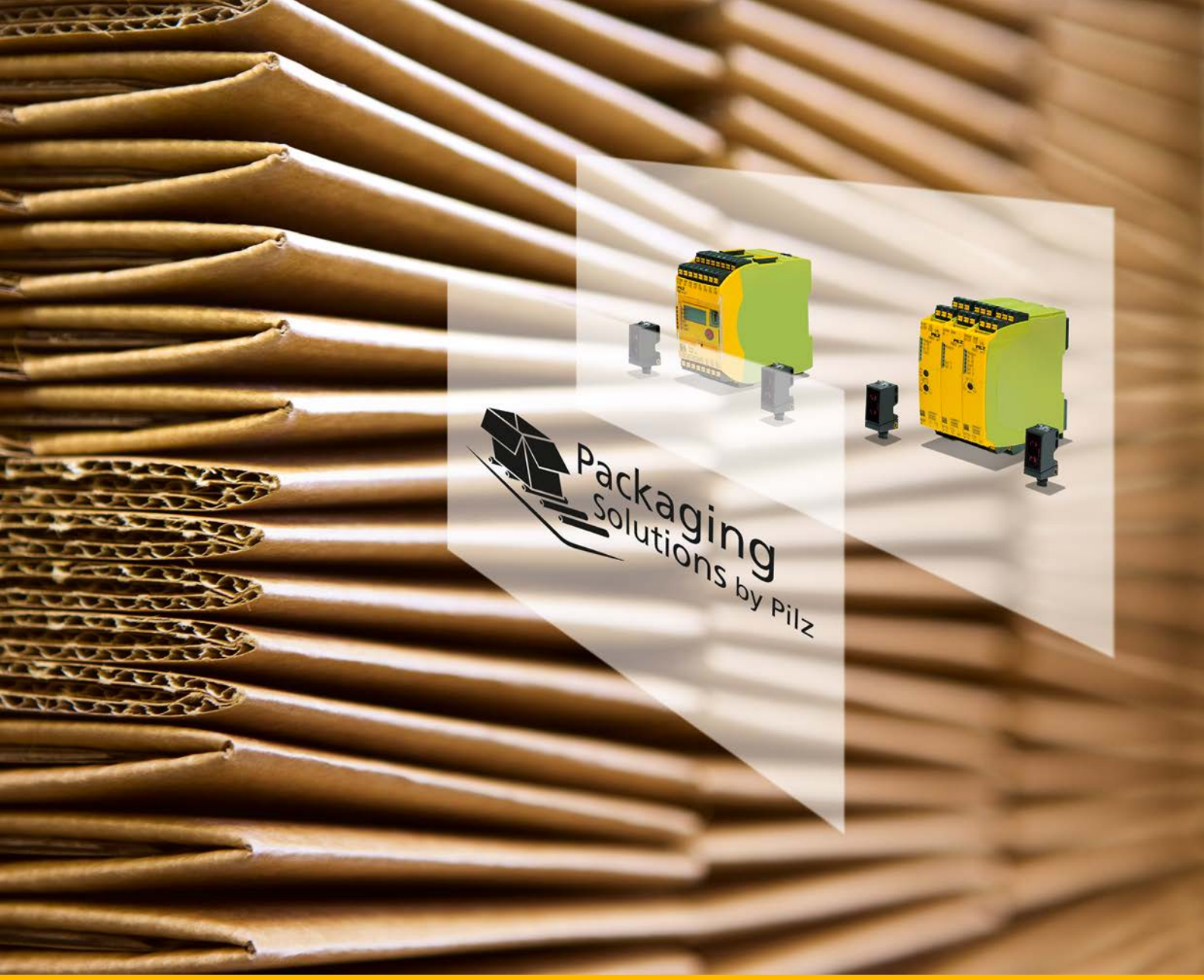

Safe monitoring of cardboard feed

PILZ
THE SPIRIT OF SAFETY

Solution description (1006148)
Status: January 2022

Disclaimer

Our white paper has been compiled with great care. It contains information about our company and our products. All details are provided in accordance with the current state of the art and to the best of our knowledge and belief. However, we cannot accept liability for the accuracy and entirety of the information provided, except in the case of gross negligence, as errors can never be completely avoided, despite the utmost care. In particular, it should be noted that statements do not have the legal quality of assurances or assured properties. We are grateful for any feedback on the contents of this operating manual.

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73760 Ostfildern

1st edition

Contents

1. Aim of document

This solution description contains the information necessary to install the safe monitoring solution for feeding cartons into a machine.
This includes the applicable phases of the solution's lifecycle:

- Installation
- Operation
- Maintenance
- Cleaning
- Decommissioning

2. Using the documentation

This document is intended for instruction. Only install and commission the solution if you have read and understood this document. The document should be retained for future reference.

3. General information

The operating manuals for the individual products shall apply. This solution description contains higher level requirements for implementing the application. In the event of any discrepancies between the operating manuals for the products and this solution description, the information provided in this solution description shall apply.

Read through all the operating manuals carefully and make sure you fully understand the contents before working on the safe monitoring solution for feeding cartons into a machine.

4. Safety regulations

4.1. Safety assessment

Before using this solution it is necessary to perform a safety assessment in accordance with the Machinery Directive.
Functional safety is guaranteed for the products PNOZmulti and myPNOZ as individual components. However, this does not guarantee the functional safety of the overall plant/machine. In order to achieve the safety level required for the whole plant/machine, the safety requirements must be defined for the plant/machine, as well as details of the technical and organisational implementation for the specific application.

4.2. Qualification of personnel

The products may only be assembled, installed, programmed, commissioned, operated, maintained and decommissioned by competent persons. A competent person is a qualified and knowledgeable person who, because of their training, experience and current professional activity, has the specialist knowledge required. In order to inspect, assess and handle products, systems and plant/machinery, this person must be familiar with the state of the art and the applicable national, European and international laws, directives and standards.
It is the company’s responsibility only to employ personnel who

- Are familiar with the basic regulations concerning health and safety / accident prevention
- Have read and understood the information provided in this description under "Safety regulations"
- Have a good knowledge of the generic and specialist standards applicable to the specific application

4.3. Warranty and liability

All claims to warranty and liability will be rendered invalid if

- The solution was used contrary to its intended purpose
- Damage can be attributed to not having followed the guidelines in this solution description or applicable operating manuals
- Operating personnel are not suitably qualified
- Any type of modification has been made (e.g. exchanging components on the PCB boards, soldering work etc.)

