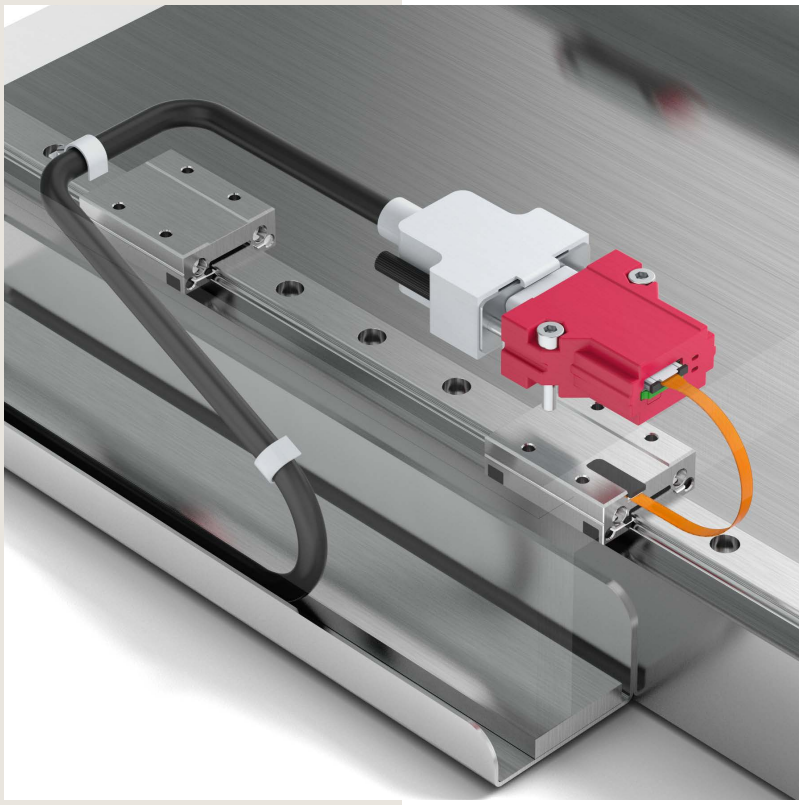
SCHNEEBERGER
LINEAR TECHNOLOGY



MINISCALE PLUS

The unique miniature guideway with integrated measuring system and a resolution of 0.1 µm

Mounting Instructions 2015

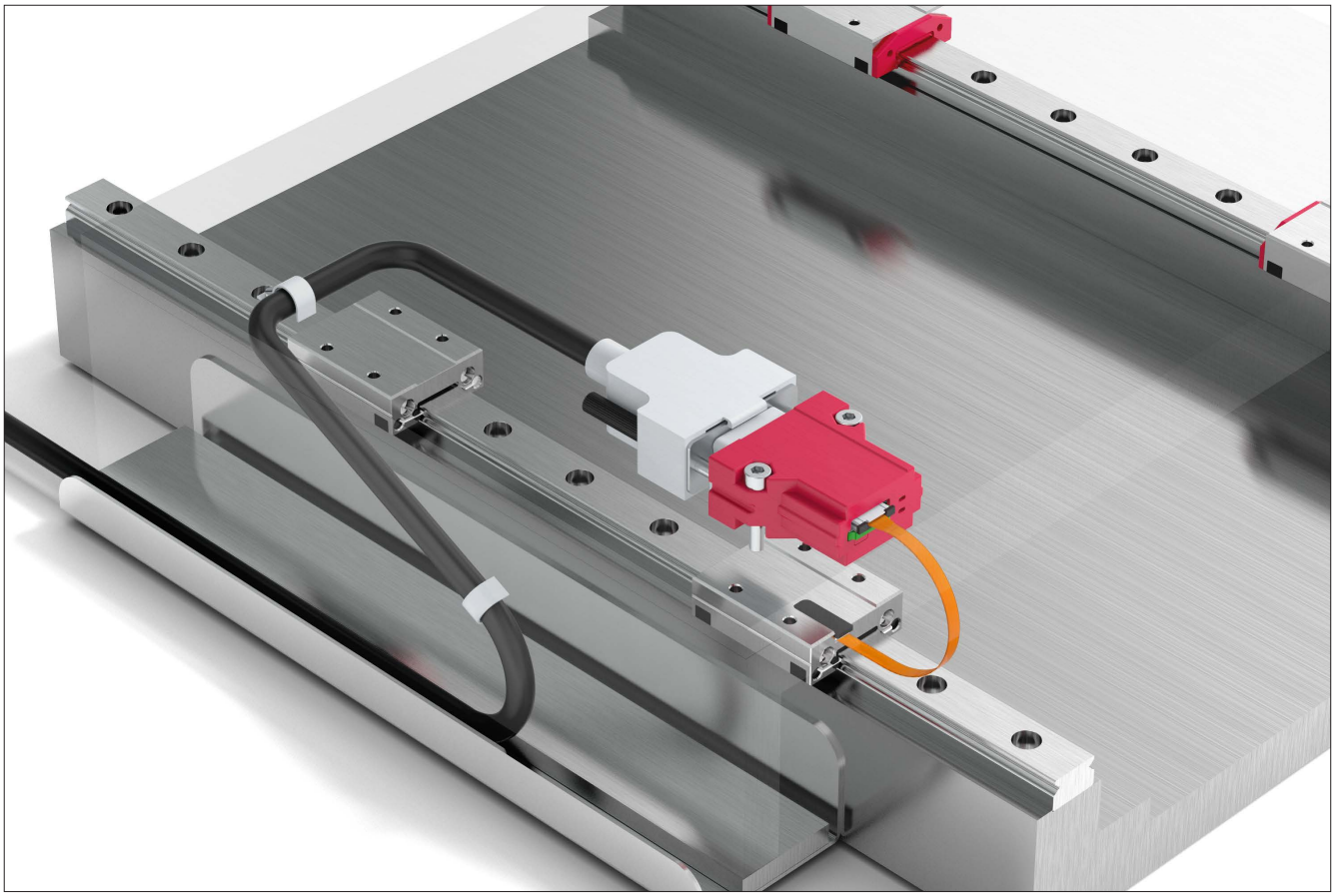
Exclusion of Liability

1 Contents

2 Introduction

2.1. Scope of Application

These instructions describe installation of the MINIRAIL and MINISCALE PLUS miniature profiled linear guideway systems.



Configuration of MINISCALE PLUS with MINIRAIL

2.2. Supplementary Literature

MINI-X Product Catalog

3 Safety Instructions

3.1. Authorized Staff

MINIRAIL and MINISCALE PLUS must only be assembled by appropriately trained specialists who have read and understood these instructions.

3.2. Intended Use

MINIRAIL and MINISCALE PLUS can only be exposed to the approved environmental influences (see MINI-X product catalogue, MINIRAIL and MINISCALE PLUS technical information)

3.3. General Safety and Protective Measures

- The power supply should be disconnected prior to any work on electrical equipment.
- ESD regulations should be observed when handling ESD-vulnerable parts (EN 100015-1).
- Country-specific regulations, standards and guidelines for accident prevention must be observed.

3.4. Environmental Protection

- Lubricants should be disposed of in an environmentally responsible way.
- Decommissioned components should be disposed of in accordance with local/national laws and guidelines.

4 Handling and Storage

4.1. Transport

MINISCALE PLUS and MINIRAIL are high-precision components and should be handled with care. For transportation of these products in-house, the following points should therefore be noted:

- Transport guideways and accessories in their original packaging
- Protect guideways against impacts
- Always transport MINIRAIL and MINISCALE PLUS carriages on guide rails or on the protective plastic rail

4.2. Protection

The following instructions should be noted to protect against damage:

- Storage in the original packaging is only possible for a limited period. The condition of the products should be checked at regular intervals.
- Protect products against moisture/humidity and do not store them out in the open
  (10% - 70%, non-condensing).
- Ensure the correct temperature range:
  MINIRAIL -40° C to +80° C.
  MINISCALE PLUS -40° C to +80° C.
- Only remove the products from their original packaging at their installation location and immediately prior to assembly.
- Check the state of lubrication.
- Always store MINIRAIL and MINISCALE PLUS carriages on the guide rail or protective plastic rail so that the rolling elements are protected.

- MINISCALE PLUS is sensitive to electrostatic discharge! The electronics can be damaged if precautions are not taken against ESD; ESD regulations should therefore be observed when handling ESD-vulnerable parts (EN 100015-1).
- The power supply should be switched off prior to connecting or disconnecting cables, and precautions should be taken to ensure it cannot be switched on again unintentionally.

Improper handling of the guideways can lead to preliminary damage and thus to premature failure.

