Safety gate monitoring and guard locking with PSENmlock

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Product

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

Document

Release Number:	04
Release Date:	02 August 2023

Document Revision History

Release	Date	Changes	Chapter
01	2016-06-20	Creation	all
02	2016-06-20	Enhancement	all
03	2016-06-20	Enhancement	all
04	2023-08-02	Editorial revision	all

Validity of Application Note

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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	
F_{max}	Maximum force	
F_{ZH}	Holding force	

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 ml b 1.1	www.pilz.com > Download 1003884
3	Operating Manual PNOZ m B1	www.pilz.com > Download 1003790
4	Operating Manual PNOZ m EF 8DI4DO	www.pilz.com > Download 1002661

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 ml b 1.1	570400	1.0	1
2	PNOZ m B1	772101	1.0	1
3	PNOZ m EF 8DI4DO	772142	1.0	2
4	PNOZmulti Configurator	-	V10.0.0	1

2.2 Hardware configuration

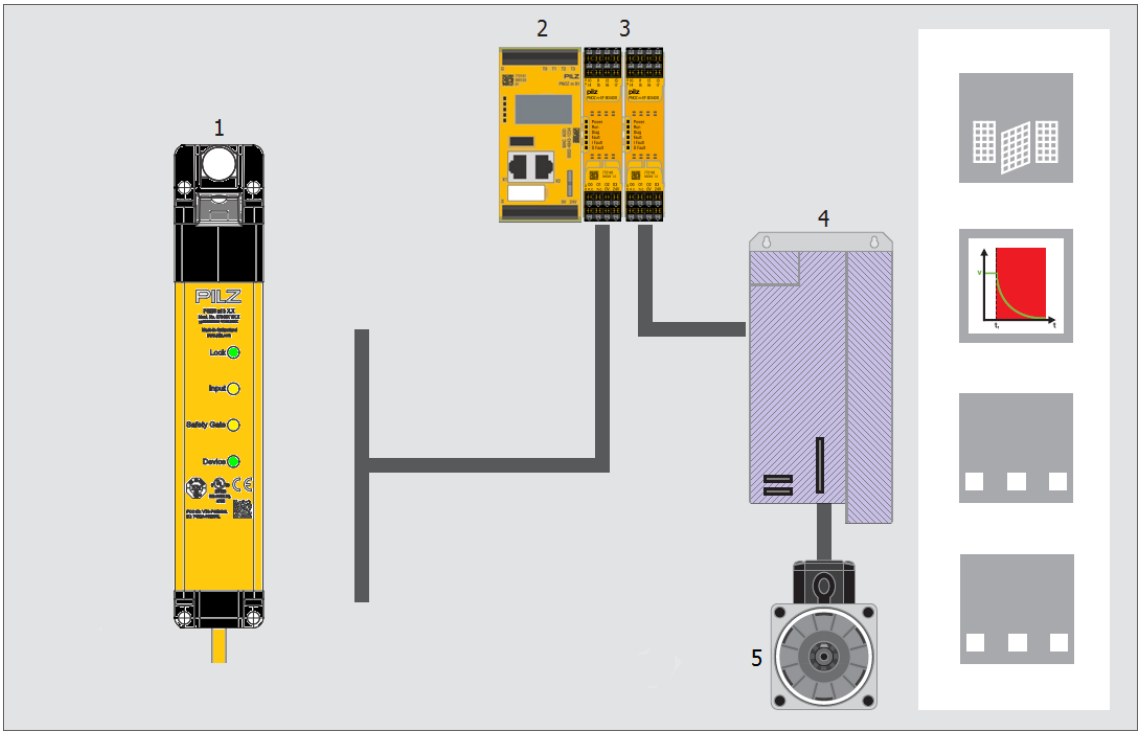


Figure 1: Hardware configuration

1. PSEN ml b 1.1 (PSENmlock)
2. PNOZ m B1 (PNOZmulti 2)
3. PNOZ m EF 8DI4DO
4. Servo amplifier
5. Motor

3 Application description

3.1 Description

This example illustrates safe monitoring of a safety gate with guard locking.
A PSEN ml b 1.1 (PSENmlock - S2) is used for safety gate monitoring and guard locking; it is evaluated via a PNOZ m B1 (PNOZmulti 2 - A1).