4.4. Disposal

- The solution was used contrary to its intended purpose
- Damage can be attributed to not having followed the guidelines in this solution description or applicable operating manuals
- In safety-related applications, please comply with the mission time T_M in the safety-related characteristic data of the products used
- When decommissioning, please comply with local regulations regarding the disposal of electronic devices (e.g. Electrical and Electronic Equipment Act).

4.5. For your safety

The products meet all the necessary conditions for safe operation. However, please note the safety provisions listed below:

- The solution description only describes the products' basic functions. The advanced functions are described in the online help for the PNOZmulti Configurator, in the "PNOZmulti Communication Interfaces" document and in "PNOZmulti Special Applications". Only use these functions if you have read and understood these documents
- You must follow the instructions in the "PNOZmulti Installation Manual"
- You must follow the instructions in the "PNOZmulti Safety Manual"
- You must follow the instructions in the "myPNOZ System Description"
- Do not open the product housing and do not make any unauthorised modifications
- Please make sure you shut down the supply voltage when performing maintenance work (e.g. exchanging contactors)

5. General description

When feeding material into a machine, there is a risk that the operator will reach into the running machine when there is too little material and injure himself in the process. To prevent this, it is necessary to monitor that there is always sufficient material in the infeed.

Figure 1 - Layout of cardboard feed

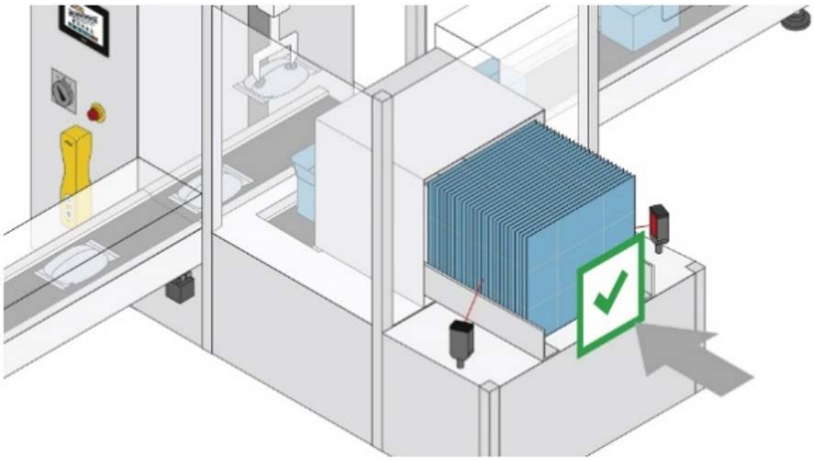

Figure 2 – Sufficient material in the cardboard feed

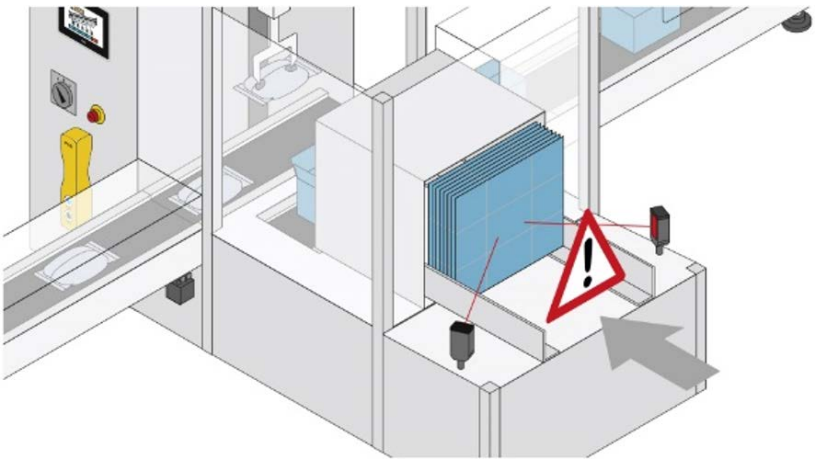

Figure 3 – Insufficient material in the cardboard feed

5.1. Solution components

Safe monitoring of cardboard feed is implemented using the following products

- Two optical sensors O300.GP.2-11246332 (diffuse sensor with background suppression) from Baumer Electric AG

in combination with

- A product from the range of small controllers PNOZmulti 2

or

- One of the following configurations of the modular safety relay myPNOZ
  - Type Code: myPNOZ.91.CKA360AB000XB700 (semiconductor outputs)
  - Type code: myPNOZ.03.CKA360AB000XD700 (relay outputs)
  - Individual configurations are possible under consideration of the notes from chapter 10.4

In the text below, the term PNOZmulti always refers to a product from the PNOZmulti 2 range.

5.2. Optical sensors

The optical sensor O300.GP.2-11246332 must be used to safely monitor cardboard feed.

5.3. Safety relay / small controllers

The optical sensors can be evaluated safely using products from the PNOZmulti 2 range. The benefit of this solution is that the function can be integrated into an existing application or additional functions can be implemented. For the solution described here, the PNOZmulti configuration must be equipped with the following inputs/outputs:

- 2 test pulse outputs
- 2 digital failsafe inputs for the optical sensors
- 1 digital failsafe output for the voltage supply to the optical sensors
- 1 digital input for the reset

The safety functions must be programmed as described in the sections below.

The optical sensors can be evaluated using myPNOZ instead of a PNOZmulti. myPNOZ is a fully configured safety relay, whose configuration is defined when ordered using the myPNOZ Creator via the Pilz eShop. The functions are defined as a result; no further programming is required and only the voltage supply and optical sensors need to be wired.

5.4. Solution’s boundaries

The solution for safe monitoring of the cardboard feed ends at the outputs of the PNOZmulti or myPNOZ.

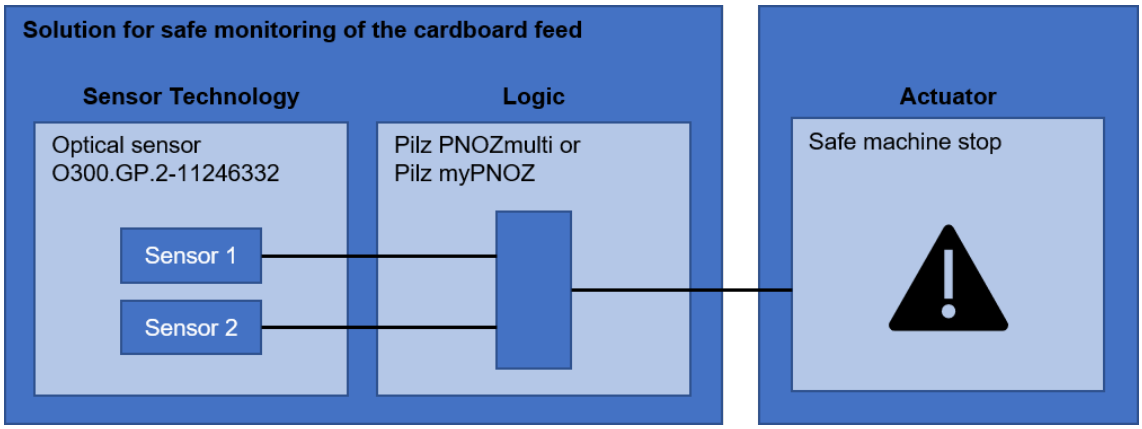

Figure 4 - Solution's boundaries

6. Intended use

The solution for safe packaging machinery is intended to safeguard cardboard feeds, during which the packaging material itself acts as the guard.