5 Installation and Adjustment Guidelines

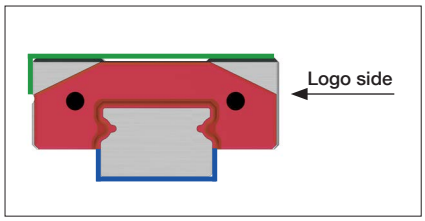
5.1. Serial Number on Guideway and Carriages

Both guideways and carriages are labelled with serial numbers. The serial number on guideways and carriages is located next to the SCHNEEBERGER logo.

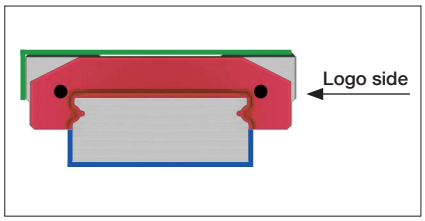
5.2. Locating and Supporting Surfaces

Locating and supporting surfaces on carriages and guideways are designated as follows.

Standard sizes 7, 9, 12 and 15



Wide sizes 14, 18, 24 and 42

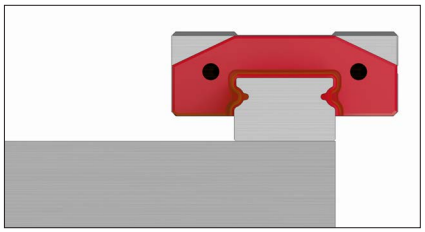


Carriage locating and supporting surfaces
Guideway locating and supporting surfaces

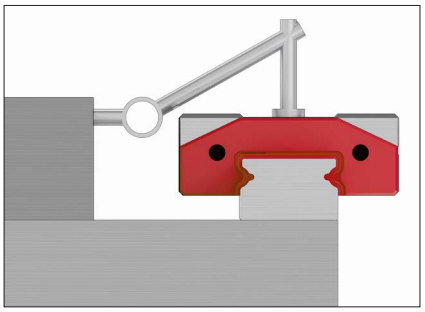
The polished locating side of the carriage is opposite the carriage side with the company logo / type designation.
The guideway can be located on both sides.

5.3. Methods for Aligning Guideways

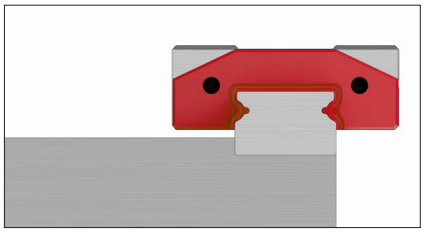
Alignment of the guide rails depends on the level of accuracy needed and must be specified in the construction phase of the machine, since this is when the number of locating surfaces as well as their positions is determined. A distinction is made between the following types of alignment:



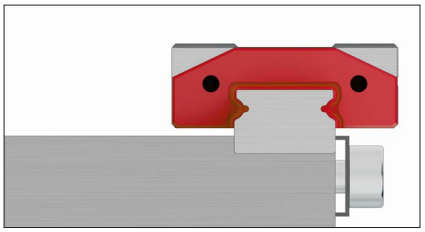
No reference edge available
- Alignment by hand without tools
- Not recommended
- Very low level of accuracy



No reference edge available
- Alignment by hand with tools, e. g. aligning gauge, guide strip, dial gauge, installation carriage
- Medium to high level of accuracy depending on the complexity



Lateral reference
- Alignment by means of pressing against the locating surface
- High level of accuracy, depending on the accuracy of the reference edge
- Very quick due to predefined reference edge



Lateral locating surface and additional lateral clamping
- Alignment by pressing against the locating surface with the help of lateral clamping elements
- Very high level of accuracy, depending on the accuracy of the reference edge
- Very quick due to predefined reference edge

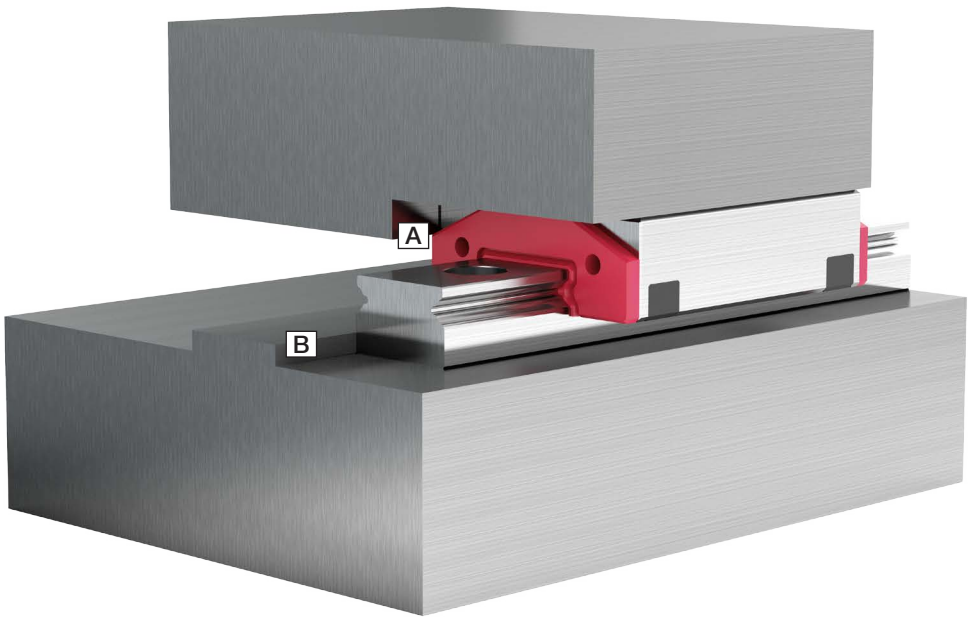
5.4. Preparing for Installation

5.4.1 Required tools and equipment

- Oil stone
- Lubricant
- Torque wrench
- Fastening screws
- White spirit or rubbing alcohol

5.4.2 Preparing the locating surfaces

- Check locating surfaces of the machine bed and mounting plate for shape and position accuracy.
- Clean all locating surfaces thoroughly. Remove ridges and surface irregularities with an oil stone.
- Use white spirit or rubbing alcohol to clean the locating and supporting surfaces of guideways. Do not use paint thinner!
- Clean dirty guideways with a soft, lint-free cloth. Do not use compressed air!
- Lightly oil the locating surfaces on the guideways and carriages.



Locating surfaces

A Reference on the mounting plate for the carriage

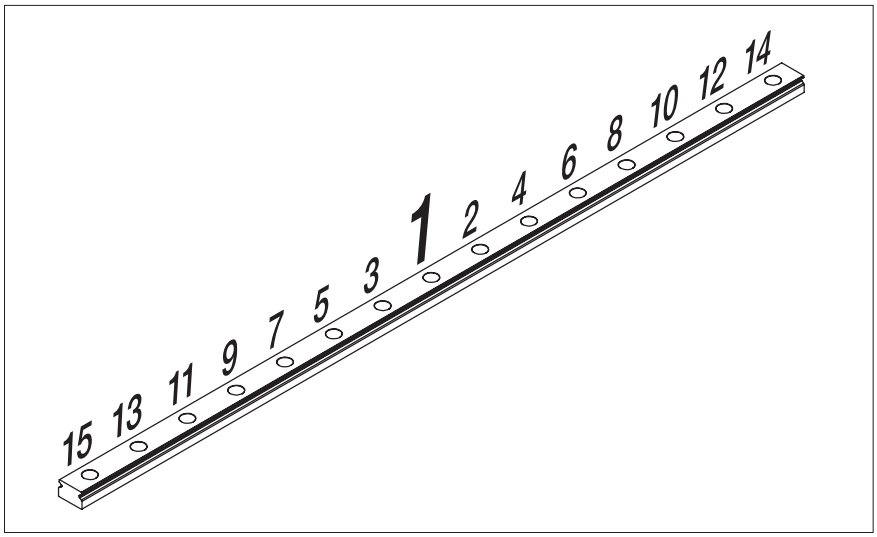
B Reference on the machine bed for the guideway (both sides of the guideway can be used as locating surfaces)

5.5 Installing the Guideway

- Before installation, the guideway, machine bed, mounting plate and fastening screws must all be at room temperature.

- The MINISCALE PLUS sensor is an electrostatically vulnerable component and is delivered in ESD-protective packaging. To ensure the sensor remains protected, the ESD-protective packaging should not be removed during installation of the MINISCALE PLUS guideway.

- Always tighten the fastening screws with a torque wrench. See chapter 5.6 for tightening torques.
- Always brace the locating surface of the guideway against the locating surface of the machine bed. The guideway can be located on both sides, the locating side of the carriage is opposite the carriage side with the company logo / type designation.
- Alternate between sides of the guideway, starting at the middle, when tightening fastening screws.



