PGV100A-F200*-B28-V1D / PGV100AQ-F200*-B28-V1D (safePGV)

Data Matrix Positioning System for Automated Guided Vehicles (AGV)

Instruction

PL e

SIL 3

Your automation, our passion.

PEPPERL+FUCHS

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1 Introduction

1.1 Content of this Document

This document contains safety-relevant information for using the device. This information is required to use the product in the relevant phases of the product life cycle. This may include information on the following:

- Product identification
- Delivery, transport, and storage
- Mounting and installation
- Commissioning and operation
- Maintenance and repair
- Troubleshooting
- Dismounting
- Disposal

Note

Availability of the Complete Product Documentation

Full information about the product can be found in the product documentation online at www.pepperl-fuchs.com. This documentation can be accessed by entering the product name (type code) or the item number of the product into the search field on the website.

The documentation comprises the following parts:

- Original instructions (this document)
- Instruction manual
- EU declaration of conformity
- Datasheet

For more information about Pepperl+Fuchs products with functional safety, see www.pepperl-fuchs.com/sil.

1.2 About This Documentation

Note on Figures in the Documentation

The figures in this documentation are provided for basic understanding and may deviate from the actual design.

1.3 Symbols Used

This document contains symbols for the identification of warning messages and of informative messages.

Warning Messages

You will find warning messages, whenever dangers may arise from your actions. It is mandatory that you observe these warning messages for your personal safety and in order to avoid property damage.

Depending on the risk level, the warning messages are displayed in descending order as follows:

Danger!

This symbol indicates an imminent danger.

Non-observance will result in personal injury or death.

Warning!

This symbol indicates a possible fault or danger.

Non-observance may cause personal injury or serious property damage.

Caution!

This symbol indicates a possible fault.

Non-observance could interrupt the device and any connected systems and plants, or result in their complete failure.

Informative Symbols

Note

This symbol brings important information to your attention.

Action

This symbol indicates a paragraph with instructions. You are prompted to perform an action or a sequence of actions.

2 Safety Information

Read the information in this document carefully and observe this information when working with the device. Failure to observe the safety information and warning messages in this documentation can lead to malfunctions of the safety devices of the machines or plants in which they are fitted.

This can result in serious personal injury or death.

Target Group, Personnel

Responsibility for planning, assembly, commissioning, operation, maintenance, and dismounting lies with the plant operator.

The personnel must be appropriately trained and qualified in order to carry out mounting, installation, commissioning, operation, maintenance, and dismounting of the device. The trained and qualified personnel must have read and understood the instruction manual.

Prior to using the product make yourself familiar with it. Read the instruction manual carefully.

Reference to Further Documentation

Observe laws, standards, and directives applicable to the intended use and the operating location.

3 Product Description

3.1 Components of the Positioning System

The positioning system described in these original instructions consists of the following components:

- Reader PGV100A-F200*-B28-V1D / PGV100AQ-F200*-B28-V1D (safePGV), hereinafter referred to as "reader."
- 2-colored Data Matrix code tapes PXV*-AA25-* and PXV*-AAM*-*, specially developed for this safety application, hereinafter referred to as "Data Matrix code tape."

3.2 Intended Use

This reader, which works with a special stationary two-colored Data Matrix code tape affixed to the ground, is a high resolution positioning system. It can be used in all applications where automated guided vehicles (AGV) are to be positioned precisely at marked positions along a given track.

The reader forms part of the positioning system in the Pepperl+Fuchs incident light process. The device's features include a camera module with an internal illumination unit, which follows a parallel stationary Data Matrix code tape affixed to the ground to detect a safe position according to SIL 3/PL e. The reader is located on an automated guided vehicle (AGV), for which it outputs the position data.

The positioning system outputs safe values, which achieve a degree of reliability as required by SIL 3 and PL e. The prerequisite for this is that the positioning device is integrated into the plant and operated within the safe parameters, as described in these original instructions.

Ensure that this device is only used in accordance with the technical specification described in these instructions with the approved Data Matrix code tape.

The device is only approved for appropriate and intended use. Ignoring these instructions will void any warranty and absolve the manufacturer from any liability.

3.3 Improper Use

Protection of the personnel and the plant is not ensured if the device is not used according to its intended use.

The device must not be used in an explosion-hazardous area.

3.4 Safety Concept

The reader forms part of the positioning system in the Pepperl+Fuchs incident light process. The device's features include a camera module with an internal illumination unit, which follows a parallel stationary Data Matrix code tape affixed to the ground to detect a safe position according to SIL 3/PL e. The reader is connected to PROFIsafe and is located on an automated guided vehicle (AGV), for which it outputs position data.

To achieve SIL 3/PL e, a single reader connected to PROFIsafe with the appropriate Data Matrix code tape is required.

Note

Note the Type of Code Tape!

The positioning system only works if the reader is used together with one of the 2-colored Data Matrix code tapes of the following type: PXV*-AA25-* or PXV*-AAM*-*.

The use of other code tapes is not permitted!

To achieve SIL 3/PL e, a single reader connected to PROFIsafe with the appropriate 2-colored Data Matrix code tape is required.

Reader Functionality

The reader offers reliable operation thanks to the 2-colored red/blue lighting of the camera module. In an algorithm evaluated as safe, the 2-color, red/blue Data Matrix code tape is also illuminated and the function of the camera module is continuously monitored.

Note

Reader Behavior Without PROFIsafe

If the reader is operated without PROFIsafe communication, it flashes red only and does not output safe X position data.

If the red LED ring of the reader is active, the blue and black areas are visible in the Data Matrix code. If the blue LED ring of the reader is active, the red and black areas are visible in the Data Matrix code.

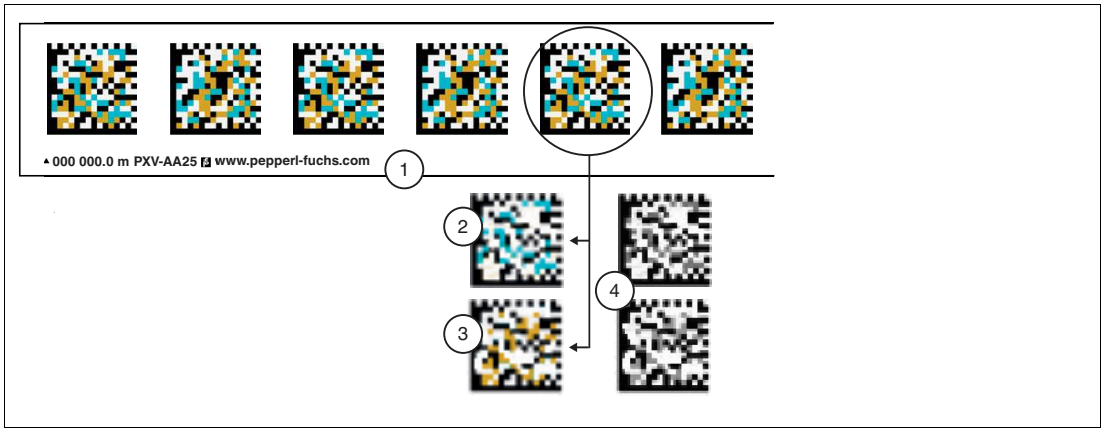

Figure 3.1 Functional principle: Data Matrix code tape for safe positioning

1 2-colored Data Matrix code tape

2 Data Matrix code with red lighting

3 Data Matrix code with blue lighting

4 Monochrome Data Matrix codes

The use of the two colors by the camera module and Data Matrix code tape and the inspection by a built-in intelligent algorithm guarantee the redundant 2-channel detection of the X position data, thus ensuring reliable operation according to SIL 3/PL e.

During positioning, the reader uses all non-safe position data. In addition to the non-safe X position, this includes the Y and Z position, angle, speed, error bit, and warning bit.

During positioning, the reader checks whether the reliably determined 2-channel X position data for navigation is within the tolerance range, i.e., within the dimensions of the safety-related reading range of the X safety data.

3.5 Dimensions of the Components of the Positioning System

Dimensions of the Reader

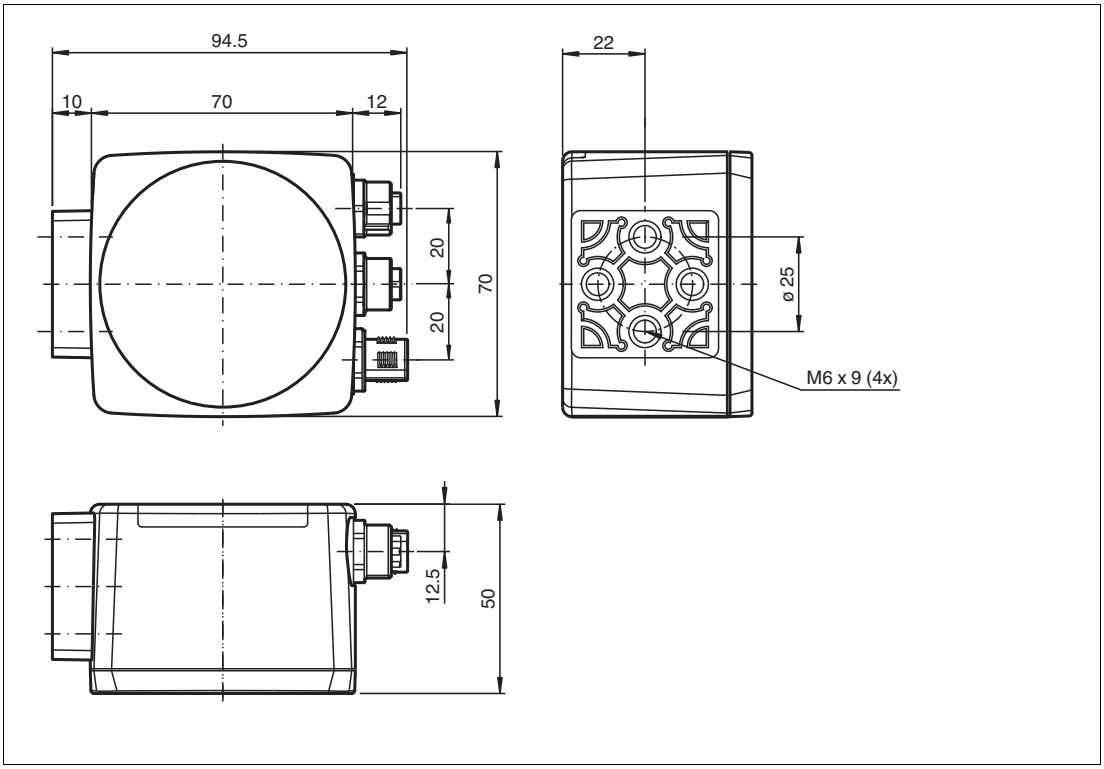

Figure 3.2 Dimensions of PGV100A-**F200A**-B28-V1D

Dimensions of the Reader

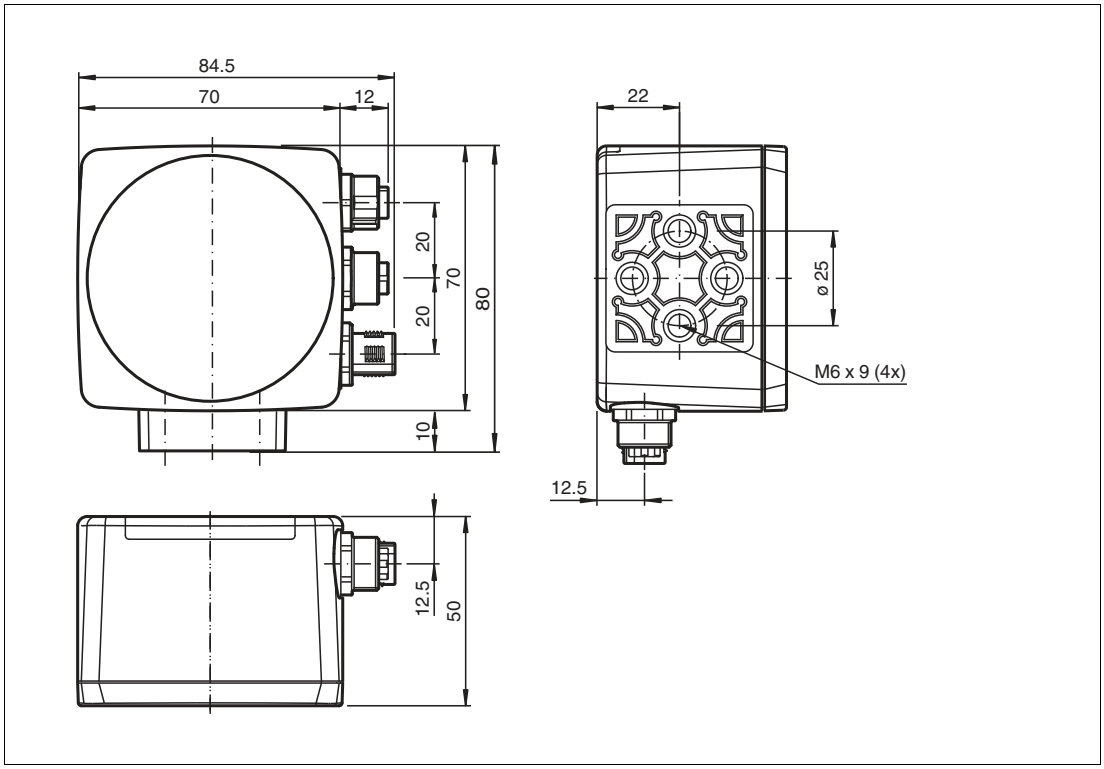

Figure 3.3 Dimensions of PGV100A-**F200**-B28-V1D

Dimensions of the Data Matrix Code Tape

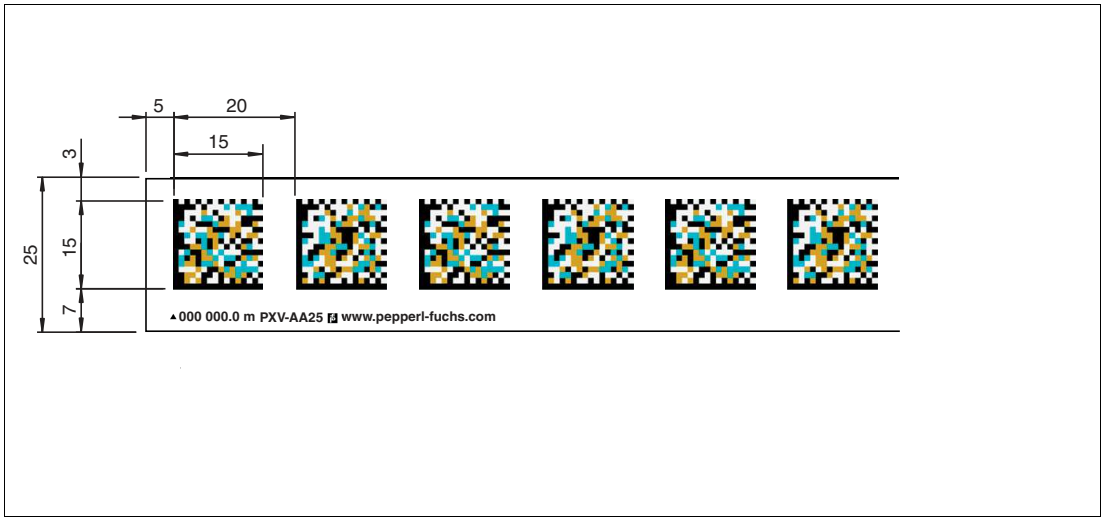

Figure 3.4 Dimensions of the Data Matrix code tape

3.6 LED Indicators and Operating Elements

The reader has 7 indicator LEDs for carrying out visual function checks and quick diagnosis. LEDs 5 and 6 have no function.

The reader has the following 2 buttons on the back of the device:

- Key 1: SERVICE: used for internal service purposes.
- Key 2: NO FUNCTION: without function.