7. Misuse

The monitored packaging materials must offer sufficient strength and size to prevent manual intervention using parts of the body. The safety system is designed to monitor and evaluate the cardboard feed. When sizing the system, please comply with the requirements of EN ISO 13857 with regard to the maximum permitted opening sizes, depending on the distance from the danger zone. Should you have any questions regarding sizing, we recommend that you contact Pilz.

8. Safety function

The machine movement must be stopped when the carton magazine is empty or contains too few cartons.
If not, there is a danger that a person could reach the danger zone inside the machine with their hands or arms.

9. PNOZmulti 2

9.1. PNOZmulti versions

The following product versions are suitable for use in this solution:

9.1.1. PNOZ m B0

HW version: from Version 1.0
FW version: from Version 1.1

9.1.2. PNOZ m B0.1

Device version: from Version 3.0

9.1.3. PNOZ m B1

HW version: from Version 01
FW version: from Version 0100

9.1.4. PNOZ m C0

HW version: from Version 01
FW version: from Version 0100

9.1.5. PNOZmulti Configurator

All versions

9.1.6. Elements

The elements “safety gate” and “semiconductor output” are part of the product firmware.

9.2. Electrical wiring

To guarantee that cartons are monitored safely, the electrical wiring must be implemented as described in the points below

- The voltage supply (+Vs) to both optical sensors must be connected to a semiconductor output Ox on the PNOZmulti
- 0V on the optical sensors must be connected to 0V on the product
- The Tx connection on optical sensor 1 must be connected to test pulse output T0 on the PNOZmulti
- The Tx connection on optical sensor 2 must be connected to test pulse output T1 on the PNOZmulti
- The Ix output signals on the optical sensors must each be wired to a safe input on the PNOZmulti

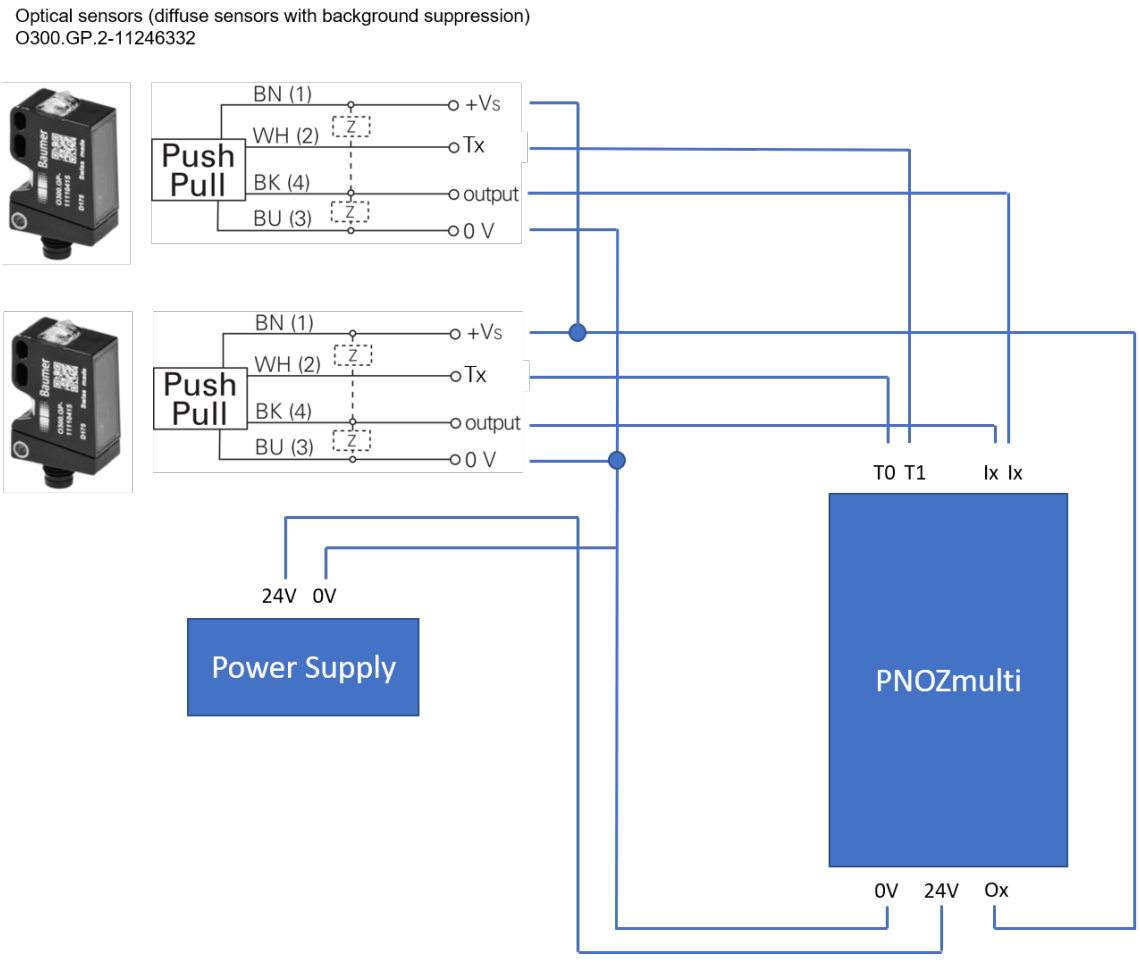

Figure 5 - Solution architecture PNOZmulti 2

9.3. PNOZmulti program

When using a PNOZmulti 2 small controller to evaluate the sensor signals, the "Safety gate" element with the following configuration must be used in the user program. **No other evaluation of the signals is permitted!**
To implement the voltage supply to the optical sensors via a semiconductor output, the "Semiconductor output" element must be used. The element's input is permanently set to TRUE via a result of a logic operation (RLO) 1. As a result, the optical sensors are supplied with voltage directly after the PNOZmulti is started.

