



L-muting with PNOZ m B0 and PSEN opII

PILZ
THE SPIRIT OF SAFETY

Product

Type: L-muting
Name: PNOZ m B0, PSEN opII, PSEN opII muting box
Manufacturer: Pilz GmbH & Co. KG, Safe Automation

Document

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

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February 2024

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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	 AN content (1002400)">www.pilz.com > AN content (1002400)
PNOZ	Pilz E-STOP positive-guided (DE: P ilz N OT-AUS- Z wangsgeführt)	 PNOZ">www.pilz.com > PNOZ
PSS	Programmable control system (DE: P rogrammierbares S teuerungssystem)	 PSS">www.pilz.com > PSS
PSS u2	PSS universal, 2 nd generation	 PSS u2">www.pilz.com > PSS u2
POU	P rogram O rganisation U nit	
NC	N ormally C losed	
NO	N ormally O pen	
AOPD	A ctive O ptoelectronic P rotective D evice	

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.

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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 PNOZ m B0 PNOZ	 Operat.Manual (1002660)">www.pilz.com > Operat.Manual (1002660)
3	Operating manual PNOZ m EF 8DI4DO	 Operat.Manual (1002661)">www.pilz.com > Operat.Manual (1002661)
4	Operating manual PSENoP3.3	 Operat.Manual (1003600)">www.pilz.com > Operat.Manual (1003600)
5	Operating manual PSEN opII muting arm	 Operat.Manual (1005831)">www.pilz.com > Operat.Manual (1005831)
6	Operating manual PSEN opII muting box	 Operat.Manual (1005830)">www.pilz.com > Operat.Manual (1005830)
7	Operating manual PIT si2.1	 Operat.Manual (21531)">www.pilz.com > Operat.Manual (21531)
8	Operating manual PSEN opII 4H-Serie	 Operat.Manual (1003501)">www.pilz.com > Operat.Manual (1003501)
9	PNOZmulti Configurator	 Software/PNOZmulti-Tools">www.pilz.com > Software/PNOZmulti-Tools
10	Operating manual PNOZmulti Special Applications	 Operat.Manual (1002337)">www.pilz.com > Operat.Manual (1002337)
11	Operating manual PNOZmulti System expansion	 Operat.Manual (1002217)">www.pilz.com > Operat.Manual (1002217)

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	PNOZ m B0	772101	V1.7	1
2	Cable/XX/M12-12SM/XXX-XXXX/A/010/0Q25/XX (see figure 1 - X1 to A1)	C1000069	-	1
3	PNOZ m EF 8DI4DO	772142	V1.0	1
4	PNOZ op3.3	630830	-	2
5	PSEN op Reflector	630323	-	2
6	PSEN opII muting box	6C000181	-	1
7	PSEN opII4H-s-30-090	632065	-	1
8	PNOZmulti Configurator	-	V11.0	1
9	PSEN opII L-muting set - 2 x Muting-Sensors PSEN op3.3, - 2 x PSEN op Reflector, - 2 x 1 m Cable for Muting-Sensors, - 1 x PSEN opII muting box Muting-Sensor-connection, - 1 x Muting-Lamp PIT si2.1, - 1 x Muting-Arm PSEN opII muting arm, - 1 x Holder for Muting-Sensor PSEN opII muting arm bracket kit	6C000182 630830 630323 380711 6C000181 620015 6C000185 6C000186	-	1

2.2 Third-party products

No.	Descriptions	Order number	Version	Number
1	Spring return key switch (override switch)	-	-	1
2	Backlit switch (start button with start status indicator)	-	-	1
3				
4				

2.3 Structure of the application (schematic)

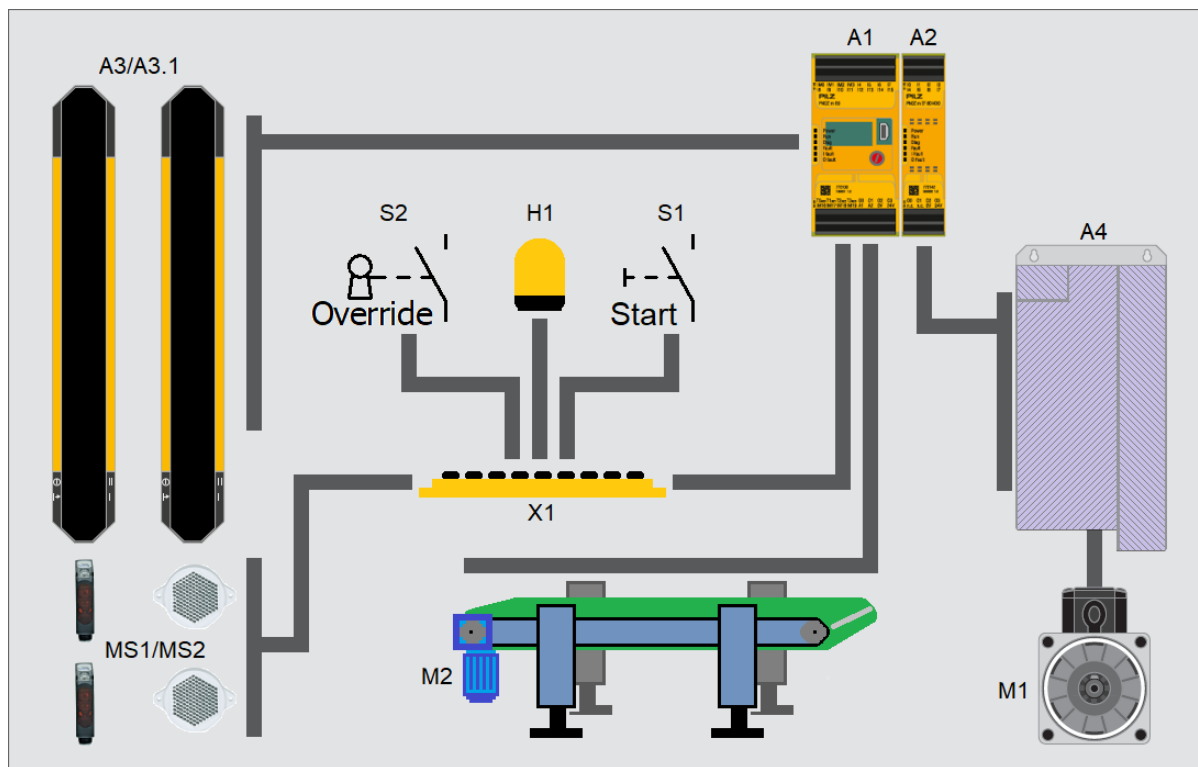


Figure 1: Application – Structure of the hardware (schematic)

Legend

[A1]	PNOZ m B0
[A2]	Input/output module PNOZ m EF 8DI4DO
[A3/A3.1]	Safety light curtain
[A4]	Servo amplifier
[H1]	Muting lamp
[M1]	Motor (dangerous machine)
[M2]	Conveyor belt/motor
[MS1/MS2]	Muting sensors with reflectors
[S1]	Start button
[S2]	Override button
[X1]	Muting box

2.4 Detail view

► Mutingbox view



Figure 2: Mutingbox X1

► View Scope of delivery of PSEN opII L-muting set



Figure 3: PSEN opII L-muting set

3 Application description

The example shows the implementation of an L-muting application using a PNOZ m B0 safe small controller, a PSEN opII 4H-s-30-090 light curtain and PSEN op3.3 muting sensors.