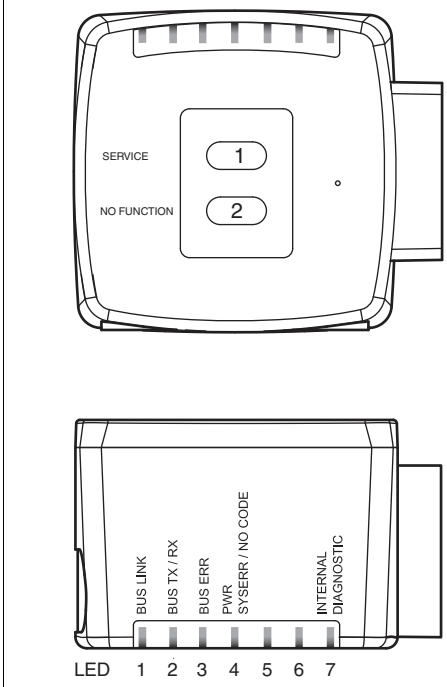

Figure 3.5 Displays and Operating Elements

Description of the LED Indicators

LED no.	Status	Description
1	Lights up green	PROFINET connection activated
2	Flashes yellow	PROFINET TX/RX data transfer
3	Lights up red	PROFINET communication error
4	Lights up red	System error
	Lights up green	Normal operation, Data Matrix code tape detected
	Flashes red	Data Matrix code not recognized
7	Lights up red	Internal error -> return delivery to Pepperl+Fuchs

Table 3.1 State and description of the LED indicators

3.7 Accessories

Compatible accessories offer potential for cost savings when commissioning, replacing, and servicing our products.

If products are used in harsh ambient conditions, appropriate Pepperl+Fuchs accessories can be used to extend the service life of these products.

Model number	Description
PXV*-AA25-*[1]	2-colored Data Matrix code tape, total length up to 100,000 m. Minimum length of 1 m, start position and length indicated in meters
V19-G-ABG-PG9-FE	Grounding terminal and plug (set)
PCV-SC12 PCV-SC12A	Grounding clip
PCV-AG100	Alignment guide
V1SD-G-*M-PUR-ABG-V1SD-G	PROFINET bus cable, M12 to M12, available in several different lengths
VAZ-V1S-B	Stopping plug for M12 plug
V19-G-*M-*	Configurable connection cable[2]

1. The type code of a Data Matrix code tape with the start position "0" always ends in "0" and is indicated in meters.
2. For further information, contact your contact person at Pepperl+Fuchs.

3.8 Marking

Pepperl+Fuchs Group Lilienthalstraße 200, 68307 Mannheim, Germany
Internet: www.pepperl-fuchs.com

PGV100A-F200A-B28-V1D, PGV100A-F200-B28-V1D	Bis SIL 3, PL e
PGV100AQ-F200*-B28-V1D	Bis SIL 3, PL e

3.9 Technical Specifications

3.9.1 Reader

General specifications

Passage speed	≤ 8 m/s
Measuring range	max. 100000 m
Light type	Integrated LED lightning (red/blue)
Read distance	100 mm
Depth of focus	± 30 mm
Field of view	typ. 120 mm x 80 mm
Sensor principle	Camera system
Ambient light limit	30000 Lux
Accuracy	
Non safety-related X, Y	± 0.2 mm
Non safety-related angle α	± 0.5 °

Nominal ratings

Camera	
Type	CMOS , Global shutter
Processor	
Clock pulse frequency	600 MHz
Speed of computation	4800 MIPS
Digital resolution	32 Bit

Functional safety related parameters

Safety Integrity Level (SIL)	SIL 3
Performance level (PL)	PL e
Category	Cat. 4
Reaction time	165 ms
MTTF	41 a
$MTTF_d$	104.74 a
Mission Time (T_M)	20 a
PFH	1.09 E-8 typ.

Indicators/operating means

LED indication	7 LEDs (communication, status messages)

Electrical specifications

Operating voltage	20 ... 30 V DC , PELV
No-load supply current	max. 300 mA
Power consumption	6 W

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Warning!

Damage to electrical components due to overvoltage

Operating the reader with a power supply that delivers a voltage of > 36 VDC can cause damage to electrical components in the device.

- Never apply more than 36 VDC to the device. Make sure that you use a PELV circuit for the electrical supply in accordance with IEC/EN 60204-1. Observe the general requirements for PELV circuits. The power supply used must meet the requirements according to SELV/PELV (IEC 60364-4-41:2005).
- If you have accidentally applied more than 36 VDC, then proceed as follows:
  - Take the device out of operation immediately. A faulty device must not be operated.
  - Send the device to the manufacturer, specifying the reasons or circumstances for the inspection.

Interface

Interface type	100 BASE-TX
Protocol	PROFINET IO Real-Time (RT) Conformance class B
Transfer rate	100 MBit/s

Ambient conditions

Operating temperature	0 ... 45 °C (32 ... 113 °F) , -20 ... 45 °C (-4 ... 113 °F) (noncondensing; prevent icing on the lens!)
Storage temperature	-40 ... 85 °C (-40 ... 185 °F)
Relative humidity	90 % , noncondensing
Altitude	max. 2000 m above MSL

Mechanical specifications

Connection type	8-pin, M12x1 connector, standard 4-pin, M12x1 socket, D-coded (LAN) 4-pin, M12x1 socket, D-coded (LAN)
Housing width	70 mm
Housing height	70 mm
Housing depth	50 mm
Degree of protection	IP67
Material	
Housing	PC/ABS
Mass	approx. 200 g

Conformity

Fieldbus standard	PROFIsafe in accordance with IEC 61784-3-3; profile 2.4
Functional safety	EN ISO 13849-1:2015 ; EN 61508:2010 part 1-7 ; EN 62061:2005 + AC:2010 + A1:2013 + A2:2015
Shock resistance	EN 60068-2-27:2009
Vibration resistance	EN 60068-2-6:2008
Emitted interference	EN 61000-6-4:2007+A1:2011
Noise immunity	EN 61000-6-7:2015
Photobiological safety	risk group 2 according IEC 62471

Approvals and certificates

CE conformity	CE
CCC approval	CCC approval / marking not required for products rated ≤36 V
TÜV approval	TÜV Rheinland 01/205/5669.00/18

3.9.2 Data Matrix Code Tape

General Data

Start position	0 ... 99,999 m (see order information)
Length	1 ... 100,000 m (see order information)
External diameter	Max. 180 mm (with max. code tape length of 100 m)
Internal diameter	76 mm (reel core)

Ambient Conditions

Operating temperature	-40 ... 150 °C (-40 ... 302 °F)
Installation temperature	10 ... 40 °C (50 ... 104 °F)
Environmental resistance	UV radiation humidity salt spray (150 hours/5 %)
Chemical resistance	Oils fats fuels aliphatic solvents weak acids

Mechanical Data

Material thickness	150 µm
Material	Polyester laminate
Finish	Polyester, matt
Weight	6.3 g/m
Tensile strength	≥ 150 N
Adhesive	Acrylate-based adhesive; curing 72 hours
Adhesive strength	Average values (FTM2) aluminum : 24 N/25 mm stainless steel : 25 N/25 mm ABS : 22 N/25 MM PP : 18 N/25 mm HD-PE : 12 N/25 mm LD-PE : 12 N/25 mm
Note	Max. code tape length of 100 m per roll

3.10 Standards and Directives for Functional Safe

Device specific standards and directives

Functional safety	IEC/EN 61508, part 1 – 7, edition 2010: Functional safety of electrical/electronic/programmable electronic safety-related systems (manufacturer)

Machinery Directive 2006/42/EC	• EN/ISO 13849, part 1, edition 2015: Safety-related parts of control systems (manufacturer) • IEC 62061, edition 2005 + A1:2012 + A2:2015 EN 62061, edition 2005 + Cor. 2010 + A1:2013 + A2:2015: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

4 Transport and Storage

Retain the original packaging. Always store or transport the device in the original packaging to protect it from electrostatic discharge (ESD) and mechanical damage.

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5 Planning

5.1 Plant Design

Before selecting and using the product, the plant designer must evaluate whether this product is suitable for the intended application. Pepperl+Fuchs has no influence on the selection and use of this product. The warranty therefore only covers the consistent quality of the product.

Ensure that this device is used only in accordance with the technical specification described in these instructions. The device must not be used in an explosion-hazardous area.

Warning!

Danger due to ambiguous position information

Using double code areas can result in duplicate position information. This can lead to unclear position information. This can result in an incorrect control logic, which poses a risk to the personnel and plant.

During planning, make sure that the position information for the reader is unique in every component of the plant. Never use double code areas.

5.2 System Behavior

The reader is located on an automated guided vehicle (AGV), for which it outputs the position data. The reader follows a parallel stationary Data Matrix code tape affixed to the ground and detects a safe position according to SIL 3/PL e.

The scenarios described below are scenarios in the safe application that do not lead to the device being in a safe state, but must still be considered separately in the application. In this case, the reader can no longer detect position data. The valid bit in the PROFIsafe container is set to "0" (valid = 0). X position data in the PROFIsafe container with valid = 0 may no longer be used. Typical scenarios include:

- Data Matrix code tape is missing
- Data Matrix code tape is not readable
- Reader is outside the sensing range
- Lens is dirty
- Reader is in the initialization phase

Further information about the PROFIsafe container, see chapter 8.3

These scenarios must be taken into account by the plant software accordingly. The type of response is determined by the function of the plant.

5.3 Assumptions

The following assumptions have been made during the FMEDA:

- The input signal is provided by a programmable logic controller (PLC) with SIL 3 or any comparable system.
- The devices were evaluated for use in safety control loops in accordance with EN/ISO 13849-1 . They comply with the requirements of PL e and are designed for category 4 applications. Observe the rules in this standard when constructing safety control loops.
- The application program in the programmable logic controller (PLC) is configured so that it responds appropriately to signal faults or reported errors.
- The failure rates are constant.
- External power supply failure rates are not included.
- The devices are not protected against power supply failures. It is within the responsibility of the user to ensure that low supply voltages are detected and adequate reaction on this fault is implemented.
- The failure rate is based on the Siemens standard SN29500.

Use the device only within the specified ambient and operating conditions.

5.4 Safety Function and Safe State

Safety Function

The device determines position values for automated guided vehicles (AGV).

The position values are determined using the stationary Data Matrix code tape affixed to the ground.

Note

Note the Type of Code Tape!

The positioning system only works if the reader is used together with one of the 2-colored Data Matrix code tapes of the following type: PXV*-AA25-* or PXV*-AAM*-*.

The use of other code tapes is not permitted!

The safety-related customer application checks the plausibility of the received values against expected values.

The plant designer assigns appropriate values when setting up the plant. After attaching the Data Matrix code tape, the plant designer determines the corresponding expected values at the positions relevant for the application. The values determined in this way are incorporated into the safety-related application and then their plausibility can be assessed during the operation of the plant using the data from the sensor. Depending on the result, the application responds to ensure the safe operation of the plant.

For the safety function, the reader provides the following data:

- Safe X position data
- Safe status

For the navigation of automated guided vehicles, the reader makes the following non-safety-related data available:

- X position data
- Y deviation
- Distance in the Z direction
- Angular deviation
- Speed

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- Status
- Warning

The valid bit reflects the state of the safe position data. For processing of the position data in the application, the state of the valid bit must be evaluated in terms of safety. Depending on the state of the valid bit, the plant control software performs further processing and the corresponding actions are triggered to continue to ensure the safe state of the plant. The response to the respective state is determined by the application and can only be displayed here by way of example.

Valid bit = "logic 1": a valid position value is delivered in the safe X position data. This can be used for further processing in the safety-related plant control software, where it is checked against the expected values of the application for plausibility. The application responds, depending on the result.

Valid bit = "logical 0": The device is unable to determine a position at this time. The content of the safe X position data is "0." This state can be triggered by the following scenarios:

- Data Matrix code tape is missing
- Data Matrix code tape is not readable
- Reader is outside the sensing range
- Lens is dirty
- Reader is in the initialization phase

It is the task of the plant control software of the respective customer to evaluate and check the plausibility of this state in each case. The result of this evaluation and the application determine the steps necessary to ensure the safety of the plant.

When planning and setting up the plant control software, the evaluation of the valid bit must be considered and incorporated in terms of safety.

The described state is not to be confused with the safe state of the positioning device.

Additional requirements, which are described below, apply to the safe state of the positioning device.

Safe State

The safe state of the reader means that it interrupts the PROFIsafe communication in defined fault cases. If the reader switches to the safe state, PROFIsafe data is no longer transferred to the safety-rated PLC.

Fault cases that result in the safe state see table "PROFINET Suberror Numbers" on page 59.

If the PROFIsafe connection from the reader to the safety-rated PLC is interrupted, this generates a communication error according to the PROFIsafe standard, which the plant designer must deal with appropriately. After the reader is restarted, it goes back to the initialization phase (INIT). If another error triggers the safe state again within 90 s, the startup lock is activated. See chapter 5.4. See the section "System startup lock in the case of a fault."

In this case, contact Pepperl+Fuchs support.

Reaction time

The reaction time for the safety function is 165 ms.

The reaction time does not include the PROFIsafe watchdog time.

System Startup Lock in the Case of a Fault

The positioning system has an internal error counter for the safe state. This is increased when the safe state occurs. If the safe state is triggered twice within 90 seconds, a startup lock is activated in the system. As a result, the safety-relevant part is no longer started, and PROFIsafe communication can therefore no longer be established.

The user can identify this state thanks to the disabled illumination unit. The non-safe PROFINET communication part remains available. The camera is thus disabled. The positioning system must be restarted (power reset) to exit this state. The counter is cleared 90 seconds after the positioning system is started, provided that no safety-critical errors occur during this period, or upon the successful establishment of PROFIsafe communication.

The following errors result in the safe state:

- Internal safety system errors
- Device-specific errors (0x48) and suberrors. See table "PROFINET Error Numbers" on page 58, see table "PROFINET Suberror Numbers" on page 59
- Abortion or termination of the PROFIsafe connection

5.5 Characteristic Safety Values

Reader, 1oo1 Structure

Parameter	Characteristic values
Safety function	Secure determination and transmission of position values on a route marked with Data Matrix codes
Assessment type and documentation	Full assessment
Device type	B
Operating mode	High demand mode
Hardware Fault Tolerance (HFT)	0
Safety Integrity Level (SIL)	3
Performance Level (PL)	e
Category	4
Mean Operating Time to Failure (MTTF)	41 years
Mean Time to Dangerous Failure ($MTTF_d$)	104.74 years
Mission Time/useful lifetime (T_M)	20 years
Proof test	Not required. For further information, see see chapter 9.2.
Probability of Dangerous Failure per Hour (PFH_d)	1.09×10^{-8} 1/h, typically
Reaction time	165 ms

Table 5.1 Characteristic safety values for the product apply only with the assumptions made in this instruction manual.

5.6 Safety-related reading range of the read head

The safety-related reading range is the part of the read head's field of view in which Data Matrix codes can be decoded. The safety-related reading range is smaller than the field of view. It must be ensured that the Data Matrix code is completely within the field of view and a quiet zone is present.

Field of view of the read head

The field of view is the maximum image on the sensor chip that is determined by the optical properties of the camera. The size of the field of view varies with the distance between the read head and the Data Matrix code tape. If the read head is farther away from the Data Matrix code tape, the field of view becomes larger. If the read head is closer to the Data Matrix code tape, the field of view becomes smaller due to the shorter distance.

Safety-related accuracy

Safety-related accuracy refers to the maximum deviation that the safety-related reading range can have around the position value detected on the Data Matrix code ("Data Matrix code content"). Because only the Data Matrix code contents can be evaluated in a safety-related manner, the position of the Data Matrix code in the safety-related reading range is not precisely defined. Therefore, the position can only be determined with an accuracy of code position +/- half of the safety-related reading range. Because the safety-related reading range depends on the distance of the read head to the Data Matrix code tape, the accuracy also changes with the distance. The closer the sensor is to the Data Matrix code tape, the smaller the safety-related reading range and the more accurately the safety-related position can be determined.