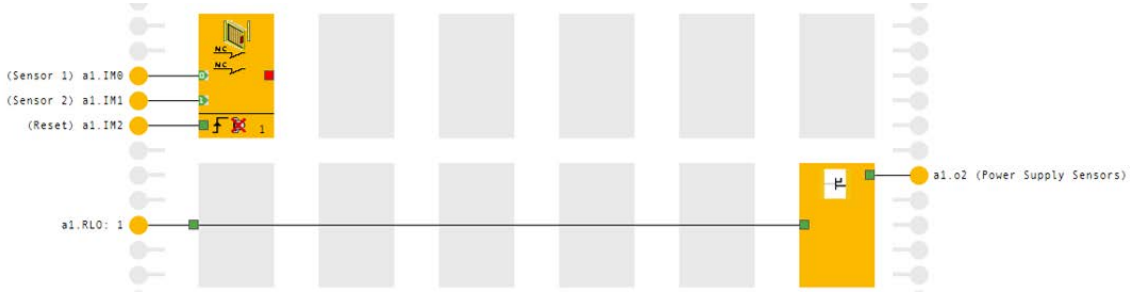

Figure 6 - PNOZmulti program

9.3.1.1. "Safety gate" element

To monitor both optical sensors, the certified "Safety gate" element must be used with "Type 3" as the switch type.

The time sequence for the safety gate element is as follows:

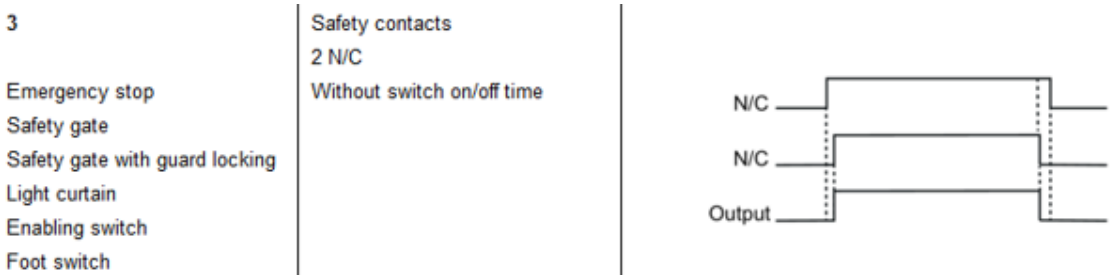

Figure 7 - Time sequence function element

Detection of shorts between contacts in the input circuit must be activated and test pulses T0 and T1 must be assigned to the inputs to which the optical sensors are connected. The configuration of the elements that are used is shown in Figures 8 to 10 below. The elements may only be used as illustrated below.

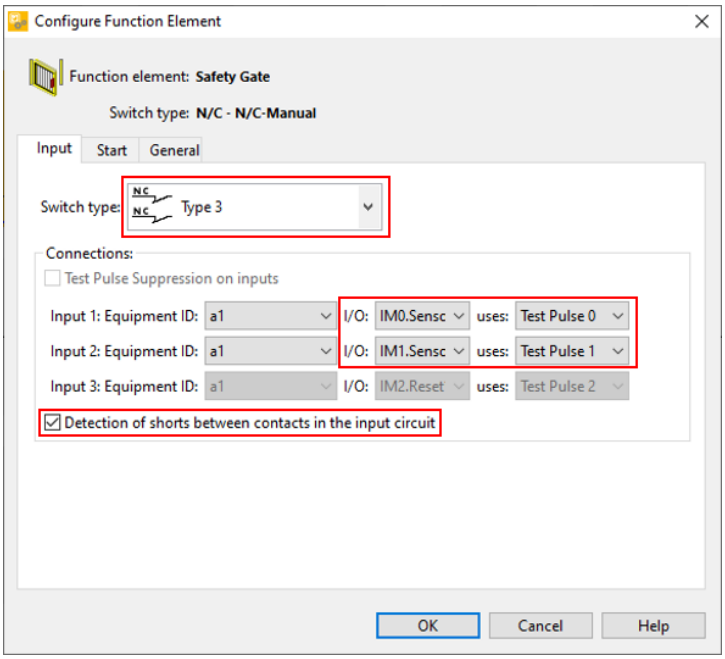

Figure 8 - Function element

To ensure that the element's output does not immediately go to TRUE when both input signals are HIGH, the "Manual start" start type must be configured. Therefore, a positive edge must be detected at the reset input, in order to switch the element's output to TRUE.
With Category 3 (EN 13849-1), a start-up test and shorts between contacts in the start circuit are not required.

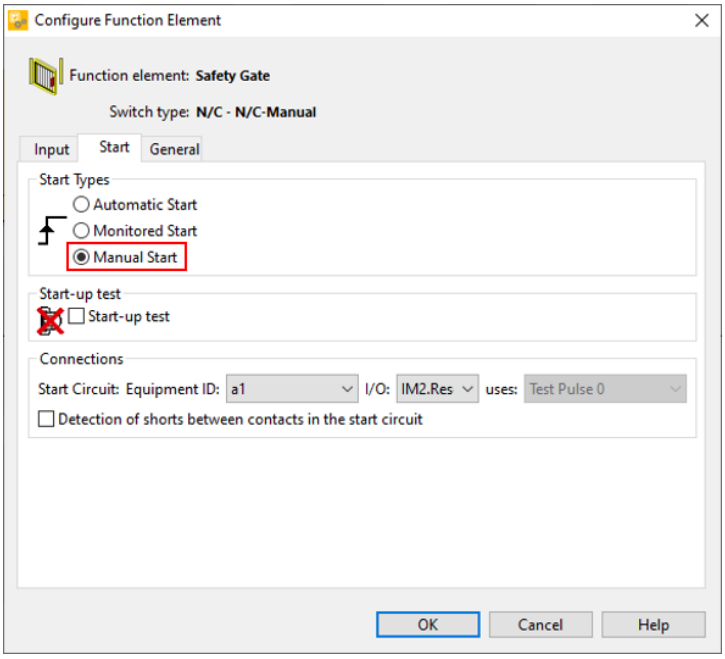

Figure 9 – Start function element

Options for resetting a partial operation error on the "Safety gate" element

If only one signal goes to FALSE at an input on the "Safety gate" element, PNOZmulti registers a partial operation error. To reset this partial operation error, the second channel must also briefly be FALSE. This can be achieved through the following options:

- Remove the cartons in the magazine
- Activate the optical sensors' close range (0mm – 30mm)
- Briefly switch off the semiconductor output, to which the optical sensors' voltage supply is connected

9.3.1.2. "Semiconductor output" element

To enable voltage to be supplied to the optical sensors via a semiconductor output, the "Semiconductor output" element must be used. The output's safety level must be selected as "Safety-related output". The number of outputs must be selected as "Single output". The feedback loop is not activated.