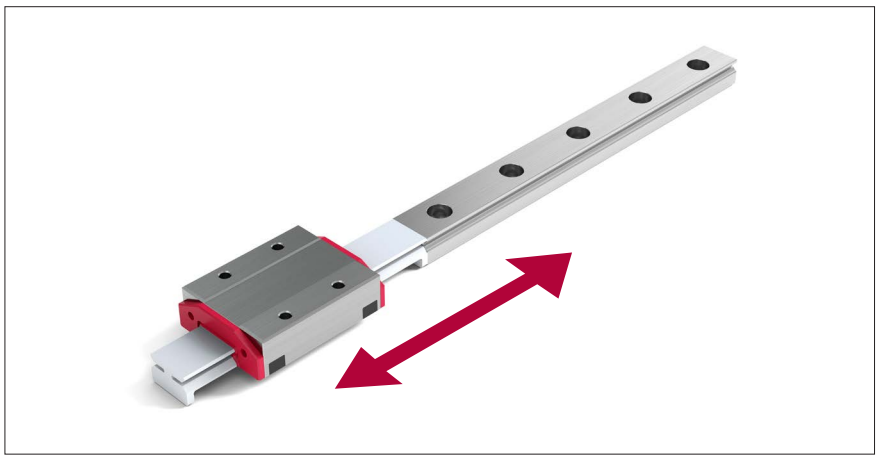
Fixing MINIRAIL Guideways Correctly

5.5.1 Cleaning Dimensional Scales

The dimensional scale of the measuring system is located on the top side of the MINISCALE PLUS guideway. After the guideway has been fixed but before the carriage is mounted, the dimensional scale must be cleaned to ensure it can be read by the sensor. Lubricants, fingerprints and other dirt residue must be removed.
A clean, lint-free cloth should be used for cleaning. White spirit or rubbing alcohol are suitable cleaning fluids.
Wipe down the dimensional scale on the surface of the guideway with a soaked cloth. Repeat the cleaning several times with a clean cloth for heavy dirt.

5.5.2 Mounting and dismounting carriages (MINIRAIL or MINISCALE PLUS) onto guideways

Use the included protective plastic rail. This protects the carriage from dirt and prevents it jamming, causing the ball bearings to subsequently escape.



Place the protective plastic rail in line with the guide rail and slide the MINIRAIL or MINISCALE PLUS carriage onto it.

For MINISCALE PLUS carriages, ensure the sensor is over the dimensional scale on the guideway.

5.6. Tightening Torques for the Fastening Screws

The recommended torque values can be found in the table. These values apply to oiled screws.

The friction coefficient μ can be reduced by up to half when using greases containing MoS2. The corresponding torque values should be reduced by half.

The following table shows the torque values for the fastening screws of strength class 12.9 (friction coefficient 0.125) and of the strength class A2-70 (friction coefficient 0.2) in accordance with DIN 912:

Thread size	Tightening torque in Ncm	
	Strength class 12.9	Strength class A2-70
M1.6	28	20
M2	60	30
M3	210	110
M4	500	260

5.7. Lubrication of MINISCALE PLUS

If MINISCALE PLUS or MINIRAIL carriages are used on a guideway, all carriages are lubricated during manufacture (with KLÜBER Isoflex NBU15). Regarding subsequent lubrication, refer to the guidelines for MINISCALE PLUS.

5.7.1 Subsequent Lubrication Intervals for MINISCALE PLUS

The subsequent lubrication interval depends on many variables, e.g. load, working environment, speed, etc. and therefore cannot be calculated. The lubrication point must therefore be observed over a longer period of time.

For subsequent lubrication, use only grease (Klüber Isoflex NBU15).

A film of grease should be applied to the tracks of the guideway using a lint-free cloth. The carriages should then be moved along the entire length of the rail so that the lubricant is applied to the ball bearings and distributed along the guideway. The grease should be applied sparingly in order to ensure no lubricant gets into the measuring system optics.

The surface of the guideway must then be cleaned, and the dimensional scale wiped over with white spirit or rubbing alcohol so that it can be read by the sensor.

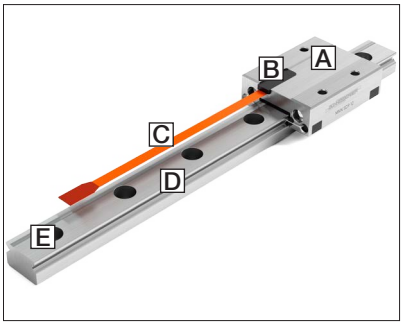
5.8. Connecting the Flexible Printed Circuit Board to the Interface Module

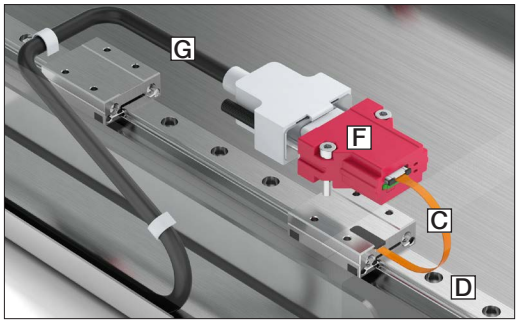
MINISCALE PLUS is an optical, incremental measuring system. It consists of the MINIRAIL guide system and the following additional standard components:

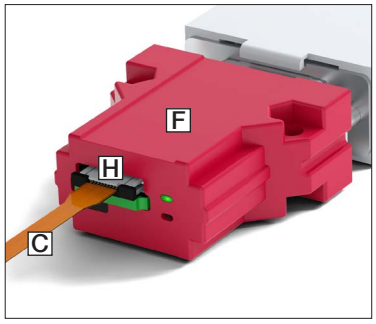
- Dimensional scale on the guide rail
- Optical sensor on the carriage with flexible printed circuit board
- Interface module with D-sub 9 connector (the control cable with D-sub 9 connector must be supplied by the customer and be a flexible cable where necessary).

5.8.1 Overview of Relevant Components

A Carriages
B Optical sensor
C Flexible printed circuit board (must not be exposed to dynamic loads)
D Guideway
E Dimensional scale on the guideway
F Interface module with D-sub 9 connector
G Control cable (supplied by customer)
H ZIF connector

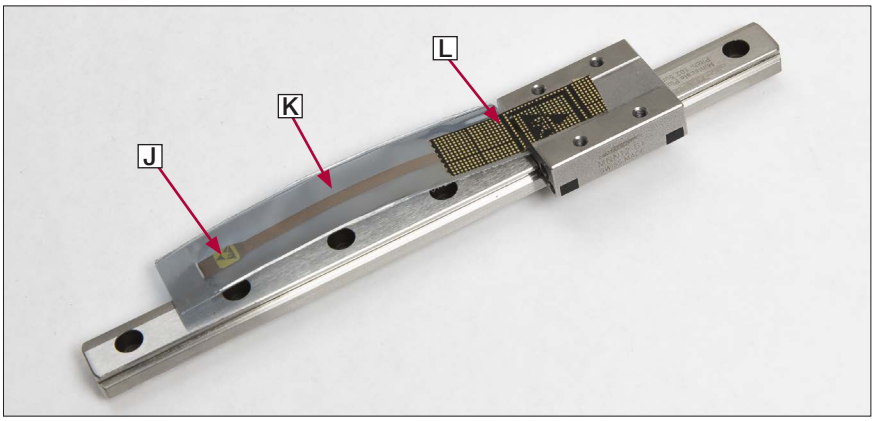






5.8.2 ESD Protection

The MINISCALE PLUS optical sensor is an electrostatically vulnerable component and is delivered in ESD-protective packaging. (Electrostatic Discharge).

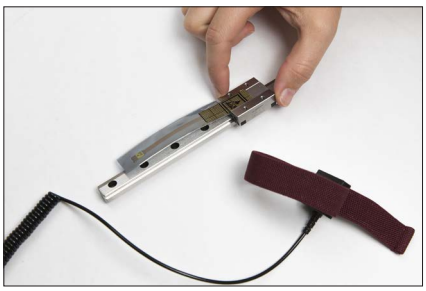


J ESD sticker
K ESD-protective packaging
L Conductive tape

As soon as it is removed from the protective packaging, MINISCALE PLUS and the interface module of the flexible printed circuit board must be protected against electrostatic fields and discharge. As soon as MINISCALE PLUS is assembled and connected ready for use, it is protected from ESD.

5.8.3 Connecting to the Interface Module

These installation instructions are not a guide on ESD but are simply to give an overview of how MINISCALE PLUS should be operated.

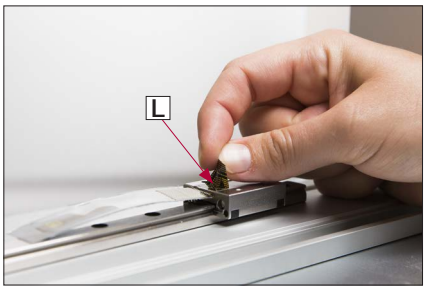


An ESD wrist strap with ground cable or crocodile clamps on the machine bed acting as such should be used as a minimum when installing MINISCALE PLUS.