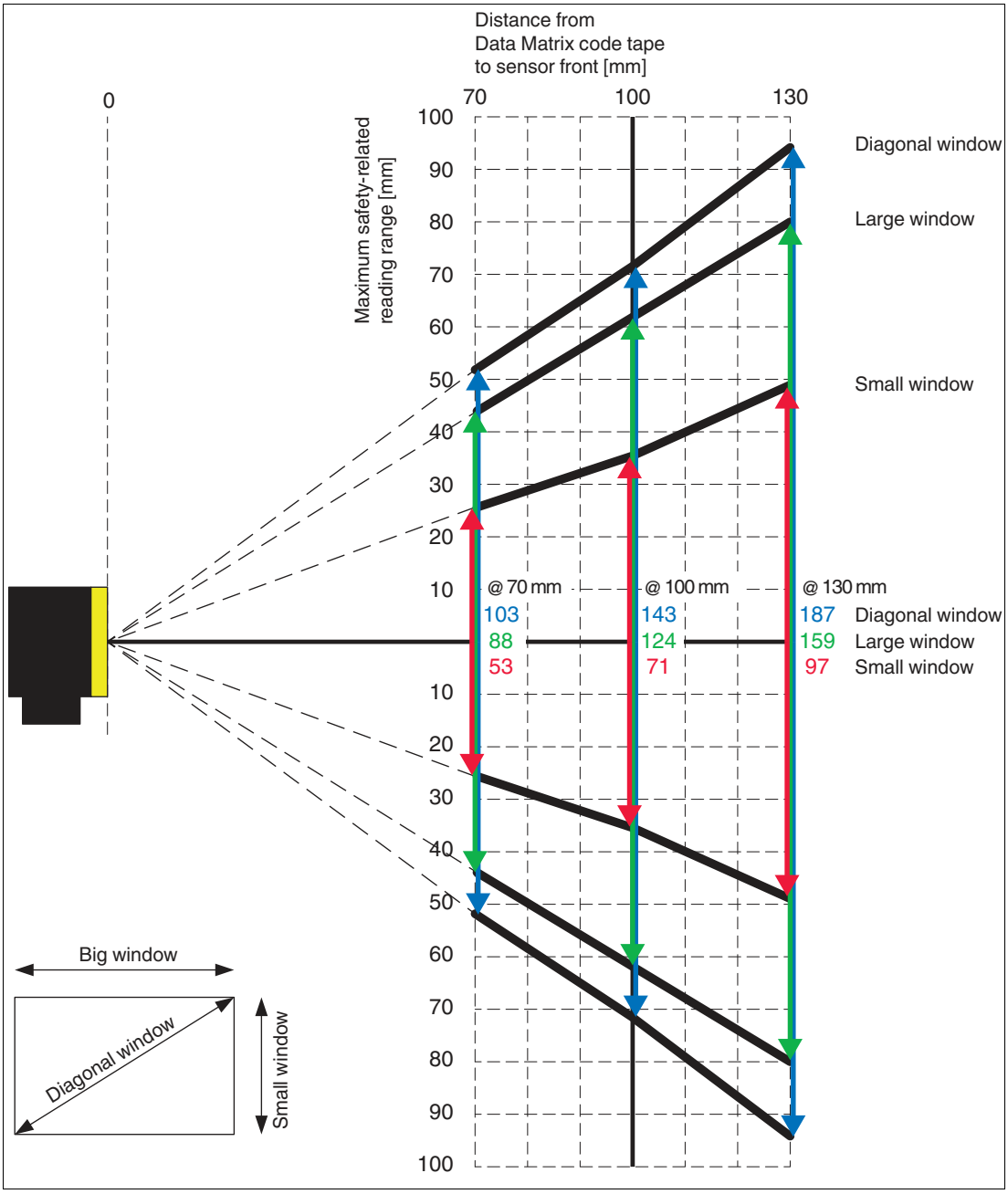

Figure 5.1 Safety-related reading range

	Distance from Data Matrix code tape to sensor front [mm]	Safety-related reading range [mm]
Diagonal window Data Matrix code tape lies diagonally in the field of view of the read head.	70	103
	100	143
	130	187
Big window Data Matrix code tape is parallel to the long side of the sensor chip.	70	88
	100	124
	130	159

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	Distance from Data Matrix code tape to sensor front [mm]	Safety-related reading range [mm]
Small window Data Matrix code tape is rotated 90° to the long side of the sensor chip.	70	53
	100	71
	130	97

5.7 Useful Lifetime

The useful lifetime is specified in the characteristic safety values. See chapter 5.5.

Although, on the basis of a probabilistic estimate, a constant failure rate is assumed, this only applies under the condition that the useful lifetime of the components is not exceeded. The result of this probabilistic estimate is only applicable until the useful lifetime ends, as the probability of a failure significantly increases thereafter. This useful lifetime largely depends on the component itself and its operating conditions, particularly the temperature. For example, electrolytic capacitors are very sensitive to the operating temperature.

This assumption of a constant failure rate is based on the course of a typical bathtub curve for electronic components.

It is therefore clear that this failure calculation only applies to components that have this constant range, and that the validity of the calculation is limited to the useful lifetime of each component.

It is assumed that the majority of early failures are detected during installation and that, therefore, a constant failure rate applies during the useful lifetime.

Use the device only within the specified ambient and operating conditions.

6 Installation

6.1 General

The positioning system is safe if it is mounted and set up in accordance with the provisions of these instructions, the reader works properly, and the Data Matrix code tape is mounted correctly so that it is stationary and readable.

General Safety Information for Mounting and Installation

Do not modify or manipulate the device.

Observe the safety information given in the product documentation.

Observe the safety loop requirements.

Only connect the device to devices that are suitable for the safety application.

During integration into the safety loop, set the PROFIsafe-specific F-parameters in the safety-rated PLC. See chapter 8.3.3.

After installation, check the safety function to ensure that the output behaves as expected. See chapter 7.

6.2 Safe Position Detection – Structural Principle

Safe Position Detection – Structural Principle

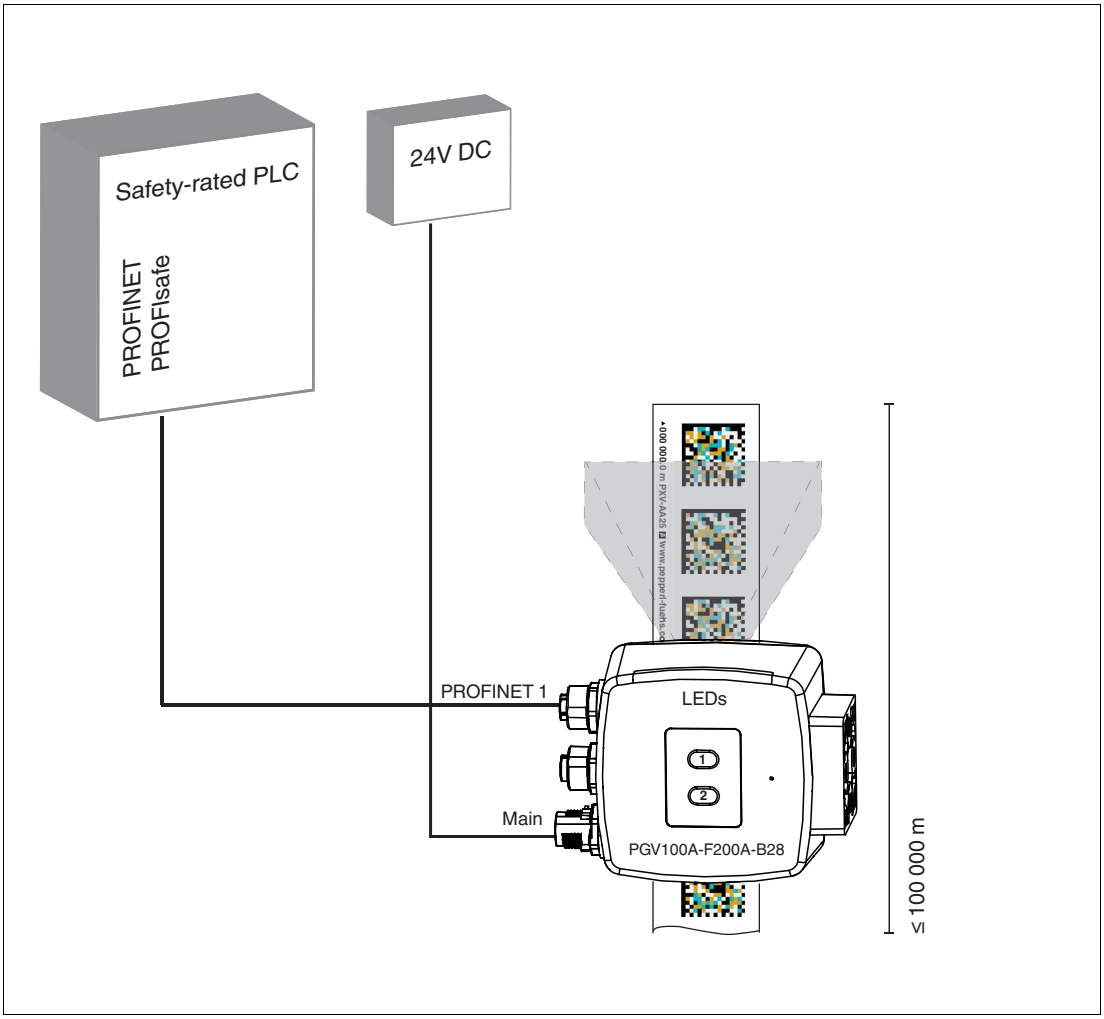

Figure 6.1 Schematic connection of the positioning system

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6.3 Mounting of the Reader

Warning!

Risk of injury due to strobe effect

Stroboscopic effects when the device camera flashes can produce optical illusions, e.g., an apparent standstill or seemingly slower motion of rotating parts in the lighting. This results in a risk of injury.

Avoid mounting and aligning the device in such a way that it illuminates rotating parts. If this is not possible in parts of the plant, clearly indicate the possible hazards.

Mounting the Reader

Make sure that you are able to mount the reader in a stable position. Before mounting the reader, make sure that the travel of the moving plant component is such that the reader's depth of focus range is never left during operation.

1. Mount the reader on the moving component of the plant, i.e., an automated guided vehicle (AGV), using the four screws on the reader mounting adapter.

Danger!

Safety function failure due to inadequate mechanical mounting!

A loosening, movement, or twisting of the reader can cause the programmed reference point to be shifted in relation to the tape. This can cause a shift between the programmed reference values of the safe control program and the safe position data of the reader.

The plant operator must ensure appropriate mechanical fixing. Information on a possible fault elimination for the error presumption "Detaching or Loosening a Fixing at Standstill or During Motion" can be found in DIN EN 61800-5-2:2017, Appendix D.3.16, Table D.8 "Motion and Position Feedback Sensors."

Caution!

Falsification of the measurement due to external illumination units in the installation area of the reader

If the reader is mounted so that a second similar illumination unit with a comparable red/blue flashing behavior shines into the field of view, the recorded image can be falsified. The code of the Data Matrix code tape can no longer be decoded correctly, meaning that the valid bit of the safe data is set to "0" and no valid position data is available.

When mounting the reader, ensure that no second similar illumination unit with a comparable red/blue flashing behavior shines into the field of view.

Caution!

Damage to the reader due to wrong mounting accessory

Using longer screws can damage the reader.

When selecting the length of the mounting screws, ensure that the maximum insertion depth of the screws in the threaded inserts on the reader is 8 mm.

Caution!

Damage to the reader due to inadequate attachment

If the reader is not sufficiently well and securely attached according to the requirements of the mechanical load due to the application, it can come loose and be damaged. Tightening the screws to a higher tightening torque can damage the reader.

Depending on the local installation conditions, the plant designer or commissioning engineer are responsible or the following:
tightening torque of the mounting screws: determining the minimum tightening torque for attachment according to the plant requirements.
Do not exceed the maximum tightening torque of 9 Nm.
Ensure that the attachment is in accordance with the mechanical load of the application.
Prevent the unwanted loosening of connections, e.g., by using thread-locking fluid.

2. Mount the reader so that the lens of the reader with ring light and camera module is pointing toward the Data Matrix code tape.
3. We generally recommend aligning the reader 90° or 270° to the Data Matrix code tape. In most cases, the field of view can be the most efficient way to detect the Data Matrix code tape, including when cornering:

Alignment of Reader with Field of View in 90°/270° Arrangement (Z Axis)

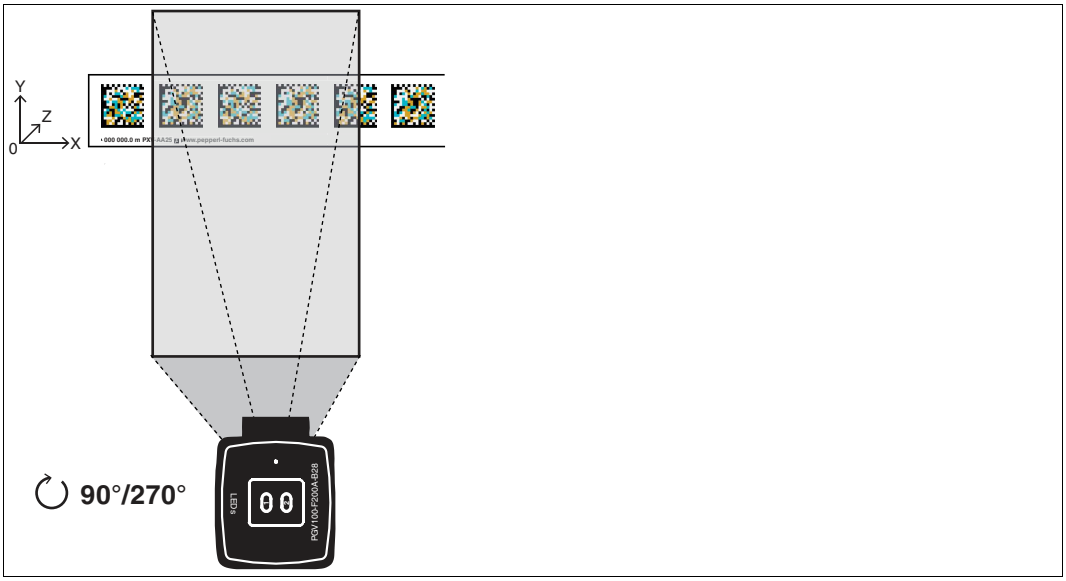

Figure 6.2 Schematic diagram, field of view 115 mm x 73 mm with a 90° or 270° arrangement in the Z axis, the number of codes may vary

4. Alternatively, the reader can be aligned 0° or 180° to the Data Matrix code tape. This is particularly suitable for large gaps in the Data Matrix code tape, as then the length of the field of view is in the X direction:

Alignment of Reader with Field of View in 0°/180° Arrangement (Z Axis)

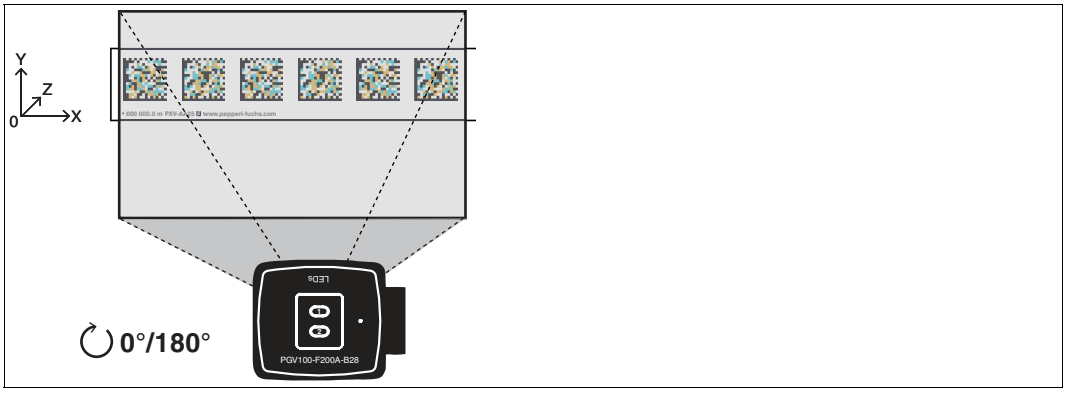

Figure 6.3 Schematic diagram, field of view 115 mm x 73 mm with a 0° or 180° arrangement in the Z axis, the number of codes may vary

5. During mounting, observe the maximum angle tolerances. Check that these tolerances are not exceeded during mounting. Simultaneous tilting on the X axis and the Y axis is permitted.

