

PXV100Q-F213-IO-0.3M-V15

**Data Matrix
Positioning System**

Manual



With regard to the supply of products, the current issue of the following document is applicable:
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1	Introduction	5
1.1	Content of this Document	5
1.2	Target Group, Personnel	5
1.3	Symbols Used	5
1.4	Registered Trademarks	6
2	Safety	7
2.1	Intended Use	7
2.2	Reasonably Foreseeable Misuse	7
2.3	Cybersecurity Information	8
3	Product Description	9
3.1	Basic System Functions.....	9
3.2	IO-Link Interface	9
3.3	Positioning on the Code Tape.....	11
3.4	Maximum Data Matrix Code Tape Length.....	11
3.5	LED Indicators	11
3.6	Accessories.....	12
4	Planning.....	13
4.1	Plant Design	13
4.2	Ambient Conditions.....	13
4.3	Positioning Targets	14
4.3.1	Characteristics of the Data Matrix Codes.....	14
4.3.2	Data Matrix Code Tape	15
4.3.3	Operating with a Data Matrix Event Marker Tape	16
4.4	Angle, Position, and Velocity Output with Data Matrix Code Tape.....	17
4.5	Field of View of the Read Head.....	21
4.6	Read Head Orientation	22
4.7	Read Head Orientation	24
4.7.1	Read Tolerance in Z Direction	24
4.7.2	Reading Tolerance in y Direction.....	25
4.7.3	Inclination Angle	26
4.7.4	Rotational Tolerance in the z Axis	27
4.8	Gaps/Interruptions	28
4.9	Behavior of the Read Head When Cornering	38
4.10	Quality Grades	41

4.11	Extrapolation	44
4.12	Frame Counter.....	45
5	Installation and Commissioning	46
5.1	Positioning Targets	46
5.1.1	Data Matrix Code Tape	47
5.1.2	Emergency Spare Code Tape	48
5.2	Read Head	50
5.2.1	Read Head Assembly	50
5.2.2	Electrical Connection	52
5.2.3	Aligning the Read Head	53
5.2.4	Alignment Using the Alignment Gauge	55
5.3	Configuration.....	56
5.3.1	Commissioning with IO-Link on a Controller (Online Parameterization)	57
5.3.2	Commissioning with IO-Link via FDT Frame Application and IODD (Offline Parameterization).....	57
6	Operation and Communication	60
6.1	Data log	60
6.1.1	Process Data Structure	61
7	Maintenance	63
7.1	Servicing.....	63
7.2	Testing.....	63
7.3	Cleaning.....	64
7.4	Repair	65

1 Introduction

1.1 Content of this Document

This document contains information that you need in order to use your product throughout the applicable stages of the product life cycle. These can include the following:

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



Note

For full information on the product, refer to the further documentation on the Internet at www.pepperl-fuchs.com.



Note

For specific device information such as the year of construction, scan the QR code on the device. As an alternative, enter the serial number in the serial number search at www.pepperl-fuchs.com/device-information.

The documentation consists of the following parts:

- Present document
- Datasheet

Additionally, the following parts may belong to the documentation, if applicable:

- EU-type examination certificate
- EU declaration of conformity
- Attestation of conformity
- Certificates
- Control drawings
- Instruction manual
- Functional safety manual
- Cybersecurity documentation
- Other documents

1.2 Target Group, Personnel

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

Only appropriately trained and qualified personnel may carry out mounting, installation, commissioning, operation, maintenance, and dismantling of the product. The personnel must have read and understood the instruction manual and the further documentation.

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

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.



Tip

This symbol brings an useful tip to your attention.



Example

This symbol provides an example of the issue described.



Action

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

1.4 Registered Trademarks

IO-Link® is a registered trademark of PROFIBUS Nutzerorganisation e.V. (PNO).

2 Safety

2.1 Intended Use

Together with the positioning targets intended for this purpose, the read head forms a high-resolution optical positioning system. This system is designed for precise linear positioning of conveyor and transport systems along defined traverse paths.

The system can be operated in two mounting versions:

- The positioning targets are attached to a fixed part of the system parallel to the traverse path, while the read head is mounted on the moving part of the system.
- The positioning targets are attached to a moving part of the system; the read head is mounted in a fixed position.

Intended use also includes the following:

- Compliance with all the information in this manual and in the associated datasheet
- Operation exclusively within the technical parameters specified therein
- Only use the intended positioning targets that are available as accessories for the read heads.
- Indoor use. Outdoor use is only permissible to a limited extent (see chapter 4.2).



Danger!

Explosion hazard if used in hazardous areas

The read head is not approved for use in hazardous areas (Ex zones).

Operating in a hazardous area can trigger an explosion. This will result in death or serious injury and significant property damage.

- Never use the read head in hazardous areas.
- Before installation, check whether the intended installation location is part of a hazardous area.

2.2 Reasonably Foreseeable Misuse

Any use that goes beyond or contradicts the intended use is considered misuse. The operator is solely liable for any resulting damage.

Reasonably foreseeable misuse includes in particular:

- Use in hazardous areas
- The installation of the positioning targets on the ground outside
- Outdoor use outside the ambient conditions permitted in the datasheet
- Use of unauthorized or reproduced positioning targets
- Operation outside the specified technical parameters (e.g., supply voltage, temperature, velocity, read distance)
- Multiple use of identical code ranges within the same traverse path (see the following warning message)
- Use as a safety-related component within the meaning of the Machinery Directive/Machinery Regulation.

**Warning!**

Danger due to ambiguous position information

Multiple use of code ranges can lead to ambiguous position specifications. As a result, the real position of the device cannot be clearly determined. The control logic can then perform an incorrect action at an incorrect position.

Uncontrolled movements can cause serious injury to persons and cause significant plant damage.

- During planning, ensure the position information for the read head is unique throughout the entire system.
 - Never use double code ranges.
-

2.3

Cybersecurity Information

The following protective measures are the responsibility of the plant operator. They must be implemented prior to commissioning and adhered to throughout the entire operation.

Physical Access Protection

- The device must be secured against physical access by unauthorized persons (e.g., lockable switch cabinet, access control).

Network Segmentation

- The device must only be operated in an isolated network segment without a direct connection to the company network, internet, or cloud services. Communication must be restricted to a higher-level control system and a defined, trustworthy group of network participants.

Protecting the Voltage Supply

- The voltage supply of the device must be protected against unauthorized access. The device has a recovery mode that allows you to change the firmware. The recovery mode is activated by lowering the input voltage to below 9 V. Tampered firmware can be installed if the voltage supply is accessed without authorization.
 - Ensure an input voltage of at least 10 V in normal operation.
 - The voltage supply must be secured against unauthorized access (e.g., locked switch cabinet).

3 Product Description

3.1 Basic System Functions

The high-resolution positioning system consists of a read head in conjunction with suitable positioning targets. Features of the read head include appropriate connection options, a camera module, and internal illumination. In addition, the read head is insensitive to overexposure due to external lighting.

First, an image is recorded for precise positioning. The read head searches for positioning targets in this image. The exact position can then be calculated based on the position of the positioning targets in the image.

The read head is mounted at the nominal distance from the laid code tape and is immediately ready for operation. Special knowledge of image processing is not required. The position is detected automatically. The read head determines position values at fixed time intervals.

The output position values are absolute. A reference run to determine the position is not required. Multiple read heads provide consistent position values for identical code tape, making them easy to replace.

The functionality of the system is determined by the type of positioning targets used, which must be compatible with the respective read head. Different types of targets influence the specific functional and application possibilities. The basic functions of the read head in combination with the various compatible positioning targets are explained in detail below.

3.2 IO-Link Interface

What is IO-Link?

IO-Link enables seamless communication and digital data transmission from the control panel level down to the sensor level. The intelligent sensors can be used to their full potential with IO-Link, paving the way for Industry 4.0 in automation technology. The internationally standardized interface provides impressive efficiency and sustainable cost reduction from plant design and installation right through to operation and servicing.

Standardized device description files (IODDs) and parameterization via software tools ensure convenient configuration and integration of IO-Link sensors. Intelligent and transparent parameter management increases application flexibility and keeps downtimes to a minimum.

Parameters can be customized quickly and easily, even for complex production and batch changes. Transparency right through to the sensor gives users access to a comprehensive range of parameterization options and device diagnostics functions, allowing them to perform predictive maintenance.

The technology offers particular benefits

- In service (troubleshooting, servicing, and device exchange)
- During commissioning (cloning, identification, configuration, and localization)
- And during operation (job changeover, continuous parameter monitoring, and online diagnostics).

IO-Link offers a number of advantages for industrial applications:

- Internationally standardized interface: The open standard is standardized in accordance with IEC 61131-9 and is compatible with established field buses on the market.
- Increased efficiency with sustainable cost reduction: High noise immunity with simplified cabling, standard cable 4/5-pin with M12 plugs unshielded up to 20 m cable length
- IO-Link minimizes downtimes: IO-Link devices can be easily parameterized via the control system, identified using a localization function, and serviced as required—the additional data provided helps minimize downtime.
- Transparency down to the lowest field level: In addition to reliable sensor identification, the newly created transparency enables access to all process and diagnostic data and to device information right down to sensor/actuator level.
- Extremely quick cycle times in the millisecond range enable highly dynamic position detection

- Automated device exchange via IO-Link
- Connection to future generations of frequency inverters with IO-Link
- ID value output directly on IO-Link

Device Description File (IODD)

The parameters of the sensors are device-specific. A standardized description of these parameters can be found in the IO Device Description (IODD). The IODD can be imported into various engineering tools from different system providers, providing they support IODD. The sensor can be configured or diagnosed using the appropriate tool.

IODDs can be integrated into a control environment to allow IO-Link devices to be used for IO-Link operation. Both programming and exchanging process data can be performed with a PLC. The IODD can also be imported into a range of engineering tools from various system providers for programming and diagnostics, provided these tools support IODD

Offline Parameterization

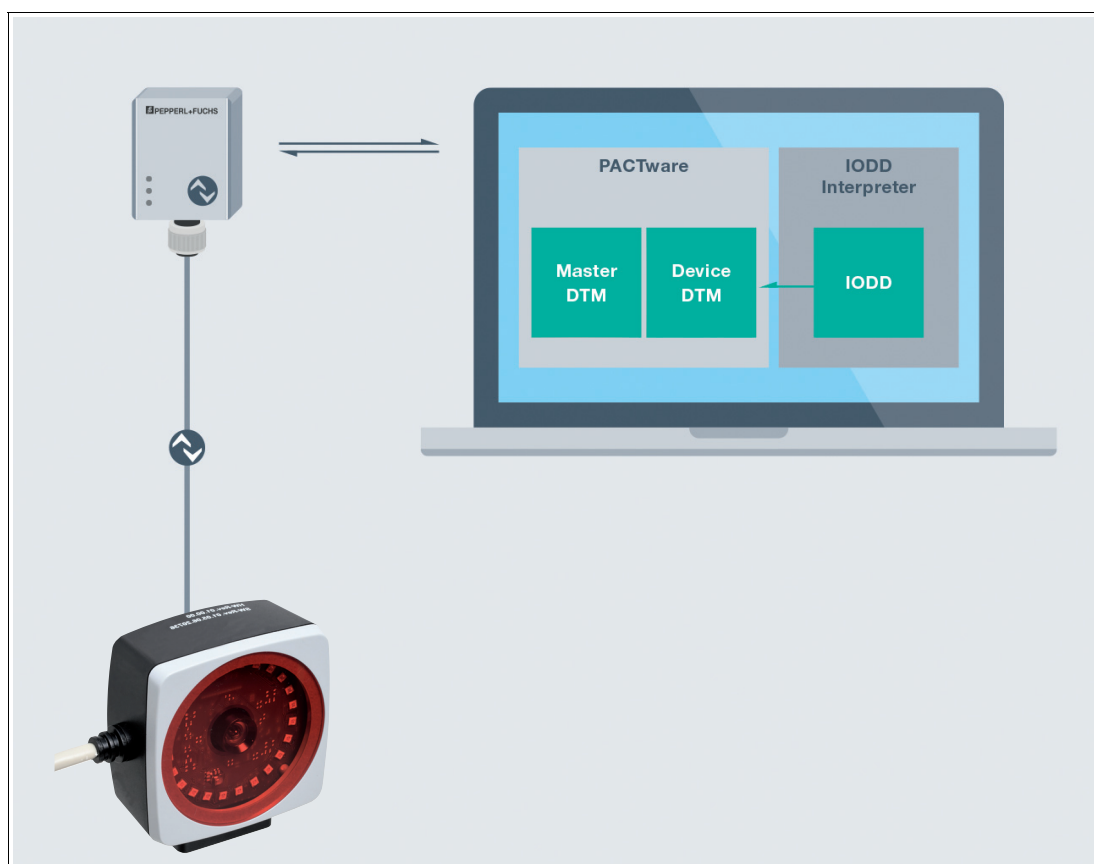


Figure 3.1

With offline parameterization, the IO-Link read head is configured before installation. To do this, use the Pepperl+Fuchs IO-Link USB master. We recommend using "PACTware" software as the FDT frame application and user interface.

An IODD is available for the read head. It is possible to use the IODD for offline parameterization.

The IODD must first be converted with the "IODD Interpreter DTM" program. "IODD Interpreter DTM" is used to transform the IODD into a tabular user interface for parameterization.

The software components required in each case are collated in the latest version of the "IO-Link Offline Parameterization Tool" software package. The software package and the documentation on its installation and use can be found online at www.pepperl-fuchs.com.

3.3 Positioning on the Code Tape

The Data Matrix code tape is used as a positioning target for precise linear positioning in conveyor and transport systems. In combination with the Data Matrix code tape, the read head records the following data:

- x-position along the code tape
- y-position (y offset to the center of the code tape)
- z-distance (height above the code tape)
- Velocity
- Angle (rotation relative to the code tape)
- Status information
- Quality Grades
- Frame counter
- Event marker number
- Number of detected codes

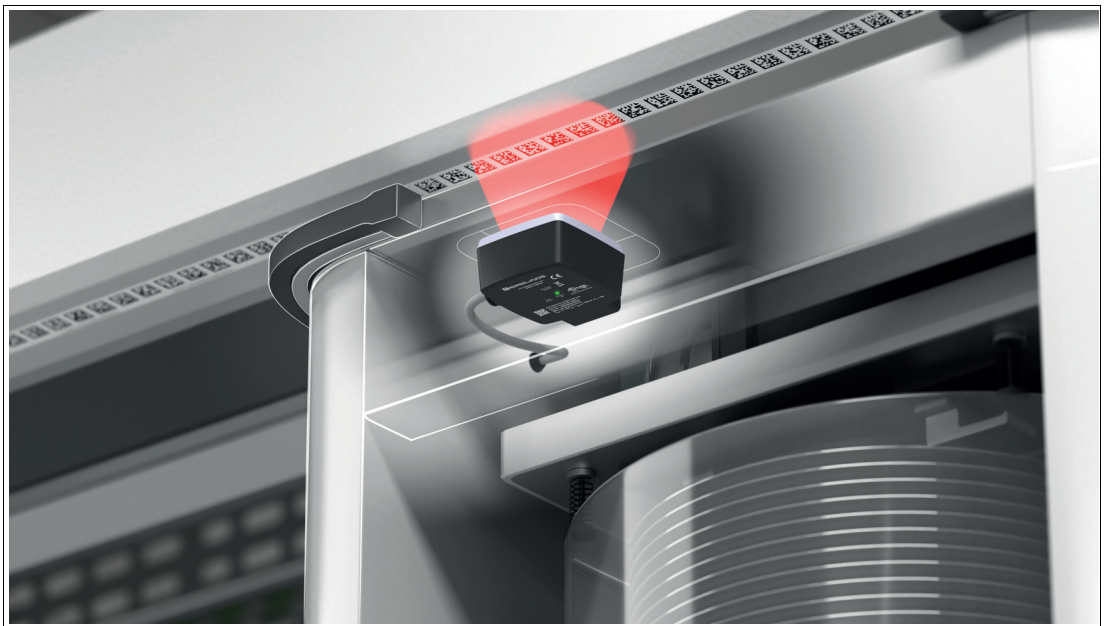


Figure 3.2 Example representation of a typical linear positioning application with a fixed code tape and read head on the moving part

3.4 Maximum Data Matrix Code Tape Length

The maximum length of the Data Matrix code tape is 100 km. The system is therefore also suitable for very large plants and offers sufficient reserves for expansions and for branched or parallel conveyor lines.

The code tape can be ordered in 1 m sections with a freely selectable start position. It is delivered on rolls with a maximum length of 100 m.

3.5 LED Indicators

The read head is equipped with two indicator LEDs for carrying out visual function checks and quick diagnostics.

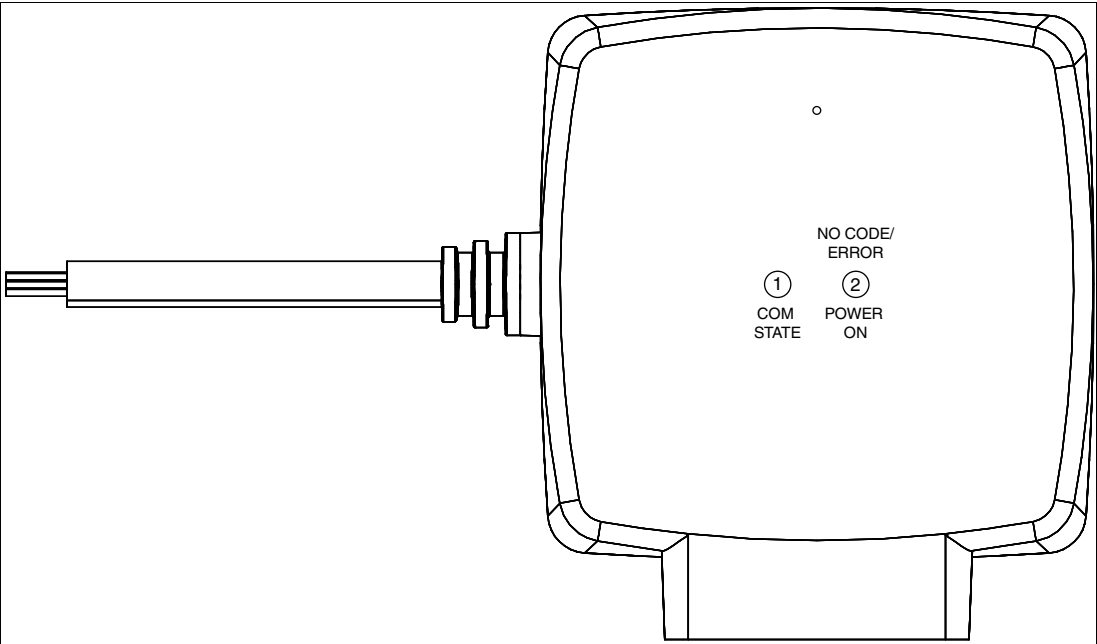


Figure 3.3 Display elements

LED Status

Item	Designation	LED Color		LED Indicator	Meaning
1	NO CODE/ ERROR POWER ON		Green	On	Codes detected
			Red	Flashing	Codes not detected
			Red	On	System error
2	COM STATE		Red	On	Internal error, voltage low
			Yellow	Flashing	IO-Link Locator function
			Green	On	Ready for IO-Link communication
			Green	Flashing	IO-Link communication active



Note

If the **COM STATE** LED lights up red while the IO-Link master is being operated via the Pepperl+Fuchs USB master, the 24 V voltage supply on the IO-Link master may be missing. Without a 24 V voltage supply, the voltage of the device is too low; it restarts repeatedly and reports an error.

Make sure that the 24 V voltage supply is connected to the IO-Link master.

3.6 Accessories

Suitable accessories for your read head can be found on the "Related products" tab of our web-site www.pepperl-fuchs.com.

4 Planning

This chapter contains all the technical device properties required for error-free system planning.

Responsibility of the System Planner

The system planner is solely responsible for assessing whether the read head is suitable for the specific application and the ambient conditions. As Pepperl+Fuchs has no influence on the selection and the specific application, Pepperl+Fuchs assumes no liability for the suitability in the specific overall system.



Note

Warranty

Pepperl+Fuchs' liability is limited to the specified and consistent quality of the individual product supplied within the scope of the applicable delivery conditions.

4.1 Plant Design

The positioning system consists of a read head and matching positioning targets. Suitable positioning targets can be found as accessories on the product details page for the respective read head on our homepage in the "Related Products" tab.

In the following sections, the read head and the positioning targets are explained both individually and in how they interact as a complete system.

Usage Conditions

The permissible ambient conditions are crucial for reliable operation. Detailed information and information on ensuring system availability, even under unfavorable conditions, are included, see chapter 4.2.

Positioning Targets and Data Output

You will receive basic information on the positioning targets and a detailed description of the system functions. The output data is named and its meaning is explained. Applications for which the respective positioning targets are suitable are described.

Mounting and Tolerances

For successful installation, the tolerance ranges of the read head are described in detail. The permissible mounting options for the read head and positioning targets can be derived from this. This information forms the basis for accurate mounting.

Additional Functions

Finally, other functions of the read head are covered, such as the output of quality values.

4.2 Ambient Conditions

This section describes the ambient conditions under which the positioning system can be operated. Detailed specifications on the degree of protection, temperature range, and applicable standards can be found in the datasheet for the read head and the positioning targets.

Indoor Use

The positioning system is primarily designed for indoor use. Compliance with specified degree of protection, temperature range, and relevant standards is the basic prerequisite for proper operation.