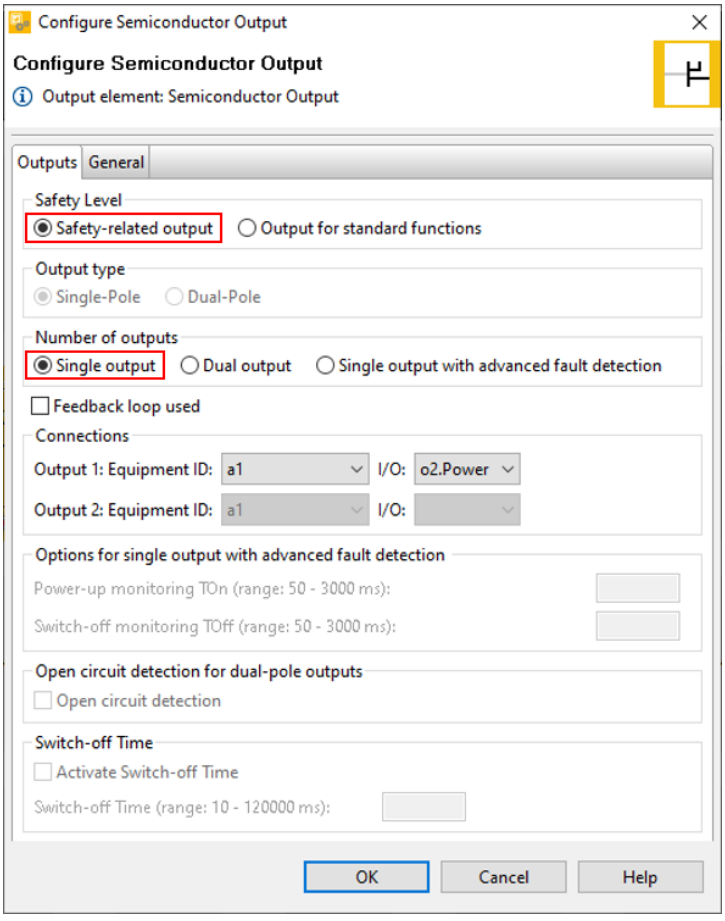

Figure 10 - Output element for voltage supply to the optical sensors

10. myPNOZ

10.1. Electrical wiring

To implement safe evaluation of the optical sensors using myPNOZ, you must use at least one head module yh1, one output module yo1 and one input/output module yio1or yio2.

10.1.1. Head module yh1

Due to the design, two situations are possible for the head module.

- If a global contact-based safety function (e.g. E-STOP) is to be used, it must be implemented using test pulses T1 and T2 and must be wired to inputs S11 and S12. The switch setting of the lower rotary switch must then be set to "Test pulse – Automatic".
- If a global safety function is used, which is wired to inputs S11 and S12 via OSSD outputs on another controller, the switch setting of the lower rotary switch must be set to "OSSD – Automatic".
- If no global safety function is used, the switch setting of the lower rotary switch must be set to "OSSD – Automatic" and inputs S11 and S24 must be wired to 24V.

As soon as inputs S11 and S12 are LOW, all outputs on all modules are switched off. The start setting is at "Automatic" due to the second switch on the device (see section 10.2), so all outputs are switched on as soon as inputs S11 and S12 are HIGH. The start input S15 must be permanently supplied with 24V.

10.1.2. Output module yo1

This module is used to implement the supply voltage to the optical sensors via a semiconductor output. Semiconductor outputs 14 and 24 are switched depending on the central safety function on the head module yh1 (inputs S11 and S12). Semiconductor output 14 serves as voltage supply to the optical sensors. If the central safety function issues the enable, the output is switched to HIGH after the myPNOZ is started. Feedback loop inputs Y14 and Y24 must be permanently bridged to 24V.

10.1.3. Input/output module yio1:

This module is used to read in the signals from both optical sensors and to switch the outputs for driving the actuators.
As soon as both optical sensors detect the cartons and a HIGH Signal is present at the safe digital inputs S11 and S12 of the myPNOZ, semiconductor outputs 14 and 24 can be switched to HIGH via a positive edge at the reset button. For this purpose, the reset button must be connected to digital input S15.
As soon as one of the two optical sensors detects no more cartons and the input signal at input S11 or S12 goes LOW as a result, outputs 14 and 24 must immediately be switched to FALSE. In this case there is a discrepancy between the two input signals S11 and S12, so the module displays a partial operation error. To rectify this error, both input signals S11 and S12 must briefly be LOW simultaneously.
If both optical sensors detect no more cartons simultaneously, i.e. both digital inputs S11 and S12 simultaneously change from HIGH to LOW, outputs 14 and 24 are also switched immediately to LOW. No partial operation error is generated in this case. Once both inputs S11 and S12 are HIGH again, outputs 14 and 24 can be switched back to HIGH via a positive edge at the reset button S15.

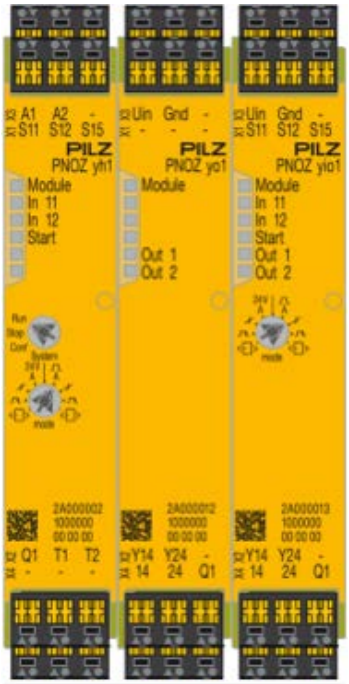

Figure 11 – myPNOZ with semiconductor outputs

10.1.4. Input/output module yio2

This module is used to read in the signals from both optical sensors and to switch the outputs for driving the actuators.
The function is as follows:
As soon as both optical sensors detect the cartons and a HIGH Signal is present at the safe digital inputs S11 and S12 of the myPNOZ, relay outputs 13/14, 23/24 and 33/34 can be switched to HIGH via a positive edge at the reset button. For this purpose, the reset button must be connected to digital input S15. As soon as one of the two optical sensors detects no more cartons and the input signal at input S11 or S12 goes LOW as a result, outputs 13/14, 23/24 and 33/34 must be changed to FALSE immediately.
In this case there is a discrepancy between the two input signals S11 and S12, so the module displays a partial operation error. To rectify this error, both input signals S11 and S12 must briefly be LOW simultaneously.
If both optical sensors detect no more cartons simultaneously, i.e. both digital inputs S11 and S12 simultaneously change from HIGH to LOW, outputs 13/14, 23/24 and 33/34 are also switched immediately to LOW. No partial operation error is generated in this case. Once both inputs S11 and S12 are HIGH again, outputs 13/14, 23/24 and 33/34 can be switched back to HIGH via a positive edge at the reset button S15.