Angle Tolerance in the Y Axis

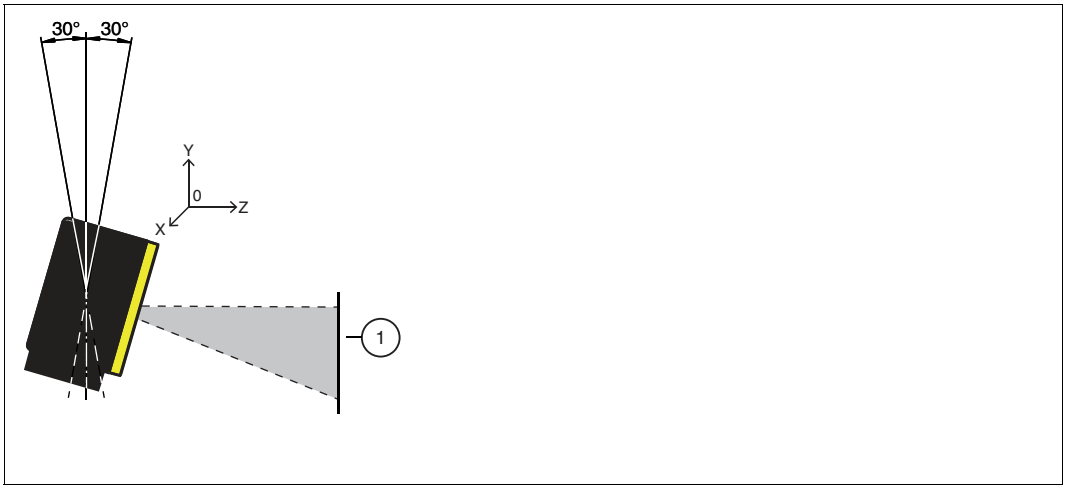

Figure 6.4 Vertical alignment tolerance

1 Data Matrix code tape

Angular Tolerance in the Y Axis

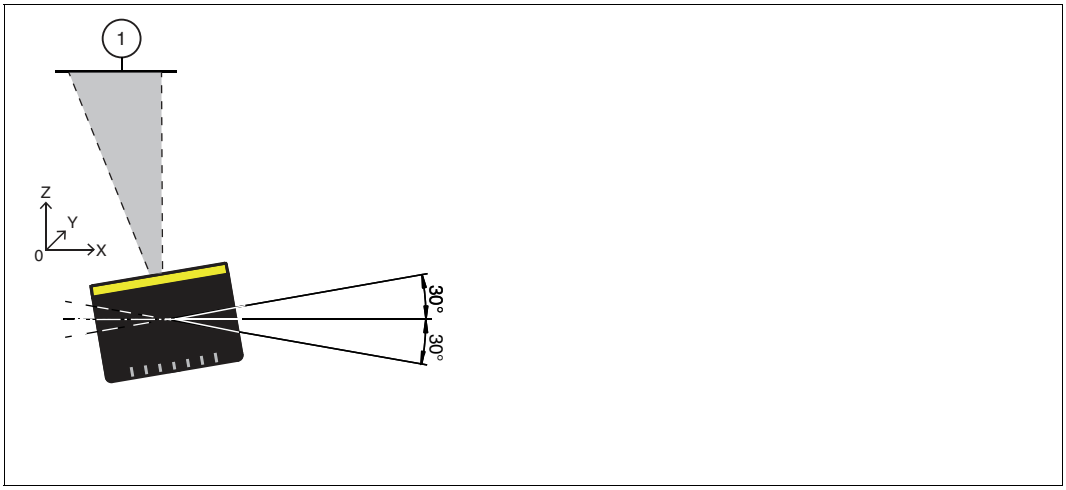

Figure 6.5 Horizontal alignment tolerance

1 Data Matrix code tape

6. Check that the distance Z from the reader to the Data Matrix code tape is the same as the read distance of the reader.
7. The optimal read distance of the reader is 100 mm with a depth of focus of ± 30 mm.

Read Distance

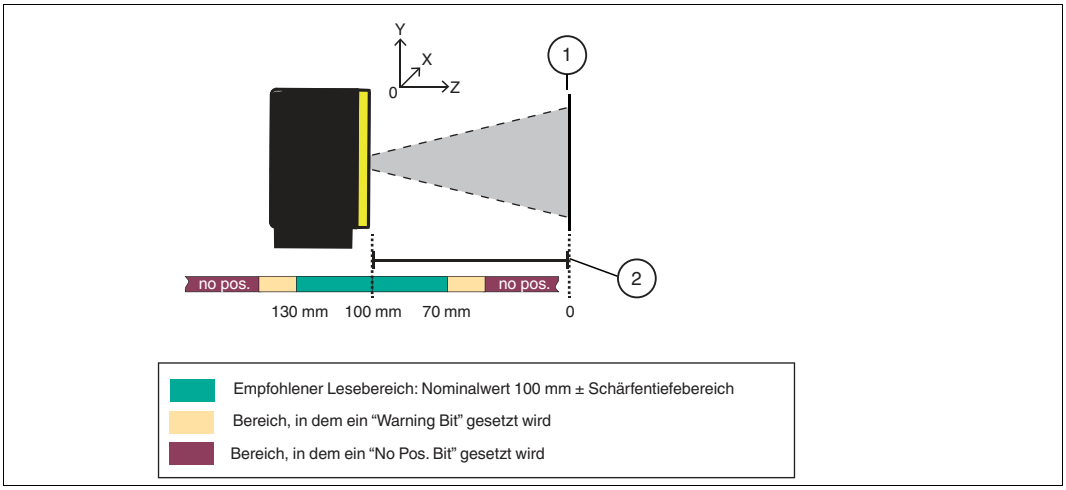

Figure 6.6 Read range of the positioning system

1 Data Matrix code tape

2 Read distance to the code tape (Z)

Maximum Number of Visible Data Matrix Codes in the Field of View

Read distance (z)	70 mm	100 mm	130 mm
Orientation			
0°/180°	4	5	7
90°/270°	2	3	4

Table 6.1 Number of Data Matrix codes, depending on the orientation and read distance (z) of the reader

6.4 Aligning the Reader

Warning!

Risk of injury due to strobe effect

Stroboscopic effects when the device camera flashes can produce optical illusions, e.g., an apparent standstill or seemingly slower motion of rotating parts in the lighting. This results in a risk of injury.

Avoid mounting and aligning the device in such a way that it illuminates rotating parts. If this is not possible in parts of the plant, clearly indicate the possible hazards.

For the easy optimum alignment of the reader relative to the Data Matrix code tape in the Z coordinate, we recommend using the alignment guide PCV-AG100.

Alignment Guide (PCV-AG100)

Figure 6.7 Alignment aid

6.5 Affixing the Data Matrix Code Tape

The Data Matrix code tape is made of silicone-free polyester film. A position marker appears every 100 mm along the lower edge of the Data Matrix code tape. For an illustration of the Data Matrix code tape with position markers, see see chapter 3.5.

These position markers are used to affix the Data Matrix code tape in the correct position. The back of the Data Matrix code tape is covered with a modified acrylate-based adhesive designed for permanent adhesion. Affix the self-adhesive Data Matrix code tape along the desired traverse distance. To do so, proceed as follows:

Affixing Data Matrix Code Tape

1. Clean the surface of any greasy or oily deposits and dust.
2. Ensure that the surface is dry, clean, and stable.
3. Pull away a few centimeters of the protective film at the beginning of the Data Matrix code tape. Place the Data Matrix code tape at the precise point of the required starting position on the surface, and press to attach.
4. Then affix the Data Matrix code tape along the desired traverse distance. To do so, observe all subsequent information in this section.
5. Remove the protective film gradually so that the Data Matrix code tape does not accidentally adhere to the surface in the incorrect position. When affixing, ensure that the Data Matrix code tape does not crease or trap air bubbles.

   ↳ The adhesive on the Data Matrix code tape hardens after 72 hours.

Note

Thermal Expansion of the Data Matrix Code Tape

The affixed Data Matrix code tape corresponds to the heat expansion coefficient of the surface with regard to its thermal expansion. Keep this in mind when installing expansion joints, for example.

6.5.1 Expansion Joints/Gaps

To compensate for temperature-related changes in length, there are usually expansion joints for longer stretches in the plant structure. We recommend interrupting the Data Matrix code tape in such places. After such an interruption, continue the attachment process using a fully readable Data Matrix code tape. The gap (a) resulting from the interruption must not exceed the following value:

- Read head orientation 0°/180°: a ≤ 60 mm with a distance of 100 mm between the read head and the Data Matrix code tape
- Read head orientation 90°/270°: a ≤ 10 mm with a distance of 100 mm between the read head and the Data Matrix code tape

Note

The maximum gap (a) varies with different distance values.

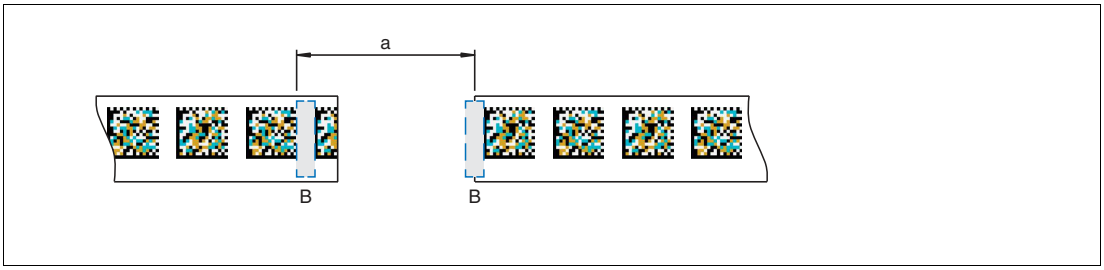

Figure 6.8 Schematic diagram: permissible distances when using the read head

Note

A quiet zone (B) (white area without coding) ≥ 3 mm is to be planned around the Data Matrix code, so that the Data Matrix codes can be read by the read head.

6.5.2 Hysteresis Y Axis

Hysteresis Y Axis

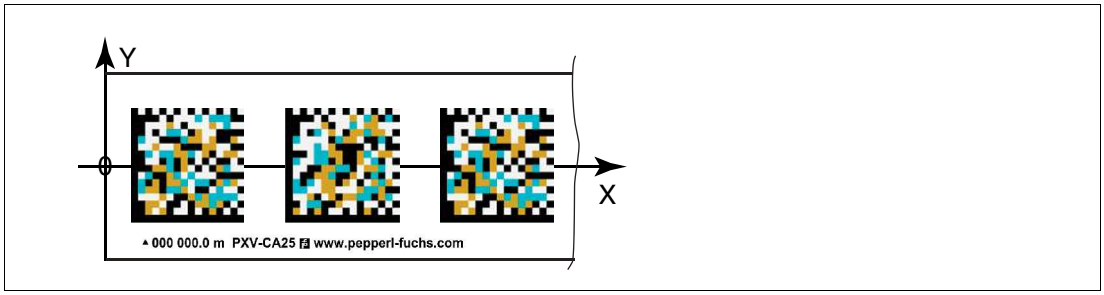

Figure 6.9 Schematic diagram: zero line for Data Matrix code tapes

If the reader leaves the zero line when traversing along the X axis, the threshold may deviate. If the deviation exceeds the defined threshold, a warning code is issued.

Y Axis Deviation Thresholds

Code tape		Threshold	
Number of tracks	Width	Exit	Entry
1	25 mm	± 8.5 mm	± 7.5 mm

Table 6.2 Data Matrix code tape thresholds for Y axis deviation

6.5.3 Reader Orientation and Value Outputs

The sensor always moves in the X direction. During mounting, the **Pepperl+Fuchs** logo and the position markers are located below the Data Matrix code. The position values then increase along the X direction.

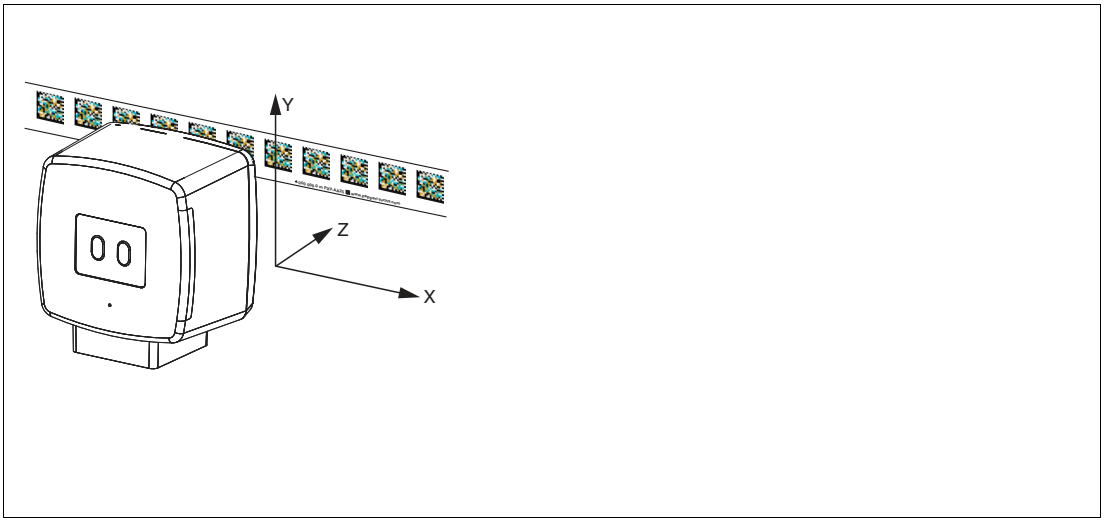

Figure 6.10 Functional principle for the reader orientation

Non-Safe Angle Output

Angles are specified as absolute values. The respective value is calculated from the resolution selected under "Angle Resolution."

With a resolution of 0.1°, an angle of 60° is output as follows: 60°/0.1° = 600
The reader detects a change in the angle of the Data Matrix code tape and transmits this value to the safety-rated PLC.

The reader detects the absolute angle in relation to the traced track with a resolution of 0.1°. The angle is specified as an absolute value relative to the traced track, as a Data Matrix code tape contains direction information. The output angle covers the range from 0° to 360°.

The resolution is set to the following value: 0.1°

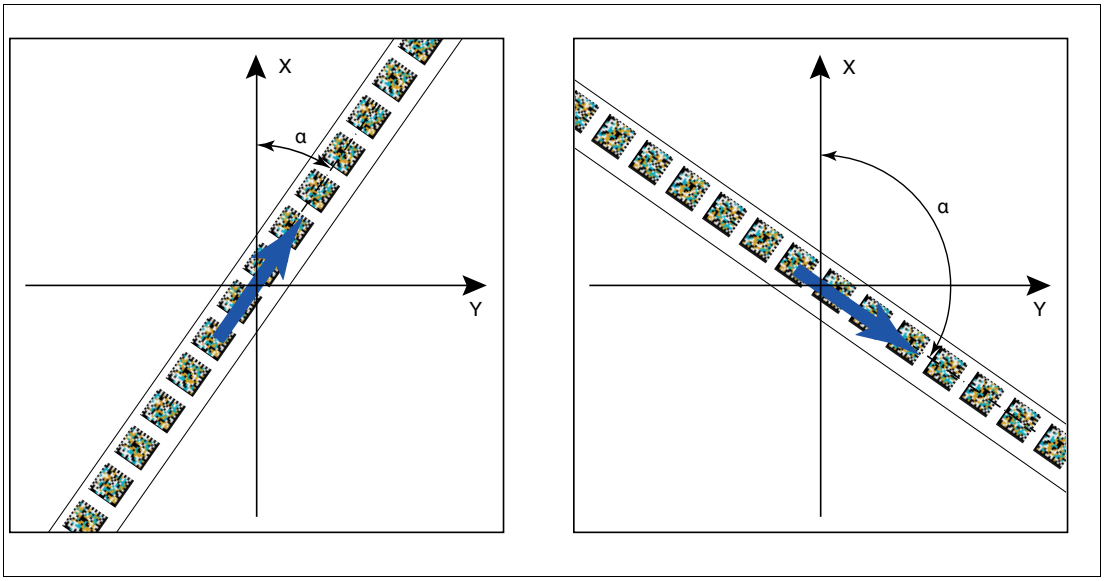

Figure 6.11 Functional principle: absolute angle

Distance Output

The reader indicates the vertical distance of the zero point in relation to the Data Matrix code tape.