A machine executes a hazardous movement within a protective enclosure (guard and safety gate). To guarantee that the operator cannot reach the action zone until any risk has passed, a delay device is started when the machine is stopped. This ensures that any movement has come to a standstill before guard locking on the safety gate can be opened (delay time > maximum stopping performance of motor).

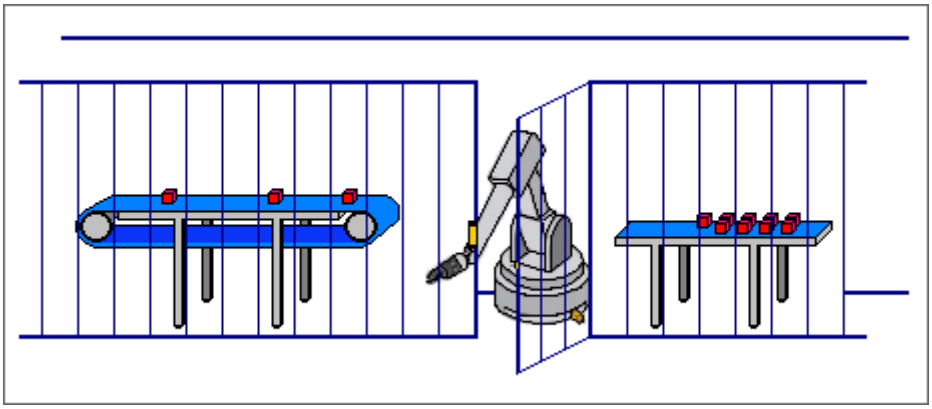


Figure 2: Application Safety gate with guard locking

The sequence is divided into the following main functions:
- Monitoring of safety gate
- Monitoring of guard locking
- Safe standstill monitoring is not described here and is represented only by way of example in the form of a time delay. The actual execution of standstill monitoring must be defined and implemented by the user, based on the specific application.

3.1.1 Monitoring of guard locking and safety gate

For the machine to start, the safety gate must be closed and guard locking interlocked via the pushbutton (S4), so that the safety gate monitoring function can be acknowledged via the reset button (S3).
Then the motor is started via the start button (S5).

The "Enable Drive" output is switched off by operating the stop button (S6). As a result, the motor (M1) is stopped and switched off via the servo amplifier (A4) using a preset ramp. Once the preset delay time has elapsed, outputs "STO 1 Drive" and "STO 2 Drive" are switched off, whereby the pulse disabler on the servo amplifier safely removes the power to the motor (STO). Guard locking on the safety switch PSENmlock (S2) can then be unlocked via the "Lock/Unlock" button (S4). The OSSD outputs on safety switch S2 are switched off as soon as guard locking is unlocked via pushbutton S4.

The functional state of guard locking (locked / unlocked) remains active even after supply voltage is removed.

CAUTION!

Guard locking may not be deactivated (unlocked) until the hazardous movement has been completed.

3.1.2 Acknowledgement of safety functions

Fault acknowledgement depends on the operating mode set in the function element (Sgate 1).
In this application example, the parameters on the function element (Sgate 1) are set so that:
- in the event of a cold start (PNOZmulti switched off/switched on),
- warm start (PNOZ multi transfers from STOP-RUN) or
- after resetting to a safe condition (safety gate closed and locked)

there must be an acknowledgement via "Reset" (S3), so that the output parameters "Enable Drive", "STO 1 Drive" and "STO 2 Drive" can be reset via the "Start" pushbutton (S5).

Although the safety function safety gate monitoring are configured to reset themselves, a PNOZ cold start or the remove to a safe condition (e.g. closing the safety gate) may not directly enable a machine to start up without further conditions being met.

3.1.3 Drive

The design and functionality of the servo amplifier is not described in detail in this example.
The user must select an appropriate drive, which is suitable for his application and meets the required safety level.

