZ m EF 1MM

The relay conforms to the following safety criteria:

- The circuit is redundant with built-in self-monitoring.
- The safety function remains effective in the case of a component failure.

General installation guidelines

- The unit should be installed in a control cabinet with a protection type of at least IP54.
- Install the system vertically on to a horizontal mounting rail. The venting slots must face upward and downward. Other mounting positions could damage the safety system.
- Use the locking elements on the rear of the unit to attach it to a mounting rail.
- In environments exposed to heavy vibration, the unit should be secured using a fixing element (e.g. retaining bracket or end angle).
- Open the locking slide before lifting the unit from the mounting rail.
- To comply with EMC requirements, the mounting rail must have a low impedance connection to the control cabinet housing.
- The ambient temperature of the PNOZmulti units in the control cabinet must not exceed the figure stated in the technical details, otherwise air conditioning will be required.
- The unit may be exposed to various types of acceleration during operation. Please note the values stated in the technical details for vibration and shock stress. The acceleration values do not apply when mechanical resonances occur, so the whole system should be subjected to extensive testing.
- For the unit to work properly, it must not be constantly exposed to heavy vibration.

General wiring guidelines
The wiring is defined in the circuit diagram of the PNOZmulti Configurator.
Please note:
- Use copper wire that can withstand 75° C.
- The cable used to connect the encoders and proximity switches must be shielded (see connection diagrams in the chapter entitled "EMC-compliant wiring").
- The shield may only be connected to earth at a single point.
- Earth loops should be avoided.
- If possible, the connections for the various earth potentials ( ) should not be connected on the PNOZ m EF 1MM but should be connected directly to the GNDs on the connected units, otherwise noise susceptibility may be increased significantly (conductor loops are not permitted).

Connection of an encoder
With SAFE encoders the requirements of the encoder manufacturer must absolutely be observed and a check of whether these can be fulfilled by the PNOZ m EF 1MM is required (e.g.: requirement sin2+cos2=1 evaluation -> is fulfilled by the PNOZ m EF 1MM).
- In the above example, a safe sin/cos encoder with sin2+cos2=1 evaluation is used.
- The encoder can be connected via an adapter (e.g. MM A Mini-IO-CAB99) or directly to the PNOZ m EF 1MM.
- Only use shielded lines for all connections.
- Always connect GND of the encoder to the GND of the mini-IO connector.

Forced dynamisation:
When monitoring safe sensors, the axis must be moved within 8 hours such that at least one signal change occurs on all connected tracks.

3.2 Functional safety

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

No.	Safety function	Achieved Performance Level	Safety-related parts of the control system
1	Dangerous movements must be stopped when the safety gate is opened; it must not be possible to restart if the safety gate is open. (SAFETY GATE)	PL e	Sensor (PSEN sg2c S1) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
2	A start must be prevented if the guard locking device is not closed. (GUARD LOCKING DEVICE - start-up)	PL e	Sensor (PSEN sg2c S1) Input (PNOZ m EF 8DI4DO A 2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
3	It must not be possible to open the guard locking device while the safe state has not been reached. (GUARD LOCKING DEVICE - standstill)	PL e	Sensor (Geber B1) Input (PNOZ m EF 1MM A4) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A2) Actuator (PSEN sg2c S1)
4	Machine shut down via E-STOP	PL e	Sensor (PSEN sg2c ESTOP S1) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
5	Shutting down a machine when the engine deviates from the stop position by more than the determined amount. (Safe operating stop – SOS)	PL e	Sensor (Encoder B1) Input (PNOZ m EF 1MM A4) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) 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 S1 - EStop	one operation per week
		Actuator KM1/2	one operation per week
4	Characteristic data of sensor B1 (assuming):	PFH_D	1.00E-08 1/h
		PL	e
5	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)	Achieved Safety Integrity Level	Subsystems
1	Dangerous movements must be stopped when the safety gate is opened; it must not be possible to restart if the safety gate is open. (SAFETY GATE)	SIL 3	Sensor (PSEN sg2c S1) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
2	A start must be prevented if the guard locking device is not closed. (GUARD LOCKING DEVICE - start-up)	SIL 3	Sensor (PSEN sg2c S1) Input (PNOZ m EF 8DI4DO A 2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
3	It must not be possible to open the guard locking device while the safe state has not been reached. (GUARD LOCKING DEVICE - standstill)	SIL 3	Sensor (Geber B1) Input (PNOZ m EF 1MM A4) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A2) Actuator (PSEN sg2c S1)
4	Machine shut down via E-STOP	SIL 3	Sensor (PSEN sg2c ESTOP S1) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (contactors KM1, KM2)
5	Shutting down a machine when the engine deviates from the stop position by more than the determined amount. (Safe operating stop – SOS)	SIL 3	Sensor (Encoder B1) Input (PNOZ m EF 1MM A4) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) 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 S1 - EStop	one operation per week
		Actuator KM1/2	one operation per week
4	Characteristic data of sensor B1 (assuming):	PFH_D	1.00E-08 1/h
		SIL	3 (IEC 61508 compliant)
5	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 Program