Indoor optical interference, especially dirt on the code tape, can affect system reliability. Although the system has high redundancy, this can affect reading performance. The read head has an internal function to evaluate the optical quality of the code tape (). This function enables early detection of dirt or damage and therefore prompt corrective action. For instructions on cleaning the code tape, see chapter 7.3.

Outdoor Use

In addition to the optical interference that can occur indoors, additional environmental influences are expected outdoors. The read head and the code tape are generally resistant to outdoor environmental conditions. However, optical interference outdoors is often unavoidable. Uncontrollable environmental factors such as snow, ice, rain, or condensation can impair the read head's view of the positioning targets and prevent reliable positioning.

Note

Protective Measures Outdoors

If the system needs to be used outdoors, steps must be taken to prevent optical interference. A key measure is to protect the code tape and the read head from rain, for example by using a canopy. Water droplets on the read head glass or on the code tape can impair the reading of Data Matrix codes. Ideally, a continuous canopy should be installed between the read head and the code tape. Without such a protection, extreme snowfall or rain may cause temporary system outages.



4.3 Positioning Targets

Positioning targets are reference points within the positioning system. They enable the read head to determine its exact position.

The selection of available positioning targets depends on the respective read head type. A suitable positioning target for your specific read head can be found on the corresponding product details page on our homepage.

The following sections explain in detail the relevant properties of the positioning targets that are important for the read head.

4.3.1 Characteristics of the Data Matrix Codes

The Data Matrix code tape consists of Data Matrix codes that contain information about the absolute position. These codes act as reference points for determining the position of the read head.

Fail-Safety via ECC200

The Data Matrix code tape uses fail-safe Data Matrix codes according to ECC200 (Error Correction Code). These contain additional information to prevent and correct read and transmission errors. This ensures reliable reading even with heavily soiled or stressed code tapes and is crucial for system redundancy.

Structure of the Data Matrix Code

The following figure shows an example of an ECC200 Data Matrix code.

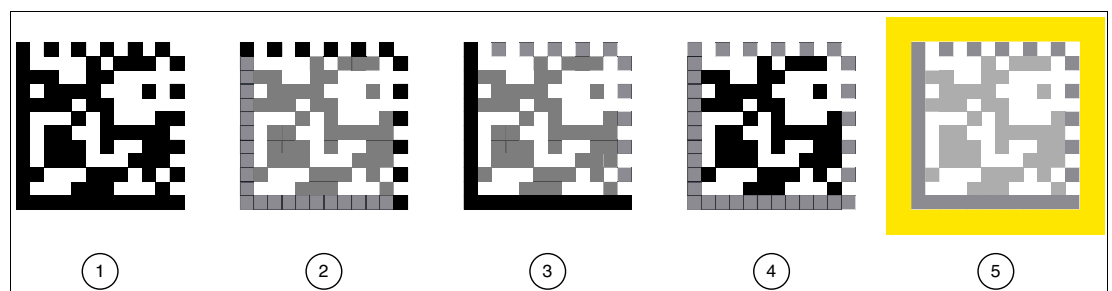


Figure 4.1 Data Matrix code ECC200

An ECC200 Data Matrix code consists of several functional areas that are required for reliable detection and evaluation:

Data Matrix Code (1)

- ECC200, symbol size 12×12, black/white

Alternating Pattern (2)

- Pattern of alternating black and white modules
- Even number of modules
- Allows the data density to be determined
- Used for symbol size recognition and ECC200 type recognition

Finder Pattern (3)

- Characteristic pattern of black modules in an "L" shape
- Allows the Data Matrix code to be found
- Detects distortion
- Clearly determines the location and size of the Data Matrix code

Data Area (4)

- Actual data field of the Data Matrix code
- Matrix of black and white modules representing the coded information
- Contains the error correction area with additional data for detecting and correcting read and transmission errors

Quiet Zone (5)

- White area around the Data Matrix code (shown in yellow in the "Data Matrix code ECC200" figure above)
- Delineates the code from other objects or the background
- Width of the quiet zone: 2 mm

Note**Respect the Quiet Zone**

The quiet zone around the Data Matrix code must have a width of **at least 2 mm**. It must not be breached by stickers or when cutting the code tape, otherwise error-free detection by the read head is no longer guaranteed.

4.3.2**Data Matrix Code Tape**

Data Matrix code tapes enable the exact positioning of linear transport systems, such as freight elevators and monorail conveyors.

How It Works

The read head detects the information on the Data Matrix code tape and continuously supplies the following values to the higher-level system:

- **Position:** x, y, and z position
- **Orientation:** Angle
- **Speed:** Traversing speed

Material and Mounting

The code tape is made of silicone-free polyester film. The rear side is coated with a permanent acrylate adhesive, which is used to affix the code tape along the travel path.

- **Orientation aid:** There is a positioning target every 100 mm along the lower edge of the code tape. This is used for exact alignment during mounting.
- **Mounting details:** For detailed information on mounting, see chapter 5.1.
- **System limits:** The maximum permissible total length is specified in .

Note**System Compatibility**

Error-free operation of the positioning system is only guaranteed if the read head and the code tape type used are compatible with each other. Information on compatibility can be found on the homepage.

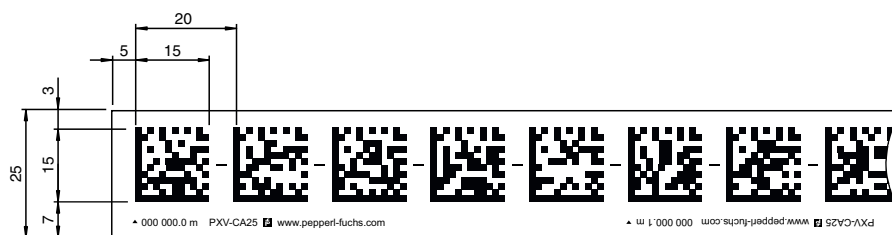


Figure 4.2

Center Line Definition ($y = 0$)

The center line identifies the reference axis at which the read head outputs the value $y = 0$.

The center line does **not** correspond to the geometric center of the code tape. It runs exactly through the center of the Data Matrix codes. For visual orientation, this line is indicated by small black markings between the individual Data Matrix codes.

4.3.3

Operating with a Data Matrix Event Marker Tape

The event marker tape is a special Data Matrix code tape with a standard length of one meter. It contains Data Matrix codes in which a fixed number from the number range 001 to 999 is coded.

Function

When entering the area of an event marker tape, the read head sets a marker tape flag and outputs the marker number. Event marker tapes are used to start defined processes at specific positions in a system. To enable this functionality, the reading of the event marker tape must be programmed as an event in the control system and the associated sequence stored.

Mounting and Position Detection

The event marker tape is affixed over or next to the standard Data Matrix code tape. The corresponding setting can be configured in the read head. For configuration details, . If the event marker tape is affixed over the standard Data Matrix code tape, the read head does not supply an absolute position, but increments the position based on the last known absolute position.



Note

No Position Determination After Restarting over an Event Marker Tape

If the event marker tape is affixed over the standard Data Matrix code tape, the read head must not be restarted directly over an event marker tape. As the event marker tape does not supply an absolute position, the system cannot determine a valid position in this case.

Length of the Event Marker Tape

The standard length of one meter can be shortened to a minimum of three Data Matrix codes. The required length depends on the movement speed of the conveyor and transport system. The higher the speed, the longer the event marker tape must be. The full length of one meter is required at the maximum permissible movement speed of the positioning system.

The minimum length as a function of the travel speed is calculated as follows:

$$L_{\text{event marker tape}} = 0.06 \text{ m} + (V_{\text{max}} [\text{m/s}] * \text{cycle time} [\text{s}] * 2)$$

The cycle time can be found in the data sheet for your read head.



Example

Example Calculation

A speed of 3 m/s and a cycle time of 100 Hz (= 0.01 s) results in:

$$L_{\text{event marker tape}} = 0.06 \text{ m} + (3 \text{ m/s} * 0.01 \text{ s} * 2) = \mathbf{0.12 \text{ m}}$$

Marking

Event marker tape can be identified by the printed number, e.g., "MARKER 012". The following figure shows a section of an event marker tape with the number #12.



Figure 4.3 Identification of event marker tape

4.4 Angle, Position, and Velocity Output with Data Matrix Code Tape

Position Output in the x Direction

The position in the x direction is determined using the Data Matrix codes recorded in the field of view of the read head. The Data Matrix codes act as reference points for determining the position. Each code contains unique position information.

A single Data Matrix code in the field of view of the read head is sufficient for determining the position. Additional codes increase the redundancy and availability of the system.

The exact position is determined by the position of the detected Data Matrix code within the field of view. The system calculates the exact position in the x direction based on the deviation from the center of the image. This enables high-precision position determination.

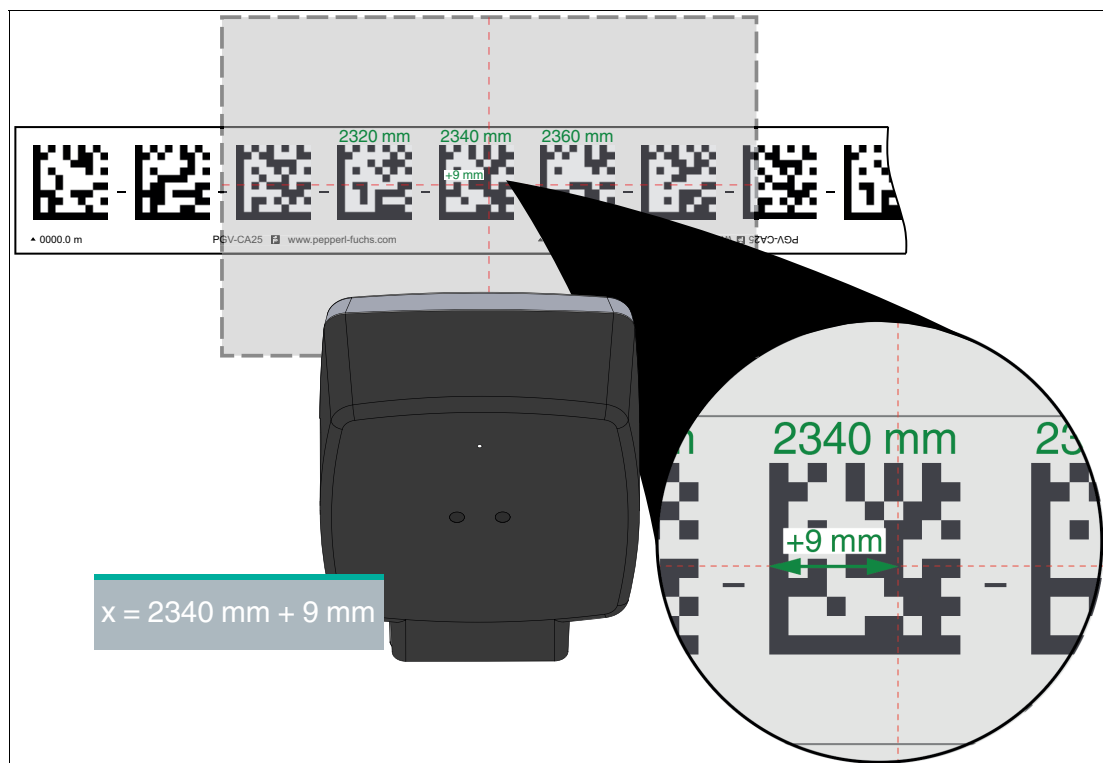


Figure 4.4 Determination of the x-position via the code offset to the center of the image

Position Output in the y Direction

The read head determines the distance from the y zero line of the Data Matrix code tape to the center of the read field. This value is transmitted to the controller.

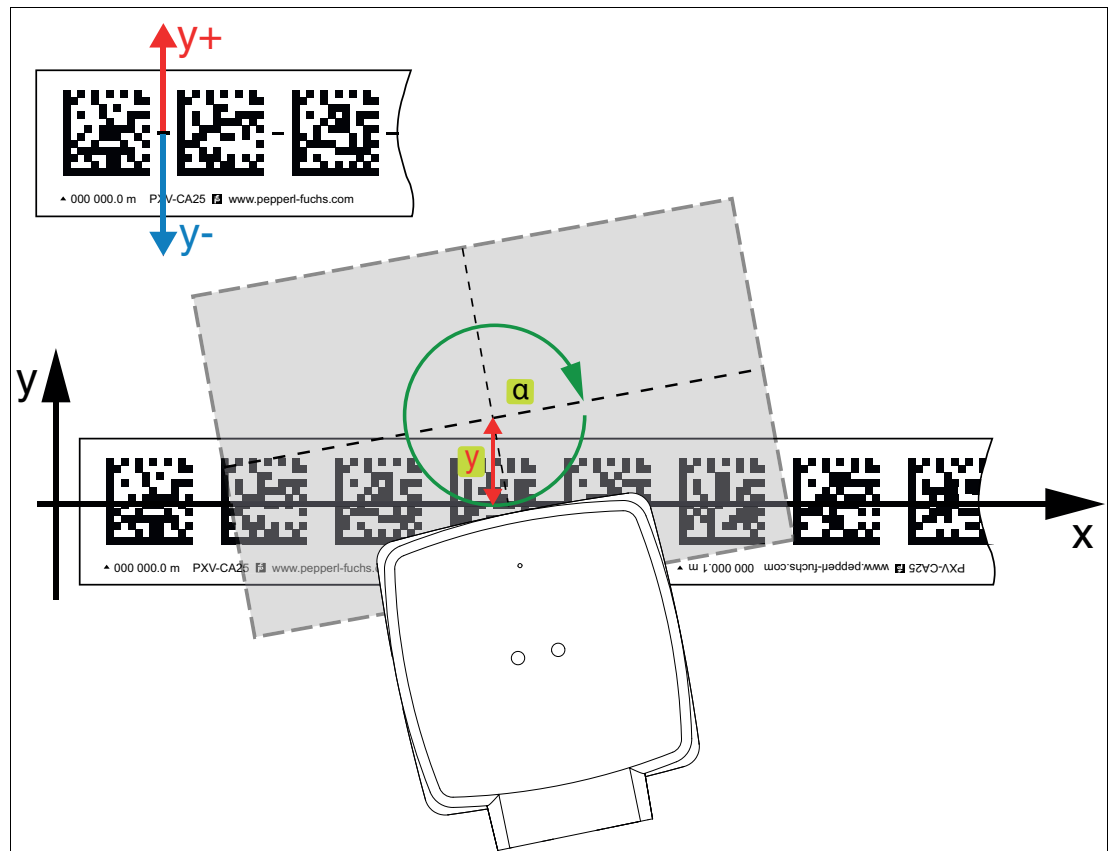


Figure 4.5 For example: Position $y = 20 \text{ mm}$ and angle $\alpha = 350^\circ$



Note

Code Tape Coordinate System

The coordinate system for the Data Matrix code tape is defined by the code tape itself. Regardless of the orientation of the read head, the positive and negative y directions always remain clearly defined and identical.

Position Output in the z Direction

The distance in the z direction to the Data Matrix code tape is determined based on the known size of the detected Data Matrix codes.



Note

Accuracy of the Position Output in the z Direction

The accuracy of the position output in the z direction requires that all Data Matrix codes located in the field of view are at the same distance from the read head. This requirement is not met, for example, if the read head is tilted.

Angle Value

The read head detects the absolute angle relative to the tracked lane with a maximum resolution of 0.1° .

Since the Data Matrix code tape contains direction information, the angle is specified as absolute to the lane. Starting from the configured orientation, an angle up to an offset of $\pm 20^\circ$ is output.

Note

Angle Specification as an Absolute Value

Angles are output as absolute values, based on the set angular resolution.

For example: With a resolution of 0.1° , an angle of 10° is output as $10^\circ / 0.1^\circ = 100$.

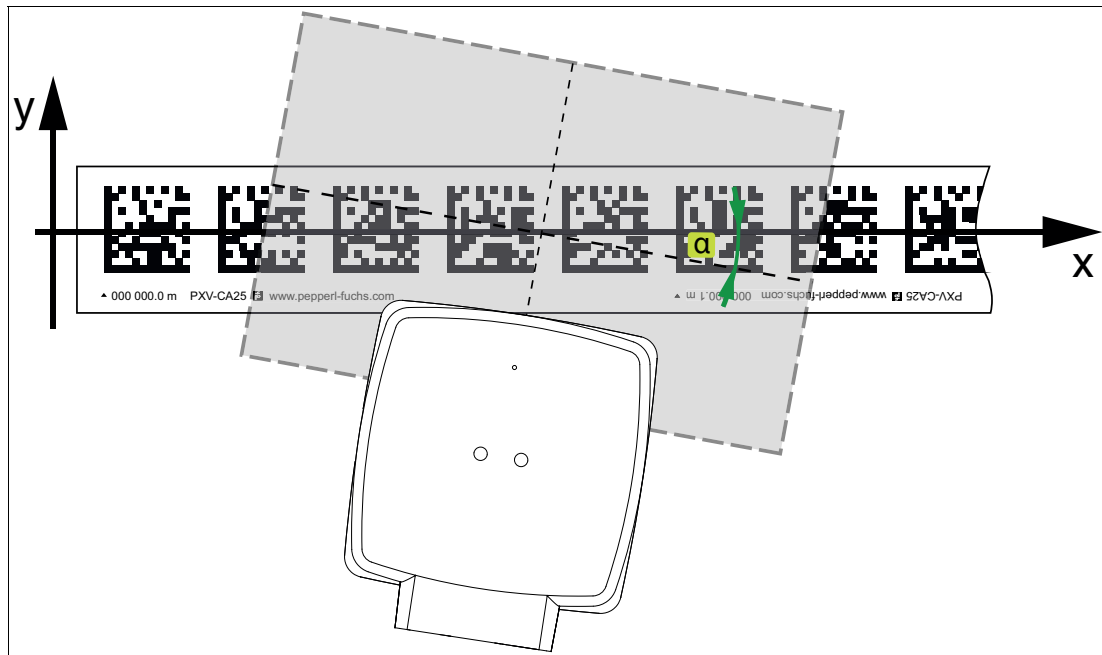


Figure 4.6 Read head alignment to the code tape at an angle of 10°

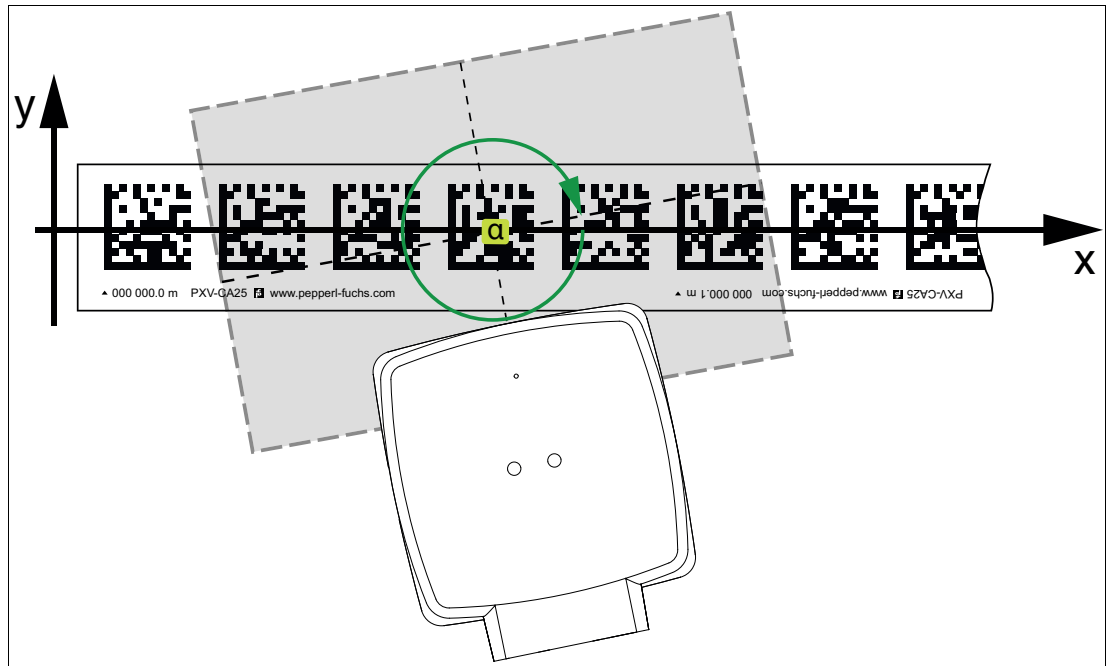


Figure 4.7 Read head alignment to the code tape at an angle of 350 °

Velocity Output

The read head determines the movement speed in the x direction based on the read Data Matrix position codes.

Direction of Travel and Sign

The output velocity can be both positive and negative to indicate the movement direction:

- **Positive velocity:** Movement in the direction of ascending Data Matrix position codes (forward travel).
- **Negative velocity:** Movement in the direction of descending Data Matrix position codes (reverse travel).

Calculating the Velocity

The velocity is determined in two steps:

1. **Momentary velocity:** First, the change in position between two cycles and the time required for this change is calculated.
2. **Average value filtering:** The output velocity is then calculated as a moving average over the last four velocity measured values (current cycle and three previous cycles).



Note

Based on average value filtering, the output velocity maps a change in the actual velocity with a slight time delay.

Example Calculation of the Output Velocity

The following example illustrates the behavior of the velocity output during acceleration.

Initial Situation

- The system moves at a constant velocity of 0.5 m/s
- The cycle time is 25 ms

Event

- At time t1, the system accelerates to 2 m/s

Calculating the Output Velocity

The new velocity of 2 m/s is now averaged with the values of the three previous cycles (0.5 m/s each).