3.1.4 Safety assessment

PSEN ml B 1.1

The safety switch conforms to the following safety criteria:

- Safe guard locking for swing gates and sliding gates
- The safety switch may only be used with the corresponding actuator PSEN ml 1.1.
- 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.
- After stop of the drive or when open the safety gate (activation STO), 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.

Foreseeable misuse

- Safety outputs 12 and 22 of the safety gate system PSEN ml b 1.1 must not be connected to 24V.

General installation guidelines

- Prevent the safety switch and actuator being exposed to heavy shock or vibration
- The fastening of safety switch and actuator has to be sufficiently stable to ensure the proper operation of the safety switch and the actuator.
- Prevent self-loosening of the fastening elements on the safety switch and actuator.
- Make sure that the safety switch and actuator cannot be used as an end stop.

Regular checks

- Perform a manual function test of the safety switch and actuator is carried out at least monthly. The safety function may only be checked by qualified personnel.
- Check that the seal on the security screw on the auxiliary release is intact. If the seal is not intact, make sure that the security screw is inserted and use varnish to seal the security screw.
- Check the safety switch and actuator for damage.
- Make sure that the safety switch and actuator are firmly secured.
- Check the offset of the safety switch and actuator.
  - Max. lateral offset
  - Max. angular offset
  - Max. vertical offset
- Check that the wiring is correct.
- Remove any dirt from the safety switch and actuator.

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.

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.

Servo amplifier

Please refer to the safety guidelines stated in the operating manual for the respective servo amplifier.

3.2 Functional safety

The safety switch with guard locking PSENmlock achieves the classification PL e of EN ISO 13849-1 and SIL 3 of EN 62061, both for safety gate monitoring and for mechanical guard locking.

- Fault exclusion is assumed for the single-channel mechanical actuator (F_{max} = 2x F_{ZH}).

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 ml [OSSD] S2) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (Servo amplifier A4)
2	A start must be prevented if the guard locking device is not closed. (GUARD LOCKING DEVICE - start-up)	PL e	Sensor (PSEN ml [OSSD] S2) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (Servo amplifier A4)
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	Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A2) Actuator (PSEN ml [Guard locking] S2)

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	Characteristic data of servo amplifier - STO (assuming):	PFH_D	5E-09
		PL	e

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 ml [OSSD] S2) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (Servo amplifier A4)
2	A start must be prevented if the guard locking device is not closed. (GUARD LOCKING DEVICE - start-up)	SIL 3	Sensor (PSEN ml [OSSD] S2) Input (PNOZ m EF 8DI4DO A2) Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A3) Actuator (Servo amplifier A4)
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	Logic (PNOZ m B1 A1) Output (PNOZ m EF 8DI4DO A2) Actuator (PSEN ml [Guard locking] S2)

Prerequisites:

No.	Description		Identification
1	Common cause failure (CCF):		ß = 2 % (must be tested on implementation)
2	Proof test interval:		20 years
3	Characteristic data of servo amplifier - STO (assuming):	PFH_D	5E-09
		SIL	3