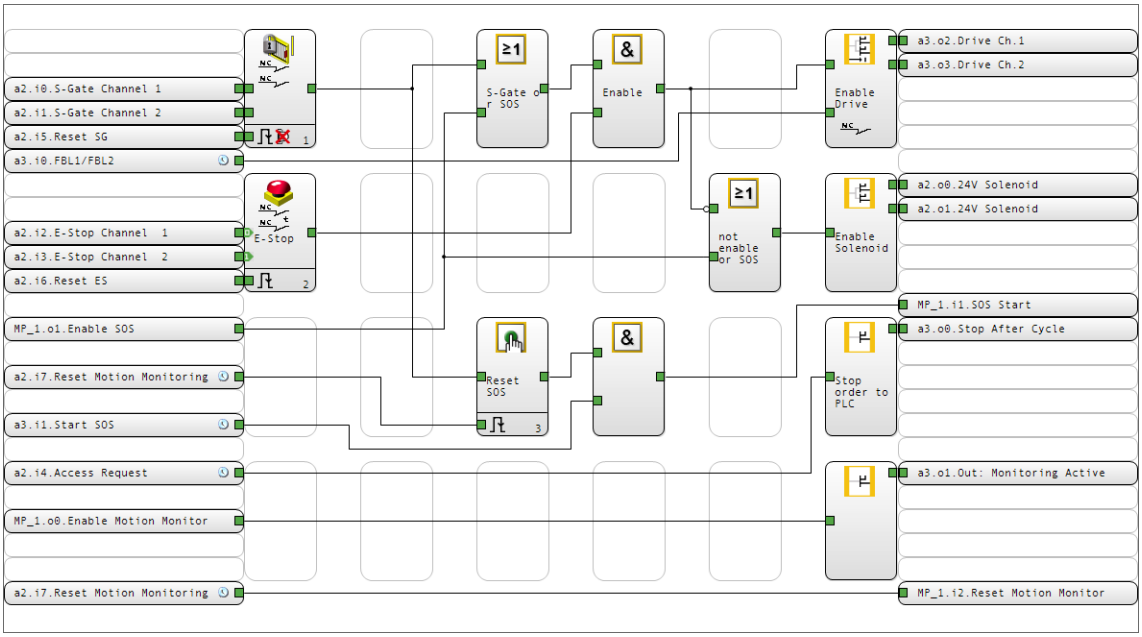


Figure 4: Safety Functions user program

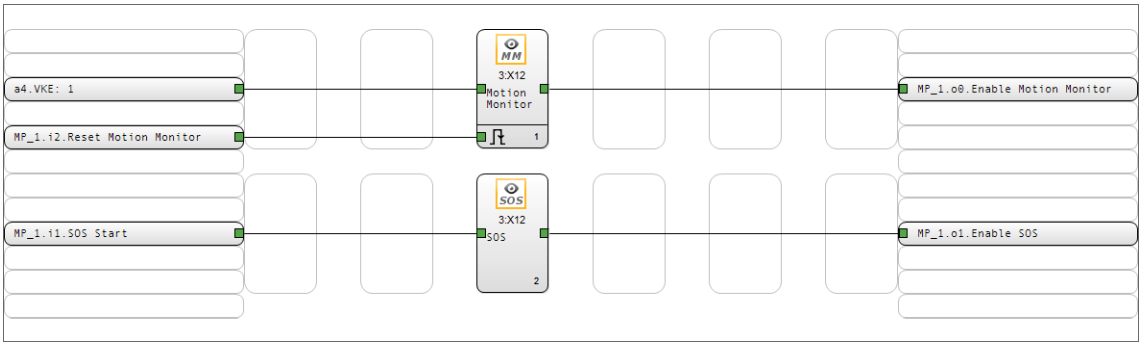
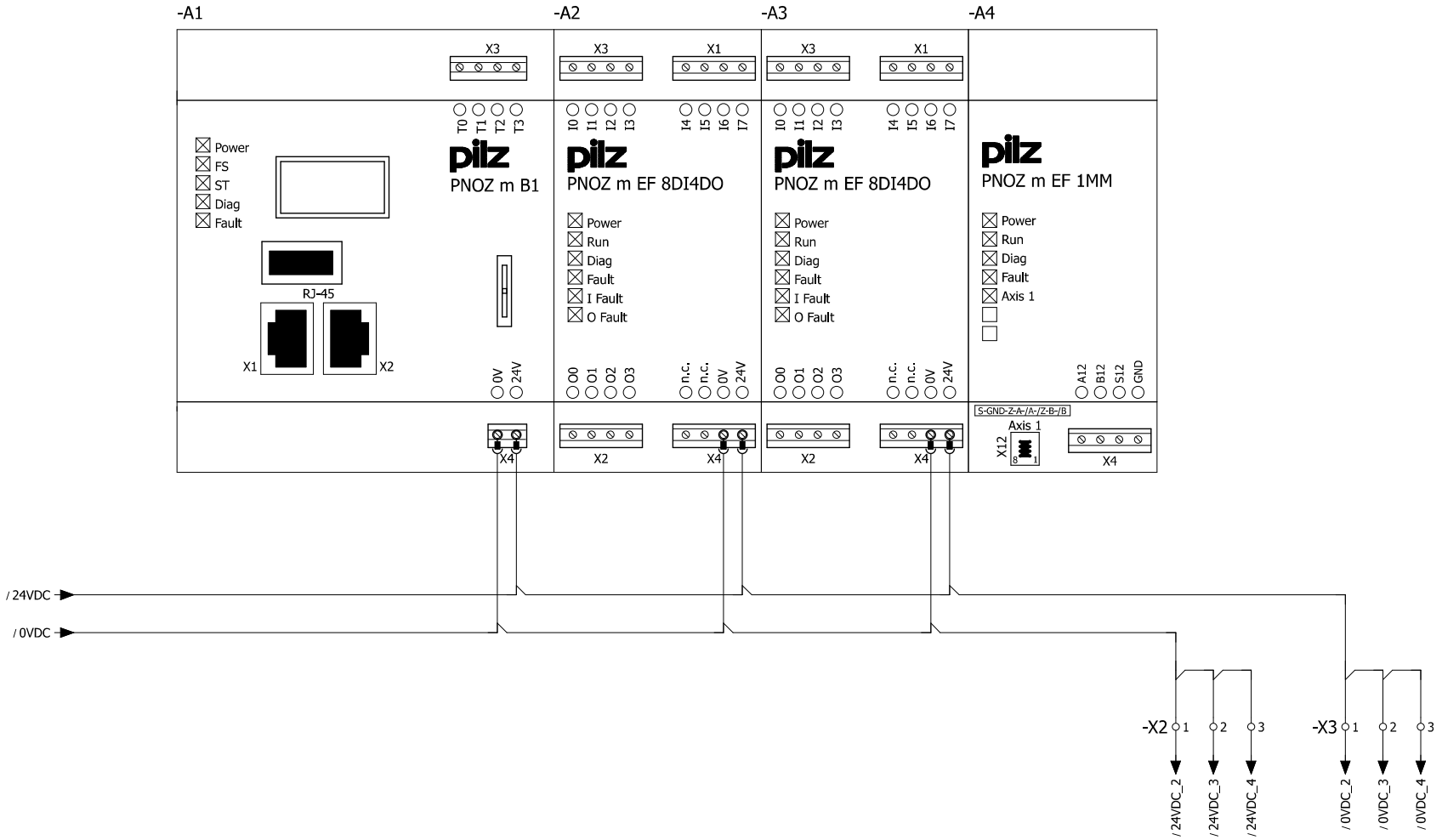


Figure 5: Motion Monitoring sub-program

Description:

- The safety gate monitoring and the safe operating stop monitoring (SOS) are OR-connected and form the enable for the drive together with the emergency stop monitoring.
- The enable for opening the magnet guard locking is performed by the safe operating stop or if there is no enable for the drive (this allows access in the event of an error).
- The request for the motor stop "Stop After Cycle" is forwarded to the standard controller without further evaluation in the example.
- The activation of the safe operating stop is initiated via the input "Start SOS" by the standard controller.
- The motion functions are called up in the sub-program (module program) "MP_1".