Provided the MINISCALE PLUS flexible printed circuit board is in the ESD-protective packaging, no ESD protection or wrist strap is necessary.

The ESD-protective packaging should not be removed during installation of the guideway so that the sensor remains protected.

The ESD-protective packaging can only be removed once MINISCALE PLUS is grounded on the machine bed and the person is properly protected from ESD (e.g. by wearing an grounded wrist strap).

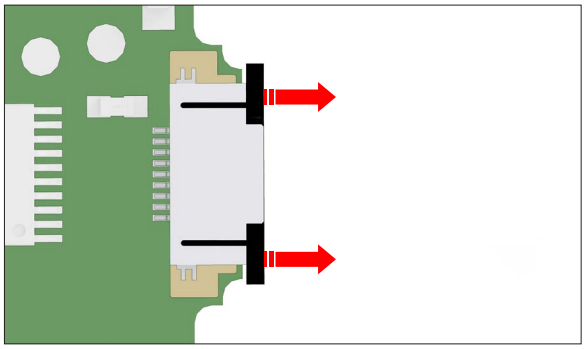


Remove tape (L)

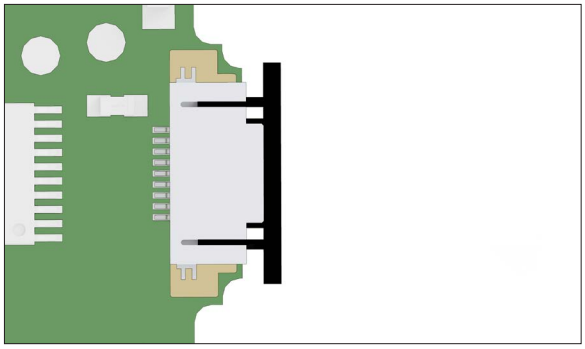
The flexible printed circuit board (C) must not be damaged during removal of the protective packaging.

After the protective packaging has been removed, MINISCALE PLUS is unprotected and must only be touched by ESD-protected persons.

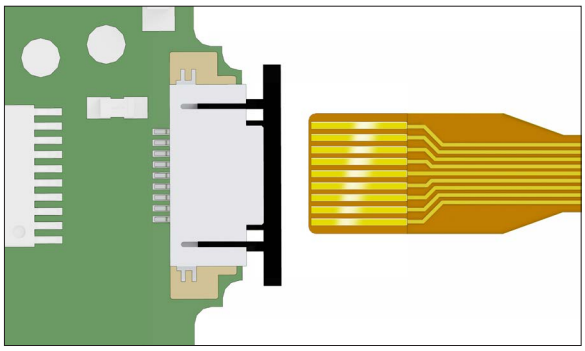
5 Installation and Adjustment Guidelines



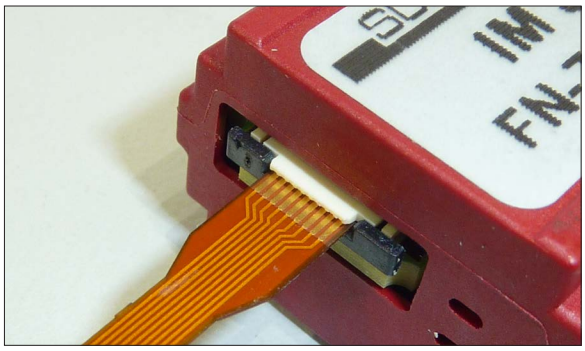
Open ZIF connector (H)



Insert the flexible printed circuit board (C) into the ZIF connector (H) of the interface module (F) without touching the gold contact points on the printed circuit board.



Make sure that the contact surfaces of the flexible printed circuit board are facing upwards so that contact is ensured.



Once the flexible printed circuit board has been inserted, push the ZIF connector towards it.

Once the sensor is connected to the interface module, which is connected to the grounded machine, it is protected from ESD and can be touched without ESD protection.

The flexible printed circuit board between the sensor and the interface module can only be used statically. The bending radius of the flexible printed circuit board must not fall below 2 mm.

The sensor head in the carriage sends sinusoidal output signals when the carriage is moved relative to the dimensional scale along the guide rail.
These signals are interpreted in the interface module and displayed in analog (see chapter 6.2) or digital form (see chapter 6.3), depending on the type of interface module.

6.1 Supply Voltage and Current Consumption

Supply voltage: 5 V DC +/- 5%
This must be adhered to in order to generate output signals.

Current consumption: 60 mA (analog) / 70 mA (digital)

6.2 ANALOG Interface Module (Analog Signal 1Vss)

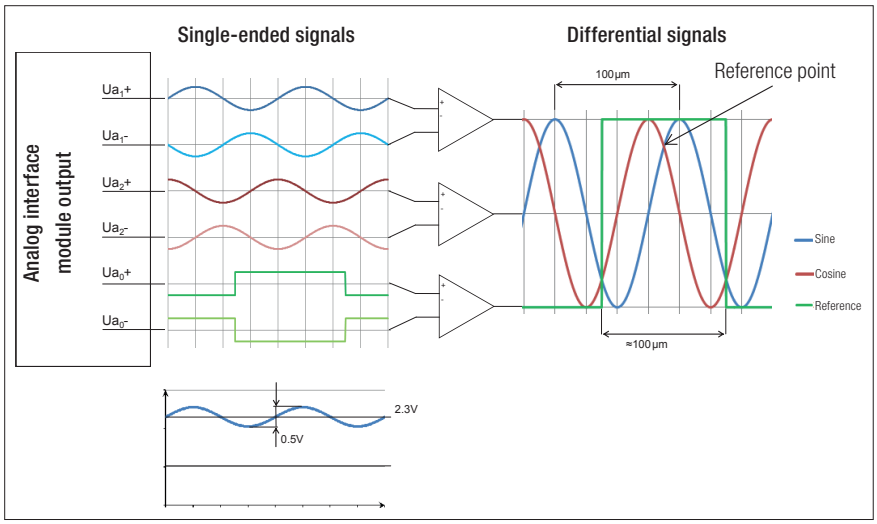
6.2.1 Output Format:

Differential, sin/cos analog signals with reference pulse
1 Vss (at 100Ω)

The incremental sine and cosine signals are displaced 90° and correlate with the markings on the incremental track. One electrical signal period (360°) corresponds exactly to the scale increment on the dimensional scale, which amounts to 100 µm.

The reference pulse always marks electrically a particular section of the path of the sine and cosine signals. The point of intersection of the two signals within the reference pulse marks a precisely defined position on the dimensional scale.

The sine signal either lags behind the cosine signal or occurs before it, depending on the direction of movement.



The analog signal must be interpolated by the customer in order to achieve an appropriate resolution (e.g. Period 100 µm, interpolation 250 times, analysed 4 times results in a resolution of 0.1 µm. The frequency of the electronics must be adjusted to the travelling speed. E.g. A speed of 2 m/s with signal period before interpolation of 100 µm results in a frequency of 20 kHz (see calculation in chapter 9.3)

6.2.2 Signaling

In order to increase the resistance to interference, transmitting the signals in an interpolated form is recommended. Transmitting signals in opposite phases symmetrically can almost entirely prevent interference. The amplitude of the differentially transmitted signals equates to $1V_{SS}$.

For single-ended signaling, the voltage changes relative to a reference potential. The amplitude of such a signal amounts to 0.5 V.

This interface works with all standard controllers that support a 1 V_{SS} voltage interface.

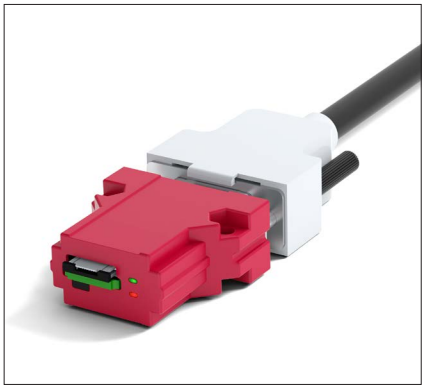
6.2.3 Pin allocation for analog interface module $1V_{SS}$ (IM SCPA)

Interface module: Male 9-pin D-sub connector.
Customer-supplied cable: Female 9-pin D-sub connector

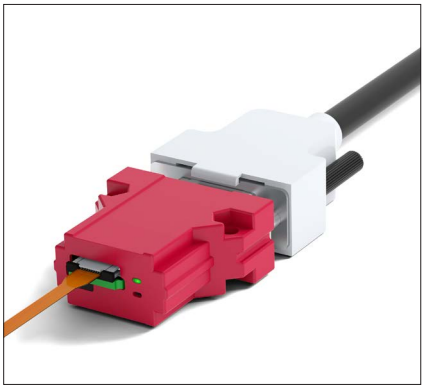
Pin	Signal	Signal type
1	Ua1 -	Sine-
2	GND	Supply voltage
3	Ua2 -	Cosine-
4	ERR NOT	Error signal
5	Ua0 -	Reference signal -
6	Ua1 +	Sine +
7	+5V DC	Supply voltage
8	Ua2 +	Cosine +
9	Ua0 +	Reference signal +

6.2.4 Function Check

The green LED will light up if the MINISCALE PLUS is correctly supplied with power.