Cycle after t1	Calculation of the Average	Output Velocity
First cycle	$(0.5 + 0.5 + 0.5 + 2.0) / 4$	0.875 m/s
Second cycle	$(0.5 + 0.5 + 2.0 + 2.0) / 4$	1.250 m/s
Third cycle	$(0.5 + 2.0 + 2.0 + 2.0) / 4$	1.625 m/s
Fourth cycle	$(2.0 + 2.0 + 2.0 + 2.0) / 4$	2.000 m/s

4.5

Field of View of the Read Head

The field of view of the read head is the maximum imaging area on the sensor chip that is determined by the optical properties of the camera.

The size of the field of view depends on the distance between the read head and the positioning targets:

- As the distance increases, the field of view **increases**.
- As the distance decreases, the field of view **decreases**.

This relationship is shown in the following figure. The exact dimensions of the field of view as a function of the distance are listed in the table below. The **nominal distance** of this read head is **100 mm**.

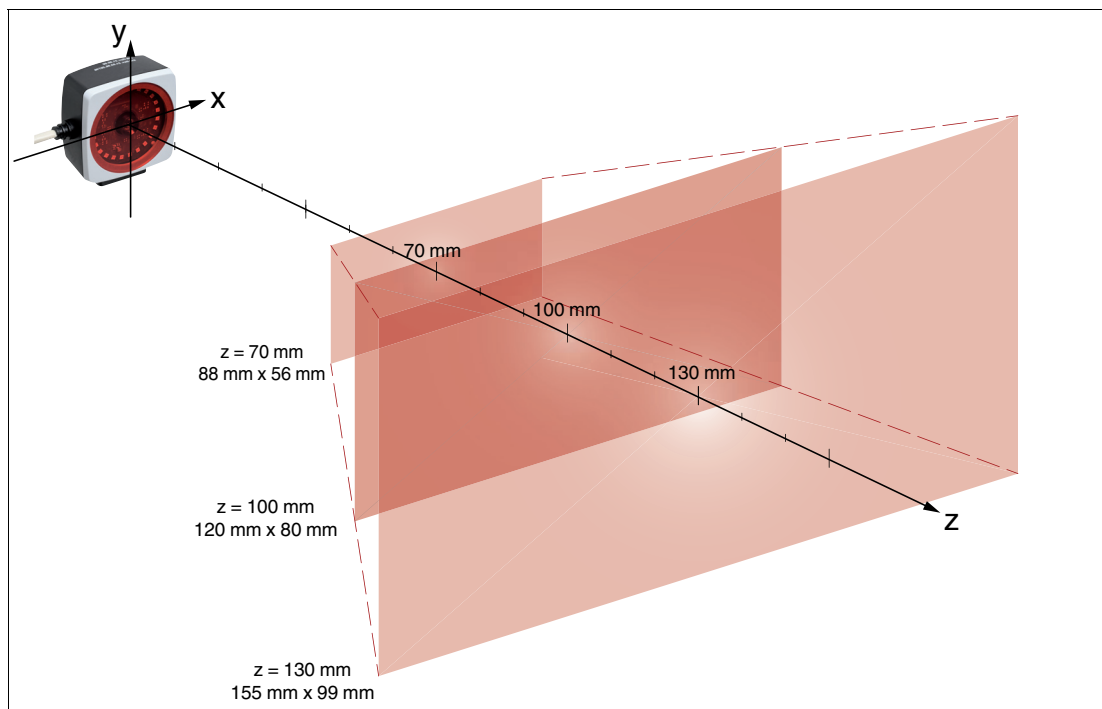


Figure 4.8 Field of view at different reading distances

Reading Distance [mm]	Field of View Size [mm]
70	88 × 56
100	120 × 80
130	155 × 99

4.6 Read Head Orientation

For maximum code redundancy, a read head orientation of $0^\circ/180^\circ$ to the Data Matrix code tape is recommended.

The following configuration options are available for orientation:

- 0°
- 180°
- $0^\circ/180^\circ$
- $0^\circ/90^\circ/180^\circ/270^\circ$



Note

Alignment Accuracy

The actual orientation of the read head must not deviate too much from the configured values. Refer to the detailed information on the rotational tolerance in the z axis.

The figure below shows how different orientations affect the alignment of the read window in relation to the Data Matrix code tape.

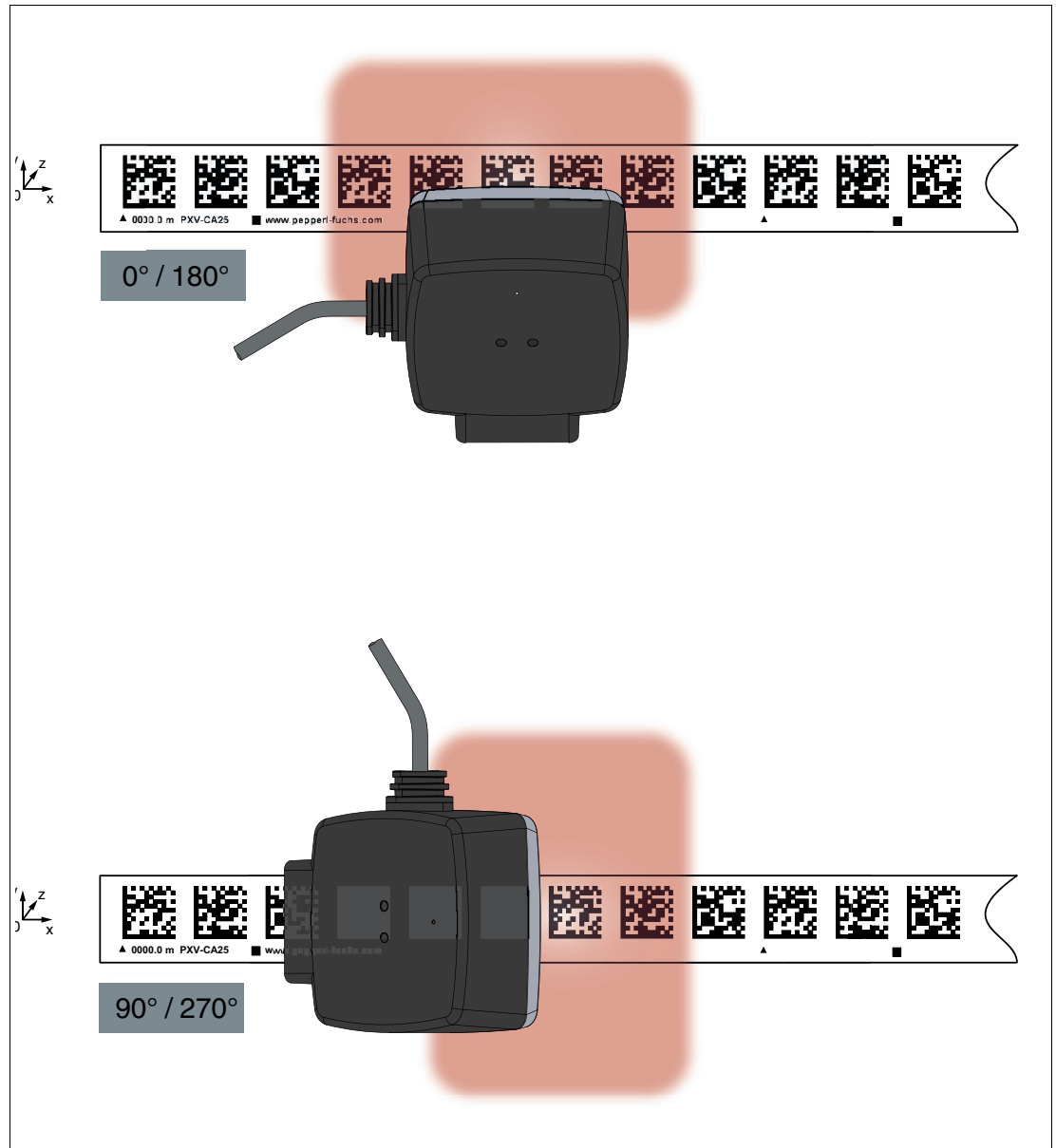


Figure 4.9 Read Head Orientation

4.7 Read Head Orientation

4.7.1 Read Tolerance in Z Direction

The read head offers a high read tolerance at different reading distances. If the read head is mounted too close or too far away from the Data Matrix code tape, a warning message is issued. We recommend that the read head always be mounted at a nominal distance of 100 mm to ensure the highest possible availability of the system (due to resolution and code redundancy). Pay particular attention to the reduced mounting tolerance in the y direction and the reduced gap width, especially at extremely close reading distances.

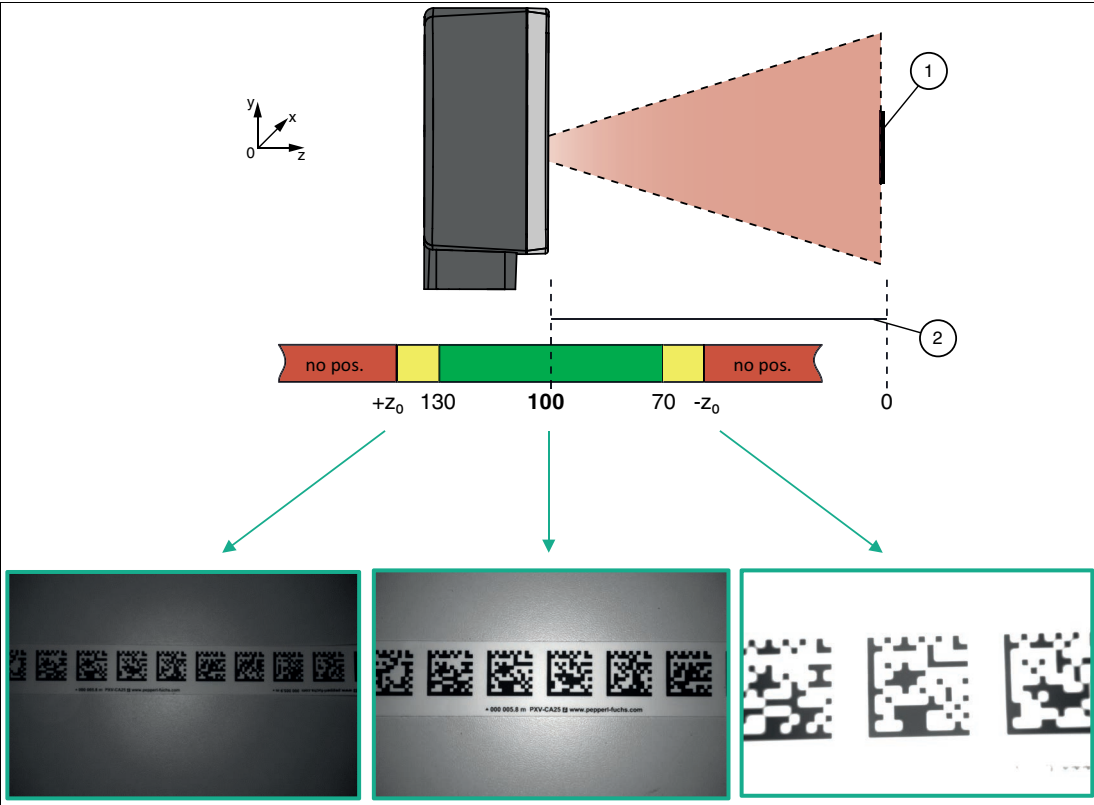


Figure 4.10

- 1 Data Matrix code tape
- 2 Read distance to the Data Matrix code tape in z direction
- Green** Recommended reading tolerance: Nominal distance 100 mm ± tolerance
- Yellow** Range in which a "warning bit" is set
- Red** Range in which a "no pos. bit" is set

Read distance (z)	Range "warning" bit	Range "no pos." bit
< -Z ₀		x
< 70 mm	x	
100 mm		
> 130 mm	x	
< +Z ₀		x

4.7.2 Reading Tolerance in y Direction

When moving along the Data Matrix code tape (x-axis), the read head continuously detects its position in the y direction and compares the deviation from the zero line (y = 0) with the permissible limit value $\pm y_0$. If the error exceeds the limit value (shown in red in the following figures), the read head loses the position, and a "no position" message is output.

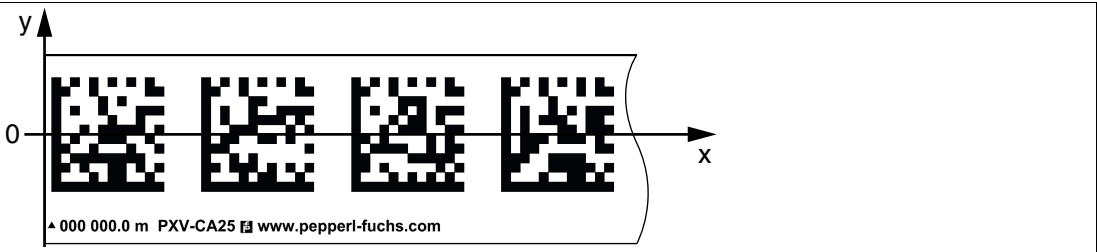
Zero Line (y = 0)

If the read head has detected a Data Matrix code tape, this code tape can move away from the zero line (y = 0) in the y direction within the field of view. The read head reacts in two stages:

- **Warning message:** in the event of a deviation from the zero line > 25 mm
- **Position loss:** when the limit values $+y_0$ or $-y_0$ are reached.

The limit values $+y_0$ and $-y_0$ depend on the distance (z) of the read head and its orientation. They are asymmetrical, especially when the read head is tilted, and are subject to component tolerances. The values here are valid for the specified nominal distance.

Nominal distance 100 mm



Nominal distance 100 mm

Height tolerance (y)	Range "Warning message"	Range "No position message"
> y_0 mm		x
> 25 $\geq y_0$ mm	x	
0 mm		
> -25 $\geq -y_0$ mm	x	
> $-y_0$ mm		x

Target Range

The read head is in an optimal position with respect to the Data Matrix code tape.

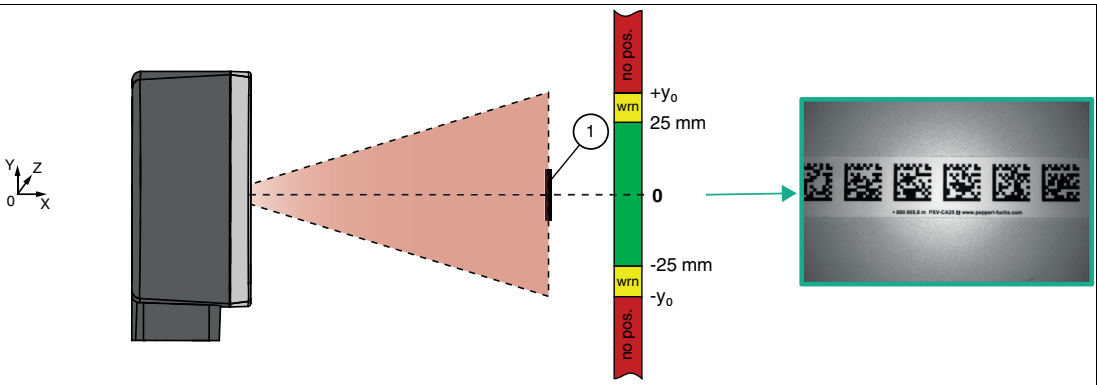


Figure 4.11 Green: recommended range
1: Data Matrix code tape

No-Position

The read head is positioned too low in relation to the Data Matrix code tape and loses the position. The message "No-Position" is output.

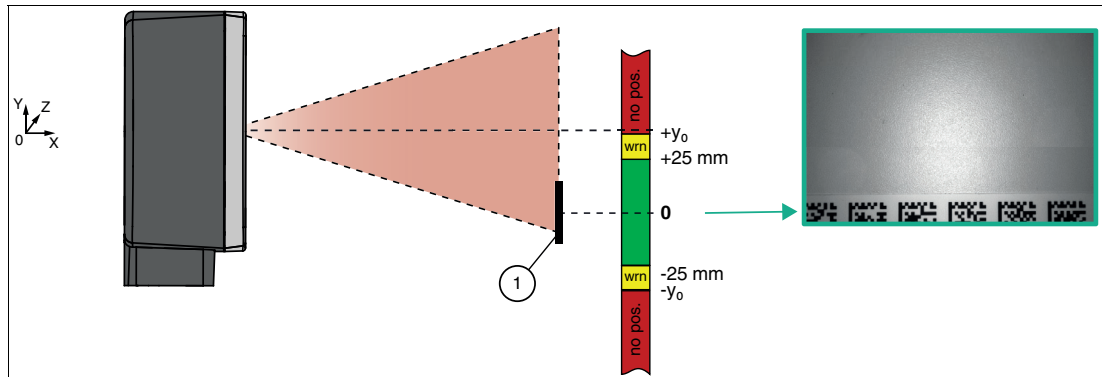


Figure 4.12 Red: Range in which a "No Position" message is set
1: Data Matrix code tape

4.7.3

Inclination Angle

An inclination angle of $\pm 30^\circ$ is possible. It should be noted that the extreme tolerances do not apply in total.



Note

Simultaneous tiltings in the x and y directions are allowed. It is important to note that tilting the sensor shifts the reading window. If the sensor is tilted too much, this can cause the reading window to stop covering the Data Matrix codes.

Angle Tolerance on the y Axis

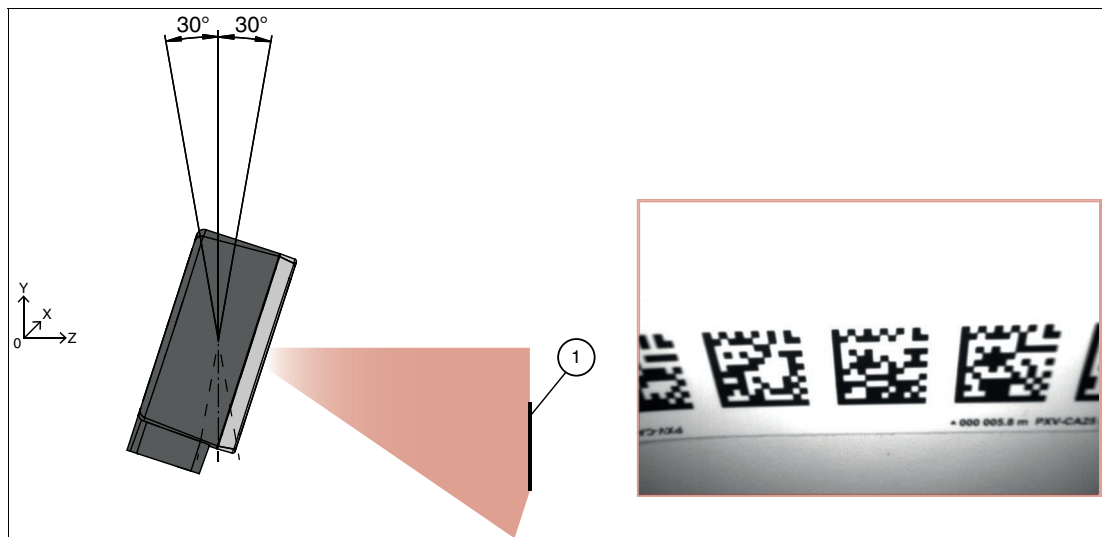


Figure 4.13 Vertical orientation tolerance
1 Data Matrix code tape

Angular Tolerance on the x Axis

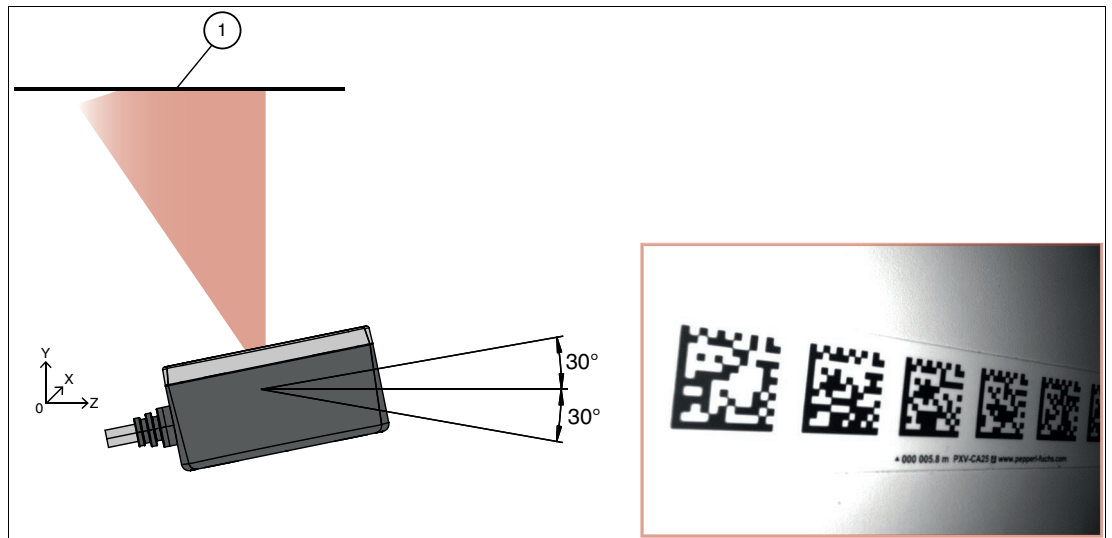


Figure 4.14 Horizontal orientation tolerance

1 Data Matrix code tape

4.7.4

Rotational Tolerance in the z Axis

The maximum permissible rotation of the read head around the z axis in relation to the code tape is $\pm 20^\circ$. With a set orientation of 0° , this results in a permissible pivot range of 340° to 20° . The specified extreme tolerances do not apply in total to the orientation set on the read head.