The light curtain (A3, A3.1) monitors the danger zone.

If a person/object is detected, the hazardous movement is shut down, so guaranteeing personal safety.

If muting is active, the transported material that is currently in the channel "protects" against unauthorised access to the danger zone.

A temporary suspension of the light curtain can be activated via the muting sensors (MS1-MS2).

A PIT si2.1 muting lamp (H1) is installed to display active muting.

"During muting, safe conditions shall be provided by other means" [EN ISO 13849-1 / EN IEC 62046] (e.g. transported material blocks access to the danger zone).

Should an error occur during muting, which causes the movement to stop, provided the transported material is still within the muting sensors, the monitored zone can be cleared using the override button (S2).

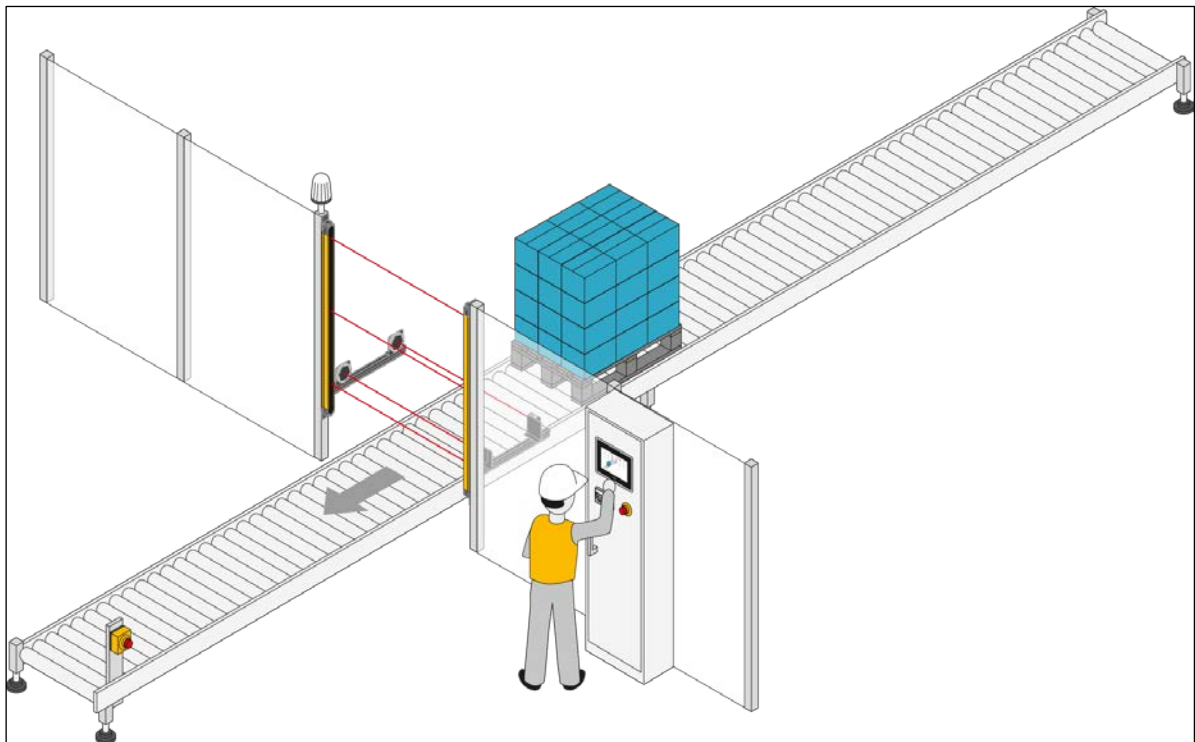


Figure 4: Application – L-muting function (schematic)

The signals are safely controlled and evaluated by the Pilz PNOZmulti elements from the PNOZmulti Configurator Logic Elements Library.

No.	PNOZmulti Library – General FS elements
1	Light curtain
2	Key switch
3	Pushbutton
4	Muting sensor

3.1 Light curtain (AOPD) monitoring function

The controller (PNOZ m B0) monitors the safety light curtain (**A3, A3.1**) via the user program. The "light curtain" function element is assigned to the light curtain. This element detects whether the assigned light curtain has been interrupted, whether implausible input signals have occurred or if the contact synchronisation time has been exceeded.

If the light curtain is interrupted or an error occurs, the enable output on the "light curtain" function element is reset immediately.

The enable output is also reset in the event of a STOP and when the PNOZmulti is switched on. The signal at the enable output must be evaluated by the user program and must lead to an appropriate reaction.

(see [chapter 3.2 Muting function, muting sensor element](#) [11 ff]).

The diagnostic elements can be used to determine why the enable was reset.

The outputs on the diagnostic elements serve as status messages.

(Evaluation of the diagnostic and status messages is not shown in this example. It can be established via the "Diagnostic word" diagnostic element or can be output to a display panel (*user interface, e.g. PMI*).)

The way in which the errors are reset depends on the operating mode set on the PNOZmulti element.

▶ In this application example, parameters for the "Light curtain" element have been set in such a way that:

- with a restart (PNOZmulti switched off/on),
- with a start-up (PNOZmulti transferring from STOP to RUN) or
- after the light curtain is cleared

no reset is required.

The enable output on the output parameter is set automatically (high) as soon as the light curtain detects that there is no interruption.

The reset obligation after the light curtain has been interrupted due to unauthorised access (muting inactive) is implemented via the "Muting sensor" element.

(see [chapter 3.2 Muting function, muting sensor element](#) [11 ff]).

Even if the light curtain and the "Light curtain" function element is configured without a restart interlock, a PNOZmulti restart or the light curtain becoming clear may not directly enable a machine to start up without further conditions being met.