Interface module without MINISCALE PLUS flexible printed circuit board. Both the green and red LEDs light up



Interface module with correctly connected MINISCALE PLUS flexible printed circuit board. The green LED lights up

If the carriage is on the guideway and the LED lights up red despite the flexible printed circuit board being inserted, the error should be found using the table in chapter 10 ‚Error Description'.

LED	Supply missing	Supply connected, normal operation	Error condition
red	Red LED does not light up	Red LED does not light up	Red LED lights up red
green	Green LED does not light up	Green LED lights up green	Green LED lights up green

The status of the interface module is shown electronically with the output («ERR NOT»). ERR NOT is a 5-volt output (TTL level), where a «low - signal» = «pending error» and a «high - signal» = «no error».

6.2.5. Using the analog interface module with the USB counter 026 or 046 (for technical information, see chapter 12 in the MINI-X product catalogue).

1-axis USB Counter 026

The USB counters mentioned above allow MINISCALE PLUS to be connected directly to a computer via USB.

Current consumption:
< 150 mA
Storage temperature of the USB counter:
-30 °C to + 70 °C
Operating temperature of the USB counter:
0° to 45 °C in relative humidity of <75%.

3-axis USB Counter 046

When using the USB counter's analog input, the interpolator built into the USB counter reaches a resolution of just 256 (= 28). As a result, the resolution displayable with the USB counter is limited to 0.39 µm. A speed of 5 m/s is guaranteed, and the maximum input frequency amounts to 75 kHz (based on one channel, e.g. the A signal.)

The maximum length for the USB cable is 5 meters. With a USB repeater cable, the USB connection can be extended up to a maximum of 25 m.

PC software for USB counter 026

- For operating the USB counter, PC software for demonstrating the functionality is available.
- A DLL file is available for customers that wish to write their own software applications.

2-axis SIRIUS II position indicator

6.2.6 Using the analog interface module with the 2-axis SIRIUS II position indicator (for technical information, see chapter 12 in the MINI-X product catalogue).

Storage temperature of the position indicator:
-40 °C to + 70 °C
Operating temperature of the position indicator:
0 °C to 45 °C in relative humidity between 15% and 95% without condensation.

The maximum input frequency is 100 kHz which guarantees a speed of 5 m/s. The built-in interpolation factor for an analog input of the position indicator is 20. This achieves a resolution of just 5 µm. We therefore recommend using the SIRIUS II position indicator with the digital input option, along with the MINISCALE PLUS digital interface module.

6.3 DIGITAL Interface Module (Digital Signal TTL)

6.3.1 Output Format:

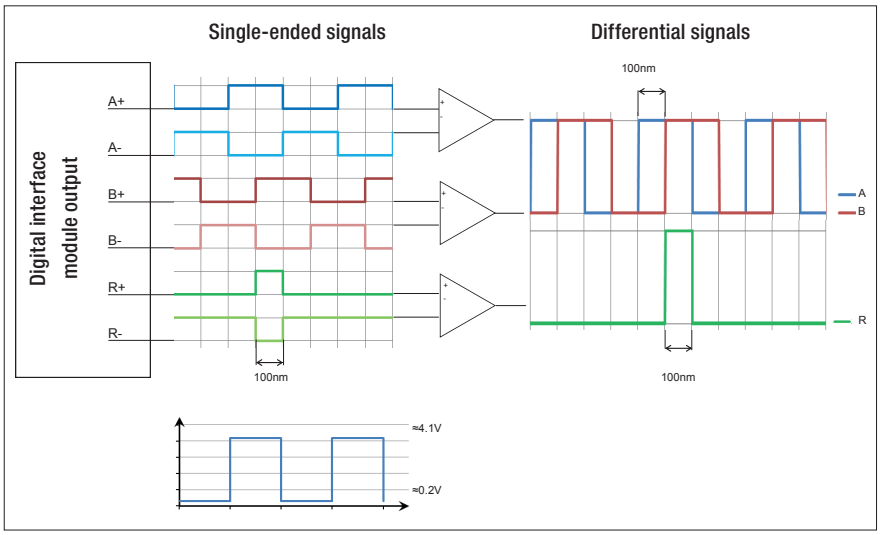
Differentially interpolated digital signals with reference pulse (A, B, R)
TTL signal, 5 volt level (RS422)

The digital interface module both processes the raw signals and interpolates the processed analog signals. The interpolation achieves a resolution of 100 nm.

The digital signal waveform consists of an A and a B signal. The spacing between the two edges of signals A and B corresponds exactly to a distance of 100 nm. Accordingly, the scale increment of 100 µm on the incremental track of the dimensional scale is divided into 1000 sections of 100 nm by means of interpolation.

The A signal either lags behind the B signal or occurs before it, depending on the direction of movement.

The reference pulse is as wide as the spacing between the two signal edges of signals A and B, which is 100 nm. The edges of the incremental and reference signals are synchronised.



The maximum output frequency of the digital interface module is 8 MHz per channel. This means that the A signal and B signal can each have a maximum frequency of 8 MHz. For a 4-edged evaluation of the A/B signals, a count rate of 32 MHz occurs, corresponding to a maximum speed of 3.2 m/s at a pitch of 100 µm.

6.3.2 Signaling

In order to increase the resistance to interference, transmitting the signals in an interpolated form is recommended. Transmitting signals in opposite phases symmetrically can almost entirely prevent interference.

A pair of wires is used to transmit the A+ signals and the inverted A- signals. The B+, B- and reference signals R+ and R- are transmitted differentially using the same method (RS 422). At the receiver, the signal is generated by creating the difference based on the difference between the two voltage levels.

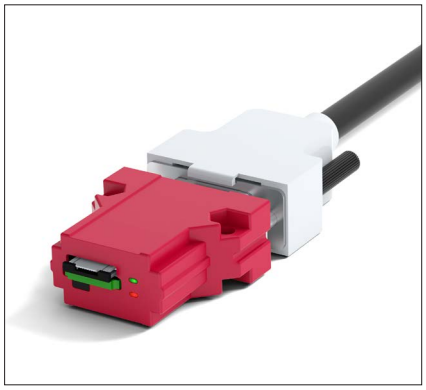
6.3.3 Pin allocation for the digital TTL/CMOS interface module (IM SCPD)

Interface module: Male 9-pin D-sub connector.
Customer-supplied cable: Female 9-pin D-sub connector

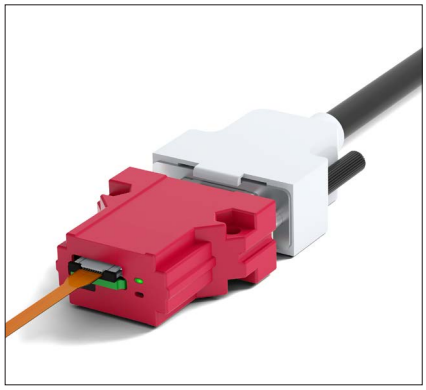
Pin	Signal	Signal type
1	A-	Quadrature signal
2	GND	Supply voltage
3	B-	Quadrature signal
4	ERR NOT	Error signal
5	R -	Reference signal
6	A+	Quadrature signal
7	+5V DC	Supply voltage
8	B+	Quadrature signal
9	R +	Reference signal

6.3.4 Function Check

The green LED will light up if the MINISCALE PLUS is correctly supplied with power.



Interface module without MINISCALE PLUS flexible printed circuit board Both the green and red LEDs light up



Interface module with correctly connected MINISCALE PLUS flexible printed circuit board. The green LED lights up

If the carriage is on the guideway and the LED lights up red despite the flexible printed circuit board being inserted, the error should be found using the table in chapter 10 ‚Error Description'.

LED	Supply missing	Supply connected, normal operation	Error condition
red	Red LED does not light up	Red LED does not light up	Red LED lights up red
green	Green LED does not light up	Green LED lights up green	Green LED lights up green

The status of the interface module is shown electronically with the output («ERR NOT»). ERR NOT is a 5-volt output (TTL level), where a «low - signal» = «pending error» and a «high - signal» = «no error».

1-axis USB Counter 026

6.3.5 Using the digital interface module with the USB counter 026 or 046 (for technical information, see chapter 12 in the MINI-X product catalogue).

The USB counters mentioned above allow MINISCALE PLUS to be connected directly to a computer via USB.

Current consumption:
< 150 mA

Storage temperature of the USB counter:
-30 °C to + 70 °C

3-axis USB Counter 046

Operating temperature of the USB counter:
0° to 45 °C in relative humidity of <75%.