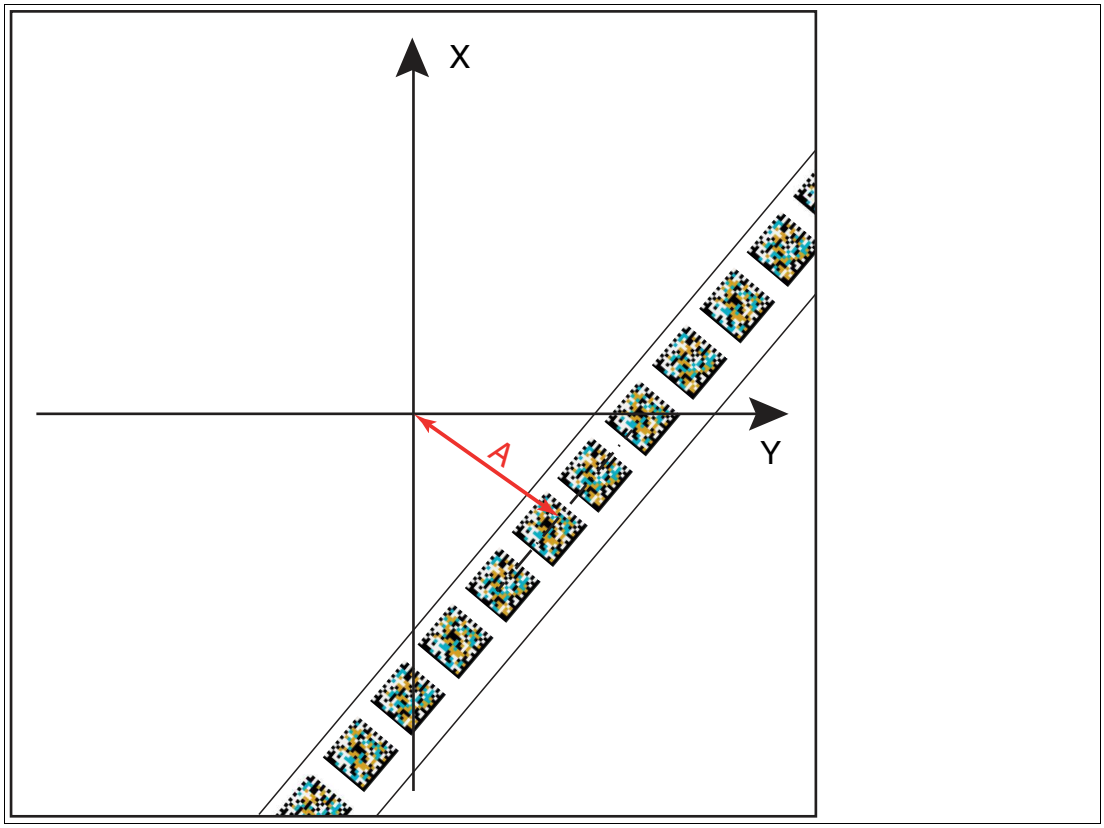

Figure 6.12 Functional principle: distance A for Data Matrix code tape

6.5.4 Bends

Preparing Data Matrix Code Tape for Bends

You can affix Data Matrix code tape in bends. To do so, cut the Data Matrix code tape repeatedly as shown here.

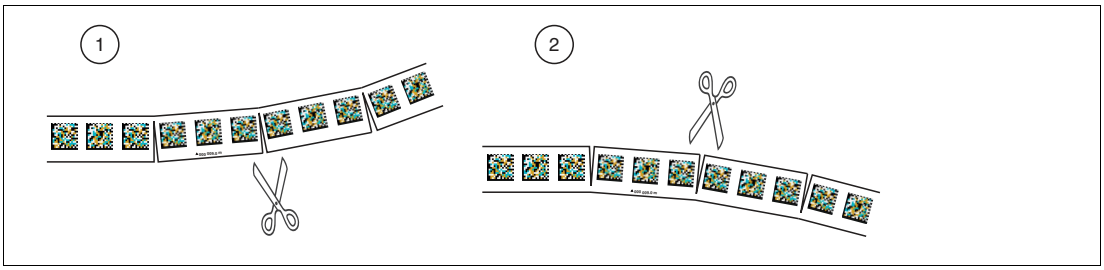

Figure 6.13 Schematic diagram: preparing Data Matrix code tape bends

1. Bend to the left
2. Bend to the right

Distances Between 2 Data Matrix Code Tapes in Bends

For branches or intersections, use 2 Data Matrix Code tapes as separate tracks. Ensure the correct distances according to the reader orientation.

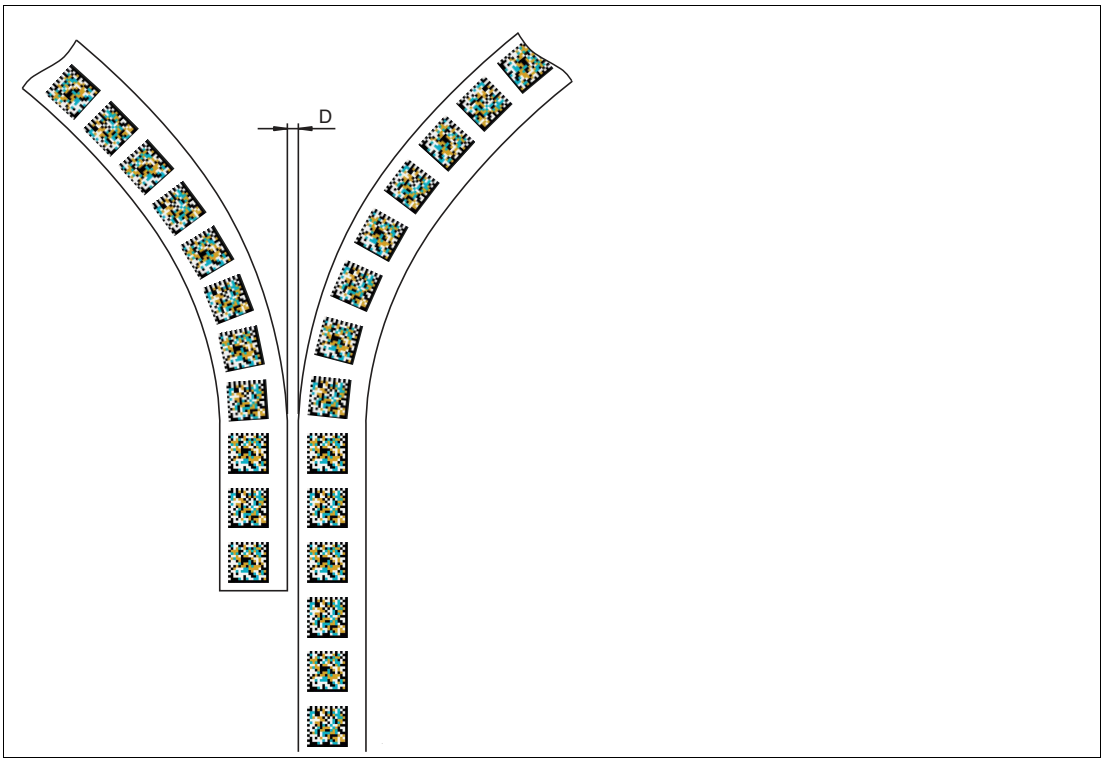

Figure 6.14 Functional principle: Distance D between Data Matrix code tapes

In the present example, a distance of 100 mm from the reader to the Data Matrix code tape is assumed.

With a reader orientation of 0°/180°, the distance D between the Data Matrix code tapes at a branch or intersection as a separate track is approximately 30 mm in this case.

For a reader orientation of 90°/270°, a distance D of 30 mm ... 60mm is recommended in this case.

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6.5.5 Branches/Lane Change

Requirement

The position of the branch or lane change is stored in the control panel by the plant designer. Thus, the change position (X position) from the old to the new track is known. When this position is reached, the automated guided vehicle (AGV) lane change is initiated.

Both tracks run parallel. The length over which the two tracks run parallel to each other depends on the driving speed and the driving characteristics of the AGV. The length must be at least dimensioned so that a clean lane change is possible.

Initial Situation

In the following example, a distance of 100 mm from the reader to the Data Matrix code tape is assumed.

Figure 6.15 Schematic diagram: Reading behavior when changing lanes between 2 parallel Data Matrix code tapes. Possible distance between the Data Matrix code tapes: 20 mm ... 50 mm

Procedure for a Lane Change

The AGV changes from track A to track B. In the period during which the AGV changes from track A to B, the reader outputs the safe and non-safe values of track A. However, while both tracks are in the field of view of the reader, a jump between the safe and non-safe X position data cannot be ruled out. As soon as only the Data Matrix codes of track B are in the field of view of the reader, the safe and non-safe X position data of track B is output.

To ensure the plausibility of the entire positioning system, we recommend that both tracks are stored as plausible in the control panel for this known lane change section. For this purpose, the route in which both tracks are located must be sufficiently long.

Reading Behavior During Lane Changes

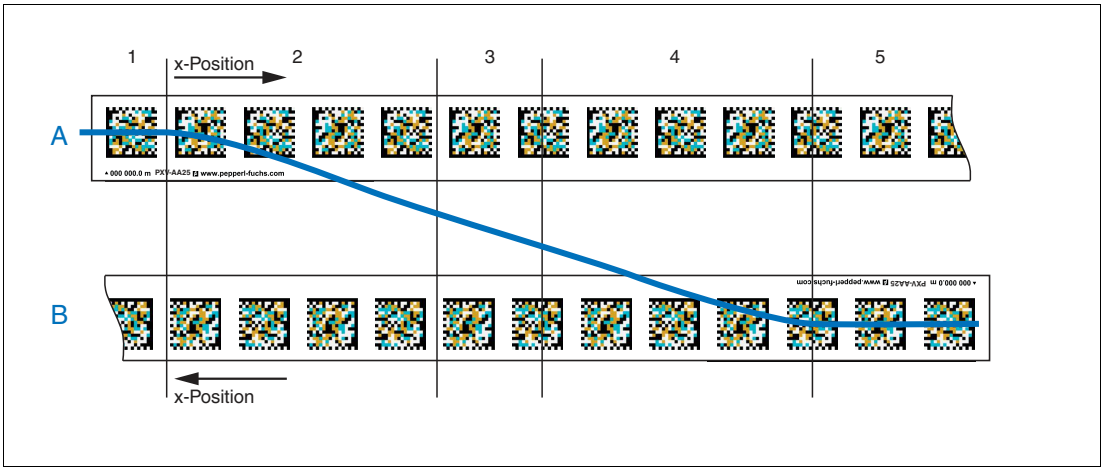

Figure 6.16 Functional principle: reading behavior during lane changes between 2 parallel Data Matrix code tapes A and B – divided into sections 1 ... 5

Collecting Position Data During Lane Changes

Range	Non-safe position data	Safe position data
1	A	A
2	A	A
3	A	A or B[1]
4	B	B
5	B	B

Table 6.3

1. Position indication can jump between A and B

Assignment of Track a and B to One Another – Scenarios

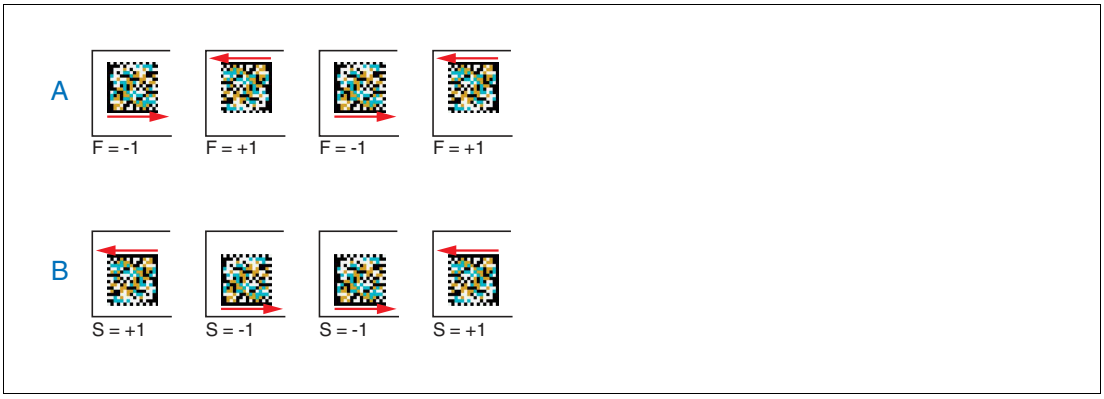

Figure 6.17 Assignment scenarios for a lane change between 2 parallel Data Matrix code tapes

F ("first lane") = old Data Matrix code lane

S ("second lane") = new Data Matrix code lane

Calculation of the X and Y Position Based on the Old Lane

Note

The following calculation is useful for the safe and non-safe X position data. It is used to simplify navigation in the area of a lane change.

The safe X position data can also jump between the two tracks as described above.

We recommend that both tracks are stored as plausible and safe in the control panel for this section!

If the reader has already changed to a new track and has output a position based on the old track again, the position on the new track can be calculated as follows.

In the following example, a distance of 100 mm from the reader to the Data Matrix code tape is assumed.

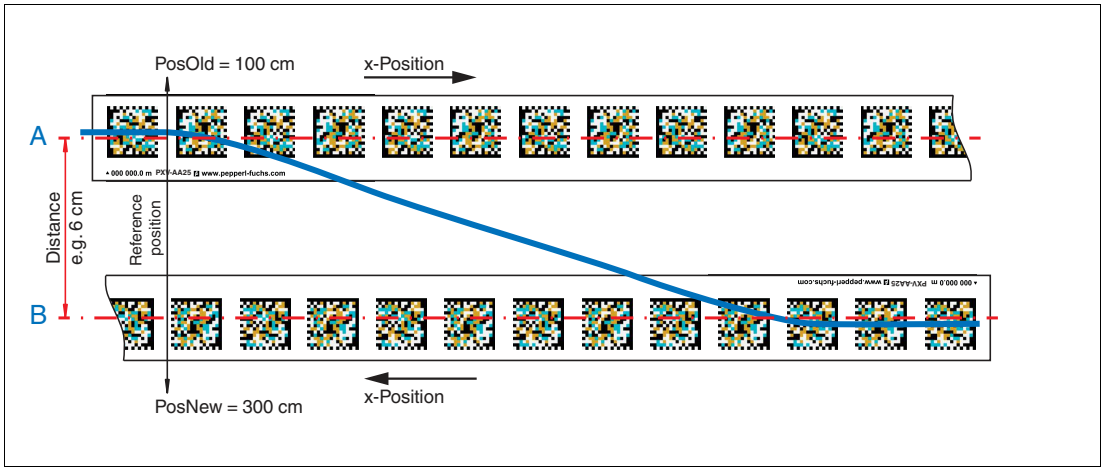

Figure 6.18 Schematic diagram: Parameters used to calculate the lane change. This includes the distance between the middle of the two parallel bands Data Matrix code tapes A and B

$$X = PosNew + [F \times S \times (XP - PosOld)]$$

$$Y = (F \times S \times YP) + (S \times distance)$$

Figure 6.19 Calculation of the X and Y position when changing lanes

Explanation of the parameters:

PosNew:	Fixed value of track A stored in the controller
PosOld:	Fixed value of track B stored in the controller
Distance:	Distance between the middle of the two Data Matrix code tapes
F:	Data Matrix code position of the old track as a fixed factor with -1 or +1
S:	Data Matrix code position of the new track as a fixed factor with -1 or +1
XP:	Current X position (position value in the PLC from the old track)
YP:	Current Y position (position value in the PLC from the old track)

Note

Default Values for Lane Changes

The values PosNew, PosOld, F, S, and Distance must be determined individually for each lane change and stored in the PLC.

The position for PosNew and PosOld can be selected as required.