Light curtain monitoring safety assessment

- ▶ A short between 24 VDC and an input circuit on the PNOZmulti input module will be detected as an error by the AOPD; the AOPD outputs are shut down.
- ▶ A short between the input circuits on the PNOZmulti module will be detected as an error by the AOPD; the AOPD outputs are shut down.
- ▶ If it is possible for the operator to fully (or possibly even partially) enter the danger zone, a risk analysis should clarify whether an additional "Manual reset function" is required.

3.2 Muting function, muting sensor element

The controller monitors the muting sensors (MS1-MS2) via the user program.

The "Muting sensor" element is used for muting. This element monitors the enable output on the "Light curtain" function element and detects whether authorised muting was triggered at the muting sensors for the assigned light curtain.

**CAUTION!**

Only use L-muting for transporting material out of the danger zone.

The "muting-sensor" element is switched between the "Light curtain" elements and the "Semiconductor output" output element. Provided the override function is not active, it forwards the enable signal from the "Light curtain" element directly to the "Semiconductor output" element.

If muting is activated (MS1-MS2 are operated in the correct switching and timing behaviour for the set muting operating mode), the enable for the element remains active. Irrespective of the enable signal present during this period for the "Light curtain" element.

The light curtain can be interrupted without the plant being shut down. This situation must not cause a hazard. During the time that muting takes place, other measures must be used to guarantee a safe state (e.g. the transported material blocking access to the danger zone).

In order to perform muting without interrupting the automatic cycle, the "Automatic start" function must be activated on the "light curtain" element. As a result, once muting is ended, the light curtain can resume its protective function directly, without any manual intervention.

If the light curtain is interrupted without muting being activated or an error occurs, the enable output on the "Muting sensor" element is reset immediately.

The enable output on the "Muting sensor" element is also reset in the event of a STOP and when the PNOZmulti is switched on. The signal at the enable output must be evaluated by the user program and must lead to an appropriate reaction.

The diagnostic elements can be used to determine why the enable was reset.

The outputs on the diagnostic elements serve as status messages.

(Evaluation of the diagnostic and status messages is not shown in this example. It can be established via the "Diagnostic word" diagnostic element or can be output to a display panel (*user interface, e.g. PMI*).)

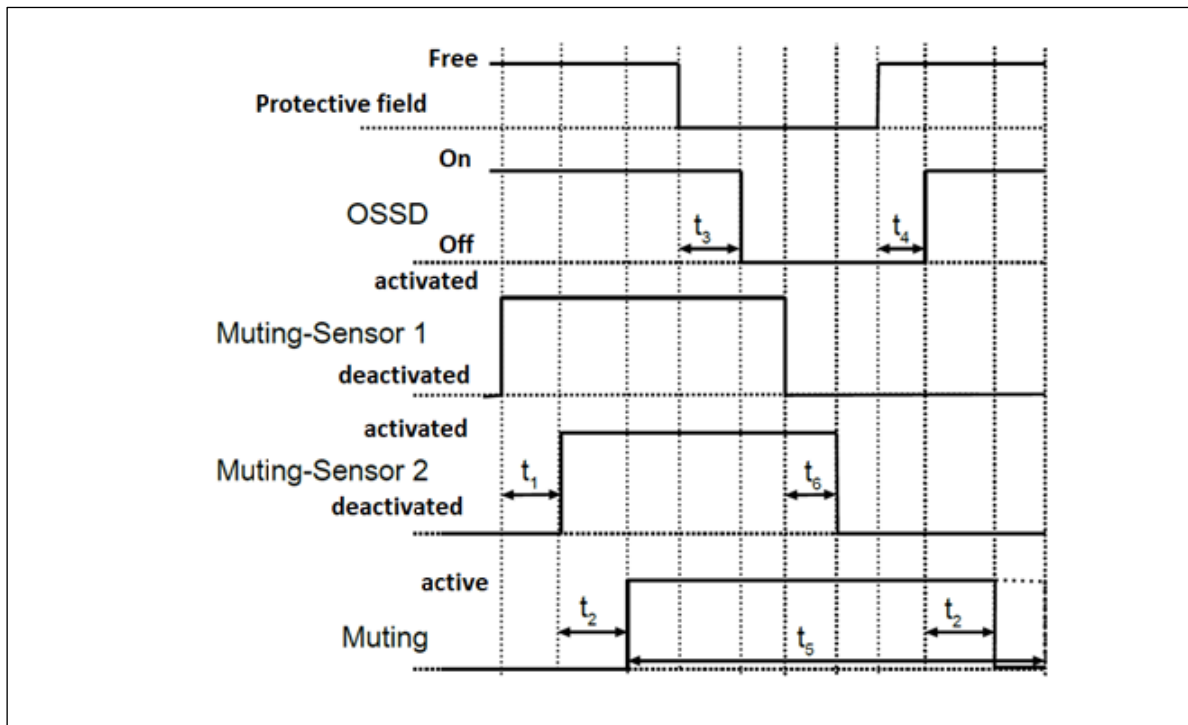


Figure 5: Flowchart, L-muting

Legend

- t1 .. Configurable simultaneity
- t2 .. maximum reaction time $t_{\text{ReactionMax}}$
- t3 .. Response time
- t4 .. Time between the protected field being enabled and the OSSDs changing to the ON state
- t5 .. Configurable maximum muting time
- t6 .. Configurable sensor enable time

The way in which the error is reset depends on the operating mode set in the "Muting sensor" element.

- ▶ In this application example, parameters for the element have been set in such a way that:
 - with a restart (PNOZmulti switched off/on),
 - with a start-up (PNOZmulti transferring from STOP to RUN),
 - after a faulty signal sequence of the muting sensors
 - after the light curtain is interrupted without active muting
 a reset is required in order for the enable output to be set.
- ▶ The "Muting sensor" element supports the operating modes:
 - Sequential muting
 - Parallel muting
 - Cross muting
 - L-muting

The decision regarding selection of one of these operating modes depends on the specific application (material, sensors, permitted direction of travel, etc.).

(More detailed information on the muting operating modes and detailed descriptions of the positioning of the muting sensors and switching conditions can be found in the PNOZmulti Online Help.)