Revision	07.07.2016	Date	19.11.2015	EN ISO 13849-1 PL e	Pilz GmbH & Co.KG Felix-Wankel-Str.2 73760 Ostfildern	PSEN sg2c with PNOZ m B1 And Safe Operating Stop Monitoring By PNOZ m EF 1MM	Mounting place + AN_1003958_05
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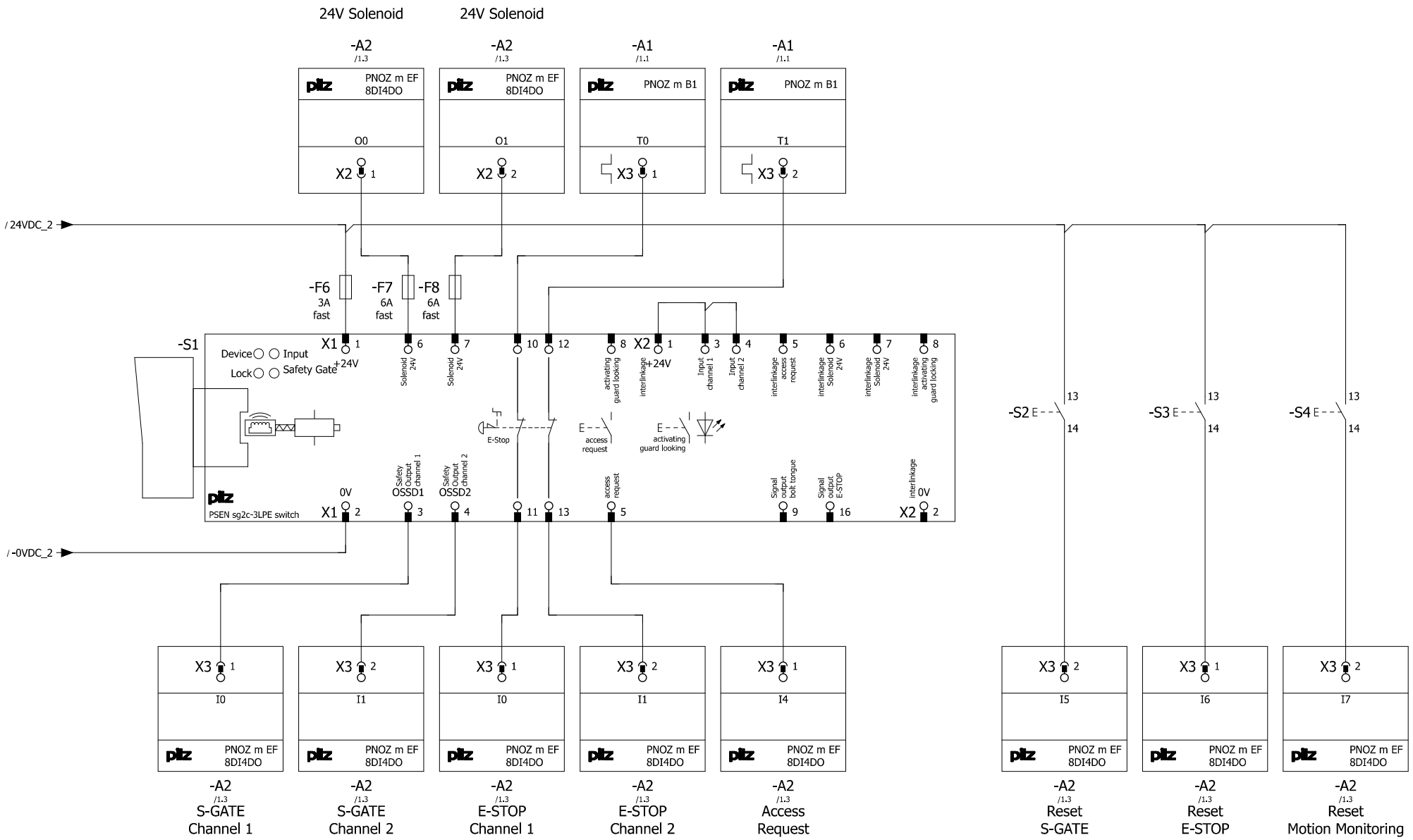