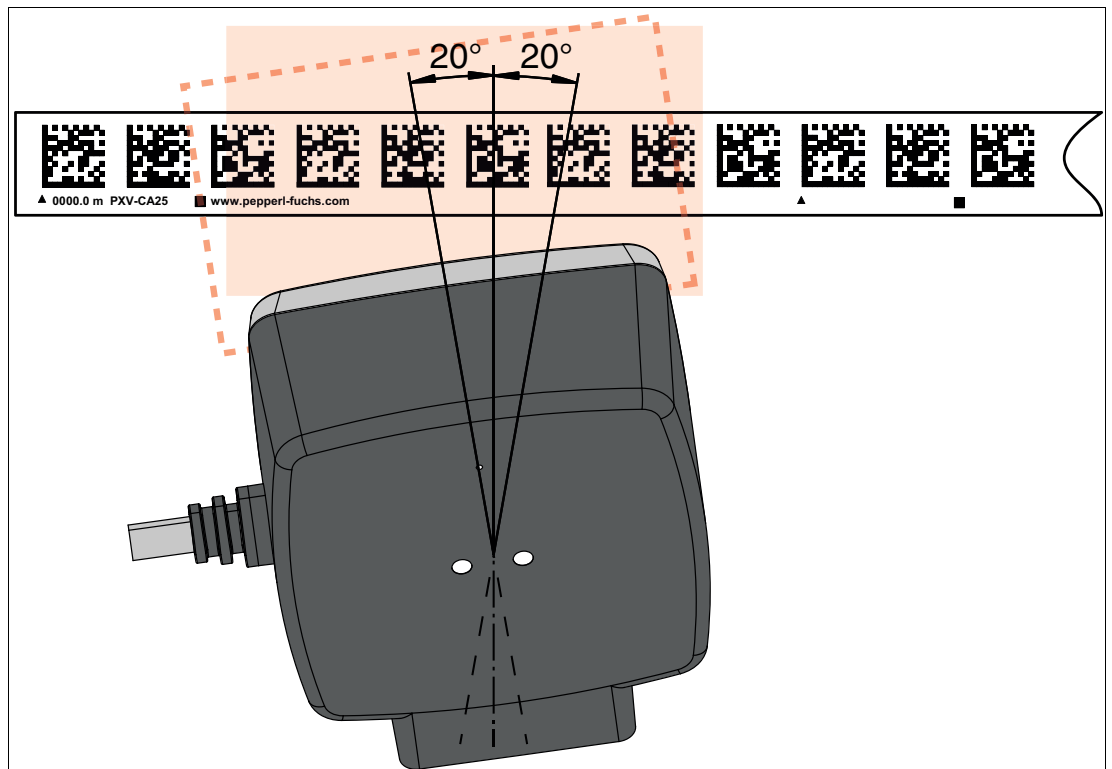


Figure 4.15 Rotational tolerance

4.8 Gaps/Interruptions

To compensate for length changes in plant structures, expansion joints are usually required for longer tracks.

Attaching the Data Matrix Code Tape Around Gaps

If a Data Matrix code tape is routed over expansion joints or other gaps, it is generally recommended to interrupt the code tape in the area of the gap. The read head is able to travel over expansion joints and gaps without loss of position.

Several mounting options are available for attaching the Data Matrix code tape at these points, which are described later.

Meaning of the Fixed Code Grid

During the design stage, it should be noted that the read head expects the Data Matrix codes in a fixed grid of 20 mm. If this grid is not adhered to in the area of the interruption or at adjacent code sections, the position and velocity values calculated by the read head may increase abruptly.

These effects must be taken into account accordingly when designing the application.

Illustrative Examples

The following examples illustrate the importance of adhering to the code grid.

Grid Adhered To

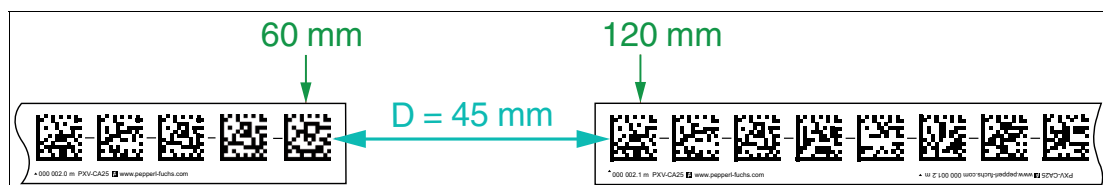


Figure 4.16 Grid adherence across gaps

- **Situation:** A gap with width "D", 45 mm, is bridged. The Data Matrix code immediately before the gap contains the position information 60 mm, the first Data Matrix code after the gap contains the position information 120 mm.
- **Result:** In this case, the grid is adhered to, because the Data Matrix codes expected in the area of the gap are not present and the Data Matrix codes continue after the gap with the correct, grid-compliant Data Matrix codes.

Grid Not Adhered To

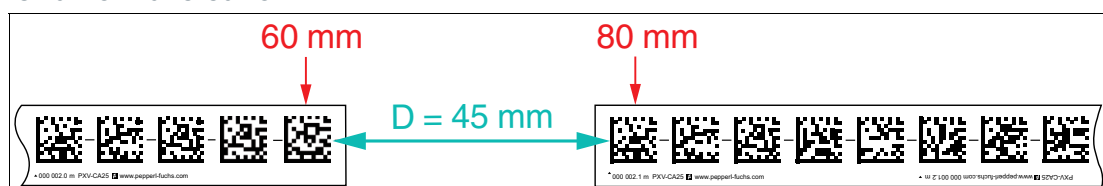


Figure 4.17 Grid violation across gaps

- **Situation:** A gap with width "D", 45 mm, is bridged. The Data Matrix code immediately before the gap contains the position information 60 mm, the first Data Matrix code after the gap contains the position information 80 mm.
- **Result:** In this case, the grid is not adhered to because the read head would have expected the Data Matrix code with the position information "80 mm" immediately after the "60 mm" code, rather than only after some additional distance in the ascending x direction. The x-position value and the velocity value change abruptly.

Maximum Gap Width

When mounting the Data Matrix code tape over expansion joints or structural gaps, the maximum gap width (D) must be observed.

The maximum gap width (D) is defined as the distance between two fully readable Data Matrix codes. It depends on the reading distance (z) and the orientation of the read head.



Note

Respect the Quiet Zone

A free area, or quiet zone, of 2 mm must be maintained around each Data Matrix code. The quiet zone is the white, code-free area between two Data Matrix codes.

- Never cut the code tape within this 2 mm quiet zone.
- An important additional note on this can be found in the "Cutting Rule" section.

Reference Values for the Maximum Gap Width (D)

Below are some typical reference values for the maximum gap width (D) depending on the reading distance (z) and the orientation of the read head.

Maximum Gap Width with a Read Head Orientation of 0 °/180 °

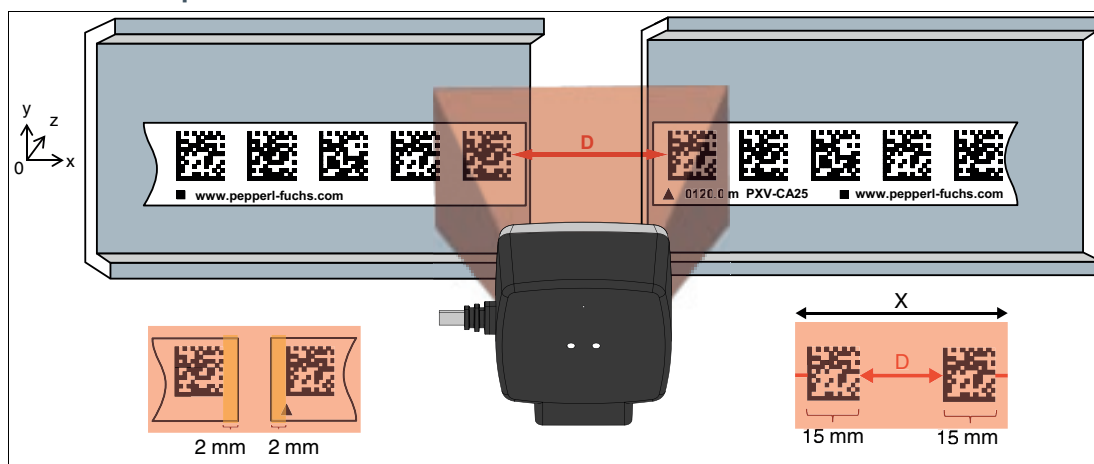


Figure 4.18

Reading distance z [mm]	Maximum gap width D [mm]
70	54
100	86
130	121

Maximum Gap Width with a Read Head Orientation of 90 °/270 °

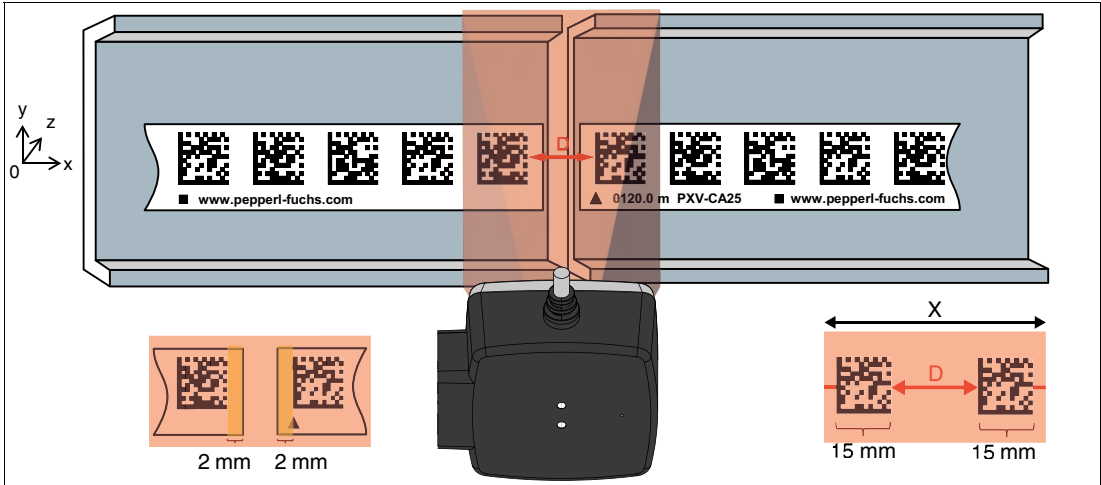


Figure 4.19

Reading distance z [mm]	Maximum gap width D [mm]
70	22
100	46
130	65

Calculating the Maximum Gap Width

Note

The specified values are reference values. The actual maximum permissible gap width depends on the exact reading distance and the orientation of the read head.

An approximation of the maximum gap width (D) can be calculated as follows:

Maximum gap width (D) = reading window width in the x direction of the code tape - 30 mm - 4 mm - safety value

Parameter	Statement
Reading window width (in the x direction)	Typical values for the reading window width are specified, . - For a read head orientation of 0 °/180 °, use the value for the long side of the reading window in the formula. - For a read head orientation of 90 °/270 °, use the value for the short side of the reading window.
30 mm	This value comprises the width of two Data Matrix codes (2 x 15 mm = 30 mm)
4 mm	Quiet zone required on both sides (2 x 2 mm = 4 mm).
Safety value	A value to be defined by you that compensates for tolerances resulting from code tape mounting or bonding inaccuracies. Use a suitable buffer for your system.

Cutting Rule

Correct cutting of the code tape is crucial for reliable reading.



Note

Incorrect reading due to violation of the quiet zone

The read head only reliably detects complete codes. Since the distance between two codes is 5 mm and each code requires a surrounding quiet zone of 2 mm, the code tape must always be cut in the middle between two codes.

Mounting Options for Bridging Gaps

Depending on the application and the size of the gap, different mounting methods are available.



Note

Constant Movement Speed

The diagrams below are based on the assumption of a constant movement speed.

Option 1: Affixing Continually with Codes Removed

- **Advantage:** Optimization to minimize abrupt position changes.
- **Effect:** Redundancy may be reduced.

The Data Matrix code tape is initially affixed continuously over the mechanical gap.

One or more Data Matrix codes are then specifically cut out in the area of the gap.

The remaining Data Matrix codes are still arranged in the defined grid.

The effective gap width (D) results from the number of codes removed and from the positioning of the code tape over the mechanical gap. Depending on how the code tape is affixed, a different effective gap width may result.

The following figure shows how the gap width (D) in the lower image is larger, although the mechanical gap is the same in both illustrations. The reason for this is that two Data Matrix codes in the lower image are unfavorably located in the area of the gap and must therefore be removed.

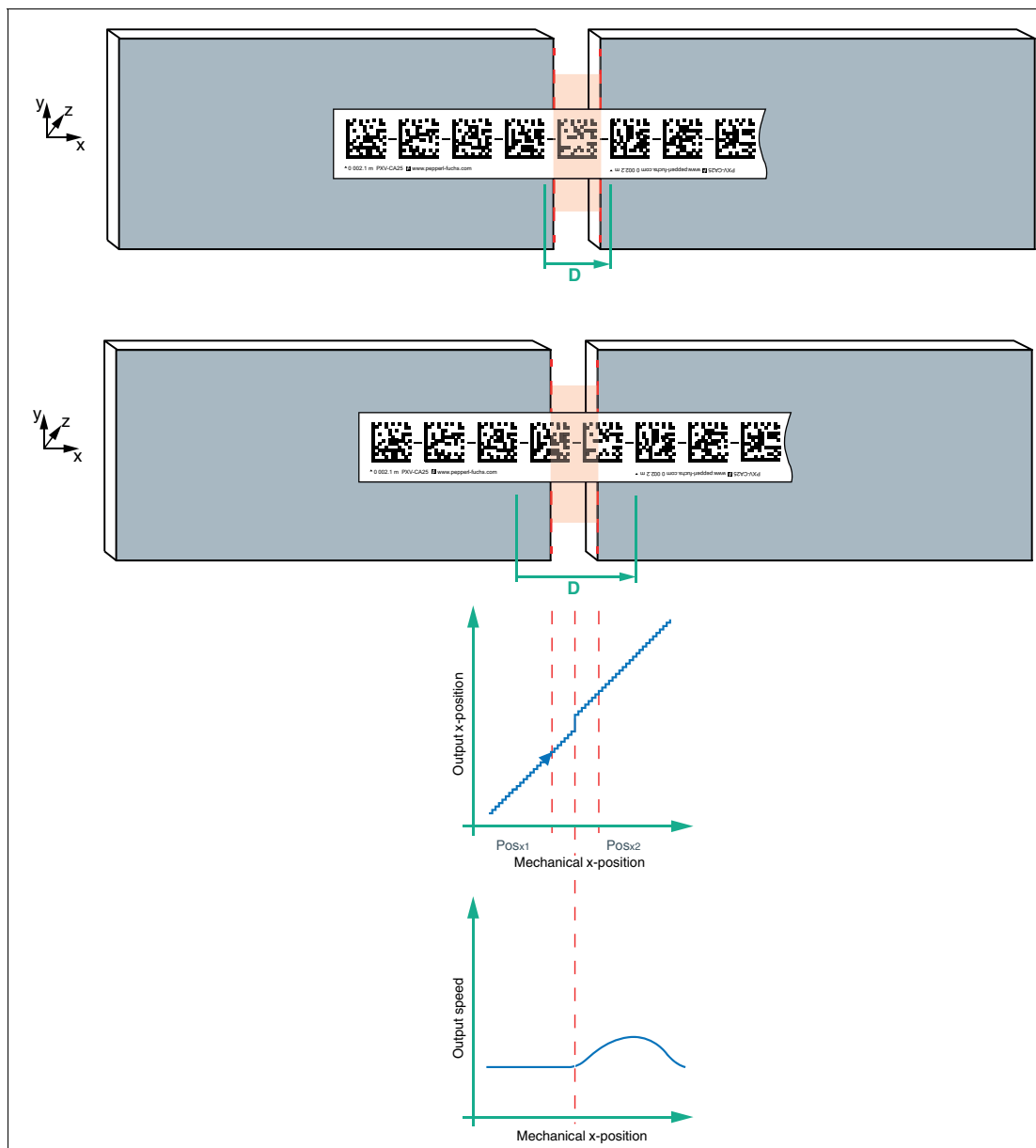


Figure 4.20 Continuous mounting with cut-out codes

Influences such as the thermal expansion of the surface can cause a small position jump.

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If a position jump occurs in the transition area, the velocity will increase simultaneously for system-related reasons (see figure above).

The increased velocity value is output for four consecutive cycles (at 10 ms per cycle, this would be 40 ms) and then subsides to the original velocity. For further details on calculating the velocity, see chapter 4.4.

The following figure shows how the gap width (D) changes when one or more codes are removed.

Examples of Gap Width (D)

Removed Codes	Effective Gap Width (D) [mm]
1	25
2	45
3	65

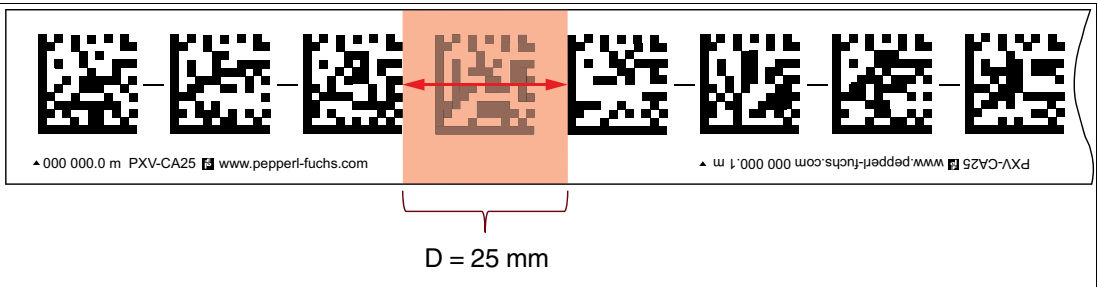


Figure 4.21 D = 13 mm

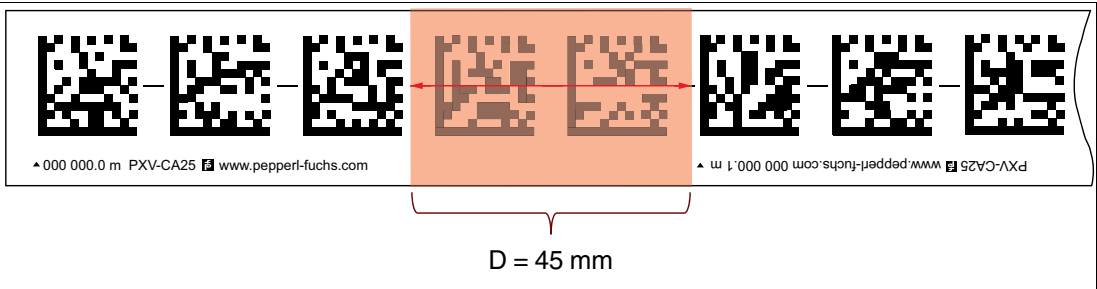


Figure 4.22 D = 23 mm

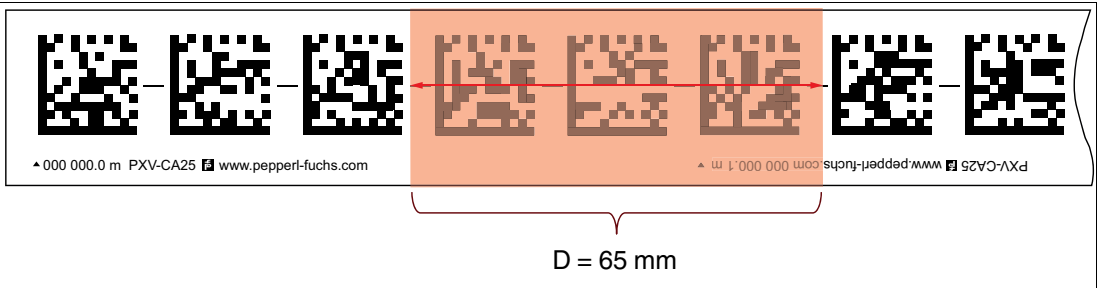


Figure 4.23 D = 33 mm



Note

Maximum Number of Removed Data Matrix Codes

The maximum permissible number of consecutive Data Matrix codes that can be removed is limited by the maximum gap width (D).

This depends on the reading distance and the orientation of the read head.

Option 2: Continuous Placement

- **Advantage:** Higher redundancy and optimal mounting along mechanical gaps.
- **Effect:** Position and velocity jump

The Data Matrix code tape is affixed up to the mechanical gap. After the gap, the code tape is continued with the next complete Data Matrix code.

Since the fixed grid of the Data Matrix codes is not maintained in this case, there is a logical jump in the transition area for the x-position values and the velocity values.

In the case of very wide gaps, the Data Matrix code tape can be optimally mounted along the mechanical gap.

Compared to the unfavorable case with option 1 where the gap width D increases despite bridging an identical gap, this option offers higher redundancy.