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

3.3 Program

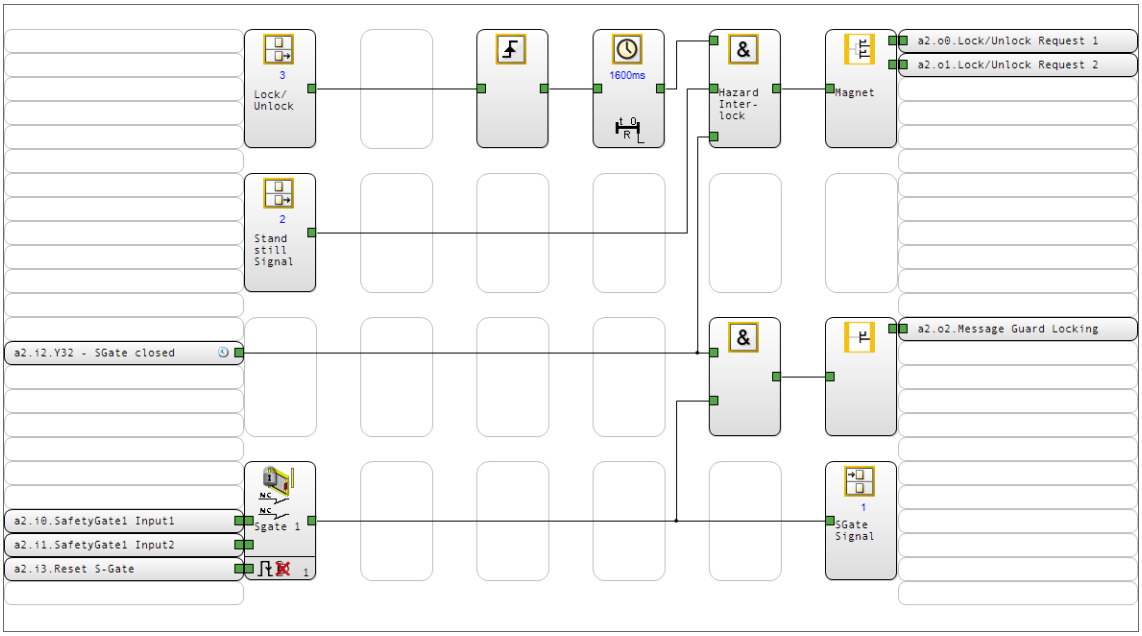


Figure 3: Program page 1

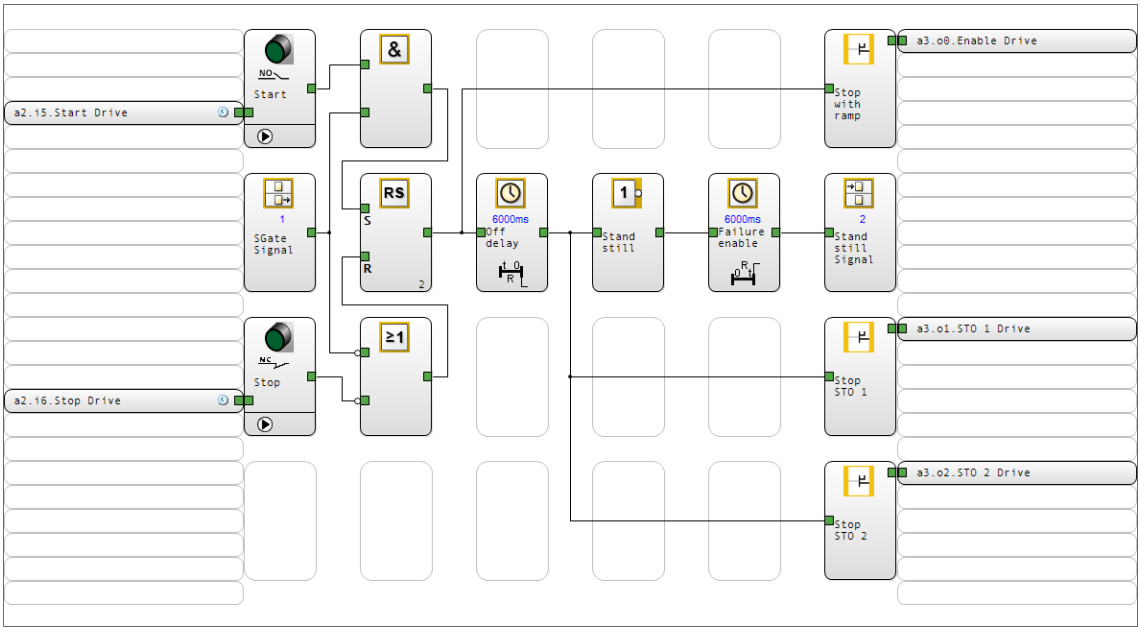


Figure 4: Program page 2

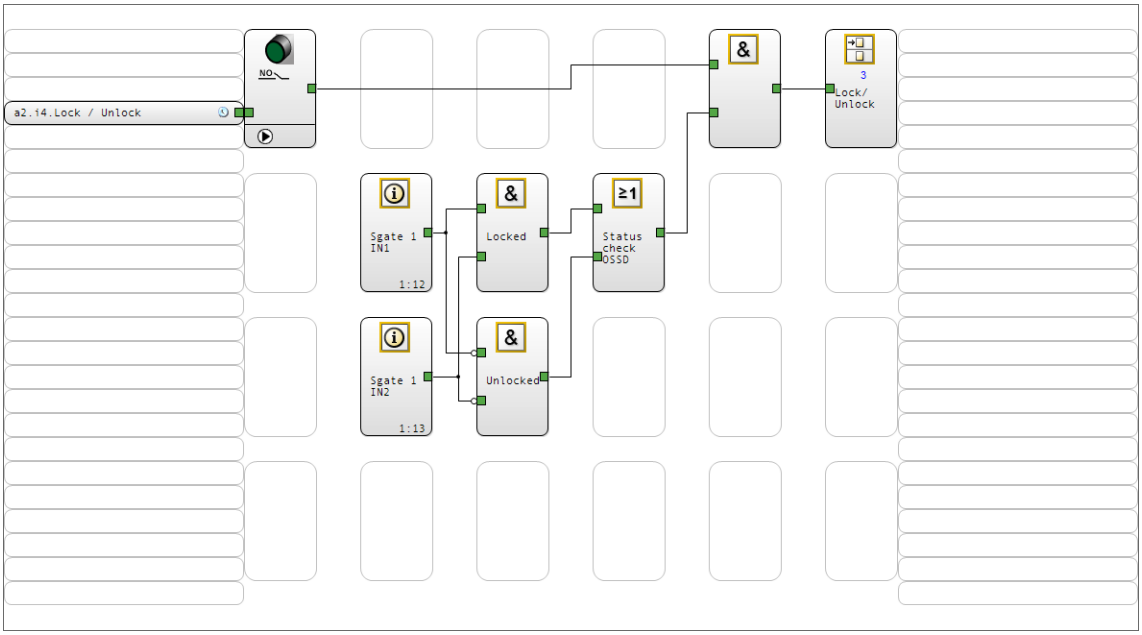