6.5.6 Intersections

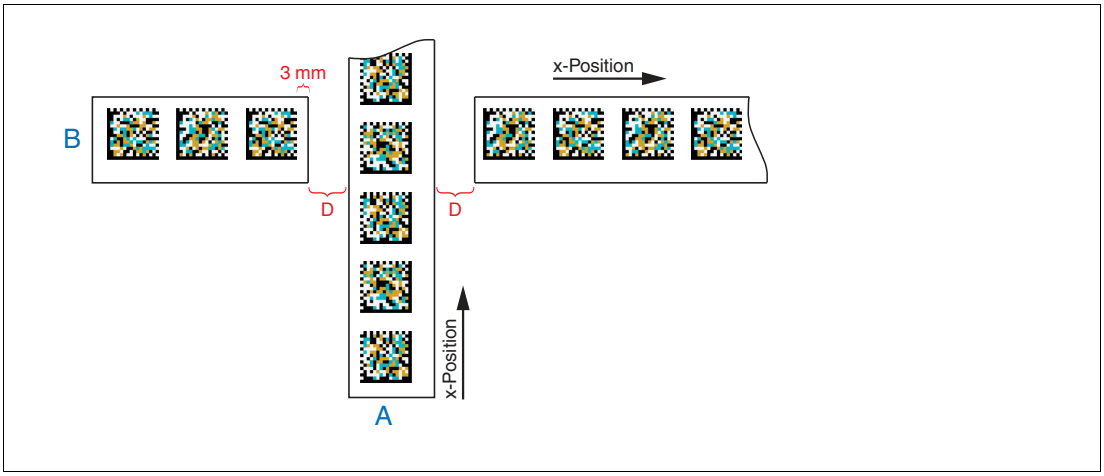

Figure 6.20 Functional principle: intersection of 2 Data Matrix code tapes

Requirement

The position of the intersection is stored in the control panel. Thus, the change position (X position) from the old to the new track is known. When this position is reached, the automated guided vehicle (AGV) change is initiated.

Creating an Intersection

2 Data Matrix tracks are affixed. One track is affixed continuously and the second track has a gap for the first track. The distance D from code tape edge to code tape edge is 20 mm … 50 mm.

In the above example, a distance of 100 mm from the reader to the Data Matrix code tape is assumed.

Reading Behavior at an Intersection

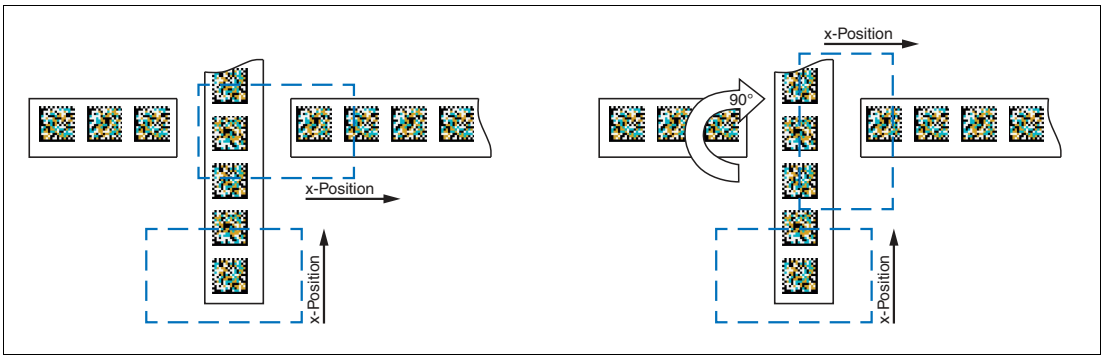

Figure 6.21 Functional principle: possible reader positions or orientation at an intersection of 2 Data Matrix code tapes

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The reader moves on track A. The non-safe and safe X position values of track A are output. The lane change is initiated, and the reader moves in the same orientation. The AGV begins to move in the direction of track B. While only track A can be detected in the reader's field of view, the safe and non-safe X position of track A is output.

From the desired position, the AGV begins to move in the direction of track B. During the change, the reader outputs the historical X position data of track A. However, a jump between the safe and non-safe X position data cannot be ruled out. As soon as only the Data Matrix codes of track B are in the field of view of the reader, the safe and non-safe X position data of track B is output.

During the process of the lane change, while both tracks are in the field of view, it is possible that the safe X position data jumps between tracks A and B. To ensure the plausibility of the entire positioning system, we recommend that both tracks are stored as plausible in the control panel for the known section.

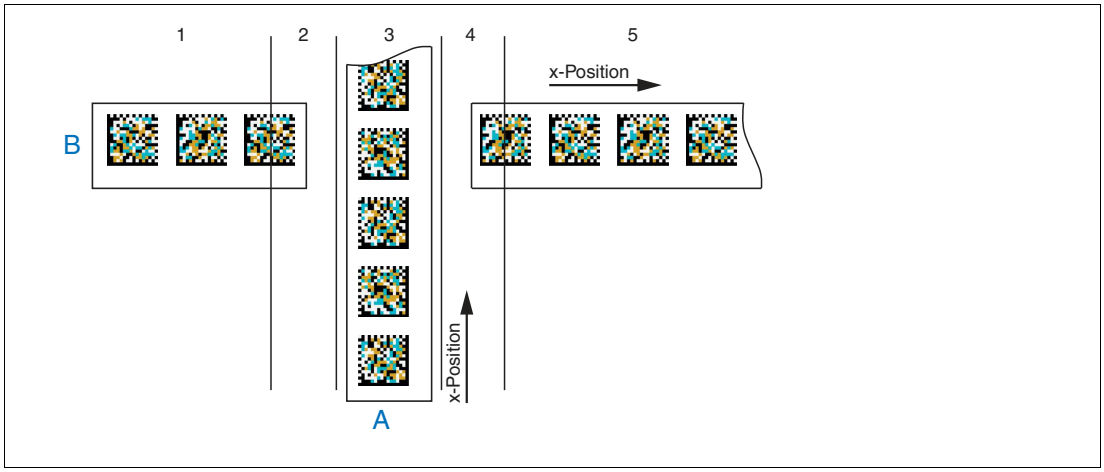

Figure 6.22 Functional principle: reading behavior at an intersection of 2 Data Matrix Code tapes

1	2	3	4	5
B*/B**	A*/A* or B**	A*/A**	A*/A* or B**	B*/B**

* Output of the non-safe X position data

** Output of the safe X position data

6.5.7 Position Jump

The reader comes off track A and moves along track B, due to an expansion joint, for example.

Reading Behavior

While the field of view of the reader is over track A, the safe and non-safe X position data from track A is output. If Data Matrix codes of track A and B are in the reader's field of view then the reader outputs the X position data of the previous track A.

However, a jump between the safe and non-safe X position data cannot be ruled out. If Data Matrix codes of track B are in the reader's field of view and the Data Matrix codes of track A are no longer visible in the field of view, then the safe and non-safe X position data of track B are output.

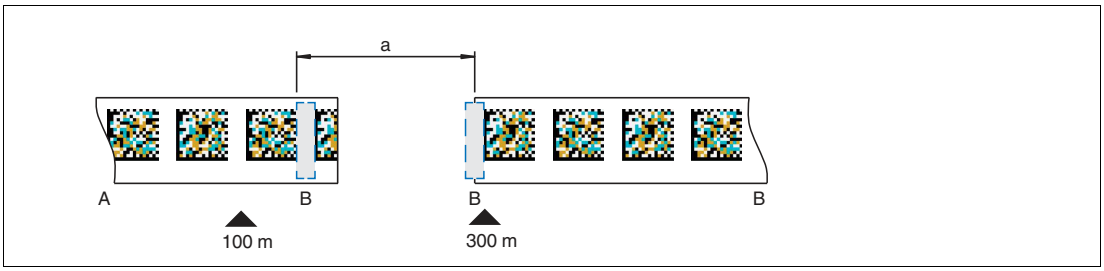

Figure 6.23 Schematic diagram: position jump for gaps in the Data Matrix code tape

6.6 Electrical Connection

Warning!

Damage to electrical components due to overvoltage

Operating the reader with a power supply that delivers a voltage of > 36 VDC can cause damage to electrical components in the device.

- Never apply more than 36 VDC to the device. Make sure that you use a PELV circuit for the electrical supply in accordance with IEC/EN 60204-1. Observe the general requirements for PELV circuits. The power supply used must meet the requirements according to SELV/PELV (IEC 60364-4-41:2005).
- If you have accidentally applied more than 36 VDC, then proceed as follows:
  - Take the device out of operation immediately. A faulty device must not be operated.
  - Send the device to the manufacturer, specifying the reasons or circumstances for the inspection.

Caution!

Damage to the device

Connecting an alternating current or excessive supply voltage can damage the device or cause the device to malfunction.

Electrical connections with reversed polarity can damage the device or cause the device to malfunction.

Connect the device to direct current (DC). Ensure that the supply voltage rating is within the specified device range. Ensure that the connecting wires on the female cordset are connected correctly.

The reader is connected electrically via an 8-pin M12 x 1 connector plug on the side of the housing. The power is supplied via this connection.

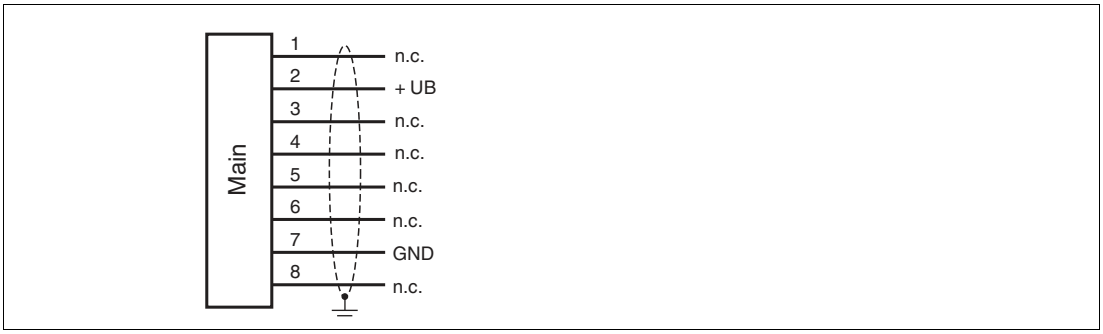

Figure 6.24 Electrical connection of the reader

Connector Assignment

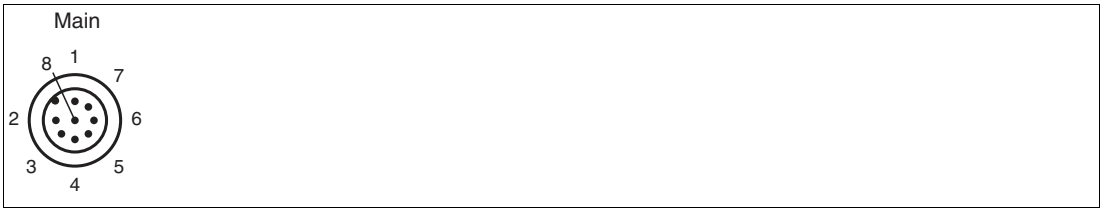

Figure 6.25 Connector assignment of the reader

Color assignment

Pepperl+Fuchs single-ended female cordsets are manufactured in accordance with EN 60947-5-2. When using a type V19-... single-ended female cordset with an open cable end on the connection **Main** connection, the following color assignment applies:

Connection pin	Strand color	Color abbreviation
1	white	WH
2	brown	BN
3	Green	GN
4	Yellow	YE
5	gray	GY
6	pink	PK
7	Blue	BU
8	Red	RD

Table 6.4 Color assignment for connection to the single-ended female cordset

Shielding Cables

The shielding of connection lines is required to suppress electromagnetic interference. Establishing a low resistance or low impedance connection with the protective conductor or equipotential bonding circuit is a particularly important factor in ensuring that these interference currents do not become a source of interference themselves. Only use connection lines with braid. Avoid connection lines with foil shield because this would increase the line capacities. The shielding is integrated at both ends, i.e., in the switch cabinet or on the PLC, **and** on the read head. The grounding terminal available as an accessory allows easy integration in the equipotential bonding circuit.

In exceptional cases, the shielding of a connection at one end may be more favorable if:

- An equipotential bonding cable is not laid or cannot be laid.
- A film shield is used.

The following points relating to shielding must be noted:

- Use metal cable clips that cover large areas of the shielding.
- Place the cable shield onto the equipotential bonding rail immediately on entering the switch cabinet.
- Direct the protective grounding connections to a common point in a star configuration.
- The cross-section of the cables used for grounding should be as large as possible.

Installation Accessories

Model number	Description
PCV-SC12	Clip for mounting an additional ground connection (included in the scope of delivery)

Table 6.5

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6.7 PROFINET Connection

The reader is connected to PROFINET via two 4-pin, D-coded connector sockets, M12 x 1, **Profinet 1** and **Profinet 2**, on the side of the housing.

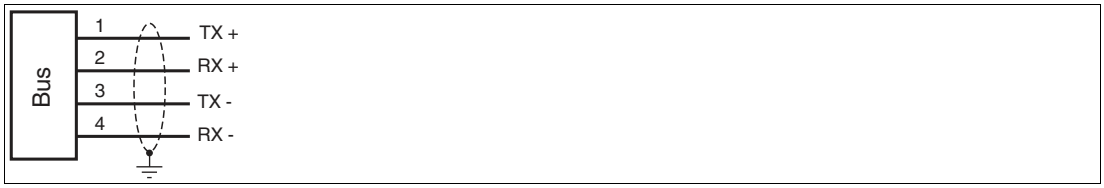

Figure 6.26 PROFINET connection diagram

Connector Assignment

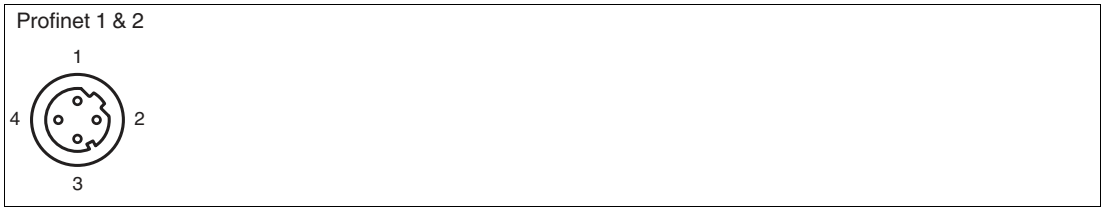

Figure 6.27 PROFINET connector assignment

Suitable PROFINET cables can be found in the accessories section of the reader datasheet at www.pepperl-fuchs.com.

7 Commissioning

The following section describes the commissioning process and reader behavior.

Commissioning the Reader with Safety Function

- The reader is connected to an approved power supply.
- The reader is connected to the safety-rated PLC via the "PROFINET 1" interface
- The reader is positioned using appropriate Data Matrix code tape.

Safe Position Detection – Structural Principle

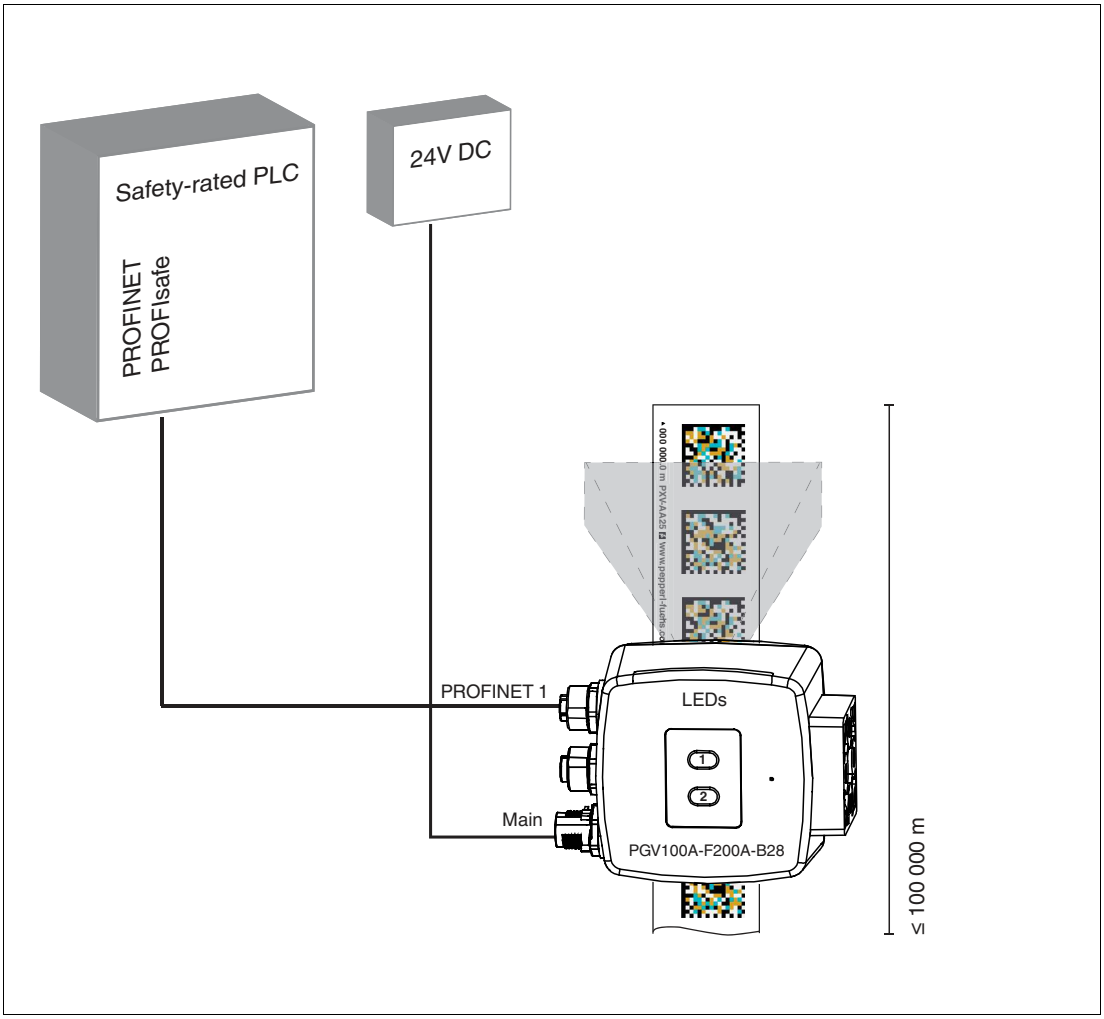

Figure 7.1 Schematic connection of the positioning system

Warning!