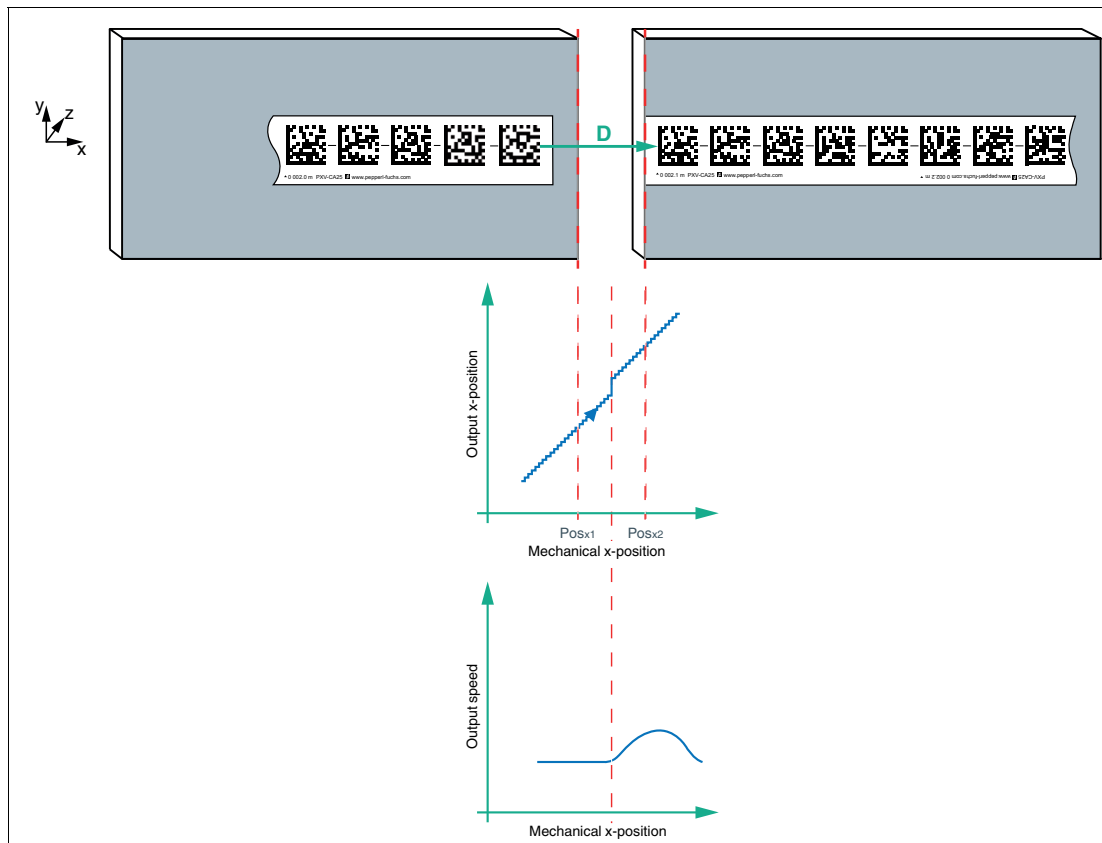


Figure 4.24 Continuous mounting

The position jump leads to a simultaneous velocity increase for system-related reasons (see figure above).

The increased velocity value is output for four consecutive cycles (at 10 ms per cycle, this would be 40 ms) and then subsides to the original velocity.

For further details on calculating the velocity, see chapter 4.4.

**Note****Avoid Cut-off Codes at the Edge of the Gap**

A code that is only partially visible at the edge of a gap must be avoided, since the read head can attempt to decode this incomplete code.

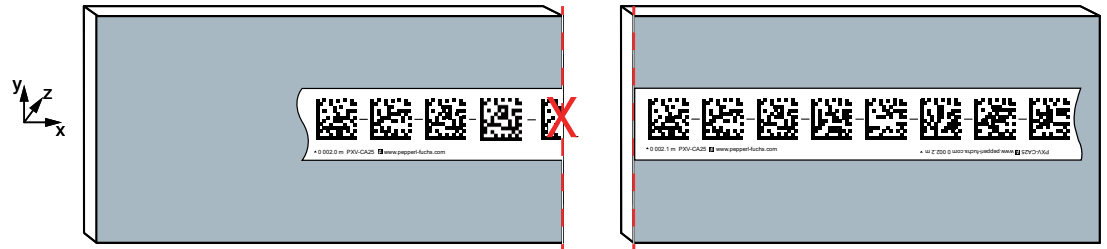


Figure 4.25 Cut-off code at the edge of the gap

- Completely remove the last code before the gap.
- When doing so, strictly observe the 2 mm quiet zone of the previous, fully visible code.

In order to specifically influence the position jump, it is possible not to continue with the next complete code directly after the gap, but to specifically remove one or more complete codes.

**Note****Effect of Grid Violations on Extrapolation**

If extrapolation is activated, a violation of the grid can lead to a short-term incorrect calculation of the x position value ().

Option 3: Continuous Placement without Velocity Jump

The Data Matrix code tape is affixed up to the mechanical gap.

After the gap, the code tape is continued with a complete Data Matrix code whose position information is more than 1 m different from the previous Data Matrix code.

In contrast to option 2, there is no velocity jump in this version as a result of a grid violation. There is no sudden increase in the velocity, because the read head detects large position differences as a jump. This is the main difference between the two options.

In the case of very wide gaps, the Data Matrix code tape can be optimally mounted along the mechanical gap.

Compared to the unfavorable case with option 1 where the gap width D increases despite bridging an identical gap, this option offers higher redundancy.

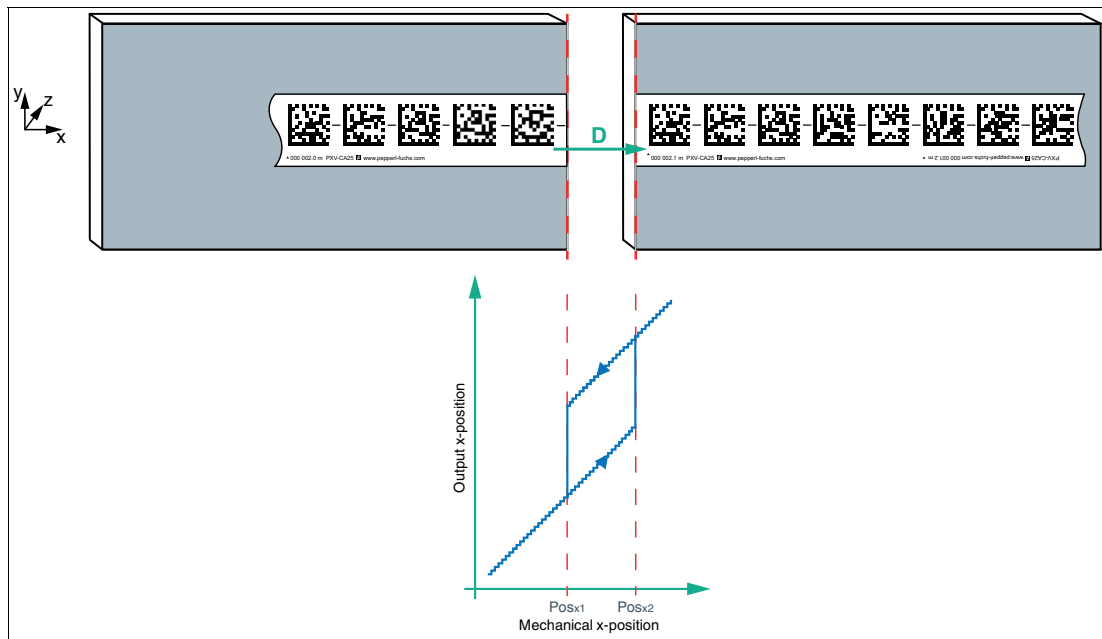


Figure 4.26 Continuous placement without velocity jump

A position hysteresis occurs in the transition area, as shown in the figure above.

As a rule, the position jump occurs when the last Data Matrix code before the gap is no longer completely within the field of view of the read head.

Note

Transition Hysteresis Behavior

The exact time of the transition hysteresis cannot be guaranteed precisely, so that the position jump can also occur within the gap area.

In the worst case scenario, the position can then jump back and forth between the different reference points in the area of the gap.

**Note****Avoid Cut-off Codes at the Edge of the Gap**

A code that is only partially visible at the edge of a gap must be avoided, since the read head can attempt to decode this incomplete code.

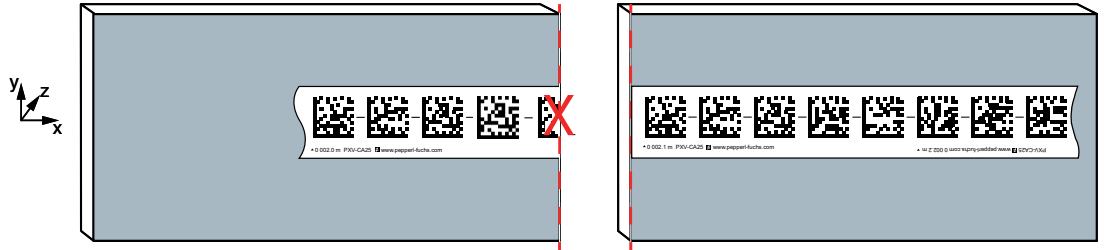


Figure 4.27

- Completely remove the last code before the gap.
- When doing so, strictly observe the 2 mm quiet zone of the previous, fully visible code.

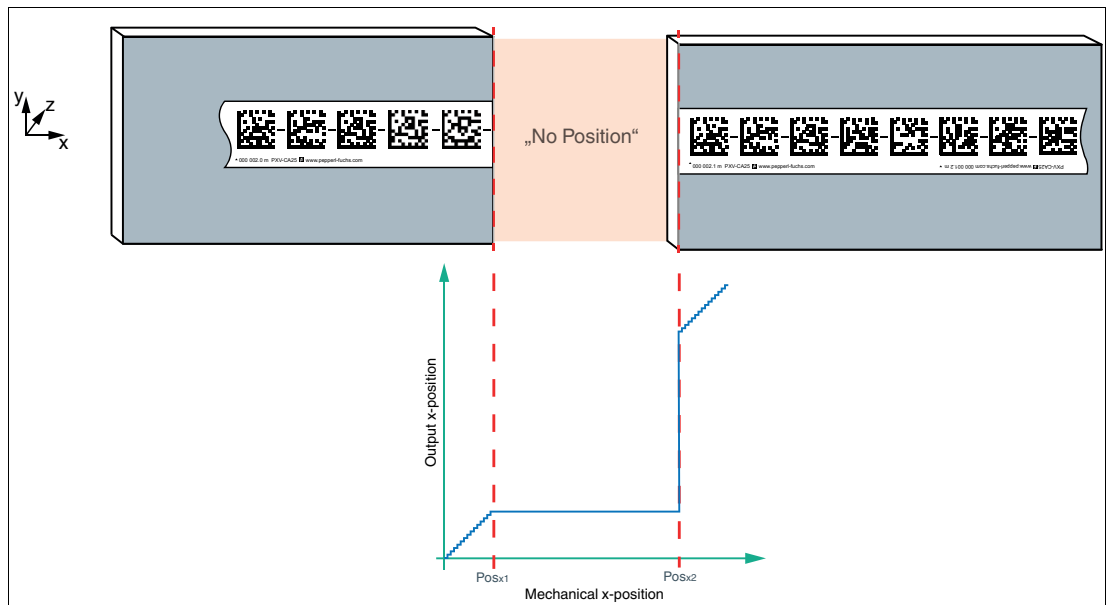
Option 4: Excessive Gap ("No Position")

Figure 4.28 Excessive gap ("no position")

If the mechanical gap is too large, the read head issues the warning message "No Position".

In this case, the "X-Position at no-position" parameter can be set to "Last valid value", .

As a result, the last valid x-position is still output over the gap.

If the "X-Position at no-position" parameter is not set, the value 0 for the x-position is output by default.

**Note****Restarting the Read Head over Gaps**

If the read head is restarted above the gap, position detection is not possible.

The last valid x-position is no longer available after a restart.

A restart over the gap should therefore be avoided, if possible.

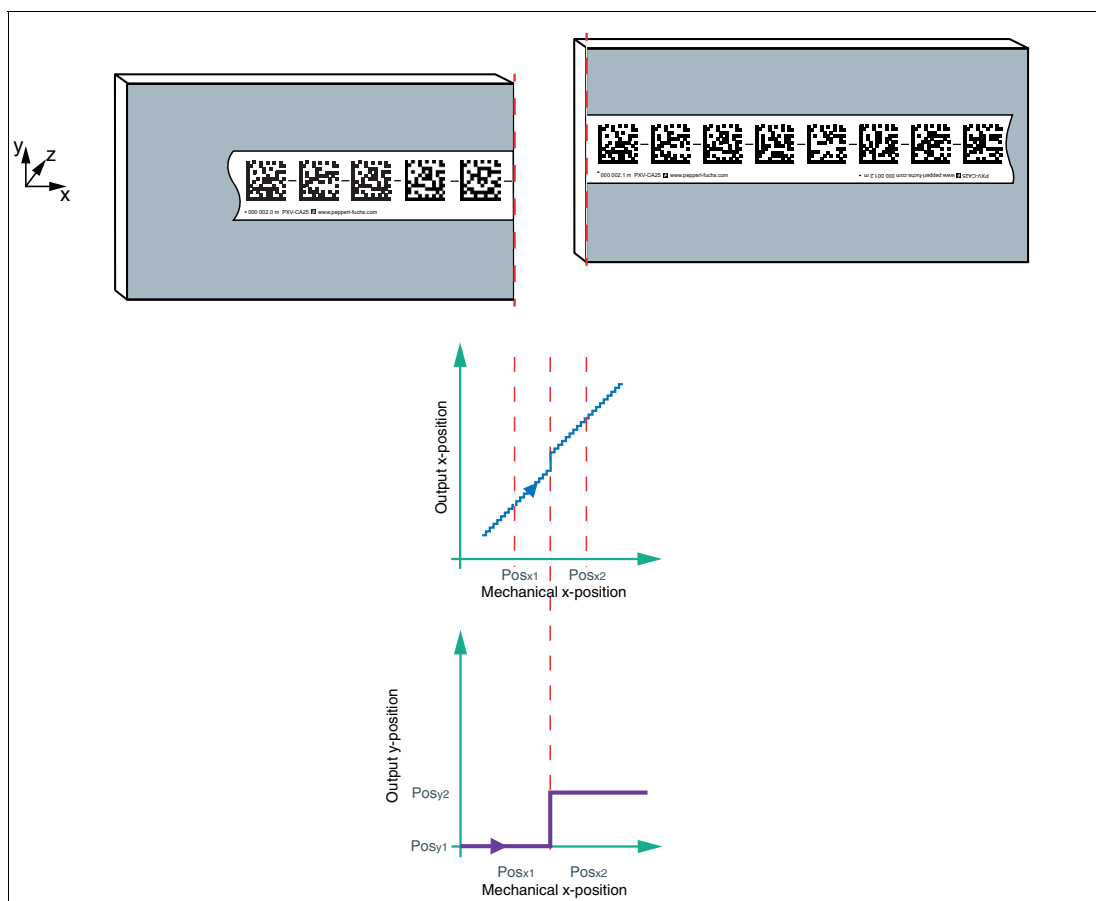
Y Offset over Gaps

Figure 4.29 Offset across gaps

If there is a Y offset between two Data Matrix code tape strips over a gap, the offset must not exceed a certain limit value.

If the Y offset is too large, the Data Matrix codes are no longer completely in the reading window of the read head, meaning that code detection is no longer possible.

**Note****Jump in the Y Position Value**

A Y offset leads to a jump in the Y position values and must be taken into account accordingly in the control logic.

Thermal Expansion of the Surface

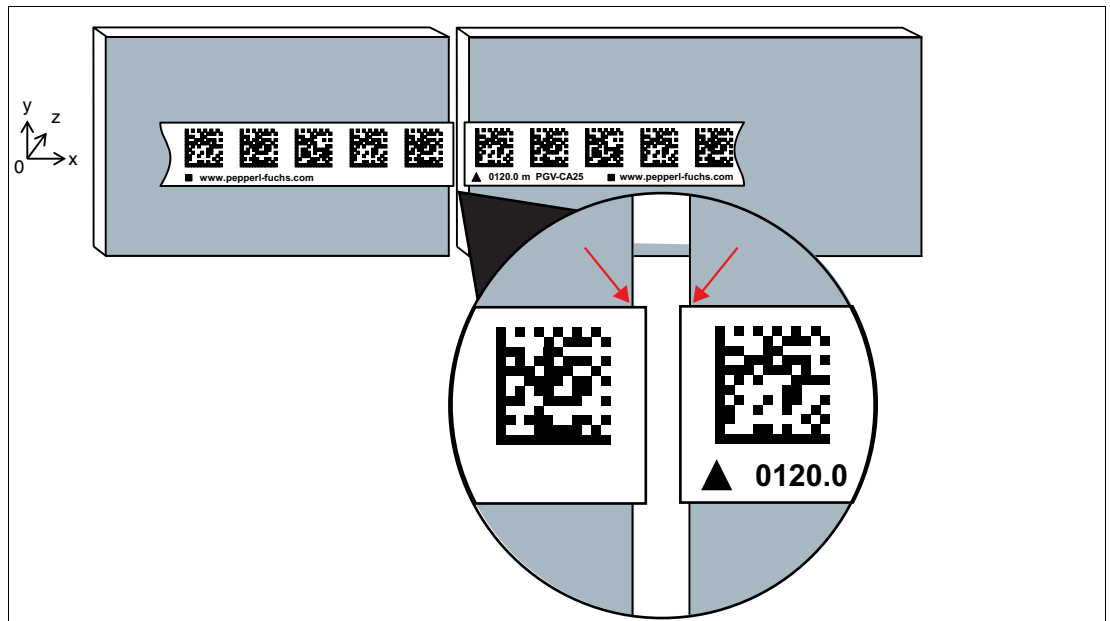


Figure 4.30 Thermal expansion



Note

Thermal Expansion of the Surface

The thermal expansion coefficient of the affixed Data Matrix code tape is significantly determined by the thermal expansion coefficient of the surface.

When designing the system, the maximum possible gap width that can occur at the minimum expected temperature must be taken into account.

One possible approach to reducing the effective gap width is to offset the butt edges of the Data Matrix code tapes a few millimeters in the direction of the gap.

It must be ensured that the code tapes do not overlap even at maximum thermal expansion, so that the quiet zone of 2 mm around the Data Matrix codes is maintained.

4.9 Behavior of the Read Head When Cornering

Minimum Curve Radius

When planning your system, please ensure that you do not fall below a minimum bending radius of **100 mm** for horizontal curves.

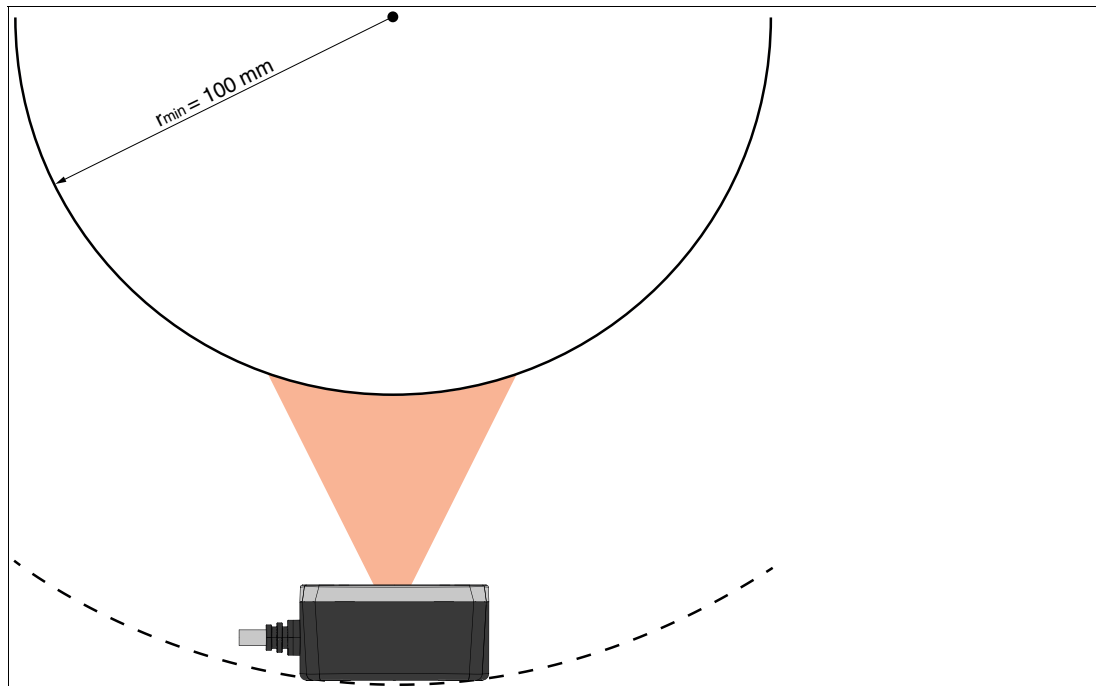


Figure 4.31

Horizontal Curves

If the read head is not mounted in the application's axis of rotation (1), the following situation can occur for horizontal curves:

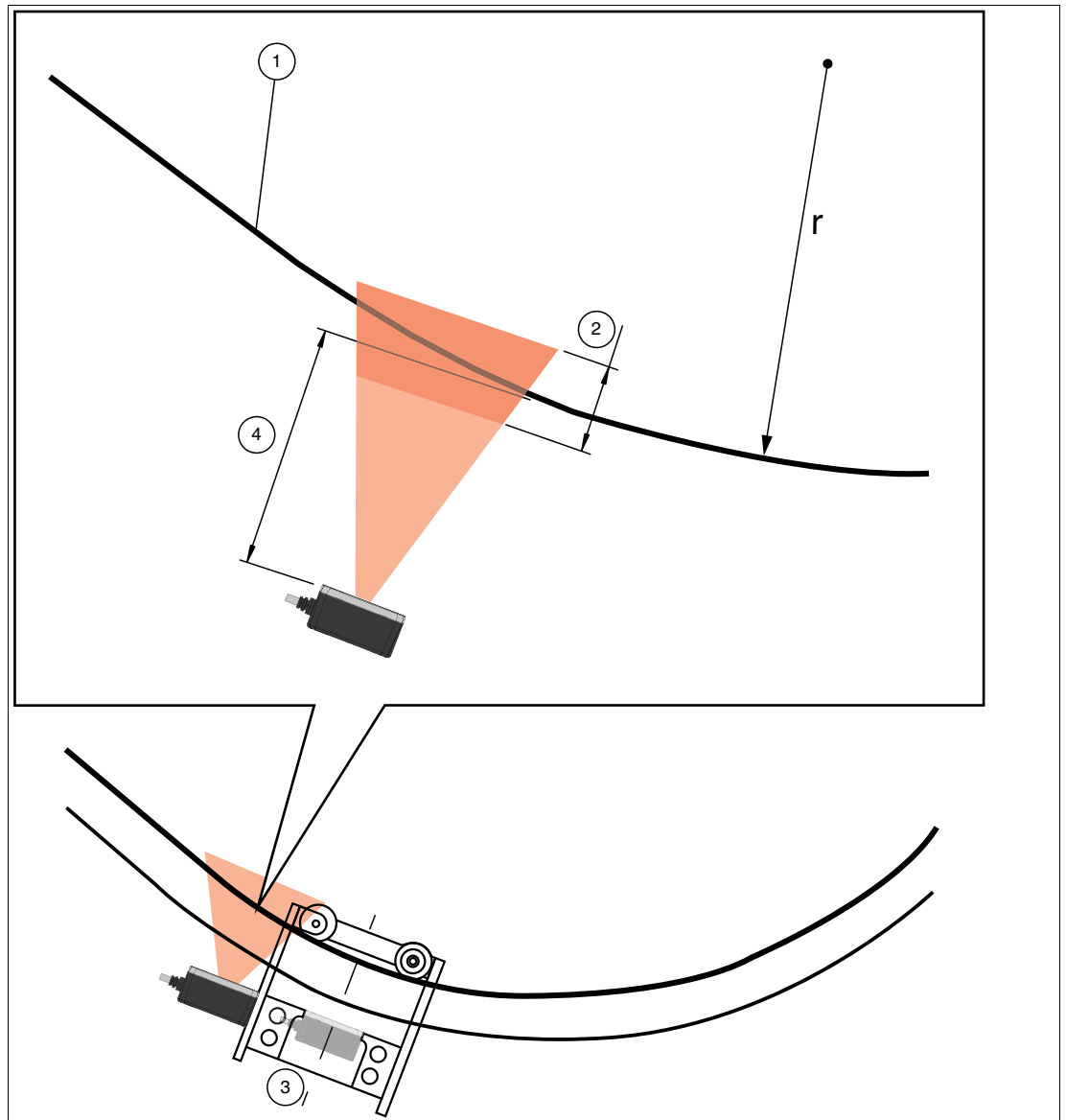


Figure 4.32

- Depending on the curve (right or left curve), the read head moves toward the code tape (1) or away from the code tape (1).
- The reading distance (4) moves out of the read head reading tolerance. If the reading distance (4) is too long, the z tolerance (2) is no longer sufficient to ensure reliable position detection.
- Note the information in .

Inclines and Declines

If the read head is not mounted in the rotation axis (1) of the application, the following situation may occur on inclines and declines:

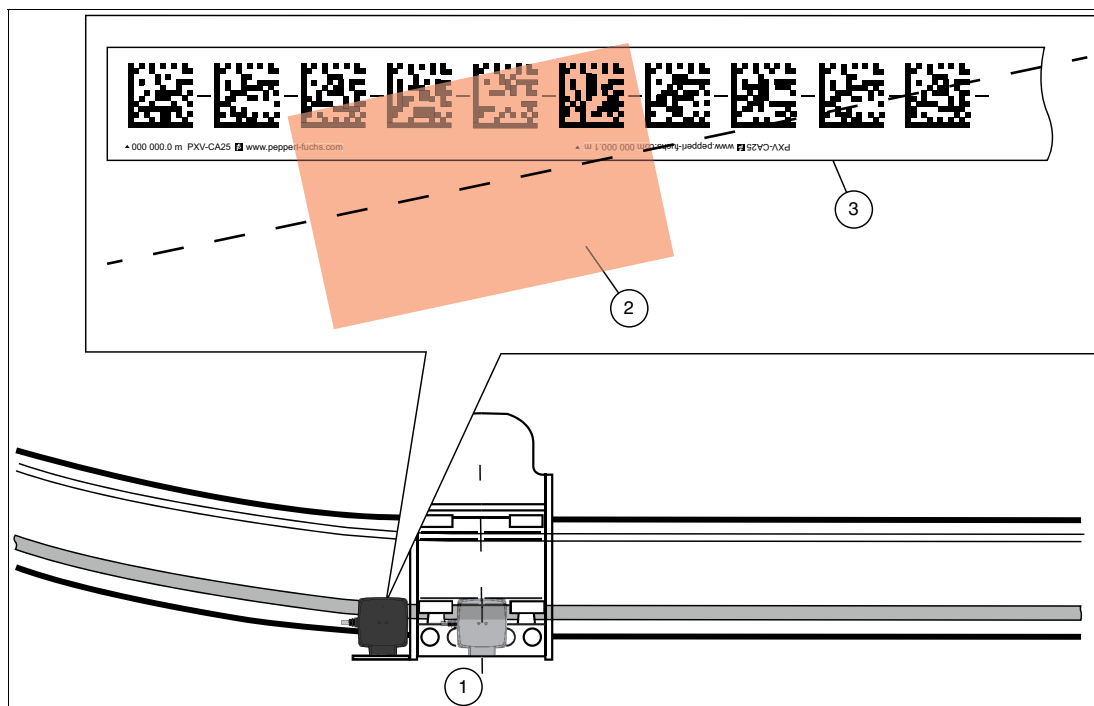


Figure 4.33

- The reading window (2) is tilted relative to the Data Matrix code tape (3). Secure position detection is only guaranteed if at least one Data Matrix code can be read.
- Note the information in the "Rotational tolerance in the z axis" chapter.

4.10

Quality Grades



Tip

Additional Diagnostic Information

In addition, the number of Data Matrix codes detected is output.

This value can be used for further diagnostics and analysis.

Continuous monitoring of the quality grades enables early detection of contamination or damage to the Data Matrix code tape and the read head.

This applies during both commissioning and operation. Regular monitoring increases operational safety and facilitates quick localization of the cause in case of fault.

The code tape quality is assessed using a scale of 1 to 6, with 1 being the best quality. Values of 3 or worse indicate that the read head or the code tape should be checked. The value 7 can also be output for the code tape quality. This means that no code was detected and therefore no position can be determined.

The quality grades are determined for the Data Matrix code tape for positioning and for the event marker tape.

**Note**

A poor quality assessment can also have the following causes:

- Inaccurate alignment of the read head
- Incorrect reading distance
- Incorrect mounting of the Data Matrix code tape
- Interruptions of the Data Matrix code tape due to expansion joints

Check these points before assuming that the code tape is damaged.

Evaluating the Quality Grade

Quality Grade for New Application of the Data Matrix Code Tape

Quality Grade	Description of the Grade	Action
1	Excellent installation	No action required
2	Good installation	No action required
3	Installation within tolerance range	Check whether the code tape is dirty and, if necessary, clean the code tape (for more information, see chapter 7.3).
4	Adequate, but not acceptable	• Check the code tape for damage and contamination. • Check the routing of the code tape. • Pay particular attention to problematic branches or intersections. • Check for unfavorable curve radii and inclines or declines.
5	Incorrect installation	See measures for grade 4. No approval for operation.
6	Defective installation	See measures for grade 4. No approval for operation.
7	No code detected: operation is not possible	See measures for grade 4. No approval for operation.

Quality Grade for Ongoing Operation

Quality Grade	Description of the Grade	Action
1	Excellent	No action required
2	Good	No action required
3	Satisfactory	Note positions with a quality grade of ≥ 3 . Check during the next routine inspection and clean if necessary (for more information, see chapter 7.3).
4	Acceptable	Immediately check positions with a quality grade of ≥ 4 for damage and contamination. Clean the code tape or repair if necessary.
5	Poor	Immediately check positions with a quality grade of ≥ 5 for damage and contamination. Immediately clean or repair the code tape.
6	Not acceptable	Immediately check positions with a quality grade of ≥ 5 for damage and contamination. Immediately clean or repair the code tape.
7	No operation possible	Immediately check positions with a quality grade of ≥ 5 for damage and contamination. Immediately clean or repair the code tape.



Note

The recommended grades and actions assume that the Data Matrix code tape has been applied in one continuous length.

Code tape gaps can cause poorer quality grades, even though there is no defect.



Note

The quality values can also be monitored via the switching outputs by configuring a threshold value and outputting it as a switching signal to the switching outputs.

The following figures show examples of different quality grades when reading the Data Matrix code tape.

The images illustrate typical states of the code tape, ranging from very good read quality to heavily contaminated or damaged areas.

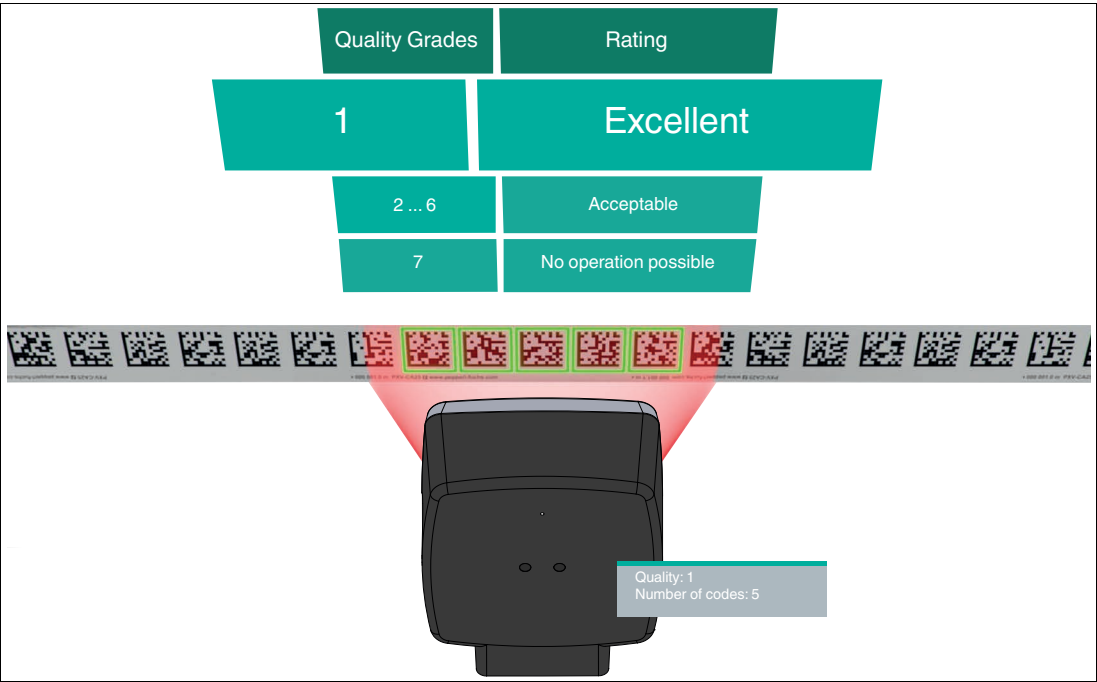


Figure 4.34 High reading quality

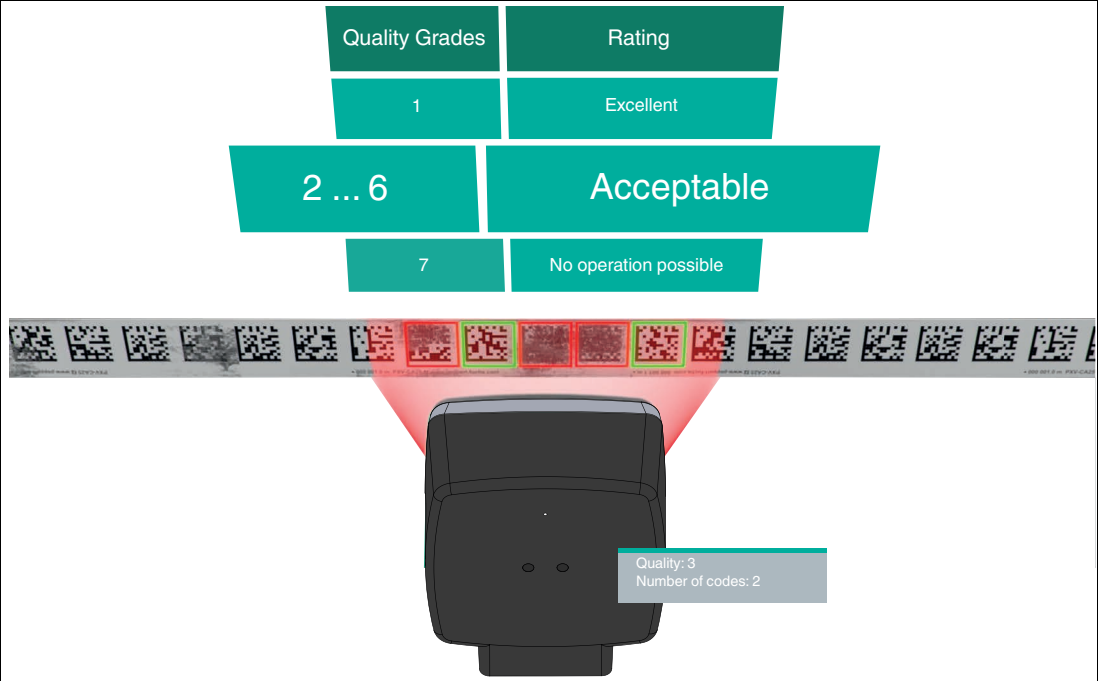


Figure 4.35 Reduced reading quality due to contamination or damage

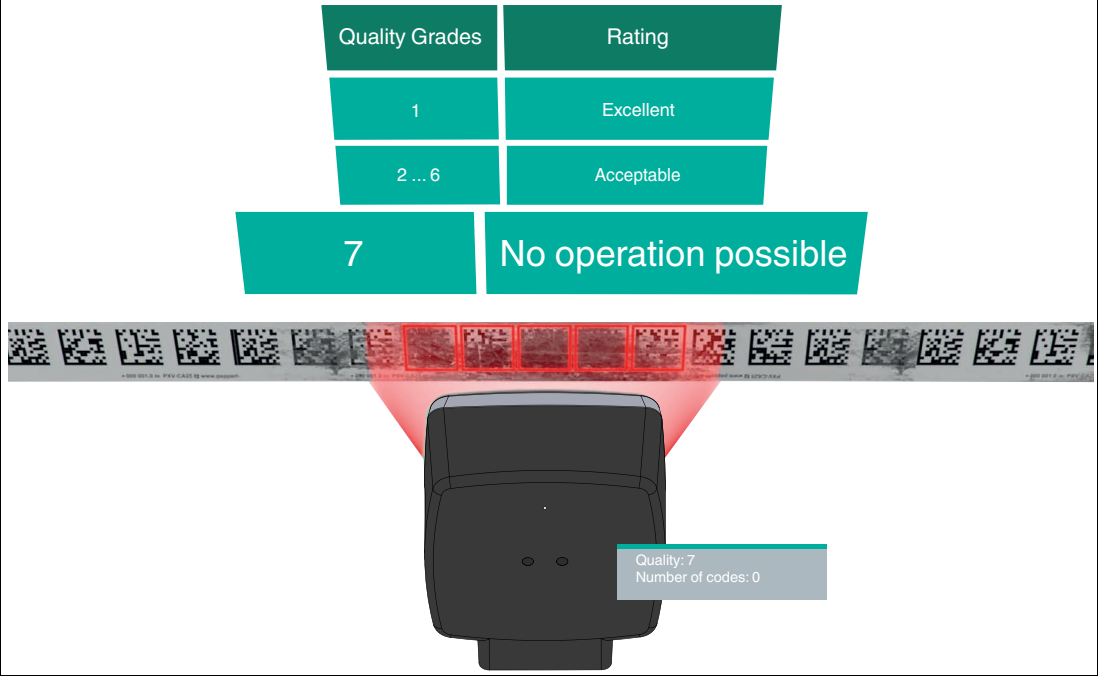


Figure 4.36 No reading quality / Code not readable

4.11 Extrapolation

The read head determines position values with a fixed update rate. If the read head is queried more frequently than new position values become available, it outputs the last determined position value several times without extrapolation. The position curve then corresponds to a stepped curve. When extrapolation is activated, the signal processor of the read head calculates intermediate values with a higher update rate from the last determined position values and the velocity derived from them. This smooths the position curve.

Note

Extrapolation can be enabled or disabled using the **Extrapolation** parameter.

A complete description of all parameters including index, data type, value range, and factory setting can be found in the separate IO-Link parameter datasheet. The IO-Link parameter datasheet is available on the product detail page under the Product documentation tab.

Advantages of Extrapolation

Smoothed position curve at high query rate

- The read head can be queried with a cycle time that is shorter than its update rate. Instead of multiple output position values, the read head delivers calculated intermediate values. The stepped curve is smoothed.

Increased Real-Time Accuracy

- If a position query takes place between two read cycles, the read head outputs a calculated position value. This is usually closer to the actual position at the time of the query than the last determined position value.

Short-term Bridging of Missing Position Values

- If the read head temporarily supplies invalid position values, for example if it unintentionally passes through an area without readable position information, it further calculates the position based on the last valid position values. The calculation is interrupted if no valid position determination takes place within 100 ms. This time span restarts with each valid position determination. Short gaps can therefore be bridged without loss of position.

Limits and Possible Deviations of Extrapolation

The calculation is based on the assumption of a constant velocity. In practice, deviations can occur that can result in incorrect position values in the short-term. These are automatically corrected by subsequent, valid position determinations.

Please note the following scenarios that may affect accuracy:

Constant Speed

- At a constant speed, the calculated position values are very accurate.

High-Velocity Changes

- Quick velocity changes can cause incorrect position values in the short-term. These are only corrected by newly determined position values.

Violations of the Code Tape Grid

- Gaps in the code tape can result in a sudden change in position and an incorrectly calculated velocity (see chapter 4.8). This also results in incorrect position values.

Delayed Reporting of a Position Loss

- If the read head leaves the area with valid position information, it continues to calculate the position until the 100 ms have elapsed and only then reports the position loss. The reaction time to a loss of position is therefore extended accordingly. Incorrect position values can occur even when specifically extending out of the reading range until a message is issued.

4.12 Frame Counter

The frame counter uniquely identifies each image capture. The frame counter counts up continuously as soon as the operating voltage is switched on.

Detecting New Image Captures

The transmission of image captures, for example via fieldbus, runs asynchronously. If the bus or communication cycle has a higher repetition rate than the image capture, the same values are transferred several times. When the frame counter value changes, this indicates a new image capture. An unchanged frame counter value indicated duplicate transferred data.

Behavior on Restart

After restarting the device, the frame counter is reset to 0. The frame counter counts up internally before communication starts. As a result, the start value at the start of communication may vary.

5 Installation and Commissioning

The following sections describe the installation and commissioning of the positioning system. Only the mounting process is described. The planning specifications for mounting must be observed, see chapter 4.

Positioning Targets

The different types of positioning targets that are compatible with this read head are addressed in separate subsections.



Note

Metal Positioning Targets

Metal positioning targets are not addressed in this manual. Corresponding information can be found in the separate manual on the Pepperl+Fuchs homepage.

Read Head

The installation and configuration of the read head is divided into the following topics:

- **Mounting the read head:** Mechanical mounting at the place of use.
- **Electrical connection:** Wiring and power supply.
- **Alignment:** Fine adjustment of the read head to the positioning target.
- **Configuration:** Software settings.

5.1 Positioning Targets

The basic mounting process is identical for all positioning targets available as accessories from Pepperl+Fuchs, as these are always affixed. Specific features of individual positioning targets are described in the corresponding subsections.

Preparing the Base Surface

The condition of the surface is crucial for permanent adhesion of the positioning target.

- Completely remove any residues such as grease, oil, and dust.
- Ensure that the surface is dry, clean, and stable.



Carrying Out the Mounting Process



Caution!

Loss of adhesive force due to contamination

Dust or skin oils on the bonding surface significantly impair adhesion.

- Do not touch the bonding surface
- Protect the exposed adhesive layer from contamination.

1. Check the temperature range specified on the datasheet for mounting the respective positioning target in advance.
2. First, remove a short length of the protective film from one end only.
3. Precisely place the positioning target in the intended position and firmly press down the exposed end.
4. Gradually remove the remaining protective film while smoothing and pressing down the positioning target.

**Note****Curing Time**

The adhesive needs **72 hours** to fully cure. Do not place a mechanical load on the positioning target during this time.

5.1.1**Data Matrix Code Tape**

During mounting, observe the planning information, see chapter 4. For Data Matrix code tapes, the specifications also apply, , , and .

Preparing for Mounting

The code tape must be mounted precisely parallel to the traverse path of the read head. Depending on the equipment and route length, two aids are available:

Using the PCV-LM25 Marker Head (Accessory)

- Mount the marker head in place of the sensor, in the optimal alignment to the code tape.
- Traverse the entire path to mark the ideal position of the code tape.