Digital signal input to the USB counter must be used in order to make use of the full resolution of the interface module. The USB counter has a maximum permissible input frequency of 500 kHz, or 1MHz for the 046 counter (frequency based on one channel, e.g. the A signal).

Consequently, a count rate around 4 times higher occurs during 4-edge evaluation. This limits the travelling speed to 0.2 or 0.4 m/s for a resolution of 0.1 µm (refer to the following table):

USB counter 026	Interpolation	Resolution	Input frequency	Speed
Digital TTL input	(4-edge evaluation)	0.1 µm	500 kHz	Max. 0.2 m/s

USB counter 046	Interpolation	Resolution	Input frequency	Speed
Digital TTL input	(4-edge evaluation)	0.1 µm	1 MHz	Max. 0.4 m/s

The maximum length for the USB cable is 5 meters. With a USB repeater cable, the USB connection can be extended up to a maximum of 25 m.

PC software for USB counter 026

- For operating the USB counter, PC software for demonstrating the functionality is available.
- A DLL file is available for customers that wish to write their own software applications.

2-axis SIRIUS II position indicator

6.3.6 Using the digital interface module with the digital 2-axis SIRIUS II position indicator (for technical information, see chapter 12 in the MINI-X product catalogue).

Storage temperature of the position indicator:
-40 °C to + 70 °C

Operating temperature of the position indicator:
0 °C to 45 °C in relative humidity between 15% and 95% without condensation.

Digital signal input to the position indicator must be used in order to make use of the full resolution of the interface module in the position indicator. This has a maximum permissible input frequency of 1 MHz (based on one channel, e.g. the A signal). Consequently, a count rate around 4 times higher occurs during 4-edge evaluation. This limits the maximum possible travelling speed to 0.4 m/s for a resolution of 0.1 µm.

SIRIUS II	Interpolation	Resolution	Input frequency	Speed
Digital TTL input	(4-edge evaluation)	0.1 µm	1 MHz	Max. 0.4 m/s

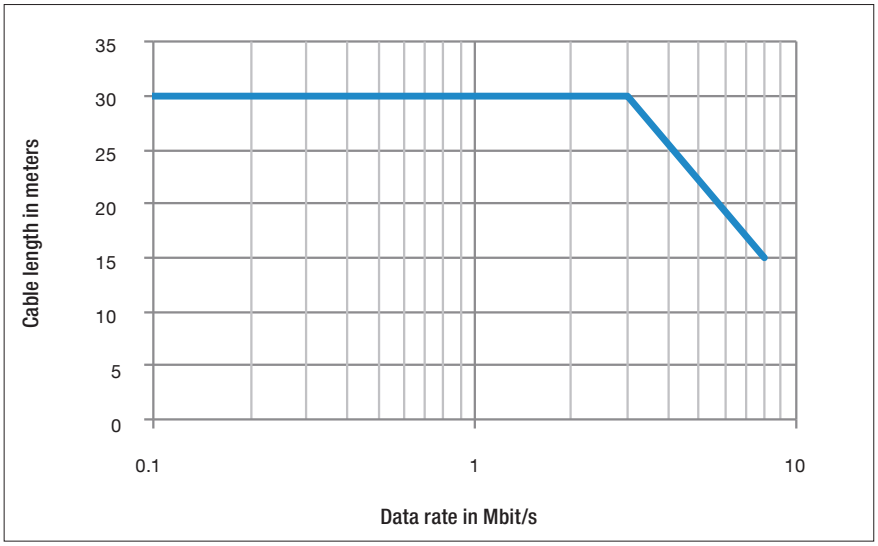
The configuration menu must be set as follows:

Name	x
Reference mode	once
Direction	positive
Counting direction	-
Signal period	100 µm
Interpolation	1000 times
Spacing	0 mm
Start point	0 mm
Base	-
Increment	0.0001 mm
Increment	0.0001 inch

6.4 Recommendations for the Customer-Supplied Cable

The flexible printed circuit board between the sensor and the interface module can only be used statically. The bending radius of the flexible printed circuit board must not fall below 2 mm. The dynamic movements must be managed by a customer-supplied cable.

- In order to ensure maximum resistance to interference, a shielded twisted pair cable is recommended. A cable with additional shielding should be used if necessary.
- Suitable shielding must be ensured in any case.
- The cable shielding must not act as a potential equalization conductor.
- Place the encoder cable apart from the power cables and ensure that the two are not parallel.
- If the cable is to be run through a cable carrier, a flexible cable that is suitable for this purpose should be used.
- Keep the cable short
- The cable length between the interface module and the controller should not exceed 30 meters.
- The maximum cable length is reduced when increasing speeds (above 1.2 m/s) in connection with the digital interface module.



Example: For a maximum speed of 3.2 m/s with the digital interface module, the data rate is 8 MHz. This corresponds to a maximum cable length of 15 meters.

- Bus termination resistors for RS 422 should be 120 Ohms.

7 System accuracy

The system accuracy consists of the long-wave deviation (linearity of the dimensional scale) and the short-wave deviation (e.g. interpolation accuracy) of the scanning system (sensor and interface module). The accuracy values refer to a room temperature of 20° C (68° F).

Long-wave deviation

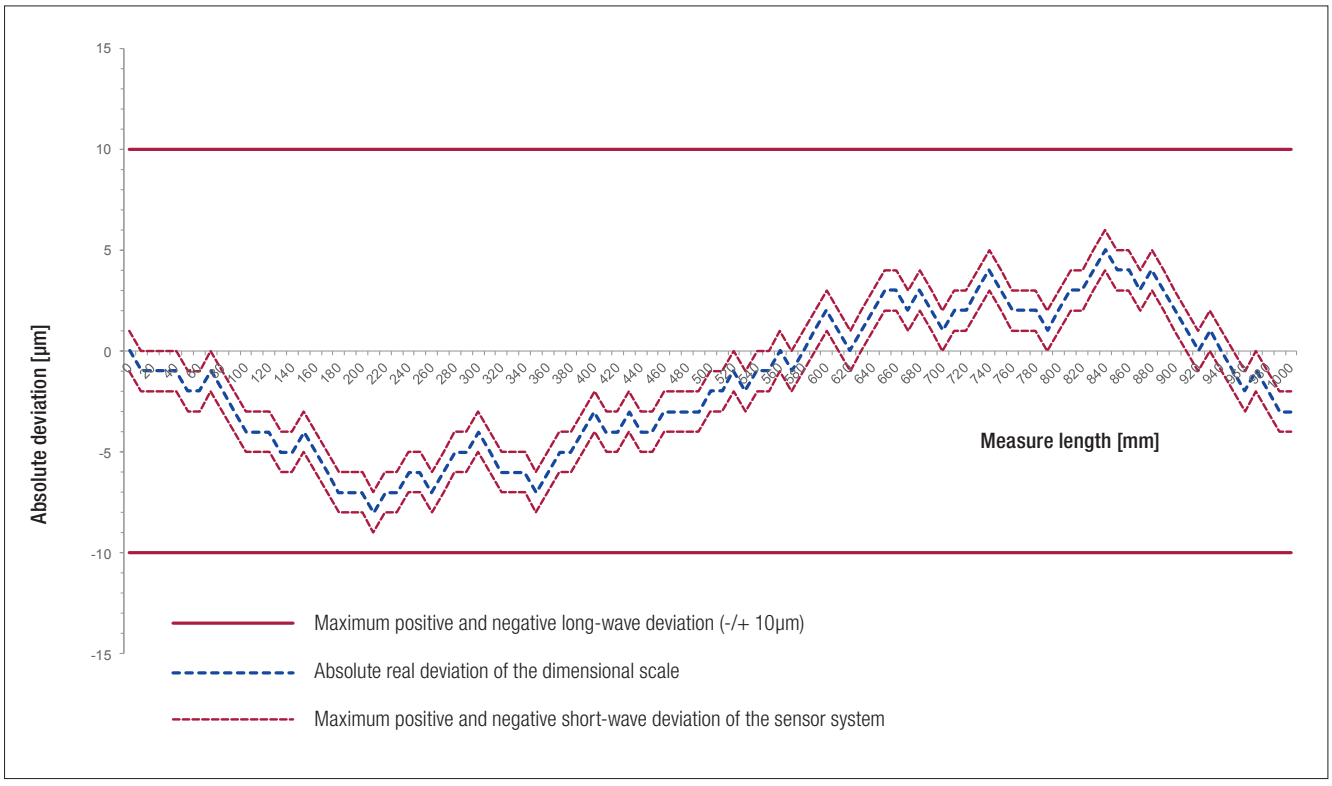
The linearity of the dimensional scale refers to the entire rail length (maximum 1 metre). At this length, the deviation of the dimensional scale is always less than +/- 10 µm at an ideal scale.

Within 40 mm, the deviation of the dimensional scale is always less than +/- 4 µm at an ideal scale.