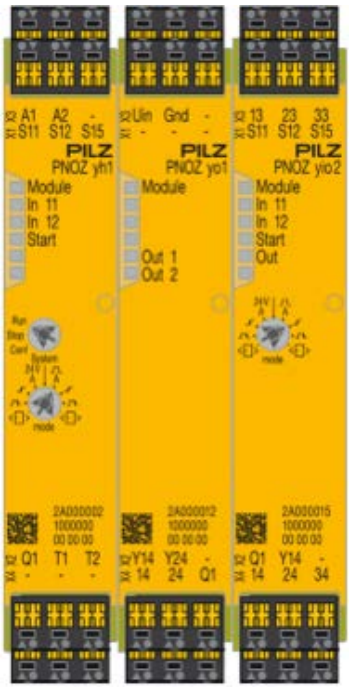

Figure 12 – myPNOZ with relay outputs

10.2. Switch settings

The switch settings on the myPNOZ modules must be as follows:

	System → Run Mode → Test pulse – Automatic or Mode → OSSD – Automatic
	Mode → Test pulse – Rising edge
	Mode → Test pulse – Rising edge

Table 1 – Switch setting myPNOZ modules

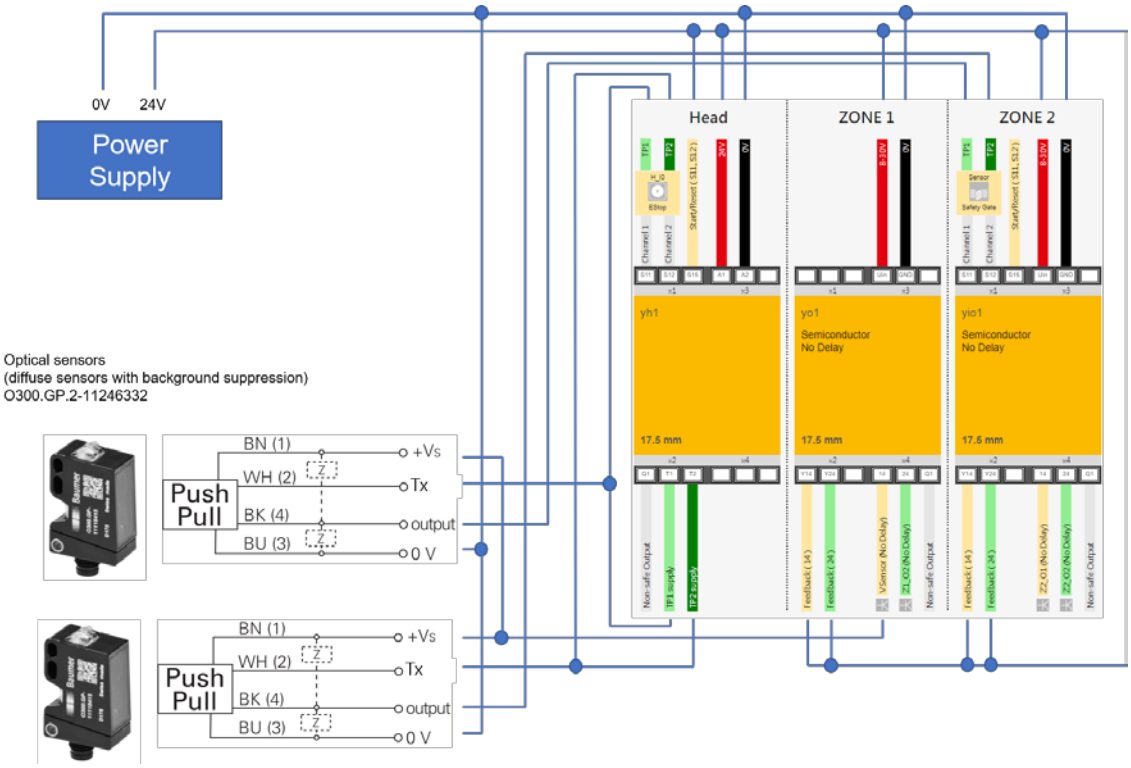

Figure 13 – Solution architecture myPNOZ with semiconductor outputs

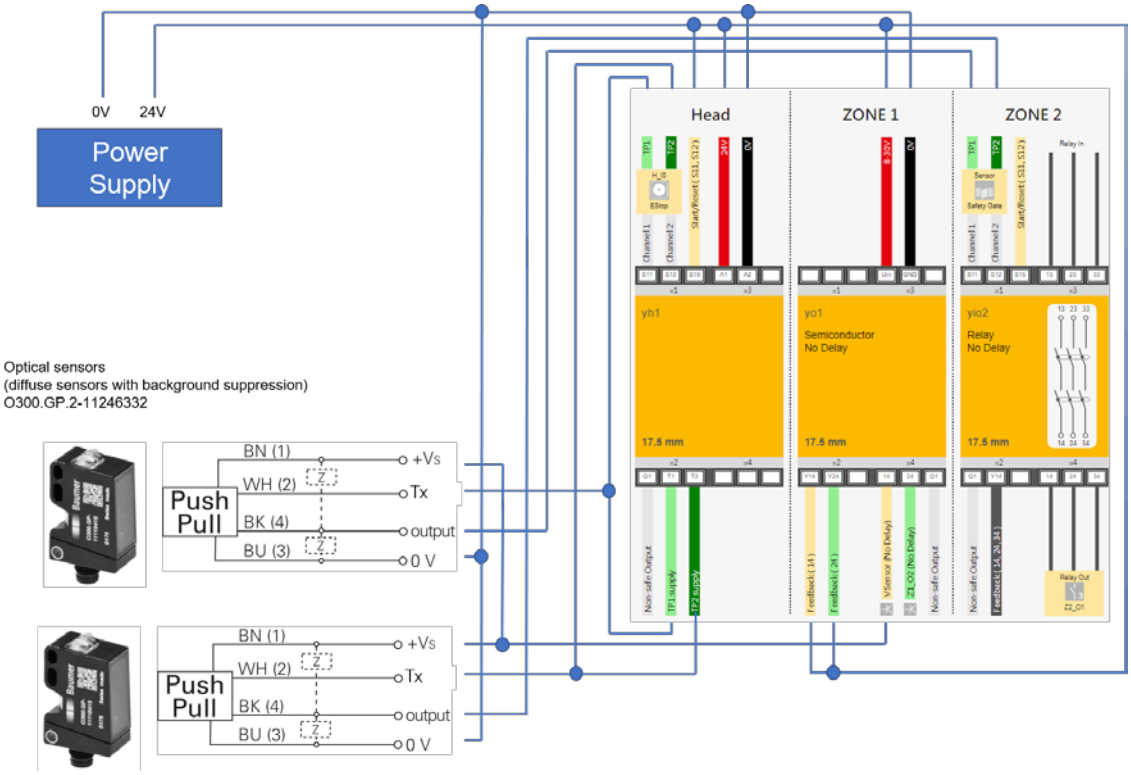

Figure 14 – Solution architecture myPNOZ with relay outputs

yh1

S11 / S12	Connection of an E-STOP or permanent connection to test pulse outputs / 24 V
Start / Reset	Reset of the E-STOP or permanent connection to 24 V
Q1	Signal output
T1 / T2	Test pulse supply to the optical sensors' diagnostic inputs

yo1

Y14	Permanent connection to 24V
Y24	Permanent connection to 24V
14	Semiconductor output for 24 VDC control voltage for voltage supply to optical sensor 1 and 2
24	Free
Q1	Signal output

yio1

S11	Connection for output of optical sensor 1
S12	Connection for output of optical sensor 2
S15	Reset button
Q1	Signal output
14 / 24	Semiconductor outputs for safety function "Monitoring of cartons through optical sensors"
Y14	Permanent connection to 24V
Y24	Permanent connection to 24V

yio2

S11	Connection for output of optical sensor 1
S12	Connection for output of optical sensor 2
S1	Reset button
Q1	Signal output
Y14	Feedback loop if present, otherwise permanent 24V
14 / 24 / 34	Relay outputs for safety function "Monitoring of cartons through optical sensors"

Figure 15 - Connection diagram myPNOZ with semiconductor outputs

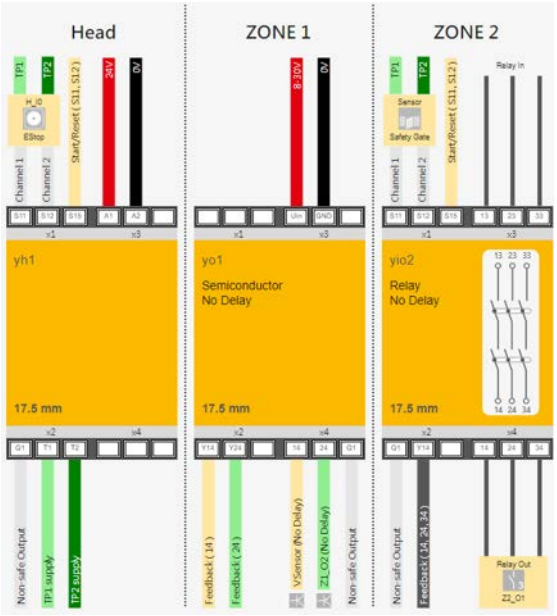

Figure 16 - Connection diagram myPNOZ with relay outputs

10.3. Zones

2 zones are required on the myPNOZ. The voltage supply to the optical sensors is implemented with zone 1. Zone 2 is responsible for safe evaluation of the optical sensors.