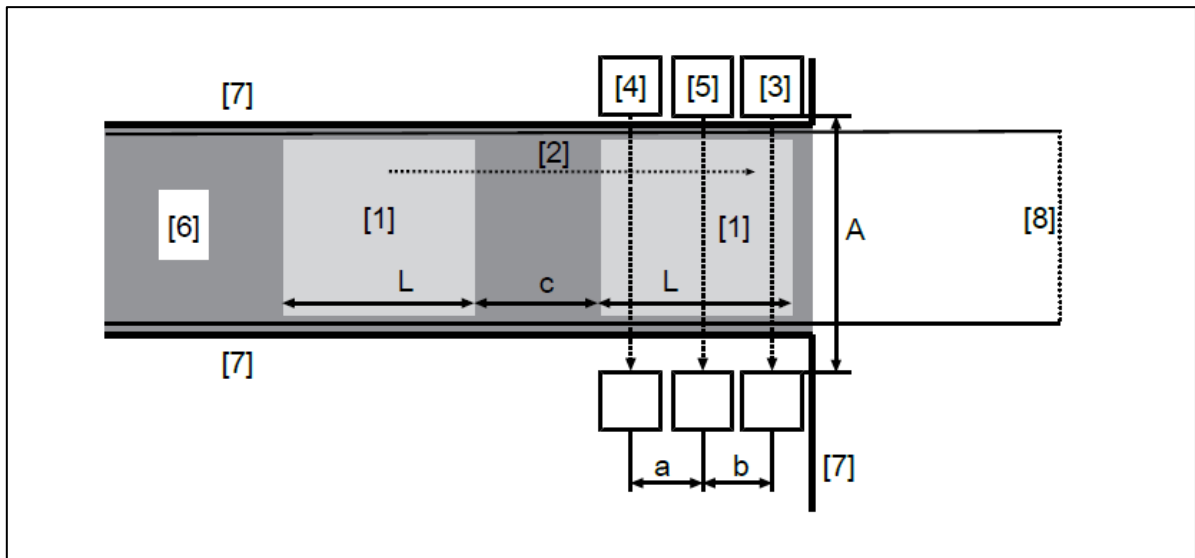


Figure 6: L-muting operating mode (schematic)

Legend

- [1] Object that is to be transported through the protected field
- [2] Direction of transport with speed v
- [3] Safety light curtain
- [4] Muting sensor 1
- [5] Muting sensor 2
- [6] Danger zone
- [7] Guard to prevent access to the danger zone
- [8] Conveyor

Comply with the following distances and times

Working distance A between the safety light curtain's transmitter and receiver

- ▶ When using the PSEN opII L Muting Set < 3000 mm
a = Distance of muting sensor 1 from muting sensor 2
- ▶ When using the PSEN opII L Muting Set > 100 mm
b = Distance of muting sensor 2 from protected field
- ▶ When using the PSEN opII L Muting Set > 100 mm
 - L = Length of the object that triggers the muting state as it passes the muting sensors
 $L > a + b$
 - c = Distance between two objects that are being transported through the protected field
 $c > a + b$

The stated distances between the muting sensor and the protected field and the working distance between the safety light curtain's transmitter and receiver apply when using the PSEN op3.3 supplied.

Muting safety assessment

- ▶ A short between 24 VDC and an input circuit on the PNOZmulti module will be detected as an error by the "Muting sensor" element due to the logic signal sequence; the enable output on the muting element is shut down.
- ▶ A short between the input circuits on the PNOZmulti module will be detected as an error by the "Muting sensor" element due to the logic signal sequence; the enable output on the "Muting sensor" element is shut down.
- ▶ Standard sensors are used as the muting sensors. In the example, these are read in via safe inputs and assigned to the "Muting" element.
- ▶ The connection cables to the muting sensors should be laid separately (cross circuit proof).
- ▶ The muting sensors must be aligned in such a way that they detect the material to be transported and not the transport device (e.g. pallet); this is to exclude the possibility of the operator reaching through, stepping through or possibly riding on the detected transport device.
- ▶ During muting, safe conditions must be provided by other means.
(e.g.: during muting, access to the danger zone is impossible due to the transported material).

The safety-related parts that perform the muting function must have an appropriate safety-relevant performance level (SIL or PL, see IEC 62061 or ISO 13849-1) and must not reduce the safety-related performance of the protective function to below the level required for the application. (EN IEC 62046)

3.3 Muting-dependent override function

The controller monitors the override switch S2 (switch, N/O contact through key with automatic reset) via the user program.

The "Key switch" function element is assigned to the override switch. This detects whether the assigned switch has been operated.

If the contact on the override switch is interrupted or an error occurs, the output on the element is reset immediately.

The output is also reset when the PNOZmulti is stopped and when the PNOZmulti is switched on.

The output signal must be evaluated by the user program and must lead to an appropriate reaction.

The enable output on the "Muting sensor" element is set automatically (high) as soon as the contact on the override switch is switched to TRUE.

Safety assessment of muting-dependent override function

- ▶ The override switch must be lockable and must have a hold-to-run control.
- ▶ The override switch must be installed in a fixed position outside the danger zone.
- ▶ The danger zone and the muting station must be visible from the override switch position.
- ▶ Activating the muting-dependent override function must not initiate motion. A separate control device must be operated to initiate this motion (EN IEC 62046).
- ▶ The maximum muting time is limited and is implemented via the "Muting sensor" element.
- ▶ A separate operating mode must be provided for the override with Override = TRUE.
- ▶ During the override, access to the danger zone is impossible due to the transported material.

3.4 Feedback loop monitoring function

The positive-guided N/C contacts of contactors KM1 and KM2 are monitored via the feedback loop input **FBL1/FBL2** of A1.

A 1-signal at the input parameter Input (Enable from light curtain/muting) of the "Muting sensor" element sets the outputs that control the contactors (Output1 and Output2) to "1"; a 0-signal sets them to "0".

If an error occurs, the outputs of the PNOZmulti output that control the contactors (Output1 and Output2) are immediately reset. Both outputs are also reset in the event of a STOP and when the PNOZmulti is switched on.

If an error occurs, once the error has been recovered, the element's Input must be operated again, so that Output1 and Output2 are reset.

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 safety controller. The load can be switched off via the second shutdown route.
- ▶ The feedback loop contacts must be installed in one installation space (control cabinet).
- ▶ To achieve PLd or PLe, 2 actuators must be used.

3.5 Drive

This example does not describe the design and functionality of the servo amplifier in any detail. The user must select an appropriate drive to suit their application and the safety level it requires.

A 0-signal at the light curtain input parameter (enable from light curtain) of the "Muting sensor" element shuts down "Enable Drive". As a result, the motor (M1) is stopped and shut down via the servo amplifier (A4), via a preset ramp.

Once the set delay time has elapsed, the outputs "STO 1 Drive" and "STO 2 Drive" are shut down, whereby the servo amplifier's pulse inhibitor safely removes the power to the motor (STO).