Short-wave deviation

All incremental distance measuring systems are influenced by the effects of periodic deviation. This periodic deviation, also called short-wave deviation, occurs due to small deviations in the sensor system or electrical signal processing. This means that the sine and cosine signals deviate from the mathematically exact form. If periodic deviations only occur during digitization and calculation of position, then we talk about an interpolation error.

The short-wave deviation of MINISCALE PLUS is always within a range of +/- 0.6µm.



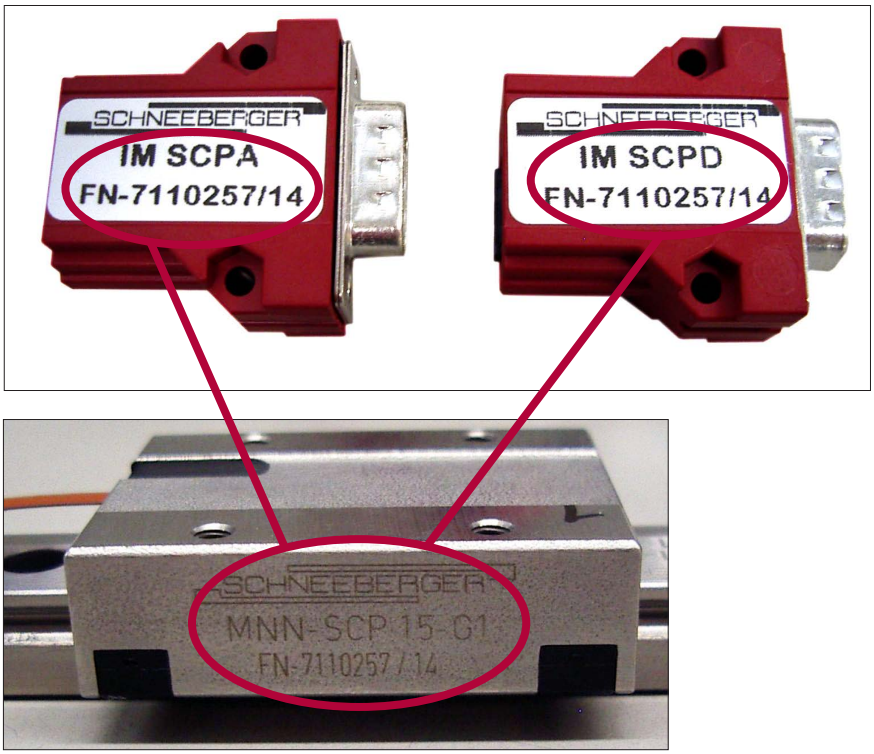
The repeatability amounts to +/- 0.1 µm unidirectionally and +/- 0.2 µm bidirectionally.

8 Matching the Interface Module with Carriages and Guideway

The interface modules are configured in factory and matched to the individual MINISCALE PLUS carriages and guideways.

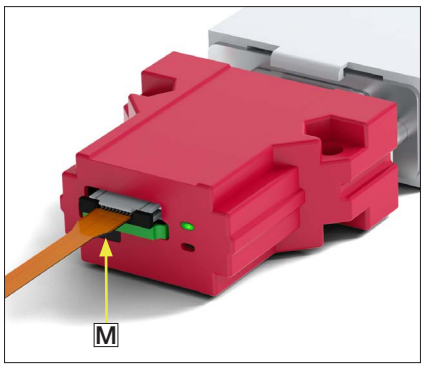
Important:
Carriage, rail and interface module are delivered as a set/ system and must be assembled as such.

The serial number of the carriage is quoted on the label of the interface module.



The carriage number is printed on the label of the interface module (analog on the left, digital on the right).

8.1. Adjustment Procedure for a Replacement DIGITAL Interface Module



M: Calibration button

Adjustment is only necessary for a subsequent delivery of the digital interface module! Calibration by the customer is not possible for the analog interface module.

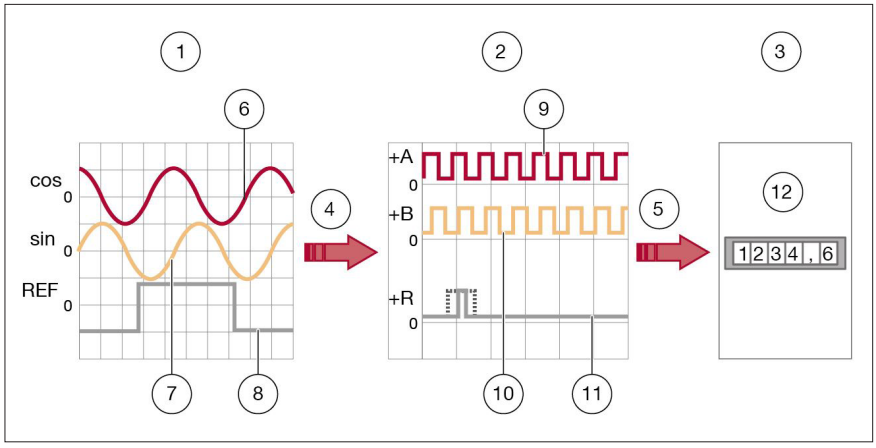
Procedure

- Switch on MINISCALE PLUS
- Press and hold the calibration button (M)
- Move the carriage slowly along the entire rail length 3 to 4 times.
- Release the calibration button
- Reset MINISCALE PLUS (= switch it off and on again)
- Drive the carriage along the guideway and make sure the green LED lights up
- If the red LED lights up, the adjustment procedure must be repeated

9.1. Interpolation

For distance measuring applications, interpolation means the signal conversion of analog input signals into digital output signals with a smaller signal period. This is necessary as counter readings and/or position readings cannot be generated directly from analog signals.

The interpolation factor defines the ratio of signal periods from the analog input signal to the digital output signal.



The analog input signals (sin, cos, REF) are interpolated (red arrow) to digital output signals (+A, +B, +R). Inverted signals are not represented:

1. Analog input signal: sin, cos, REF
2. Digital output signal: +A, +B, +Z
3. (Downstream electronics)
4. Interpolation
5. Signaling
6. Analog input signal (cos)
7. Analog input signal (sin)
8. Analog input signal (REF)
9. Digital output signal (+A)
10. Digital output signal (+B)
11. Digital output signal (+Z)
12. Measuring counter, PC, controller for machine etc.

9.2 Digital Signaling and Evaluation

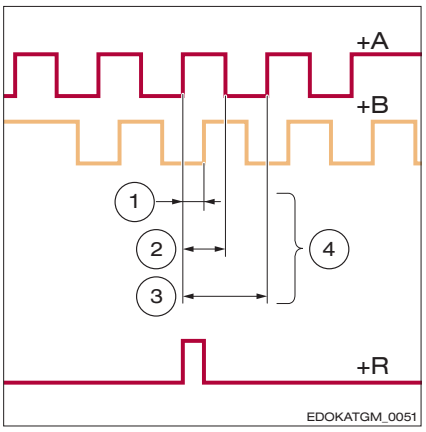
The digital signals, consisting of the two incremental signals A+ and B+ and the reference signal R+, are transmitted to the downstream electronics. This can be a single measuring counter, a PC or a machine controller.

The downstream electronics determines the position value from the digital signals by counting the signal edges. The counting direction is determined from the level of the other channel in question. Depending on how many edges are being evaluated, we talk about:

1) Single edge evaluation:
   Only one edge is counted per channel. One measuring step will therefore correspond to one digital signal period.

2) Two-edge evaluation:
   Both rising and falling edges of a channel are counted. One measuring step will therefore correspond to half the digital signal period.

3) Four-edge evaluation:
   Both rising and falling edges of both channels are counted. One measuring step will therefore correspond to a quarter of the digital signal period.



1 Four-edge evaluation
2 Two-edge evaluation
3 Single edge evaluation
4 In each case one measuring step

Edge evaluation

9.3 Analog Signal Frequency

In order to achieve an appropriate resolution, the analog signal must be interpolated. The frequency of the electronics must be adjusted according to the travelling speed.

$$f = \frac{v}{P}$$

f = Frequency in Hz
v = Speed in m/s
P = Increment in m

Example calculation:

v Speed	2 m/s
P Signal period before interpolation	100 µm (0.0001 m)

Therefore:

f Frequency $\quad \frac{2 \text{ m/s}}{0.0001 \text{ m}} = \underline{20'000 \text{ Hz}}$

9.4 Accuracy class

The accuracy class specifies the maximum expected measuring deviation of a system under the specified operating conditions. A distance measuring system with an accuracy class of 5 µm allows deviations of +/- 5 µm. For reasons of comparability, the accuracy class is specified assuming a reference length of 1 m.

9.5 Resolution

The resolution describes the smallest possible measurable positional change in the measuring system. It is determined by the analog signal period, the interpolation factor and the evaluation procedure (integration time or sampling rate). For example, given a set interpolation factor of 250 and an input signal period of 100 µm you get an output signal period of 0.4 µm and according to four-edge evaluation in the controller a resolution of 0.1 µm.