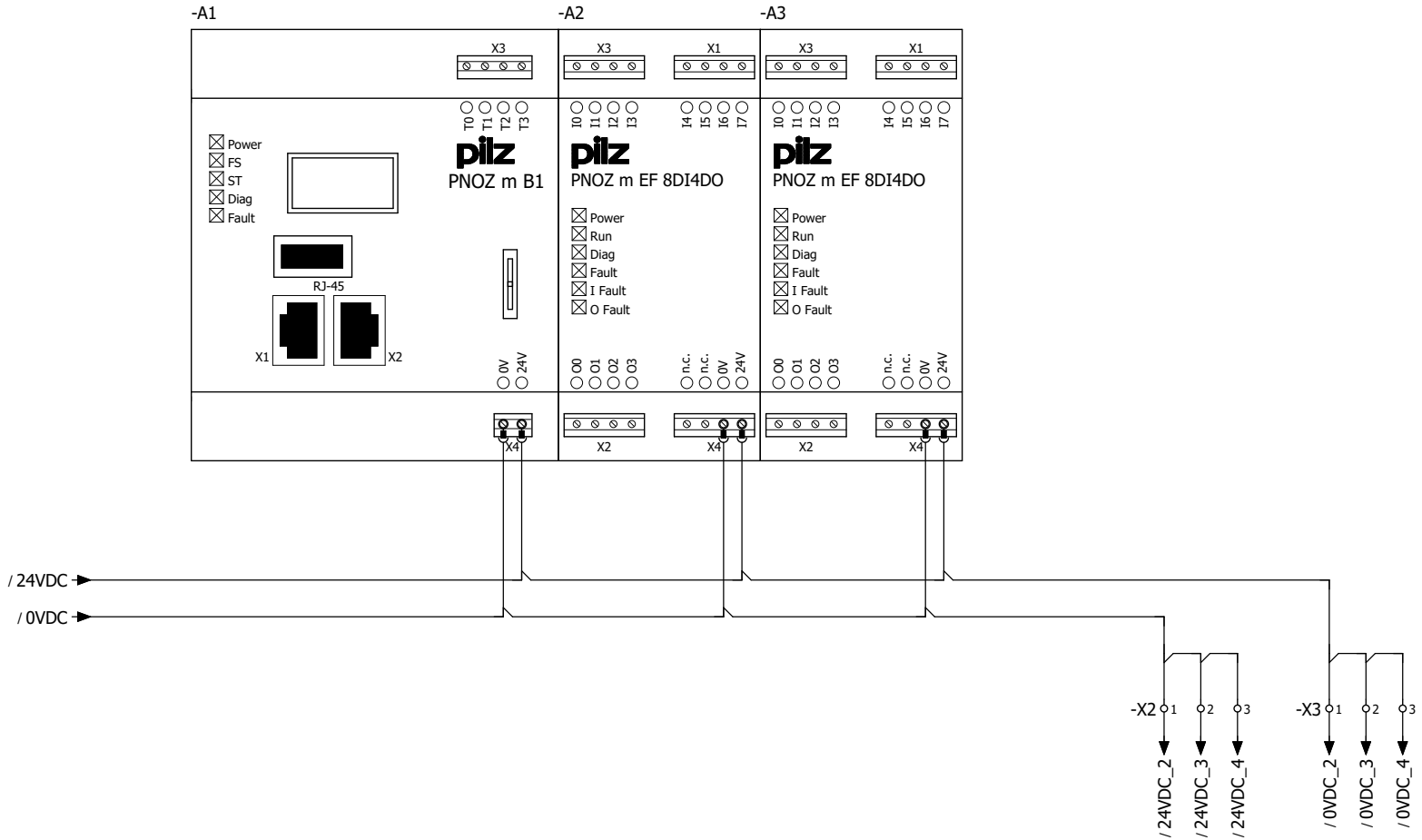
Figure 5: Program page 3

Description of program sequence
The control system monitors the safety gate switch (S2) via the user program.
The function element "Safety gate with interlock" (Sgate 1) is assigned to the safety gate switch. This function element detects whether the assigned safety gate switches have been operated, but also detects incorrect input signals, whether the contact synchronisation time has been exceeded, etc.