3.6 Functional safety

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

No.	Safety function	Performance Level	Safety-related parts of the control system
1	Switching off a machine when the safety light curtain is interrupted. (Motor 1 - dangerous machine)	PL e	Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m E F 8DI 4DO Actuator Servo amplifier A4
2	Switching off a machine when the safety light curtain is interrupted. (Motor 2 - conveyor belt)	PL e	Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m B0 Actuator Contactors KM2.1, KM2.2
3	Timely limited automatic suspension of a safety device. (Muting)	PL e	Sensor PSEN op3.3 MS1-MS2 Input PNOZ m B0 Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m B0 Actuator Contactors KM2.1, KM2.2

No.	Description	Identification
1	Common cause failure (CCF):	The requirements are met (to be checked when implemented)
2	Mission time:	20 years
3	Operating interval (electromechanical components):	Actuator KM2.1/KM2.2 one operation per day
4	Characteristic values of contactors KM2.1/KM2.2:	B10 _D 1,300,000
5	Characteristic values of muting sensors MS1/MS2:	MTTF _D 3141 years
6	Characteristic values of servo amplifier - STO: (assumption)	PFH _D 5E-09
		PL e

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

3.6.2 Safety-related characteristics in accordance with EN 62061

No.	Safety-related control function	Safety Integrity Level	Subsystems
1	Switching off a machine when the safety light curtain is interrupted. (Motor 1 - dangerous machine)	SIL 3	Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m E F 8DI 4DO Actuator Servo amplifier A4
2	Switching off a machine when the safety light curtain is interrupted. (Motor 2 - conveyor belt)	SIL 3	Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m B0 Actuator Contactors KM2.1, KM2.2
3	Timely limited automatic suspension of a safety device. (Muting)	SIL 3	Sensor PSEN op3.3 MS1-MS2 Input PNOZ m B0 Sensor PSEN opII 4H-s-30-090 A3, A3.1 Input PNOZ m B0 Logic PNOZ m B0 Output PNOZ m B0 Actuator Contactors KM2.1, KM2.2

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):	Actuator KM2.1/KM2.2 one operation per day
4	Characteristic values of contactors KM2.1/KM2.2:	B10 _D 1,300,000 Dangerous failure rate 75 %
5	Characteristic values of muting sensors MS1/MS2:	MTTF _D 3141 years
6	Characteristic values of servo amplifier - STO: (assumption)	PFH _D 5E-09 SIL 3

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

3.7 PNOZmulti project

To operate a plant with one or more programmable control systems PNOZmulti, a project must be created using the PNOZmulti Configurator.

A project consists of the hardware configuration and the user program.

3.7.1 Wiring the periphery

► Electrical assignment of the sensors:

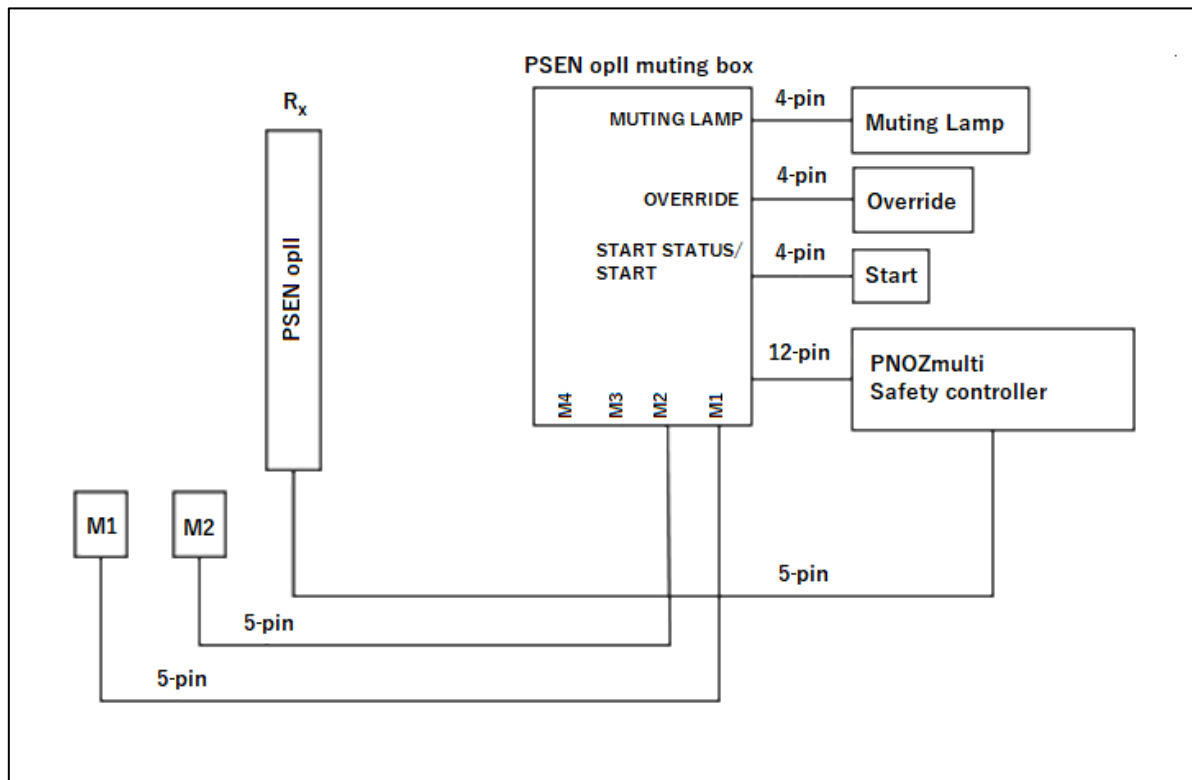


Figure 7: Application – Wiring with the PSEN opII muting box (schematic)