9.6 Sampling Rate

The sampling rate describes the frequency at which the analog signal is sampled per time interval. Usually the time interval is one second, which is why the unit for the sampling rate is Hz. In order to guarantee a complete reproduction of the original signal, the sampling frequency should be at least twice that of the original signal in accordance with the Nyquist–Shannon sampling theorem.

9.7 Repeatability

Unidirectional repeatability of a measuring system is generally understood to mean the ability to repeat the results that a particular system returns under exactly the same environmental conditions. In assessing this, the measuring deviation must be known and be factored into the analysis.

The repeatability of an axis position can be determined for a specific travelling speed using simple methods by calculating the arithmetic mean and the standard deviation of many measurements.

9.8 Referencing

Incremental measuring systems cannot determine the exact position after being switched on. For this reason, another track is added alongside the incremental track; the reference track. One or multiple reference points can be marked on the reference track.

A reference run of the carriage is required to reference the system. The axis usually travels in one direction until a mechanical stop. From there, the axis travels backwards until the reference mark is covered. Usually, the equidistant reference mark is always approached from the same direction.

The controller can then modify the internal counter to a specified value using the reference signal. For the analog interface module, the controller recognizes a predefined position for the incremental signals (this is usually SIN = COS and both greater than zero), as well as REF = ‚high' as the reference position.

9.9 Periodic Deviations

All incremental distance measuring systems are influenced by the effects of periodic deviation, whose wavelength corresponds exactly to the graduation spacing or a fraction of it. This periodic deviation, also called short-wave deviation, occurs due to small deviations in the sensor system or electrical signal processing. This means that the sine and cosine signals deviate from the mathematically exact form. Deviations can be classified depending on the arrangement (harmonics).

SWD period	Deviation occurs due to
1 signal period	Sine/cosine offset
1/2 signal period	Sine and cosine amplitude are different
1/3 – 1/8 signal period	Sensors deliver a signal which is fundamentally different from the sine wave shape

9.10 Interpolation Errors

If periodic deviations only occur during digitization and calculation of position, then we talk about an interpolation error. This can occur in some circumstances if the transmitter and receiver circuitry are not precisely matched to one another.

9.11 Comparator Errors

The comparator error, also referred to as the Abbe error, is a systematic deviation which occurs when the axis of the length standards do not coincide with the axis of the distance standards. The causes for the deviation are minute rotary movements in the axis design, which influence the measuring result.

9.12 Single-Ended Signaling

For single-ended signaling, the voltages change relative to a reference potential (electrical ground). This is a simple and convenient way of transferring data, requiring just one wire per signal.
The disadvantage is the relatively high susceptibility to interference. This type of signaling should therefore only be used for short distances and low speeds.

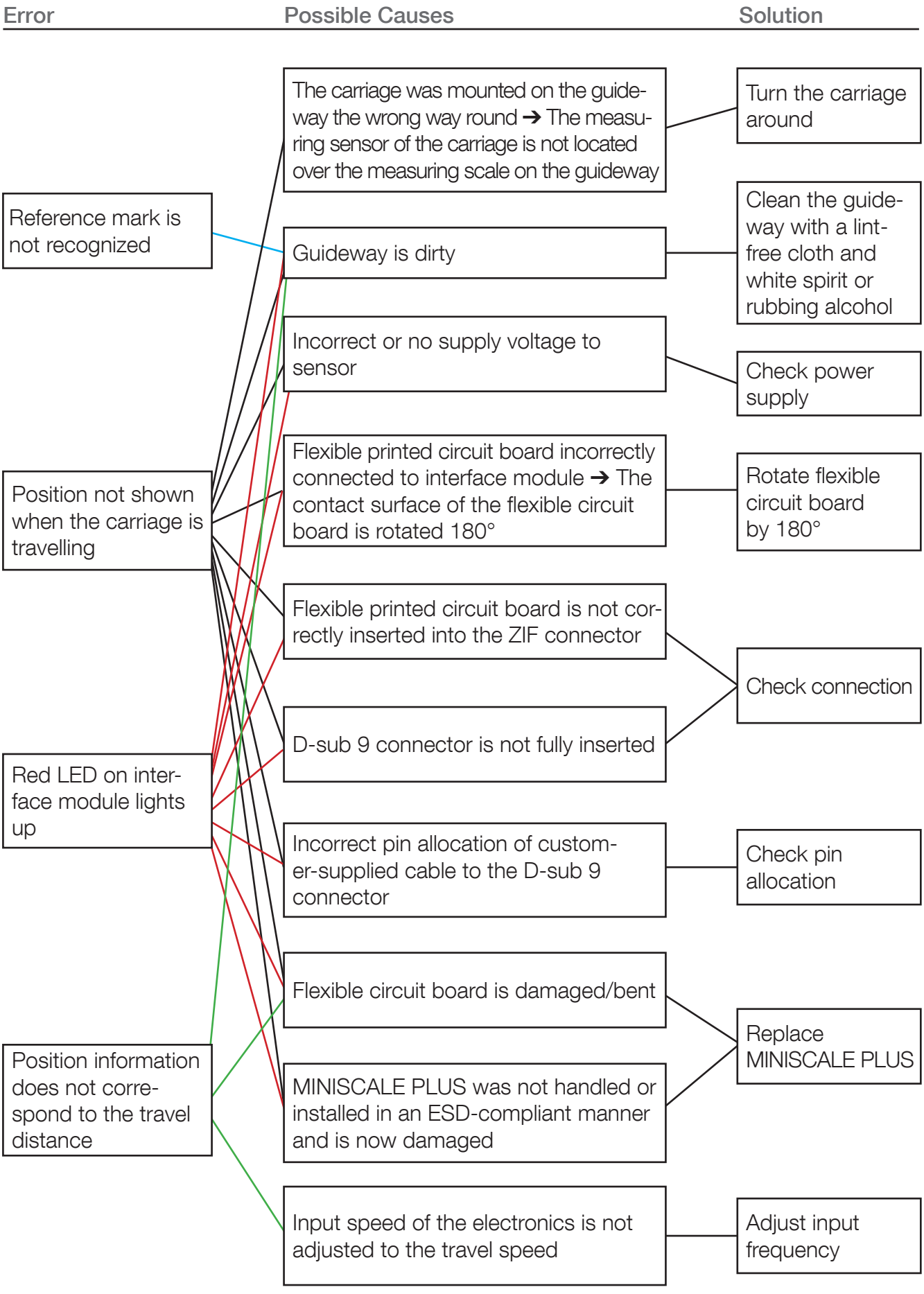
9.13 Differential Signaling

For differential signaling, the signals are described by a voltage difference without reference to electrical ground. Instead of a single signal conductor, a pair of wires is used. One wire carries the signal, and the other carries its inverse. The controller then composes the difference between the two signals into the so-called difference signal. (e.g. the A + and A - signals become A).
Differential signaling is the better solution for most applications as it is more tolerant to interference. Couplings to the signals are almost identical for both wires such that interference is almost eliminated when generating a difference.
The RS422 standard (differential) was specifically developed for larger distances and higher transfer rates.

9.14 Direction of Travel

If the carriage moves in the direction of the flexprint, the signal on channel A is 90° ahead of channel B. From this the controller recognizes a positive direction of travel, meaning that the counter counts upwards. In the other direction, the signal on channel A is 90° behind channel B. The counter counts downwards.
The counting direction for the analog interface module is reversed.

10 MINISCALE PLUS Error Description



Error	Possible Causes	Solution
Resolution is not achieved	Interpolation too low	Increase interpolation
	Evaluation too low	Repeat evaluation 4 times
	Incorrect input frequency	Adjust frequency to travelling speed
	If using USB counter: Interpolator has a resolution of just 256, meaning the displayable resolution is limited to 0.39 µm.	Use digital interface module and digital input of the USB counter (caution: maximum speed 0.2 m/s)
Digital interface module is not working correctly	Maximum speed of 3.2 m/s exceeded	Limit the speed to 3.2 m/s
	The number on the interface module does not match the MINISCALE PLUS carriage number	Check number relationship between interface module, carriages and guideways
		Adjust as described in chapter 6.1
		Return the system to SCHNEEBERGER
Analog interface module is not working correctly	The number on the interface module does not match the MINISCALE PLUS carriage number	System must be returned to SCHNEEBERGER for adjustment
Incorrect position during high speeds when using USB counter	Digital input has a maximum input frequency of 500 kHz. The speed is therefore limited to 0.2 m/s (or 0.4 m/s) for a resolution of 0.1 µm.	For higher speeds, use the analog interface module and analog input (caution: maximum resolution 0.39 µm)
Visible interference in the measurement signal	Incorrect customer-supplied cable	Use a shielded twisted pair cable
Further errors	Further investigation needed	Contact SCHNEEBERGER

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