Using an Application Device

- For long paths, a mechanical device is recommended to guide the code tape evenly and to avoid overstretching due to excessive tensile force.
- The code tape is delivered on a roll. A suitable mechanical application device can be designed for the respective application, e.g., in the form of a bracket that holds, guides, and positions the roller with the code tape.

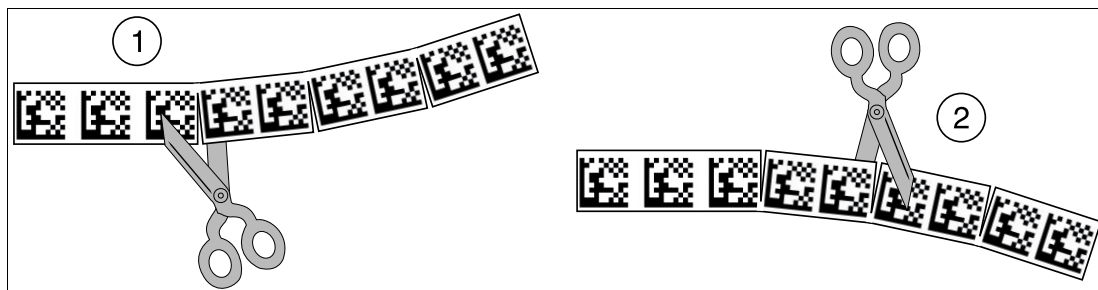
**Affixing the Code Tape****Caution!**

Loss of adhesive strength

Avoid accidental application of the code tape, as repeated removal and reaffixing significantly reduces adhesion and durability.

- Affix the code tape precisely during the first contact.

1. Pull off the protective strip on the back of the code tape piece by piece.
2. Affix the code tape along the intended position. Make sure that you do not stretch the code tape.
3. **Inclines and Declines:** For steep inclines or declines, incisions must be made on the outside of the code tape (see the following figure).



- 1 Incline
- 2 Decline

4. **Roller transitions:** At the transition to the next roller, make sure that the 20 mm grid of codes continues precisely.

**Note****Quality Grades**

If the quality values have declined after the code tape has been mounted, this may indicate contamination, damage, or incorrect alignment. For more information, .

**Note****Length Changes**

The specified length markings and tolerances apply to the unmounted code tape. The actual length may vary due to:

- Improper application can shorten the effective length of the code tape.
- Tensioning the code tape can cause an extension of the effective length.
- Temperature expansion of the surface can influence the effective length of the code tape during operation.

5.1.2**Emergency Spare Code Tape**

A code tape printed on paper can be used as a short-term interim solution if code tape segments are defective, heavily soiled, or not present.

A code tape generator is available for this purpose on the Pepperl+Fuchs homepage.

**Note****Limited Durability of Printed Code Tapes**

Printed paper is **not a permanent replacement** for the rugged original code tapes. The printout must only be used as an **emergency solution**.

The durability of the paper code tape is severely limited, depending on the application.

**Note****Mounting Specifications**

The specifications also apply to the mounting of replacement code tapes and must be observed, see chapter 5.1.1.

**Creating and Installing a Replacement Code Tape**

1. Open the code tape generator on the homepage at www.pepperl-fuchs.com. To do this, enter the search term "code tape generator" in the search field and start the search.

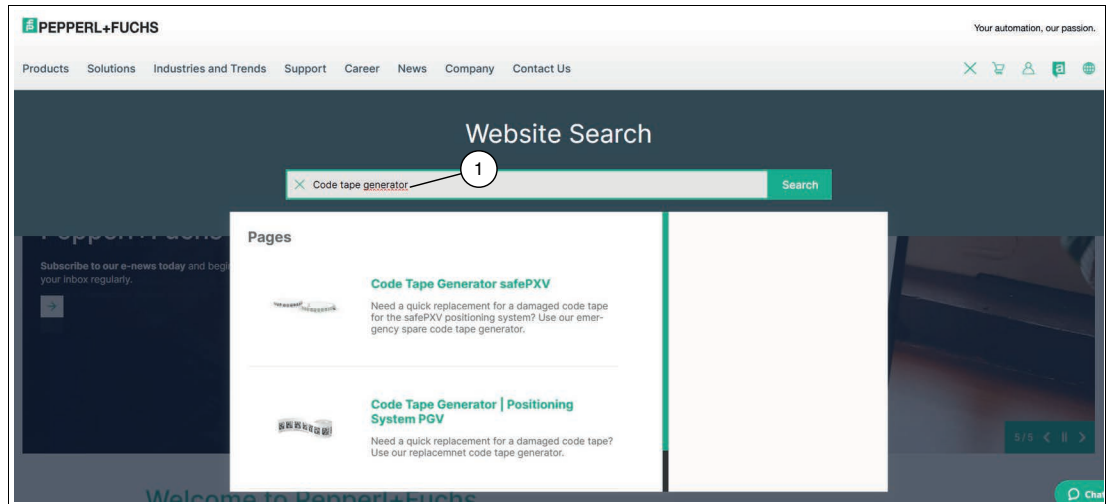


Figure 5.1 Code Tape Generator

2. Select the code tape generator that is compatible with your system.
3. Follow the instructions on the generator.
4. Print the pages of the required code tape segments and cut them precisely to size.

**Note****Print Settings**

Make sure that the printer settings are selected so that the code size exactly matches the original code tape.

The correct scaling can be checked using the dimensions on the top and right of the first page of the document.

5. Affix the replacement code tape over the defective area of the existing code tape.
6. Preferably apply adhesive to the back of the replacement code tape.

**Note****Avoid Placing Tape on the Front**

Do not cover the codes or the quiet zone with adhesive tape. Transparent adhesive tape can also impair the detection of the codes due to reflections.

7. Align the replacement tape so that it seamlessly continues the grid of the code tape.

**Tip****Suitable Protective Film**

To increase the resistance of the paper code tape, we recommend that you apply a suitable protective film. You can find suitable accessories on our homepage.

**Warning!**

Danger due to uncontrolled movements!

If code tape segments are not replaced properly or replaced by code tapes with deviating position information, the taught-in reference points may change. This can cause the control logic to perform actions at incorrect positions.

The resulting uncontrolled movements can cause serious injury to persons and considerable damage to the system.

5.2 Read Head

The read head is commissioned in several steps. The recommended sequence may vary depending on the installation situation and application. The individual steps are described in the following subsections:

- Mounting
- Electrical Connection
- Alignment

Certain alignment procedures require an electrical connection to be established in advance. In addition, the code tape must already be mounted to align the read head.

The following procedure is therefore generally recommended:

1. Mount the code tape
2. Mounting the read head
3. Establish the electrical connection
4. Align the read head on the code tape



Caution!

Risk of injury due to strobe effect

Strobe effects may occur when lighting is flashing. These can cause optical illusions, such as rotating parts appearing to be at a standstill or moving more slowly. This results in a risk of injury.

- Mount and align the device so that no rotating parts are illuminated.
 - If such an arrangement is unavoidable for system-related reasons, mark the hazardous area in the system with clearly visible warnings.
-

5.2.1 Read Head Assembly



Note

Technical Drawing

A technical drawing of the read head with full dimensions is included in the datasheet.

Planning and Preparation

The appropriate installation position is selected as part of the plant design (see chapter 4). Pay particular attention to the requirements, , and .

- The assembly must be designed to make subsequent fine adjustment possible. Alternatively, the read head must be precisely aligned during initial assembly.
- We recommend the use of mounting brackets with slots to enable flexible and precise alignment.

A suitable mounting bracket with slots is available under the product designation PCV-MB1 on our homepage.



Figure 5.2 Mounting bracket (PCV-MB1)

- Mount the bracket so that the slots allow adjustment in the direction of the code tape.

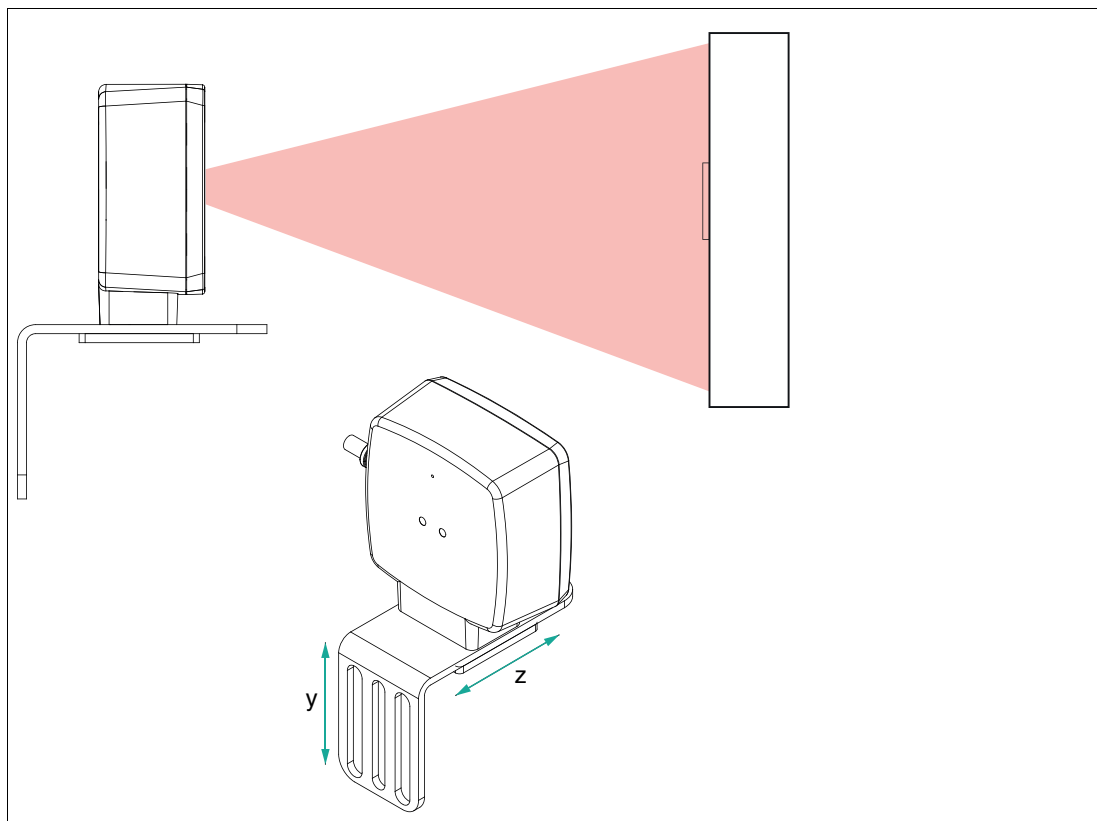


Figure 5.3 Example illustration of the read head on the mounting bracket

Mechanical Installation

Secure the read head using three screws. To ensure long-term stability and to prevent damage to the housing, observe the following limit values:

Parameter	Value
Max. tightening torque	9 Nm
Max. screw-in depth	9 mm
Min. tightening torque	System-specific (to be defined by the designer)

Notes on Fastening

- The screw connection must be designed for the individual mechanical loads (vibrations, shocks) of the application.
- If necessary, use thread-locking fluid to prevent loosening due to temperature or vibration.



Warning!

Personal injury due to incorrect position values

Loose fastenings result in the read head moving uncontrollably during operation. The resulting incorrect position values can result in unpredictable travel movements, which pose a risk to personnel and the system.



Caution!

Property damage due to inadequate securing

If the read head is not secured in accordance with the mechanical load, it can completely detach. This could result in the destruction of the device and potential consequential damage to the system.

5.2.2 Electrical Connection

IO-Link is a serial, bidirectional point-to-point connection for signal transmission and power supply under any network, fieldbus, or backplane bus.



Caution!
Property damage and system malfunctions due to incorrect pinout
Incorrect assignment of the wire pairs to the respective pins can result in property damage and system malfunctions.

- Note the assignment of the wire pairs to the pins as shown in the respective wiring diagrams.

Connection

The read head is connected via a 5-pin M12 plug.

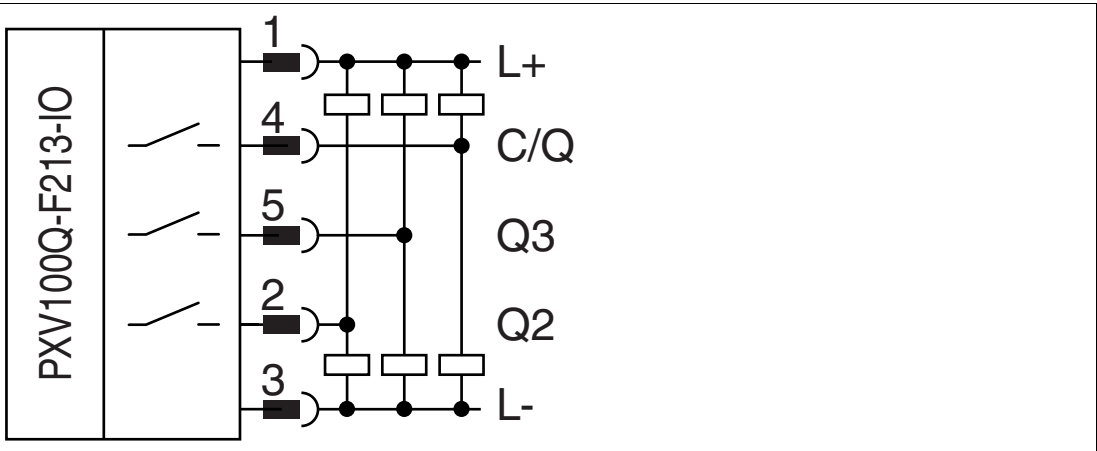


Figure 5.4 Connection assignment

Pin	Designation	Description
1	L+	Supply voltage
2	Q2	Switching input/output can be parameterized
3	L-	Ground
4	C/Q	IO-Link data communication
5	Q3	Switching input/output can be parameterized

The default settings for the configurable inputs and outputs can be found in the read head data-sheet.

5.2.3 Aligning the Read Head

Align the read head, see chapter 4. Carry out a fine alignment using the position values as set out below. This procedure is possible for all device types and ensures maximum system availability and accuracy.

System-Specific Alignment Method

In systems with several vehicles along a traverse distance, a system-specific alignment method must be developed. This ensures that all read heads are aligned equally with the truck. This is also recommended for systems with only one vehicle per traverse distance, so that the alignment can be precisely restored when a device is replaced.

Significance of Uniform Orientation

The following figure illustrates the problem. Despite the identical x-position of the read head, the conveyor containers are offset if the mechanical mounting position on the conveyor container varies.

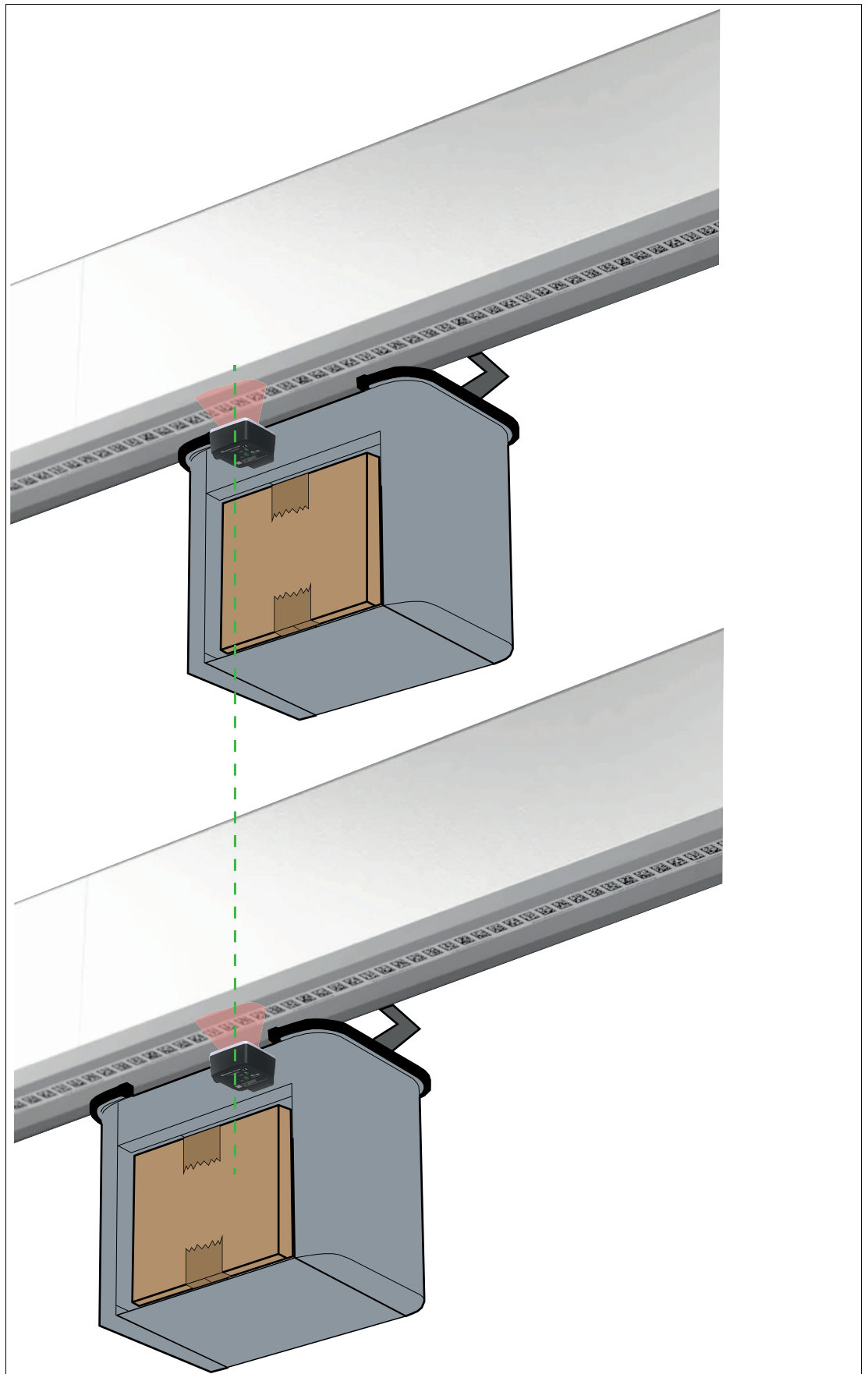


Figure 5.5 Illustration

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Carrying Out the Alignment Procedure

1. Define a position for the alignment. It must be possible to position the vehicles manually at this position without reference to the read head (e.g., using colored markings).
2. Align all read heads in this position to specified x, y, and z values.
3. Display the position values in the controller.

Alignment Criteria

x-Position

- Alignment to a defined x-position is critical to ensure that all the conveyor containers are positioned identically along the route.

y- and z-Position

- In many systems, changes occur along the traverse distance including
 - the reading distance
 - the height of the read head relative to the positioning targets.

When aligning using position values, the y- and z-values must be selected to represent an optimal compromise for the entire system. Identical orientation of all read heads to the same y- and z-position helps significantly to increase availability.

Angle Position

- Avoid twisting or tilting the read head in relation to the code tape.

Alternative Alignment Methods

Depending on the read head type, other methods are available for aligning the read head.

These are set out in the following sections.

The above instructions apply regardless of the selected alignment method.

Selecting the Reference Point

If you do not align to predefined position values, the alignment is performed by optimizing at the selected reference point.

The alternative methods are designed to optimize the orientation locally at this point, and can replace an orientation to fixed y- and z-positions.

The reference point must be a representative compromise for the entire system with regard to the reading distance and height to the code tape.

However, these methods cannot be used to ensure alignment to a defined x-position.

5.2.4 Alignment Using the Alignment Gauge

A particularly simple and precise way to align the read head to the correct height and specified reading distance is to use the alignment gauge. This is available as an accessory on the product detail page of the respective read head on our website under the "Related Products" tab.



Installation Procedure

1. Place the alignment gauge onto the read head from the rear.



Note

Correct Positioning of the Alignment Gauge

The correct positioning depends on the selected mounting position or orientation of the read head and is shown in the following figure.