3.7.2 Hardware configuration

- ▶ Pilz components
 - PNOZ m B0
 - I/O expansion PNOZ m EF 8DI4DO

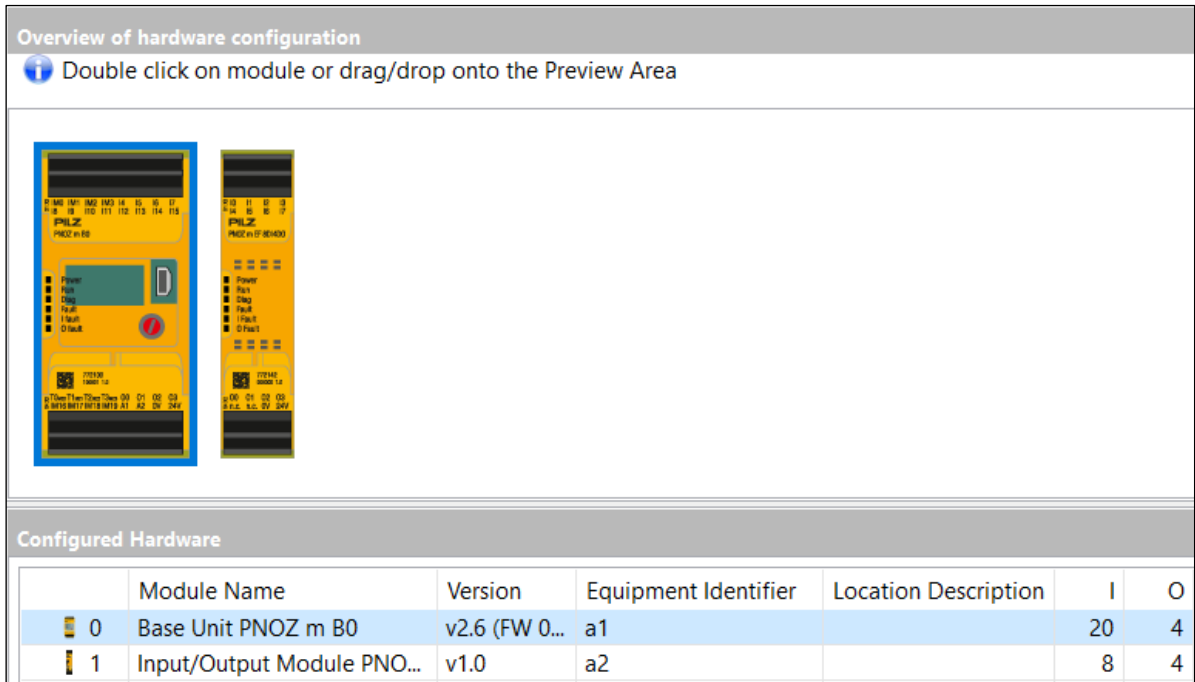


Figure 8: PNOZmulti Configurator – Hardware configuration

3.7.3 PNOZmulti programming

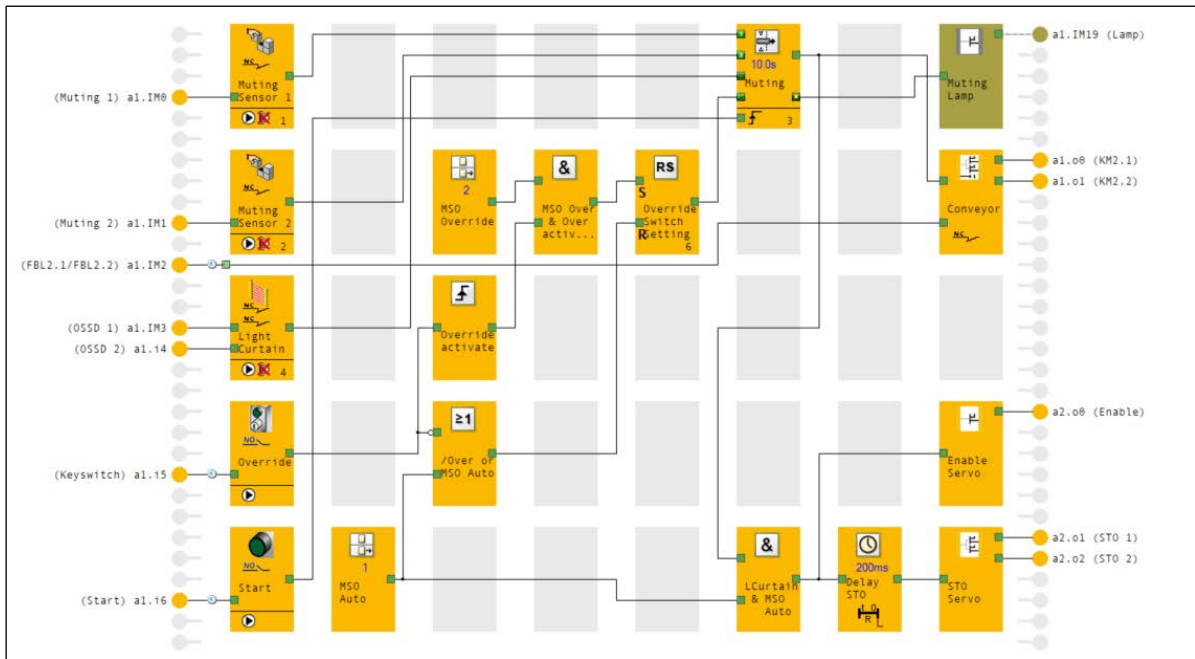


Figure 9: PNOZmulti Configurator – Program, Page 1 » Logic

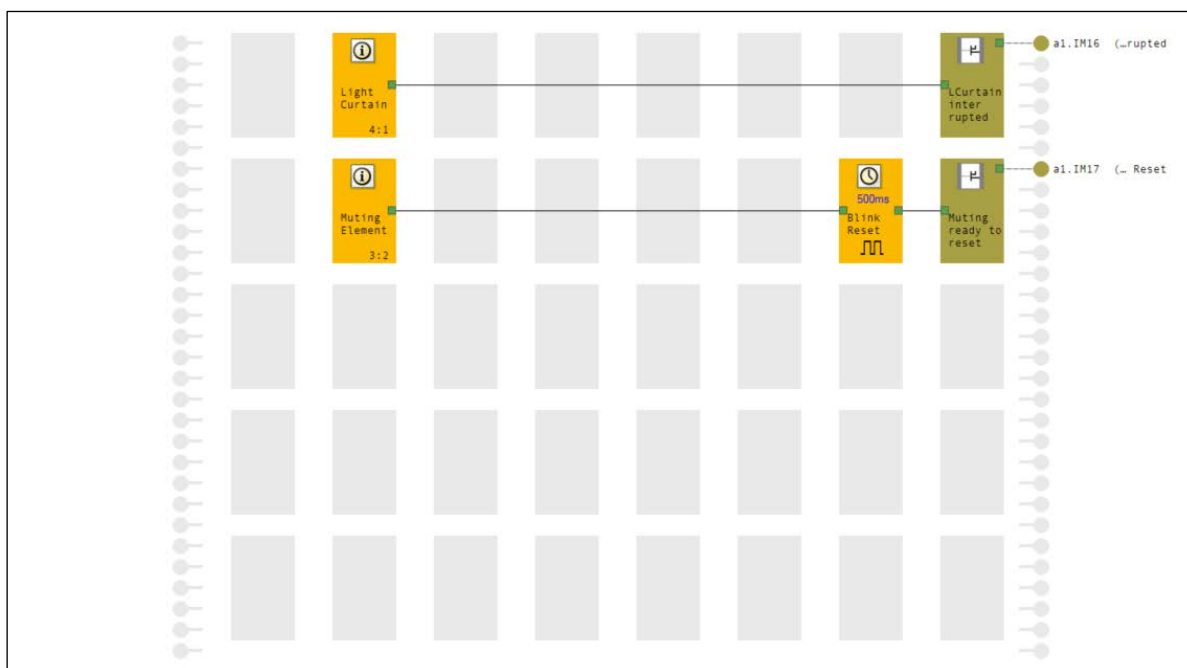


Figure 10: PNOZmulti Configurator – Program, Page 2 » Diagnostics

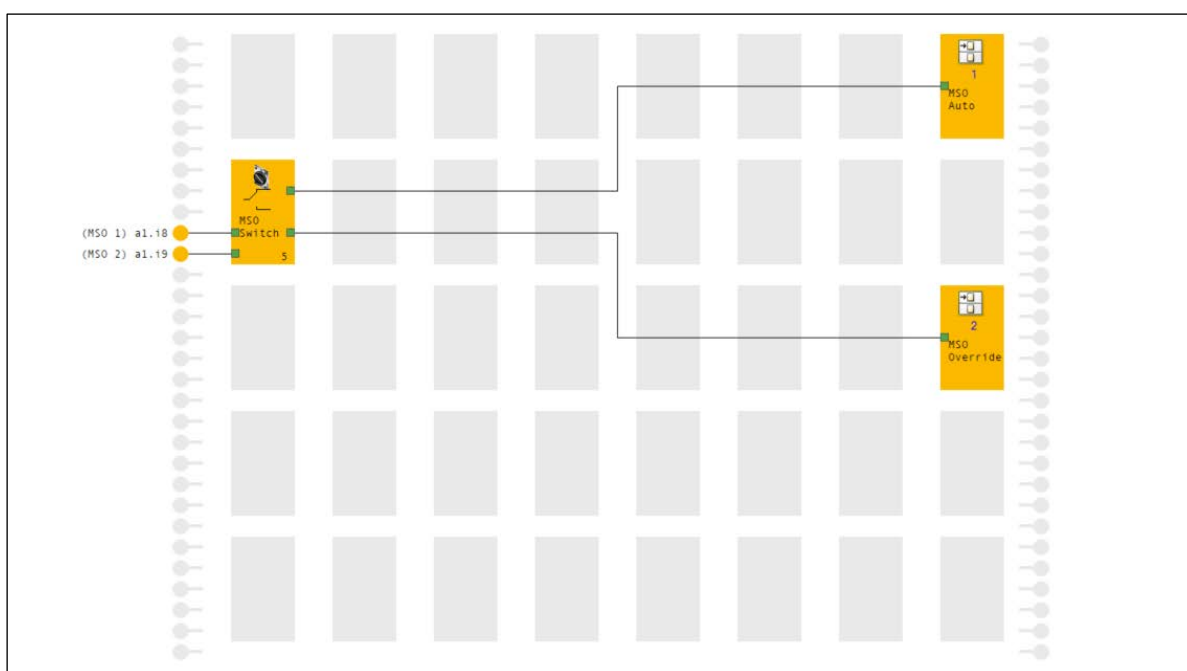


Figure 11: PNOZmulti Configurator – Program, Page 3 » Operating mode selection

Description of program cycle

The controller monitors the light curtain (A1-A2) via the user program.
The "light curtain" function element is assigned to the light curtain.