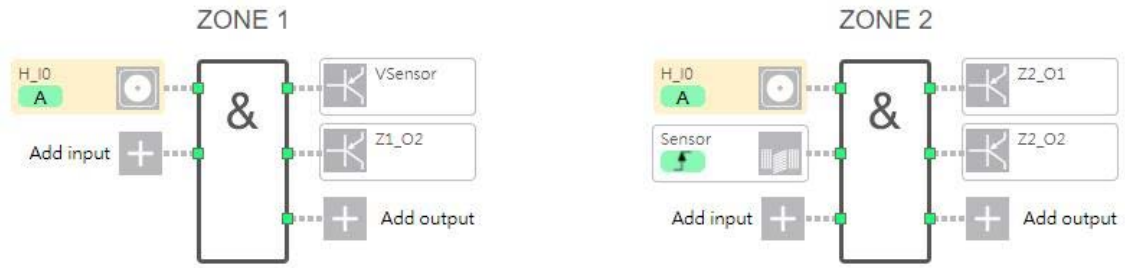

Figure 17 – myPNOZ zones

10.4. myPNOZ expanded with further safety functions

The first three myPNOZ modules must be inserted and wired as described in the previous sections. The switch setting must also be adopted as described. From the fourth myPNOZ module onwards, further modules and therefore zones can be added.

11. Optical sensors

The mechanical installation of the optical sensors must be carried out as described below.

11.1. Installation

The optical sensors must be installed in such a way that the object to be detected (an end face of the carton stack) is within the detection range of 30mm to 100mm.

- Attach the optical sensors to both fixing points
- Only use self-locking nuts
- Use washers
- Align the fixing screws before tightening them up
- The maximum tightening torque is 0.8Nm for the fixing point with metal sleeve and 0.4Nm for the fixing point without metal sleeve

11.2. Alignment

The optical sensors must point to two different areas of the end faces on the carton stack. It's important that the beam from the optical sensors doesn't just detect the last carton in the magazine. There must always be sufficient cartons in the infeed to prevent anyone reaching into the machine.

The optical sensors have a non-adjustable detection range of 30mm to 100mm. The distance from the end face of the carton stack should ideally be 40mm to 60mm.

The optical axis of the sensors should be aligned to the end face of the carton stack, at a slight angle (10° to 40°) to the cartons' direction of travel, so that the beam cannot enter the gap between the cartons and therefore be unable to detect an object.

The optical axis of the sensors should be aligned to the end face of the carton stack, at a slight incline (10°) towards the connector outlet transversely to the direction of travel, so that not even a small amount of light from the object is reflected back to the optical sensor.