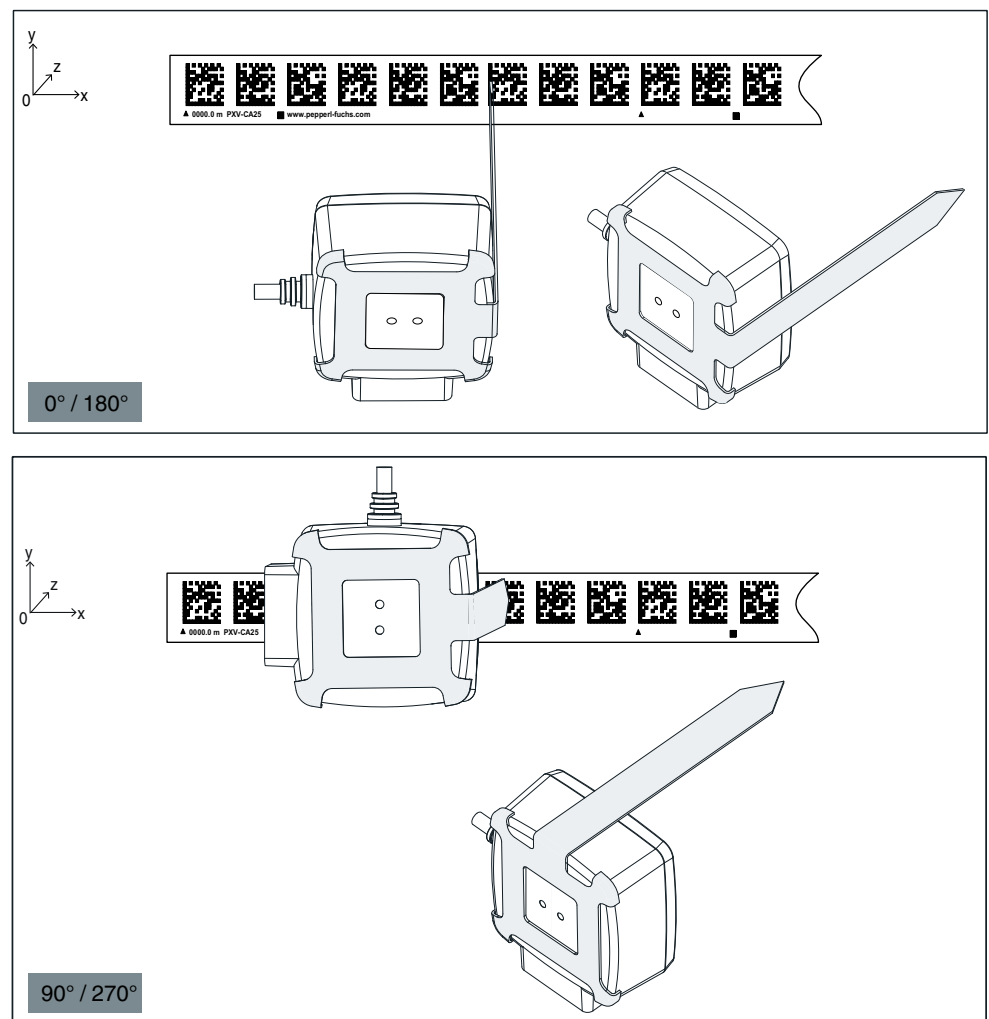


Figure 5.6

2. Align the read head so that the tip of the alignment gauge lightly touches the code tape.
3. The tip must point exactly to the $y = 0$ line of the code tape.

5.3 Configuration

This chapter sets out the procedure for parameterizing the device.

For a detailed description of the individual parameters, .

Two options are available for parameterizing the device:

- Parameterization via the "**PACTware**" software tool
- Parameterization via the **IO-Link IODD description file**

5.3.1 Commissioning with IO-Link on a Controller (Online Parameterization)



Note

The device description file (IODD) required for integration into an IO-Link system and for the parameterization and diagnostics is available online. Visit www.pepperl-fuchs.com and navigate to the relevant product page for the read head.

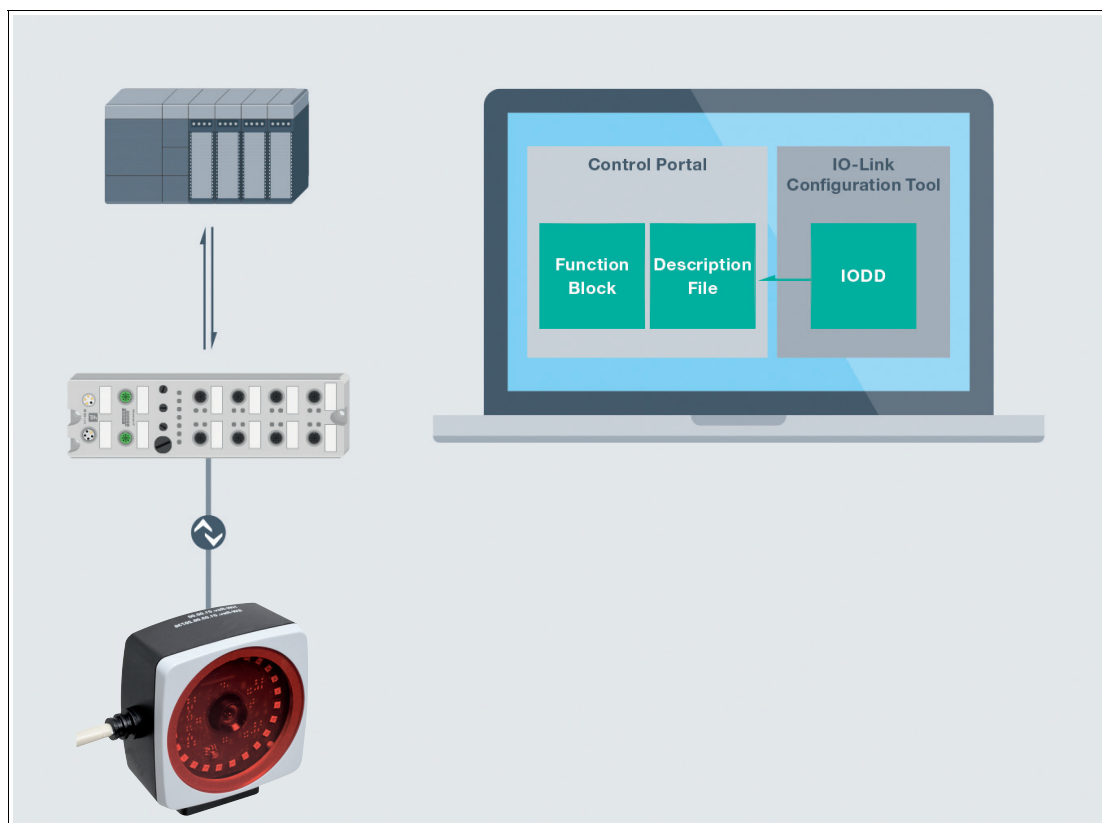


Figure 5.7

When commissioning machines and systems, the master and IO-Link read head must be integrated into the respective control environment. Depending on the components used, different software is required.

The devices can then be configured and parameterized using an IO-Link configuration tool. During operation, you can check the parameter settings of the IO-Link devices and read out and monitor status and diagnostic data. IO-Link data is integrated into an application program using function blocks.

5.3.2 Commissioning with IO-Link via FDT Frame Application and IODD (Off-line Parameterization)

This manual sets out how to parameterize using the "PACTware" FDT frame application in which the DTM (Device Type Manager) is loaded. In principle, you can also use other appropriate FDT frame applications. It is also possible to use the appropriate IODD for parameterization instead of using the DTM. However, some analysis options are not available because they require graphic representations.



Note

An M12 connecting cable is required to connect the read head to the IO-Link master. Suitable connecting cables can be found at www.pepperl-fuchs.com on the product page for the relevant read head.



Prerequisites for Commissioning

To address the read head via IO-Link using the "PACTware DC" software and the associated DTM (device type manager), proceed as follows:

1. Ensure that PACTware DC and the necessary DTMs (device type managers) or the IODD device description for the read head and the IO-Link master are installed.
2. Connect the read head to the IO-Link USB master using an M12 connecting cable.
3. Connect the IO-Link USB master to the PC using the USB cable.



Setting up read head communication with PACTware DC

1. Launch PACTware DC by double-clicking the PACTware DC icon.

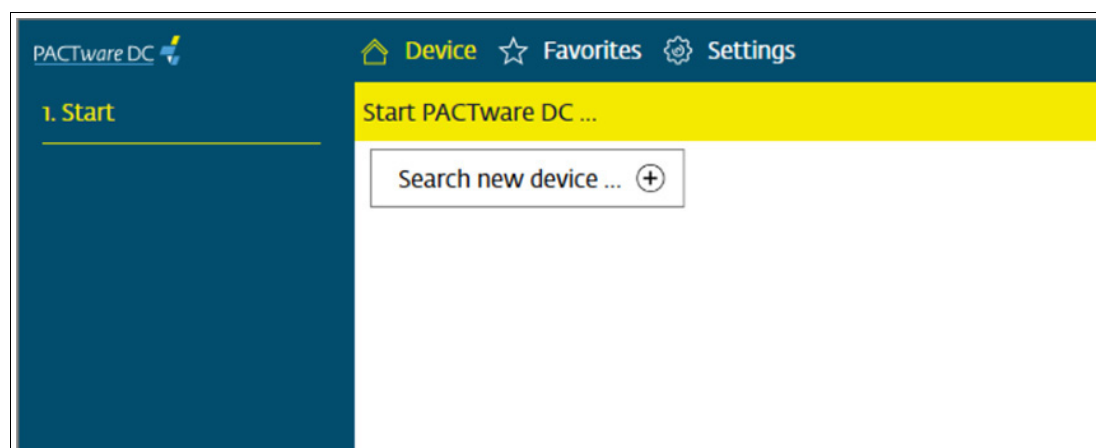


Figure 5.8

2. Click on **Search for new device...** at the top.
 ↳ The IO-Link USB master will be detected by the PACTware DC if it is connected to the PC.

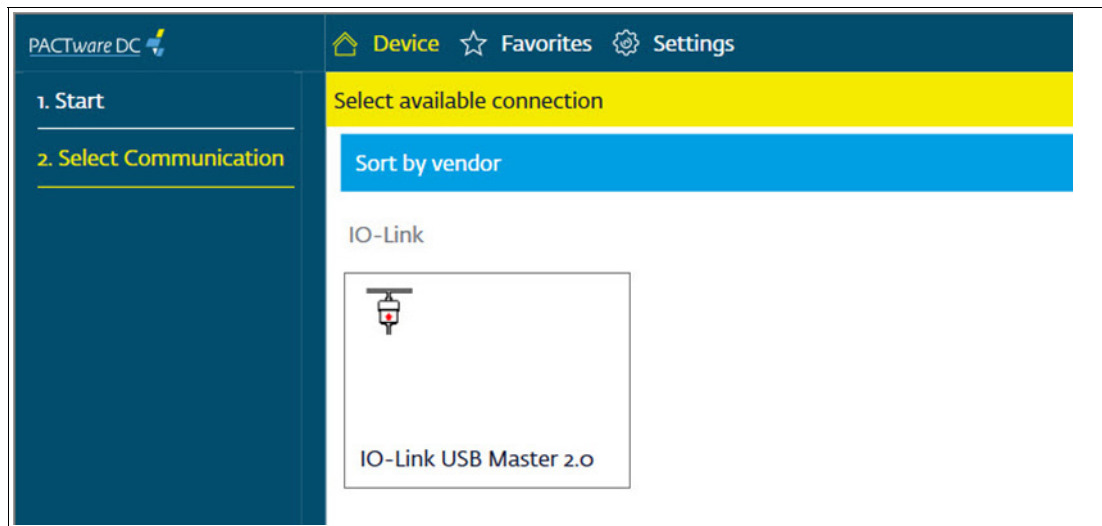


Figure 5.9

3. Click on **IO-Link USB Master 2.0** in the project.
↳ If the read head is connected to the IO-Link USB master, PACTWare DC automatically establishes the connection to the read head.
4. Confirm the "Read from Device (Upload)?" dialog with "Yes" to synchronize the parameter values displayed in PACTware with the parameter values in the read head.

6 Operation and Communication

6.1 Data log

Device description IODD

An electronic device description is available for each device, the IODD file (IO device description). The IODD contains a wide range of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process, and diagnostic data
- Device data
- Text description
- Image of the device
- Logo of the manufacturer

The structure of the IODD is the same for all devices from all manufacturers. The structure of the IODD is always displayed in the same way in the IO-Link configuration tools of the master manufacturers. Operation is therefore guaranteed for all devices regardless of the manufacturer.

Data types

There are essentially four types of data available:

- Process data: Synchronous data
- Value status: Synchronous data
- Device data: Acyclic data
- Events: Acyclic data

Process Data

The process data of the devices is transmitted cyclically in a data telegram, with the process data size determined by the device. Process data from 0 to 32 bytes are possible per device (input and output in each case). The consistency width of the transmission is not fixed and is therefore master-dependent.

Value status

Each port has a value status (PortQualifier). The value status indicates whether the process data is valid or invalid. The value status can be transmitted cyclically with the process data.

Device data

Device data can be parameters, identification data, or diagnostic information. It is exchanged acyclically and on request from the IO-Link master. Device data can both be written to the device (Write) and from the device (Read).

Events

When an event occurs, the device notifies the master that an event has occurred. The master then reads the event. Events can be error messages (e.g., short circuit) or warnings/maintenance instructions (e.g., contamination, overheating). Error messages are transmitted from the device to the controller or the HMI via the IO-Link master. For its part, the IO-Link master can also transmit events and statuses. Wire breakage and communication termination are examples of such events.

Device parameters or events are transmitted independently of the cyclic transmission of process data. The transmissions do not affect one another.

6.1.1 Process Data Structure

Input data (sensor > controller)

Byte	Bit Offset	Name	Data Type	Length	Value
19	1	No Position Detected	Boolean	1 bit	true false
	2	Warning	Boolean	1 bit	true false
	3	Event	Boolean	1 bit	true false
	4	Reserved	-	1 bit	
	5	Overspeed	Boolean	1 bit	true false
	6	Illumination Off	Boolean	1 bit	true false
	7	Reserved	-	1 bit	
18	8	Code With Non-PXV Content	Boolean	1 bit	true false
	9	Sensor Too Close To Code Tape	Boolean	1 bit	true false
	10	Sensor Too Far Away From Code Tape	Boolean	1 bit	true false
	11	Y-Position Too High	Boolean	1 bit	true false
	12	Y-Position Too Low	Boolean	1 bit	true false
	13	Reserved	-	3 bits	
17	16	Number of Detected Codes	UInteger	8 bits	
16	24	Quality Value	UInteger	8 bits	1 ... 7
12 ... 16	32	X-Position	Integer	32 bits	-2147483648 ... 2147483647
10 ... 12	64	Event Marker	UInteger	16 bits	0 1 ... 32767
8 ... 10	80	Speed	Integer	16 bits	-32768 ... 32767
6 ... 8	96	Y-Position	Integer	16 bits	-32768 ... 32767
4 ... 6	112	Angle	Integer	16 bits	-32768 ... 32767
2 ... 4	128	Z-Distance	Integer	16 bits	-32768 ... 32767
0	144	Frame Counter	UInteger	16 bits	

Output data (controller > sensor)

Byte	Bit Offset	Name	Data Type	Length	Value
0	0	CSC - Illumination Control	Boolean	1 bit	true false



Note

For a complete description of all parameters, including index, data type, value range, and factory setting, please refer to the separate **IO-Link Parameter Datasheet**.

This **IO-Link Parameter Datasheet** is available on the product detail page under the Product Documentation tab.

7 Maintenance

General Procedure

When replacing devices, follow the same work instructions as for initial commissioning. For detailed information, see chapter 5.

Using an Original Device

In the event of a defect, the device must always be replaced with an original device from the manufacturer. After replacing the device, the plant operator is obliged to reconnect the device and, if necessary, change the device name, address, and device configuration to match the replaced device.

Manufacturer-Specified Accessories

When replacing other system components, only use accessories that have been specified by the manufacturer. As an interim solution, defective or very dirty code tape can be temporarily replaced with a self-printed replacement tape (see chapter 5.1.2).



Caution!

Danger due to heat generation on the device

The device may heat up when used for a long period of time. The temperature of metal surfaces (plugs) and the housing of the read head may increase after a long period of operation.

Allow the device to cool down before carrying out any work.



Caution!

Danger due to changed position information

If a defective code tape is replaced with a section with different position information, the previously learned reference points are lost. Multiple use of identical code ranges can lead to ambiguous position information, meaning that the actual position of the device cannot be precisely determined. Before installing a replacement code tape, ensure that the position information for the read head is unique in the entire plant area.

If the code tape is not replaced with sufficient precision or the read head is aligned differently relative to the vehicle, the learned reference points will shift accordingly. This can lead to reduced positioning accuracy within the plant. Therefore, make sure that the replacement is carried out carefully and precisely.

7.1 Servicing

The device is maintenance-free.

7.2 Testing

Regular Inspection

To ensure high operational availability, we recommend regularly inspecting the read head and the Data Matrix code tape for mechanical damage and removing any contamination (see chapter 7.3). There is no need for an additional proof test because the prescribed interval is longer than the normal service life of the device.

Additional Inspection under Exceptional Ambient Conditions

If the device is exposed to ambient conditions in the plant that could cause potential mechanical damage or vibration, it is advisable to regularly inspect the integrity of the device housing (especially water ingress) and the correct seating of fasteners (e.g., loose fastening screws).

7.3

Cleaning



Note

General Information

Even with the correct sensor alignment, read errors can occur due to contamination. This is especially likely when the code tape is installed on the floor. This chapter describes the correct cleaning procedures for the code tape and read head.

Cleaning the Code Tape

Cleaning intervals

Because contamination levels vary between installations, fixed cleaning intervals cannot be defined. Note the following:

- In some circumstances, the read head may fail to read codes that still appear to be legible.
- It is difficult for the human eye to assess readability for the read head.
- To maintain system performance, early cleaning is recommended when there is visible contamination.
- Quality grades are used for early detection of contamination.
- Cleaning becomes essential once read errors begin to occur.

The image below shows a heavily soiled code tape that is barely legible. At this level of contamination, individual codes may already be unreadable, which can lead to system disruptions.

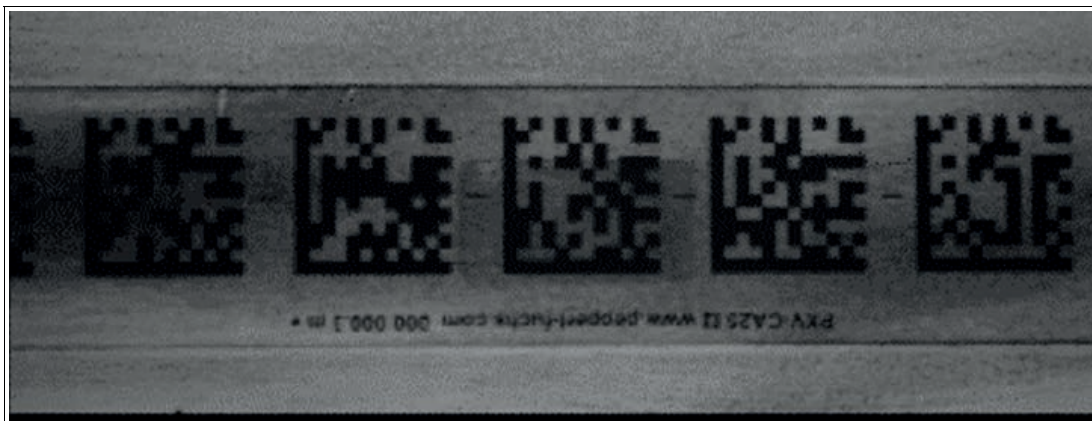


Figure 7.1

Correct cleaning method

The surface of the code tape is designed to diffuse incident light and minimize disruptive reflections.



Note

Impaired Functionality Due to Incorrect Cleaning

Incorrect cleaning may polish the code tape, causing reflections that may not be visible to the human eye but that interfere with system performance. To check this, capture an image with the read head.

The image below shows a reflective code tape with visible reflections of the lighting ring.

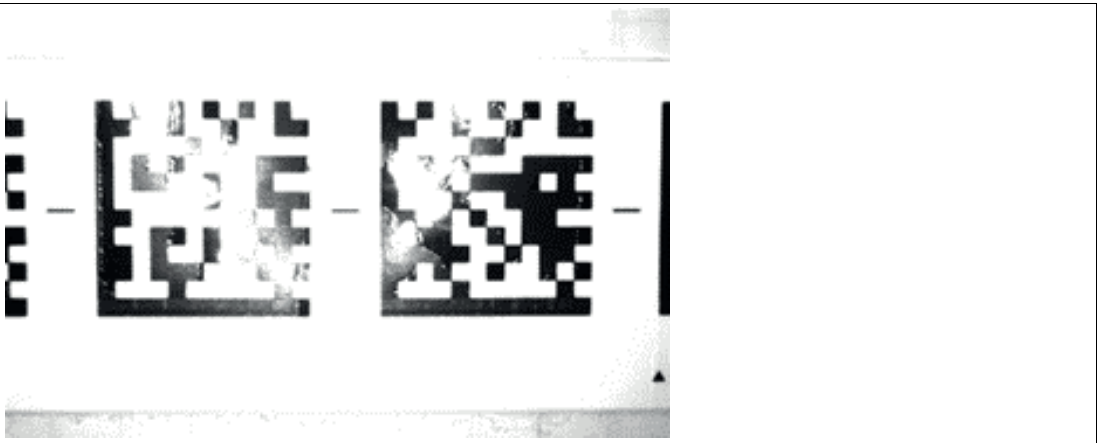


Figure 7.2

Recommended Cleaning Agents and Materials

	Recommendation	Do not use
Cleaning cloths	Cotton or microfiber cloths	Brushes or rough cloths (e.g., paper towels)
Cleaning agents	Plastic-safe cleaner only	Acetone, petroleum, brake cleaner, isopropanol

Cleaning technique

Avoid applying excessive pressure so as not to polish the surface.

Automated cleaning

- Recommended: Contactless cleaning systems (e.g., mobile suction systems)
- Not recommended: Cleaning systems in continuous direct contact with the code tape (e.g., mobile brushes) because these may polish the surface over time and cause disruptive reflections

Code tape replacement

If cleaning is not possible, a temporary workaround is to generate and print a new code tape using a generator.

Cleaning the Read Head

Cleaning intervals

Because contamination levels vary between installations, fixed cleaning intervals cannot be defined. The impairment of read performance depends heavily on the type of contamination. If in doubt, capture an image with the read head to check whether contamination is affecting the optical surfaces.

Components to be cleaned

Only the optically active surfaces of the read head need to be cleaned:

- Front glass (located in front of the lighting unit and lens)

	Recommendation	Alternative
Cleaning cloths	Water	Non-aggressive cleaning agents
Cleaning agents	Lint-free cotton or microfiber cloths	-

7.4 Repair

Repairing or manipulating the device is not permitted.

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