The "Muting sensor" element is connected downstream of this, which also evaluates the two muting sensors, MS1/MS2, as well as the start button (S1) and the override key switch (S2).

The enable output on the "Muting sensor" element controls the conveyor (M2) and hazardous machine (M1) via interlocking logic.

(More detailed information on programming with PNOZmulti can be found in the PNOZmulti Online Help)

Extract from EN 62046:

"The muting-dependent override function should only enable those movements necessary to remove obstructions from the protected field of the safeguard.

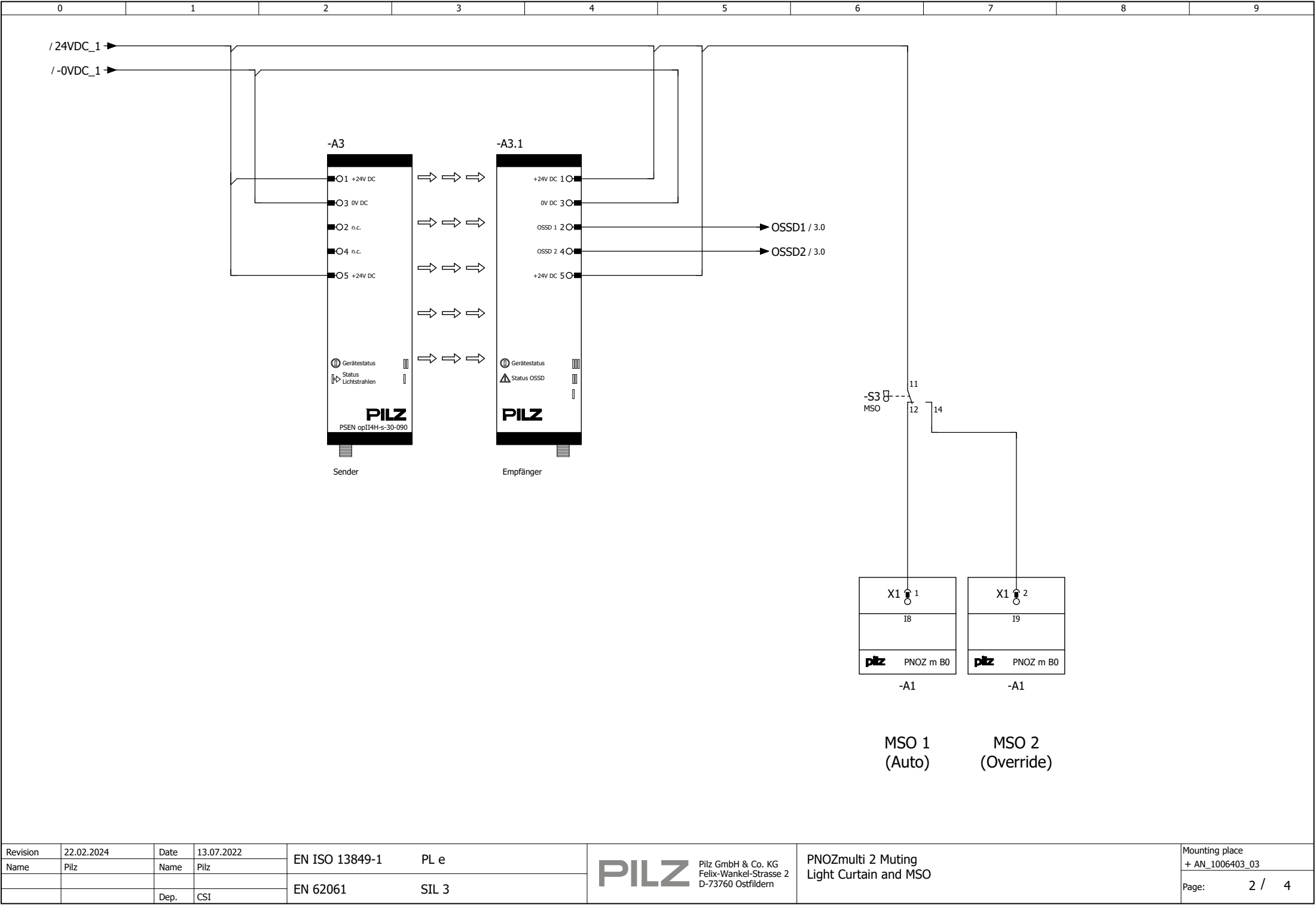
This means: only the conveyor M2 may be activated via the override switch S3, and not the hazardous machine M1. For this purpose, an appropriate interlocking device has been inserted, which only allows the output to be enabled when the permitted operating mode is active."