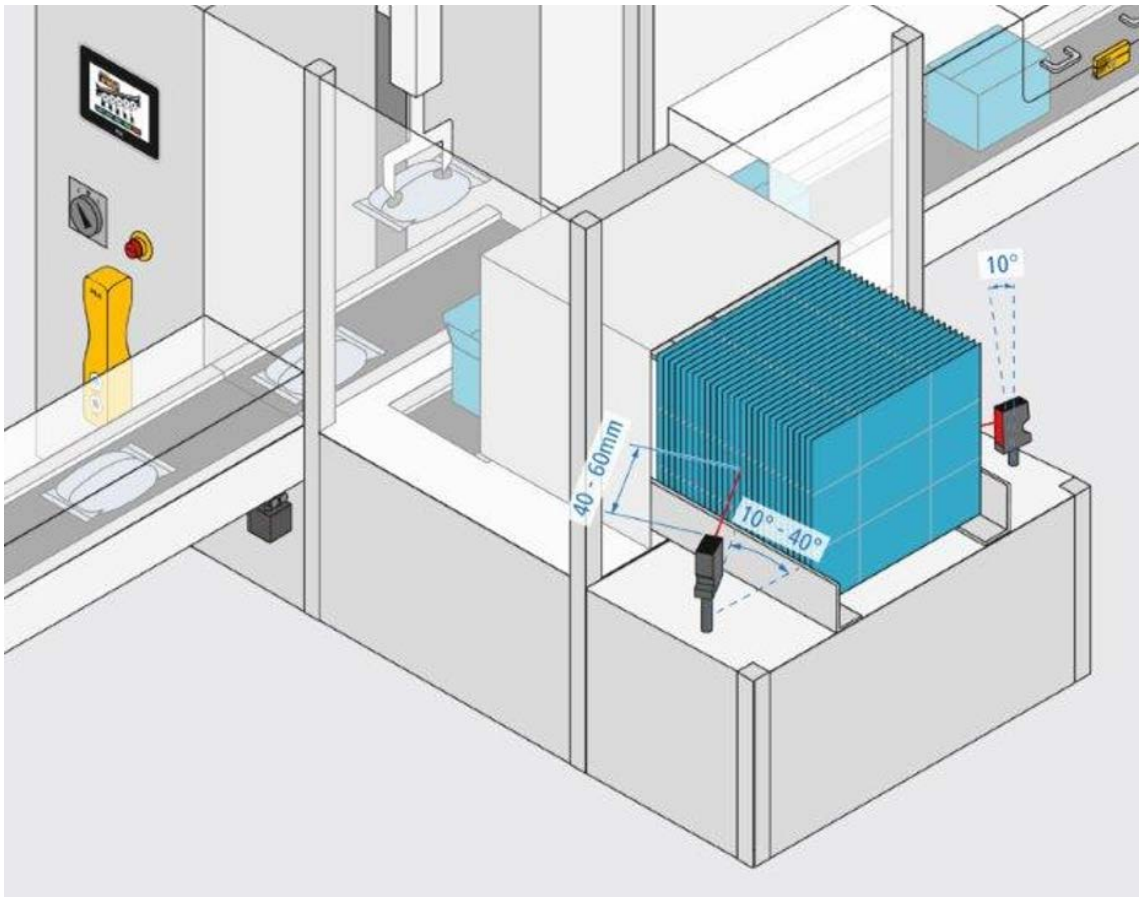

Figure 18 – Alignment of the optical sensors

When there are no cartons present, the rays from one optical sensor must not be directed at the other optical sensor. A reflective surface on the carton (e.g. due to plastification) should also be taken into consideration.

11.3. Properties of the optical sensors

Objects to be detected should have a diffuse reflection of between 2% (ultra black carton surface) and 90% (white carton surface).

11.4. Factors that interfere with the optical sensors

- Very dark object surfaces and surfaces that do not diffuse the optical sensor's beam but rather change its direction, are not permitted. This applies in particular to retroreflective, shiny, reflective, holographic and transparent surfaces. It also applies for extending the beam path and detection range when there are no objects (cartons) present
- Light sources should be prevented when extending the beam path and detection range
- Direct sunlight on or in the detection range should be prevented
- Illumination of the optical sensors with external light should be prevented
- Dust and dirt on the optical sensor's front cover should be prevented
- Moisture, in particular liquid drops, are not permitted on the optical sensor
- Keep aggressive substances away from the optical sensor (recommendation: clean using a dry, lint-free cloth)

If these interfering factors cannot be avoided, appropriate tests must be carried out to check and guarantee the correct function of the optical sensors.

If there are interfering factors due to surfaces or objects when extending the beam path, the optical sensors must either be angled differently or the surfaces or objects removed, angled, covered, matted or black varnished.

12. Commissioning

12.1. Validation

The basic validation procedure is described in the Pilz Safety Compendium (webcode 150626). The following points must also be considered:

- The specifications stated in the solution description and operating manuals for the individual components must be observed
- The safety function must be triggered as soon as one of the two optical sensors detects no material
- All components must be selected and wired correctly
- The created PNOZmulti program / positioning and switch setting of the myPNOZ modules must match this solution description
- The optical sensors must be installed and aligned correctly
- It must not be possible to manipulate the system by changing the position of the optical sensors or by introducing an object into the response range
- The application-specific reaction times must be determined and validated
- The worst case reaction time for the PNOZmulti with relay outputs (incl. optical sensors) is 62ms
- The worst case reaction time for the myPNOZ with relay outputs (incl. optical sensors) is 42ms
- The reaction times of the individual components are listed in the operating manuals among the technical details
- It is essential to work through the check lists (Chapter 16)

12.2. Verification of the configuration

The configuration must be verified in both versions (see EN ISO 13849-1 Clause 4.)

13. Regular function test

To detect whether both optical sensors operate without error, a function test must be carried out on the optical sensors at regular intervals (e.g. when changing material), but at least once per year.

14. Maintenance / care

The optical sensors should be inspected regularly and cleaned if necessary. A dry, dust and lint-free cloth (microfibre cloth) should be used for cleaning.

15. Troubleshooting

Diagnostics on all devices is via LEDs. A description of the LEDs and remedies are described in the respective operating manual for the individual products. When the PNOZmulti is used there is also the option to read the device's error stack using the PNOZmulti Configurator.

16. Check lists

Check lists for planning, configuration, installation, commissioning and maintenance / change can be found in the PNOZmulti Safety Manual.
You must also work through the following check list.

	OK	Not OK
Does the monitored material prevent access to the danger zone?	☐	☐
Does the safeguard comply with the required PL/SIL and PFHd in accordance with EN ISO 13849-1 / EN 62061?	☐	☐
Have protective measures been taken to prevent reaching over or under and to protect against manipulation?	☐	☐
Have the optical sensors been installed as described in the documentation?	☐	☐

Table 2 - Check list

17. Technical details

The environmental conditions, along with all other technical details, are listed in the operating manuals for the individual products, under "Technical details". As the optical sensors are installed in the field and the evaluation devices in the control cabinet, the environmental conditions may differ. The technical specifications are contained in the following documents:

- O300.GP.2-11246332 O300.GP.2-11246332_XX_yyyymmdd_DS
- Pilz myPNOZ myPNOZ_System_Description_1005377-XX-XX.pdf
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