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Name	Pilz	Name	Pilz				
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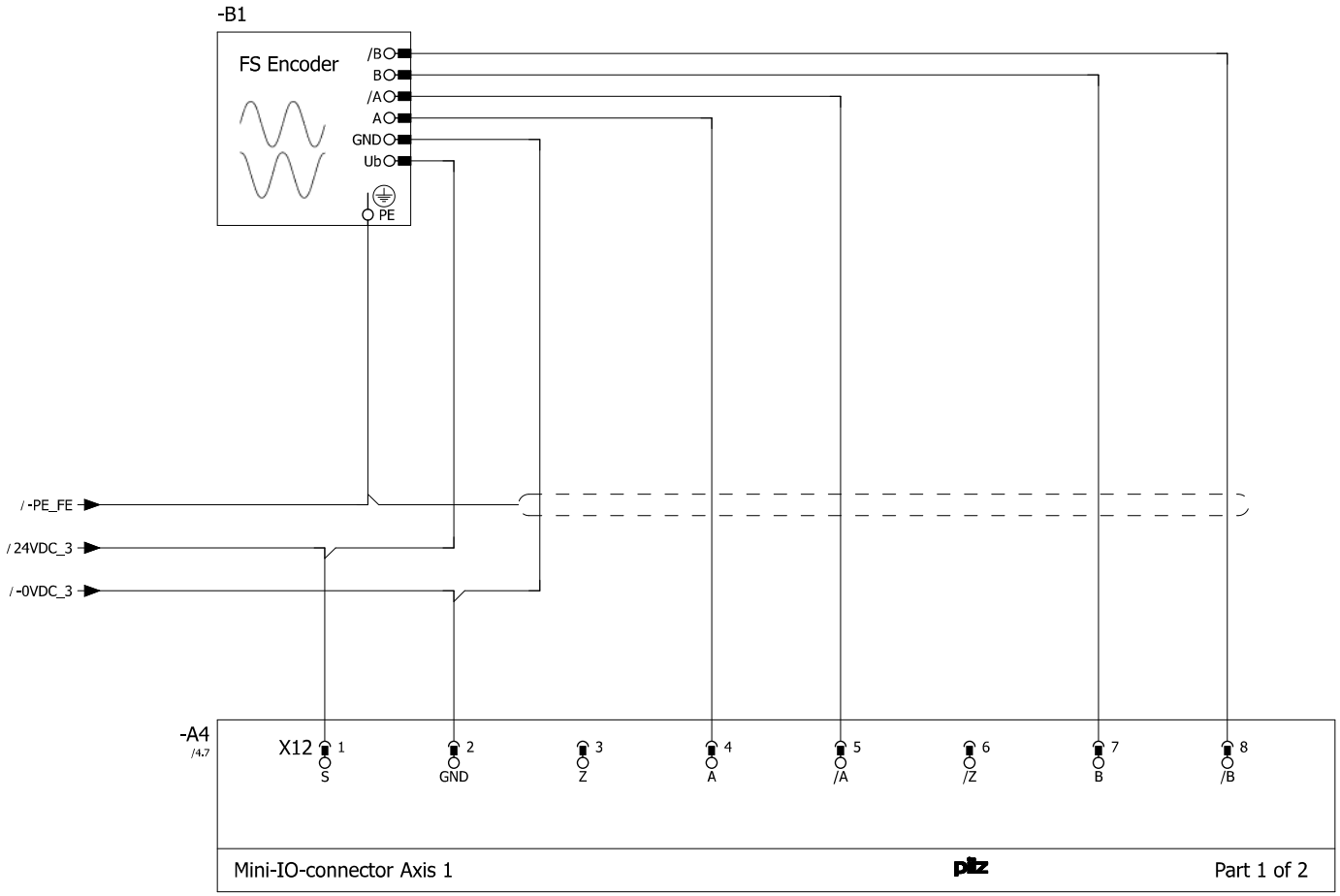
		Dep.	CS				