Risk of injury due to flash frequencies

Certain flash frequencies of the device camera may trigger epileptic seizures.

Persons who suffer from epilepsy should not stay within the illumination area of the sensor for longer periods of time or look into the lighting.

Start the reader. The reader lens begins to flash red.

The PROFIsafe connection between the reader and control panel is established. The initialization phase begins.

In the PROFIsafe protocol, the INIT flag in the status is set to "1" during this time, and the position data is "0" or invalid. The non-safe data transmission is not affected by this.

Note

Occurrence of Errors During Commissioning

There is no fault tolerance during initialization. Each error leads to a restart of the initialization phase.

If an error occurs during the initialization phase (INIT flag is set), the initialization is restarted. In the process, events that trigger the safe state always takes precedence. If an event occurs that triggers the safe state, this is triggered **regardless of the initialization**.

If the PROFIsafe connection from the reader to the safety-rated PLC is terminated, this generates an error in the control program, which the plant designer must deal with appropriately. After the reader is restarted, it goes back to the initialization phase (INIT).

In this phase, if another error triggers the safe state again within 90 s, the startup lock is activated. See chapter 5.4. See the section "System startup lock in the case of a fault."

In this case, contact Pepperl+Fuchs support.

The initialization phase lasts approx. 1 second.

To check the safety-related plausibility of the route through the plant, continue over the entire distance.

The reader is then ready for operation with safety function.

8 Operation and Communication

General Safety Information for Operation and Communication

Danger!

Danger to life from missing safety function

If the safety loop is put out of service, the safety function is no longer guaranteed.

- Do not deactivate the device.
- Do not bypass the safety function.
- Do not repair, modify, or manipulate the device.

Warning!

Risk of injury due to dazzling

The device camera is an intense light source with a significant dazzling effect. After glancing into the bright light source, temporarily restricted vision or after-images can lead to irritation, impairments, injury, or accidents.

Never look directly into the camera during operation.
Only carry out a visual inspection on the lens when the reader is no longer active.

Warning!

Risk of injury due to flash frequencies

Certain flash frequencies of the device camera may trigger epileptic seizures.

Persons who suffer from epilepsy should not stay within the illumination area of the sensor for longer periods of time or look into the lighting.

Observe the safety information given in the product documentation.

Only connect the device to devices that are suitable for the safety application.

8.1 Communication via PROFINET

8.1.1 General Information on Communication via PROFINET

PROFINET is an open standard for industrial automation based on industrial Ethernet. PROFINET integrates information technology with established standards such as TCP/IP and XML in automation technology.

Within PROFINET, PROFINET IO is the communication concept for the construction of decentralized applications. This means that decentralized field devices are integrated through PROFINET IO. The familiar IO view of PROFIBUS DP is used where the usable data of the field devices is transferred to the controller process image in cycles. PROFINET IO is a device model consisting of slots and channels, which is based on the main features of PROFIBUS DP. The field device properties are written in a Generic Station Description Markup Language (GSDML) based on XML. PROFINET IO is engineered in the same way as has long been the case for system integrators of PROFIBUS DP. The decentralized field devices are assigned in the design of a controller.

PROFINET IO distinguishes between the following three device types:

- IO controller: Controller that executes the automation program.
- IO device: Decentrally assigned field device that is assigned to an IO controller.
- IO supervisor: Programming unit/PC with commissioning and diagnostic functions.

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8.1.2 PROFINET I/O Interface

The reader functions as a PROFINET I/O device that communicates cyclically with the assigned PROFINET I/O controller during operation.

The PROFINET interface of the reader supports the following features:

- 100 Mbits/s transfer rate
- Real-time category (RT)
- The range of functions in accordance with **Conformance Class B**
- Identification and maintenance functions (I&M) IM0 ... IM4

8.1.2.1 Identification & Maintenance (I&M) Data

Identification and maintenance data (I&M data) is information stored in a device. I&M data uniquely identifies a device within a plant. The identification data (I data) includes information about the device, for example the item number and device name. Identification data cannot be changed.

Maintenance data (M data) includes information about the device within the plant, for example the installation location and installation date. Maintenance data is initially stored in the device during installation. Maintenance data can be changed.

Accessing and Editing I&M Data

The Step7 software from Siemens can be used to display and change the I&M data.

1. To do so, open the hardware configuration **HW Config** and call up the "Target system" menu.
2. Open one of the following functions:
   - "Download module identification"
   - "Download module identification in PG"

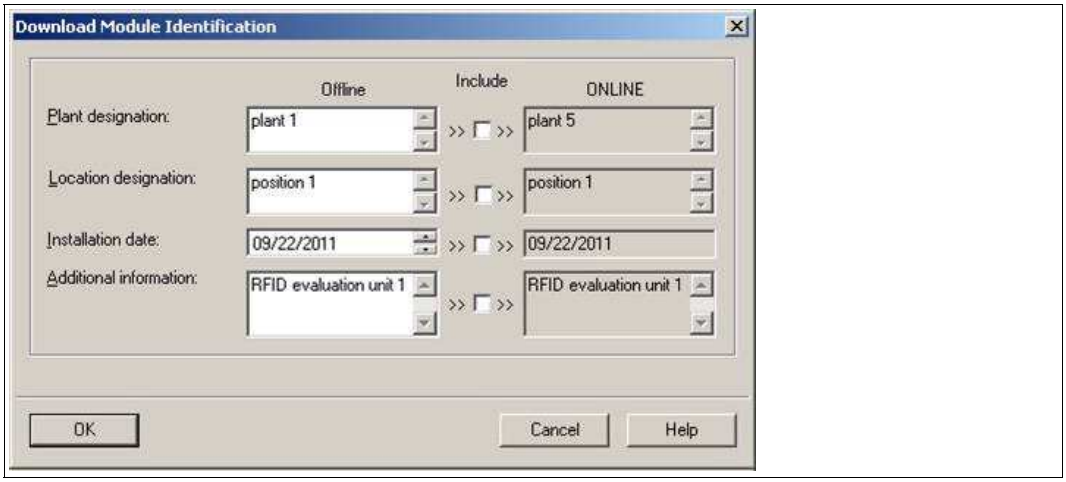

Figure 8.1

3. Depending on the requirement, read or edit the following I&M data:
   - I&M data 1: higher-level assignment, location designation
   - I&M data 2: installation date
   - I&M data 3: additional information

8.1.3 Project Planning Using Device Description

A field device is integrated into the project planning tool by way of a device description. The field device properties are described in the GSDML file. The GSDML file contains the field device data that you need to operate the device in a PROFINET network. This includes technical features and information about communication.

The GSDML file is imported into a project planning tool. Assign peripheral addresses to the individual channels of the field devices as usual. The peripheral input addresses incorporate the received data. The user program evaluates and processes this data. The user program generates the peripheral output values and sends them to the control interface.

Once project planning is complete, the IO controller receives the project planning and configuration data. The IO controller parameterizes and configures the field devices automatically.

Downloading the GSDML File

You can find the relevant GSDML file in the **Software** section of the product detail page for the device.

To access the product detail page for the device, go to http://www.pepperl-fuchs.com and type e.g., the product description or the item number into the search function.

8.1.4 PROFINET Modules

1 word = 16 bit value

1 byte = 8 bit value

8.1.4.1 Modules with Input Data Telegram

The following modules enable reader data to be retrieved using PROFINET.

You receive modules that contain non-secure data for positioning, and one module that contains secure data according to PROFIsafe.

Module 1

Bit No.	Content
0 ... 15	Status[1]
16 ... 47	Position data Y[2]
48 ... 63	Angle data[3]

1. see "Status"
2. see "Position Data Y"
3. see "Angle Data"

Module 2

Bit No.	Content
0 ... 15	Status[1]
16 ... 47	Position data Y[2]
48 ... 63	Angle data[3]
64 ... 95	Position data X[4]
96 ... 111	Speed[5]
112 ... 127	Position data Z[6]

1. see "Status"
2. see "Position Data Y"
3. see "Angle Data"
4. see "Position Data X"
5. see "Speed Data"
6. see "Position Data Z"

Module 3

Bit No.	Content
0 ... 15	Warning[1]

1. see "Warning"

Module 4 (only applies to PGV100AQ-F200*-B28-V1D)

Bit No.	Content
0 ... 31	Quality value, number of decoded codes[1]

1. see "Quality Value"

Position Data X

This data is non-safe position data for positioning in the X direction.

Size	Type	Content
4 bytes consis-tent	Input data	32 bit X position data MSB[1] first Resolution: 0.1 mm

1. MSB = **m**ost **s**ignificant **b**yte

Input Data

Bit / Bytes	7	6	5	4	3	2	1	0	Function
1	XSP31	XP30	XP29	XP28	XP27	XP26	XP25	XP24	X position data
2	XP23	XP22	XP21	XP20	XP19	XP18	XP17	XP16	X position data
3	XP15	XP14	XP13	XP12	XP11	XP10	XP09	XP08	X position data
4	XP07	XP06	XP05	XP04	XP03	XP02	XP01	XP00	X position data

Table 8.1 Input data telegrams for X position data

Error Codes (in Position Data X)

Code	Fault Type	Priority
2	No clear position can be determined (difference between codes is too great, code distance incorrect, etc.)	3
1000	Internal error	1

Table 8.2 Possible error codes

Position Data Y

Size	Type	Content
4 byte consistent	Input data	32 bit Y data MSB first Resolution: 0.1 mm

Input Data

Bits / Bytes	7	6	5	4	3	2	1	0	Function
1	YP31	YP30	YP29	YP28	YP27	YP26	YP25	YP24	Y position data
2	YP23	YP22	YP21	YP20	YP19	YP18	YP17	YP16	Y position data
3	YP15	YP14	YP13	YP12	YP11	YP10	YP09	YP08	Y position data
4	YP07	YP06	YP05	YP04	YP03	YP02	YP01	YP00	Y position data

Table 8.3 Input data telegrams for Y position data

Angle Data

Size	Type	Content
2 byte consistent	Input data	16 bit angle data Resolution: 0.1°

Input Data

Bit / Bytes	7	6	5	4	3	2	1	0	Function
1	ANG15	ANG14	ANG13	ANG12	ANG11	ANG10	ANG09	ANG08	Angle data
2	ANG07	ANG06	ANG05	ANG04	ANG03	ANG02	ANG01	ANG00	Angle data

Table 8.4 Input data telegrams for angle data

Speed Data

Size	Type	Content
1 word consistent	Input data	16 bit speed data Resolution: 0.1 m/s

Input Data

Bits / Bytes	7	6	5	4	3	2	1	0	Function
1	SP15	SP14	SP13	SP12	SP11	SP10	SP09	SP08	Speed
2	SP07	SP06	SP05	SP04	SP03	SP02	SP01	SP00	Speed

Table 8.5 Speed data input data telegram

Status

Size	Type	Content
1 word consistent	Input data	16 bit status

Input Data

Bits / Bytes	7	6	5	4	3	2	1	0	Function
1	0	0	0	0	0	0	0	0	Reserved
2	0	0	0	0	RES	WRN	NP	ERR	Reserved

Table 8.6 Status input data telegram

RES Reserved

WRN Warnings present. See information on warning.

NP No position information/OUT
(XP = 0, YP = 0, ZP = 0, ANGL = 0, SP = 0)

ERR Error message present
see Error Codes.

Warning

Size	Type	Content
1 word consistent	Input Data	Last warnings Last warning no.

Input Data

Bits Bytes	7	6	5	4	3	2	1	0	Function
1	WRN15	WRN14	WRN13	WRN12	WRN11	WRN10	WRN09	WRN08	Warning, see Warning Data Set
2	WRN07	WRN06	WRN05	WRN04	WRN03	WRN02	WRN01	WRN00	Warning, see Warning Data Set

Table 8.7 Input data telegrams for warning

Warning Data Set

Number	Warning
WRN00	Code with non-PXV content found
WRN01	Reader too close to code tape
WRN02	Reader too far from code tape
WRN03	Y position too large; the sensor is just before OUT
WRN04	Y position too small; the sensor is just before OUT
WRN05	The reader is rotated or tilted in relation to the code tape
WRN06	Low level of code contrast
WRN07	Repair tape detected
WRN08	Temperature too high
WRN09 ... WRN15	Reserved

Table 8.8 Existing warning data sets

If no warnings are present, all bits in the warning data set are set to 0.

Position Data Z

Size	Type	Content
1 word consistent	Input data	16 bit Z data MSB first Resolution: 1 mm

Input Data

Bit No.	Content Word 1 Z data
0	ZP00
1	ZP01
2	ZP02
3	ZP03
4	ZP04
5	ZP05
6	ZP06
7	ZP07
8	ZP08
9	ZP09
10	ZP10
11	ZP11
12	ZP12
13	ZP13
14	ZP14
15	ZP15

Table 8.9 Input data telegrams for Z position data

Quality Value (only applies to PGV100AQ-F200*-B28-V1D)

The quality values allow constant control of the code tape and the camera over the entire travel distance. This allows you to react in advance to possible damage or soiling of the code tape or the camera during commissioning and in subsequent regular operation. This increases the overall functional reliability of your system and in the event of a fault, you can immediately locate the problem.

The evaluation is based on a grading system from 1 to 6, whereby the value 1 represents the best possible reading quality. A value greater than 3 or worse requires an inspection of the camera or the track. Value 7 means "no position", because no code was detected.

Poor quality assessment can also be caused by incorrect alignment, incorrect measuring distance or incorrect attachment of the code tape.

Size	Type	Content
4 Byte	Input Data	Quality Value Number of decoded codes

Input Data

Bits / Bytes	7	6	5	4	3	2	1	0	Function
1	QLV07	QLV06	QLV05	QLV04	QLV03	QLV02	QLV01	QLV00	Quality value of the code tape
2	DCO07	DCO06	DCO05	DCO04	DCO03	DCO02	DCO01	DCO00	Number of decoded codes
3	RES07	RES06	RES05	RES04	RES03	RES02	RES01	RES00	Reserved
4	RES15	RES14	RES13	RES12	RES11	RES10	RES09	RES08	Reserved

Table 8.10 Input data telegrams for quality value

Number of decoded codes
In the reading window of the camera there are 5 codes at a nominal distance of 100mm and a visible track. Only one code is required in total for position calculation. If the number of codes read constantly fluctuates considerably, this may indicate individually dirty, damaged codes or fluctuating measuring distance.