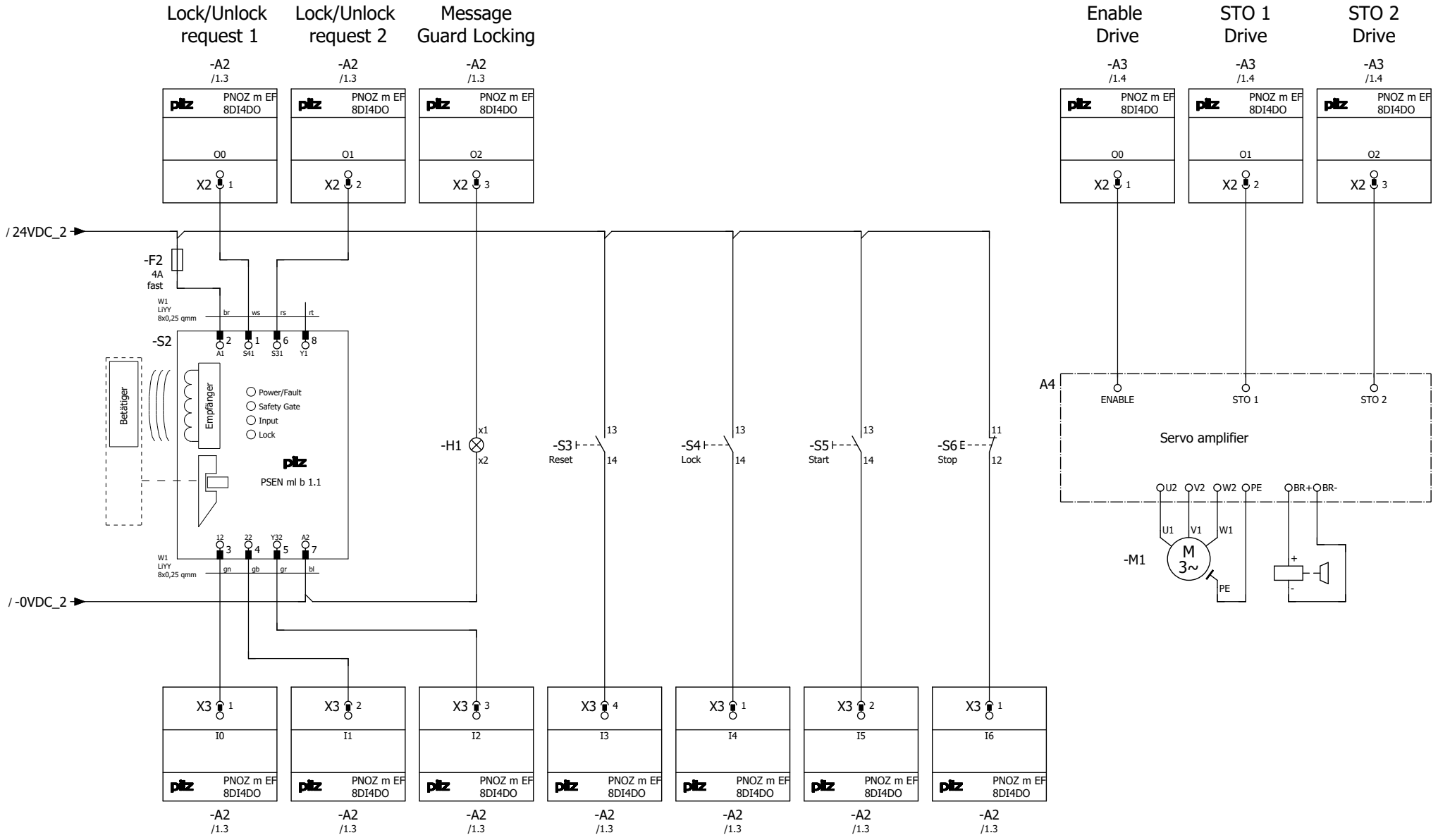
If the safety gate switch is operated or guard locking is unlocked, the OSSD outputs on S2 are switched off and the function element's (Sgate 1) enable output "Enable" is immediately reset.

With the pushbutton "Lock/Unlock" (S4), guard locking on the safety switch is interlocked / unlocked via a high pulse at safety inputs S31 and S41 on S2.
To monitor that both OSSDs on S2 are in the OFF state (gate not locked) or that both OSSDs are in the ON state (gate locked) before S31 and S41 are activated, the "Lock/Unlock" (S4) button is interlocked and includes monitoring of both OSSDs to ensure they have the same state.
To exclude the possibility of an invalid pulse at the safety inputs causing guard locking to be unlocked, the machinery may not execute the solenoid's switching operation to open and close guard locking until the hazardous machine function is complete. For this purpose, activation of the solenoid is interlocked via the programming, with standstill detection (time delay) as illustrated in the example.

If a machinery stop is triggered (S6), the "Enable Drive" signal to the servo amplifier (A4) is immediately switched off, triggering the set deceleration ramp in the servo amplifier. Both outputs "STO 1 Drive" and "STO 2 Drive" are switched off with a time delay, triggering the STO function in the servo amplifier once the motor (M1) has come to a standstill.



Revision	01.08.2023	Date	12.02.2016	EN ISO 13849-1	PL e	PILZ Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	PNOZmulti 2	Mounting place + AN_PSEN_MLOCK_02
Name		Name						
				EN 62061	SIL 3			Page: 1 / 2
		Dep.	CS					



Revision	01.08.2023	Date	12.02.2016	EN ISO 13849-1	PL e	PILZ Pilz GmbH & Co. KG Felix-Wankel-Strasse 2 D-73760 Ostfildern	PSENmlock	Mounting place + AN_PSEN_MLOCK_02
Name		Name						
				EN 62061	SIL 3			Page: 2 / 2
		Dep.	CS					

4 Table of figures

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