Revision	07.07.2016	Date	19.11.2015	EN ISO 13849-1 PL e	PILZ Pilz GmbH & Co.KG Felix-Wankel-Str.2 73760 Ostfildern	PSEN sg2c with PNOZ m B1 And Safe Operating Stop Monitoring By PNOZ m EF 1MM	Mounting place + AN_1003958_05
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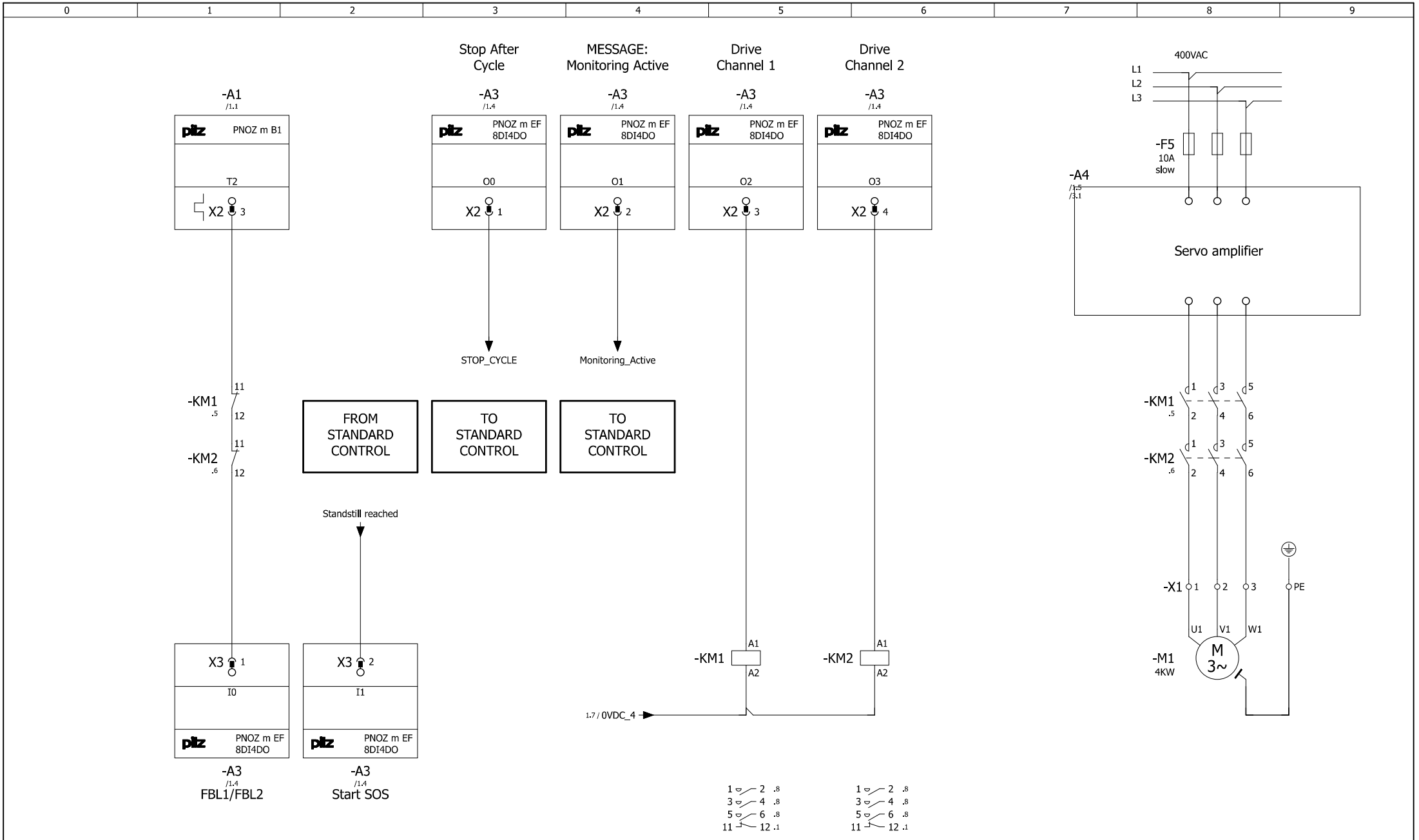
				EN 62061 SIL 3			Page: 3 / 4
		Dep.	CS				



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		Dep.	CS				

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Support

Technical support is available from Pilz round the clock.

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Pilz develops environmentally-friendly products using ecological materials and energy-saving technologies. Offices and production facilities are ecologically designed, environmentally-aware and energy-saving. So Pilz offers sustainability, plus the security of using energy-efficient products and environmentally-friendly solutions.

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We are represented internationally. Please refer to our homepage www.pilz.com for further details or contact our headquarters.

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