Graduation of Q-Rating in case of new installation of DMC-Code:

Grade	Description of rating	Action
1	Very good installation	none
2	Good installation	none
3	Installation in tolerance range	check if code tape is dirty, Action: cleaning
4	Sufficient but unacceptable	check code tape for destruction and contamination. Also check course, possibly not optimal branches/ intersections are excluded.
5	Poor installation	see grade 4/ no release
6	Deficient installation	see grade 4/ no release
7	No operation possible now and later	see grade 4/ no release

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Graduation of Q-Rating in case of running operation:

Grade	Description of rating	Action
1	Very good	none
2	Good	none
3	Satisfactory	position with grade ≥ 3 Keep in focus and look at the next routine inspection, clean if necessary
4	Sufficient	check positions with grade ≥ 4 promptly for damage and soiling, clean or repair directly ifneccessary
5	Poor	check positions with grade ≥ 5 immediately for damage and soiling, clean or repair directly if necessary
6	Deficient	check positions with grade ≥ 5 immediately for damage and soiling, clean or repair directly if necessary
7	No operation possible	check positions with grade ≥ 5 immediately for damage and soiling, clean or repair directly if necessary

Note

The grades should be monitored over time by the PLC in order to detect deviations.

Note

The recommended classifications and measures refer to a continuous Data Matrix code tape. Please take into account that code tape gaps can cause lower quality values.

8.2 PROFINET Diagnostic Information

The reader has diagnostic functions to detect and eliminate faults. The reader automatically signals an operating fault and provides additional detailed information. Plant-wide diagnostics help to avoid unplanned downtime. In case of a fault, the positioning system issues a manufacturer-specific diagnostic message. The manufacturer-specific diagnosis is read from the positioning system via asynchronous read access and issues the manufacturer-specific error.

PROFINET Error Numbers

Number (HEX)	Number (DEC)	Diagnostic information
0x00	0	There are no longer errors in the PROFIsafe communication
0x40	64	The parameterized destination address does not match the destination address of the F-application.
0x41	65	Invalid destination address (0 or 0xFFFF)
0x42	66	Invalid source address (0 or 0xFFFF)
0x43	67	Invalid watchdog time (= 0)
0x45	69	Maximum length of the usable data does not match the parameterized CRC width
0x46	70	Invalid F-parameter version
0X47	71	F-parameter CRC – error
0X48	72	Device-specific error (see table Suberror Numbers)
0x4C	76	Invalid block ID
0x4D	77	CRC error: a data inconsistency was detected in the PROFIsafe communication.
0x4E	78	Timeout error: a timeout was detected in the PROFIsafe communication.

Table 8.11 Error numbers and associated diagnostic information

PROFINET Suberror Numbers

Number (HEX)	Diagnostic information	Action
0x00	No camera errors present	
0x01	Wrong checksum of valid position data	Check whether the appropriate original Data Matrix code tape from Pepperl+Fuchs has been used. If the error occurs repeatedly, the device is locked. In this case, contact Pepperl+Fuchs.
0x02	Wrong color in position data	If the error occurs repeatedly, the device is locked. In this case, contact Pepperl+Fuchs.
0x03	Internal integrity error	
0x04	Internal integrity error	
0x05	Internal integrity error	
0x06	Internal integrity error	
0x07	Maximum operating voltage exceeded	Check that the power supply is functioning correctly. If the error occurs repeatedly, the device is locked. In this case, contact Pepperl+Fuchs.
0x08	Internal communication error	If the error occurs repeatedly, the device is locked. In this case, contact Pepperl+Fuchs.

Table 8.12 Suberror numbers and the associated diagnostic information

8.3 Communication via PROFIsafe

8.3.1 General Information on the PROFIsafe Layer

PROFIsafe was developed to ensure functionally safe communication in often risky industrial processes. This ensures that PROFIsafe is currently one of the world's leading end-to-end technologies for functional communication, which has been normatively defined by IEC 61784-3-3 since 2007. With PROFIsafe, the residual error probability of data transfers between a fail-safe host (safety control system) and a fail-safe device (safety device) is reduced to a level required by the standards.

PROFIsafe describes a protocol that is superimposed on the PROFINET protocol. Here, the PROFIsafe protocol is transferred together with the standard protocol via the same bus cable. This is possible because the PROFIsafe protocol has no effect on the PROFINET network.

The properties of PROFIsafe-compatible field devices are described by a Generic Station Description Markup Language (GSDML) based on XML.

8.3.2 PROFIsafe Protocol Structure

The PROFIsafe protocol is used to transmit safe messages. Safe messages are referred to as F-messages. These messages are sent between the F-host and the F-device in PROFIBUS or PROFINET telegrams. F-messages are transmitted in the form of a safety protocol data unit (SPDU).

The SPDU consists of 3 fields, containing the following information:

1. Safe input data and output data
   vendor-specific length
2. Information about the synchronization of the PROFIsafe protocol machines
   SPDU from the F-host: 1 control byte
   SPDU from the F-device: 1 status byte
3. CRC signature consisting of 3 bytes

F-input/output data	Status/control bytes	CRC signature
Manufacturer-specific length	Each 1 byte	3 bytes

Table 8.13 SPDU consisting of 3 fields

For more information on this topic, see PROFIBUS Nutzerorganization e. V. (ed.): PROFIsafe System Description.

8.3.3 PROFIsafe-Specific Parameters

The following settings are possible for the PROFIsafe information in the safety-rated PLC.

Watchdog Time

F_WD_Time: 40 ms ... 2000 ms (standard)

Default value. This value can be changed.

Source Address

F_Source_Add: address of the safety-rated PLC

Default value. This value can be changed.

Destination Address

F_Dest_Add: address of the reader

Value range 1 ... 65534

Changeable value. This value must be adapted to the address of the reader that is used.

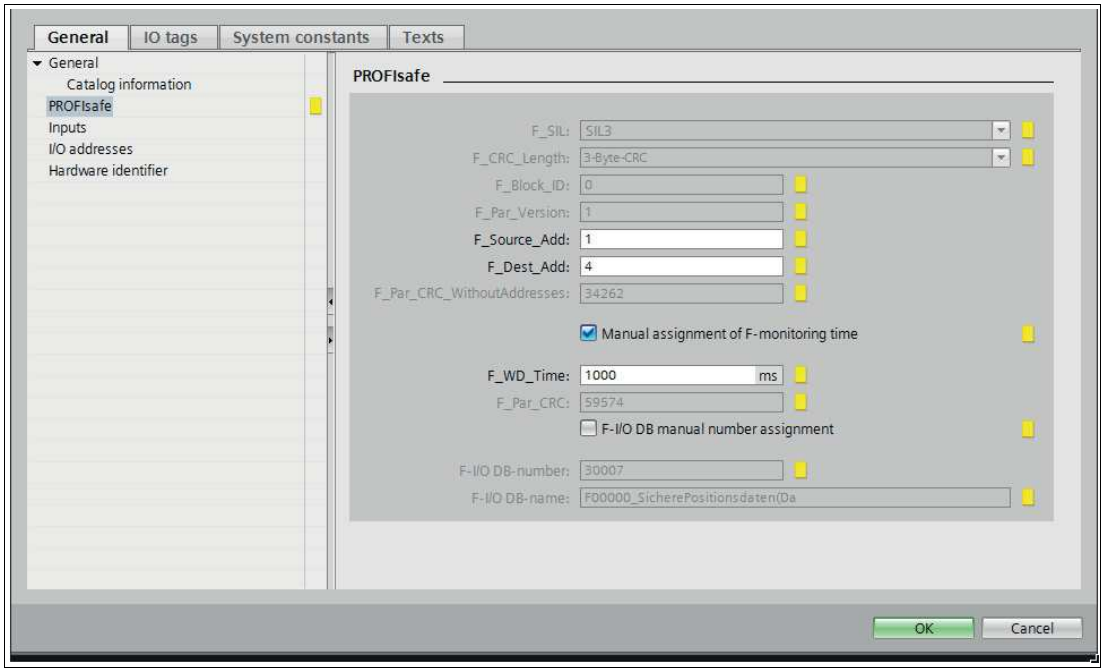

Figure 8.2 PLC default settings for PROFIsafe

8.3.4 PROFIsafe Address and Identification of the Device

The following settings are possible for the PROFIsafe information in the safety-rated PLC.

Every PROFIsafe IO device has a unique device identification. This device identification consists of the following components:

- **MAC ID:** The MAC ID is printed on the back of the device.
- **PROFIsafe address:** The default device name is **pgv-f200-sil**. The default PROFIsafe address is "3

  Insert the PROFIsafe address of the device using the device name. To do this, use a suffix that contains the address of the device.
  Example: pgv-f200-sil**.f-6** -> xxx.f-6 -> the address **6** is adopted.
- **IP address:** The default IP address is **192.168.2.2.**

8.3.5 PROFIsafe Module

Note

Note on Fail-Safe Values (FV)

If the PROFIsafe-specific failsafe values (FV), which are not vendor-specific data, are activated in the PROFIsafe protocol, then the content of the vendor-specific data is "Status", "Status negated", and "X position data" = "0."

This must be observed when implementing the safety-related application.

If the PROFIsafe-specific failsafe values (FV) are activated, then the safety-related input data is invalid and may not be used by the safety-related application.

Modules with Input Data Telegram

The following modules enable safe reader data to be retrieved using PROFIsafe. The modules are compatible with PROFIsafe V2.4 and each consist of 6 bytes.

Safety Module – Data Format 32 Bit DINT

This data is safe status data and safe position data. STEP 7 Safety Advanced supports the DINT data format.

Size	Type	Content	Data type
6 bytes consis-tent	Input data	8 bit safe status data	Bit
		8 bit safe status data negated	Bit
		32 bit safe X position data	DINT
		Resolution: 10 mm	

Input Data

Bits / Bytes	7	6	5	4	3	2	1	0	Function
1	0	0	0	OVD	OT	INIT	0	VAL	Safe status
2	/VAL	1	/INIT	/OT	/OVD	1	1	1	Safe status negated
3	XS31	XS30	XS29	XS28	XS27	XS26	XS25	XS24	Safe X position data
4	XS23	XS22	XS21	XS20	XS19	XS18	XS17	XS16	Safe X position data
5	XS15	XS14	XS13	XS12	XS11	XS10	XS09	XS08	Safe X position data
6	XS07	XS06	XS05	XS04	XS03	XS02	XS01	XS00	Safe X position data

Table 8.14 Input data telegrams for the safety module (data format 32 bit DINT)

Bit	Value	Description
VAL	1	Safe X position data is valid
	0	Invalid; safe X position data = 0x00000000
INIT	0	Initialization inactive
	1	Initialization active
OT	0	No excess temperature detected on the HiCore module. The temperature is not safety-related.
	1	Excess temperature detected on the HiCore module. The temperature is not safety-related.
OVD	0	No overvoltage detected on +UB
	1	Overvoltage > 32 VDC detected on +UB

Table 8.15 Description of the individual bits in the safety module (data format 32 bit DINT)

Safety Module – Data Format 2 x 16 Bit INT

This data is safe status data and safe position data. STEP 7 Distributed Safety supports the data format INT.

Size	Type	Content	Data type
6 bytes consitent	Input data	8 bit safe status data	Bit
		8 bit safe status data negated	Bit
		16 bit safe X position data (MSB)	INT
		16 bit safe X position data (LSB)	INT
		Resolution: 10 mm	

Input Data

Bits Bytes	7	6	5	4	3	2	1	0	Function
1	0	0	0	OVD	OT	INIT	0	VAL	Safe status
2	/VAL	1	/INIT	/OT	/OVD	1	1	1	Safe status negated
3	XS31	XS30	XS29	XS28	XS27	XS26	XS25	XS24	Safe X position data
4	XS23	XS22	XS21	XS20	XS19	XS18	XS17	XS16	Safe X position data
5	XS15	XS14	XS13	XS12	XS11	XS10	XS09	XS08	Safe X position data
6	XS07	XS06	XS05	XS04	XS03	XS02	XS01	XS00	Safe X position data

Table 8.16 Input data telegrams for the safety module (data format 2 x 16 bit INT)

Bit	Value	Description
VAL	1	Safe X position data is valid
	0	Invalid; safe X position data = 0x00000000
INIT	0	Initialization inactive
	1	Initialization active
OT	0	No excess temperature detected on the HiCore module. The temperature is not safety-related.
	1	Excess temperature detected on the HiCore module. The temperature is not safety-related.
OVD	0	No overvoltage detected on +UB
	1	Overvoltage > 32 VDC detected on +UB

Table 8.17 Description of the individual bits in the safety module (data format 2 x 16 bit INT)

Functional Description of the Valid Bit

The valid bit reflects the state of the safe position data. Only when the state of the valid bit ="logic 1" may the safe X position data be used for the plausibility check and further processing in the control program.

If the state of the valid bit="logic 0", the reader cannot determine safe position values at this time. The plant control software has the task of carrying out further processing and triggering the appropriate actions to ensure the safe state of the plant.

9 Maintenance

Caution!

Device may become hot during prolonged operation

After a long period of operation, the metal surfaces (plug) and the housing of the sensor have an elevated temperature relative to the environment.

This must be taken into account during service work. Let the device cool down before handling it.

If the reader is faulty, it must be replaced with a new device. The reader may not be repaired.

No position values can be determined wherever sections of the Data Matrix code tape are dirty or destroyed.

Note

Replacing Damaged or Destroyed DataMatrix Code Tape

The operator is responsible for replacing dirty or destroyed sections of Data Matrix code tape with original Data Matrix code tape. Replacement sections can be obtained from Pepperl+Fuchs, see chapter 3.7.

Maintaining, Repairing or Replacing the Device

In case of maintenance, repair or replacement of the device, proceed as follows:

1. Implement appropriate maintenance procedures for regular maintenance of the safety loop.
2. While the device is maintained, repaired or replaced, the safety function does not work.
   Take appropriate measures to protect personnel and equipment while the safety function is not available.
   Secure the application against accidental restart.
3. Do not repair a defective device. A defective device must only be repaired by the manufacturer.
4. If there is a defect, always replace the device with an original device.

Note

Prior to Use of a Replacement Device

In case of a replacement, the plant operator is responsible for setting the PROFINET name and the PROFIsafe address, as well as the F-parameters, according to the old device.

9.1 Maintenance

The device is maintenance-free.

9.2 Testing

The device does not need to be tested. To ensure adequate availability, we recommend regularly examining the reader and the Data Matrix code tape for mechanical damage and removing contamination.

A regular proof test is not required as the minimum interval for a proof test is longer than the useful lifetime. If the device is subjected to sources of potential mechanical damage or vibration in the plant, we recommend regularly inspecting the device with regard to the integrity of the housing (water ingress) and the right mounting (loose mounting screws).

9.3 Cleaning

Check that the components are securely mounted and that optical surfaces are clean.

Caution!

Property damage due to improper cleaning

Treating surfaces with the wrong cleaning materials and liquids can damage the surface and thus disrupt the functioning of the device or put it out of operation.

Use a soft, lint-free cloth to clean the surfaces. Only use water, alcohol, or spirits as cleaning fluids.

Regularly clean the surface of the reader lens. The cleaning interval depends on the ambient conditions and the climate within the plant.

9.4 Repairs

Danger!

Danger to life due to missing safety function

If the safety loop is taken out of operation, the safety function is no longer guaranteed.

Do not bypass the safety function.

Do not repair or manipulate the device.

If there is a defect, always replace the device with an original device.

Only use accessories specified by the manufacturer.

10 Disposal

The device, built-in components, packaging, and any batteries contained within must be disposed in compliance with the applicable laws and guidelines of the respective country.

11 Change History

The chapter "Change History" lists the changes made to each documentation version of the original instructions in this document.

Document Version	Change	See
DOCT-6011	First edition of the original instruction	-
DOCT-6011A	Warning message revised	Kap. 6.3
DOCT-6011B	Terminology adaptation: "reading range" changed to "safety-related reading range" Text adaptation: description text revised and table added **Graphic adaptation: Graphic "Safety-related reading range" revised** **Correction: Calculation of "Safety-related accuracy"**	Kap. 5.6
	Technical data added	Kap. 3.9
	Text adaptation	Kap. 3.2
		Kap. 3.7
		Kap. 5.4
		Kap. 6.5.1
		Kap. 7
		Kap. 8.1.4
		Kap. 8.3.4
		Kap. 8.3.5
DOCT-6011C	New device variant PGV100AQ-F200*-B28-V1D	-
	New base material for Data Matrix code tape, added / PXV*-AAM*-*	Kap. 3.1
		Kap. 3.4
		Kap. 5.4
	Table extended with new device type	Kap. 3.8
	Feature "Safety related X" removed	Kap. 3.9.1
	Module 3 "Warning" added Module 4 "Quality Value" added	Kap. 8.1.4.1
	Adjustment MTTF value	Kap. 3.9.1 Kap. 5.5

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