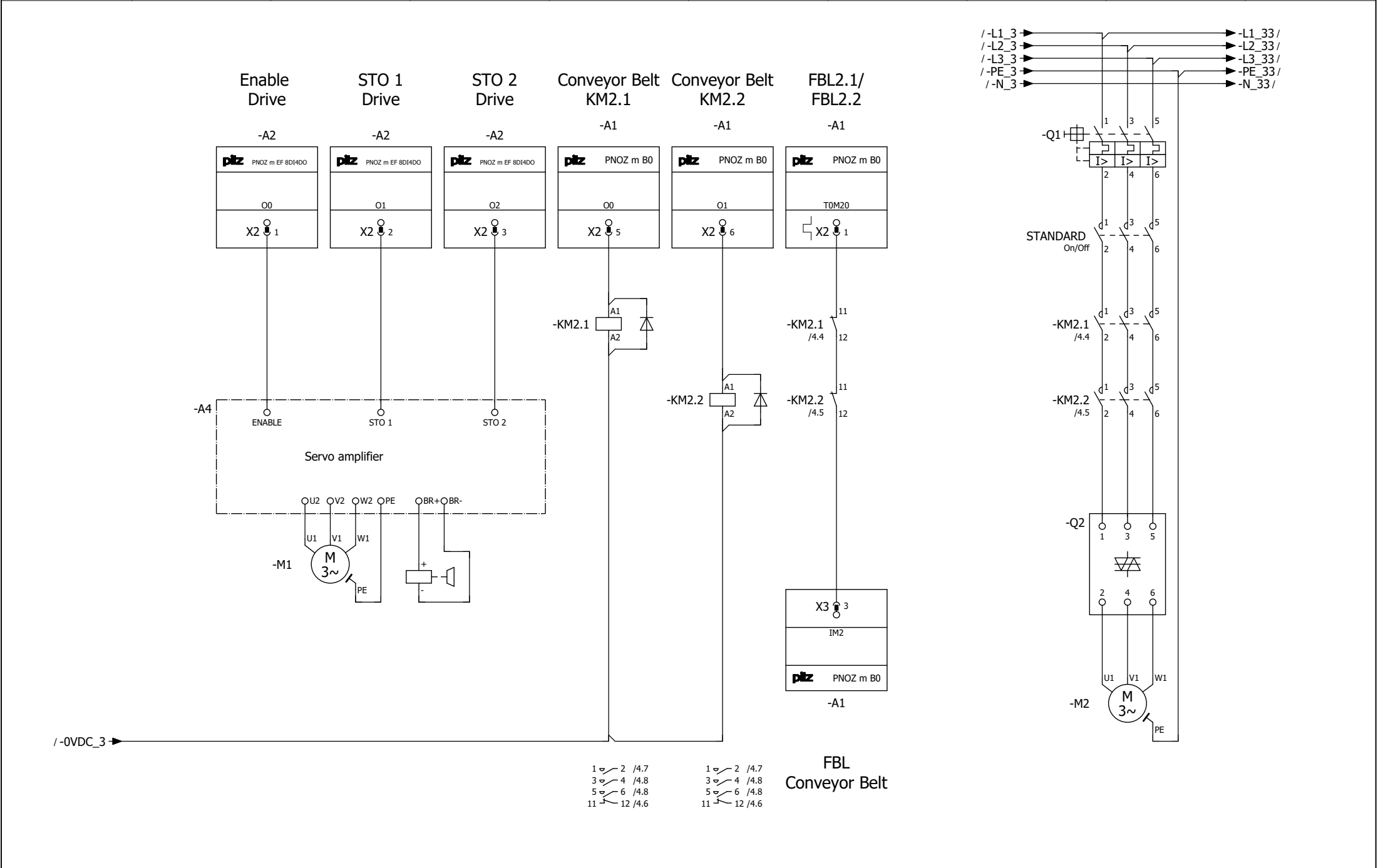


INFORMATION

- ▶ This application note does not illustrate operating mode selection (MSO Auto, *MSO Override*). This functionality can be implemented using the PNOZmulti element "Operating mode selector switch", for example.
- ▶ An emergency stopping device must be installed close to the override switch. The functionality of an emergency stop pushbutton can be implemented using the PNOZmulti element "*E-STOP*", for example. A description of this function is not part of this application note.







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► Support

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Americas

Brazil

+55 11 97569-2804

Canada

+1 888 315 7459

Mexico

+52 55 5572 1300

USA (toll-free)

+1 877-PILZUSA (745-9872)

Asia

China

+86 21 60880878-216

Japan

+81 45 471-2281

South Korea

+82 31 778 3300

Australia and Oceania

Australia

+61 3 95600621

New Zealand

+64 9 6345350

Europe

Austria

+43 1 7986263-0

Belgium, Luxembourg

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+49 711 3409-444

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Headquarters: Pilz GmbH & Co. KG, Felix-Wankel-Straße 2, 73760 Ostfildern, Germany
Telephone: +49 711 3409-0, Telefax: +49 711 3409-133, E-Mail: info@pilz.com, Internet: www.pilz.com

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