OPERATING INSTRUCTIONS

TMS/TMM22

Inclination sensor

SICK
Sensor Intelligence.

Described product

TMS/TMM22

Manufacturer

SICK AG
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Legal notes

Original document

This document is an original document from SICK AG.

For use in NFPA 79 applications only.

2 About this document

2.1 Purpose of this document

These operating instructions are intended to give technical personnel working for the machine manufacturer or machine operator instructions on the mounting, electrical installation, commissioning, and operation of the TMS22 and TMM22 inclination sensors.

These operating instructions do not provide information on operating the machine in which an inclination sensor is integrated. For information about this, refer to the operating instructions of the specific machine.

2.2 Explanation of symbols

Warnings in these operating instructions are labeled with symbols. The warnings are introduced by signal words that indicate the extent of the danger. These warnings must be observed at all times and care must be taken to avoid accidents, personal injury, and material damage.

DANGER
... indicates a situation of imminent danger, which will lead to a fatality or serious injuries if not prevented.

WARNING
... indicates a potentially dangerous situation, which may lead to a fatality or serious injuries if not prevented.

CAUTION
... indicates a potentially dangerous situation, which may lead to minor/slight injuries if not prevented.

NOTICE
... indicates a potentially harmful situation, which may lead to material damage if not prevented.

NOTE
... highlights useful tips and recommendations as well as information for efficient and trouble-free operation.

3 Safety information

3.1 Intended use

The TMS/TMM inclination sensors are measuring devices consisting of an electronic sensor and integrated evaluation electronics. The tasks for which the measuring device is designed include recording inclinations in solar thermal energy, photovoltaics, or heavy truck applications.

SICK AG assumes no liability for losses or damage arising from the use of the product, either directly or indirectly. This applies in particular to use of the product that does not conform to its intended purpose and is not described in this documentation.

3.2 Improper use

The inclination sensors do not constitute safety components according to the EC Machinery Directive (2006/42/EC). The inclination sensors must not be used in explosion-hazardous areas. Any other use that is not described as intended use is prohibited. Any use of accessories not specifically approved by SICK AG is at your own risk.

WARNING DANGER DUE TO IMPROPER USE!
Any improper use can result in dangerous situations. Therefore, observe the following information:

- Use only in accordance with the intended use.
- All information in these operating instructions must be strictly observed.

3.3 Requirements for the qualification of personnel

The personnel who work on and with the device must be suitably authorized, trained, and sufficiently qualified. Skilled personnel refers to the following:

- A member of staff who has received specialist training, which is backed up by additional knowledge and experience.
- A member of staff who knows the relevant technical terms and regulations.
- A member of staff who can appraise the work assigned to them, recognize potential hazards, and take suitable safety precautions.

Table 1: Skilled personnel qualifications

Task	Qualification
Mounting	• Technical training • Knowledge of the current safety regulations in the workplace
Electrical installation	• Electrotechnical training • Knowledge of the current electrotechnical workplace safety regulations • Knowledge of the operation and control of the sensor in the particular application
Commissioning, configuration, and operation	• Technical training • Knowledge of the operation and control of the sensor in the particular application

4 Technical data

NOTE
This section contains an extract of the technical data. For full details, see the product page of the TMS/TMM22 at www.sick.com

4.1 Technical data for TMS/TMM22 Eco

Table 2: Technical data for TMS/TMM22 Eco

	TMS22	TMM22
General parameters		
Number of measuring axes	1	2
Measuring range up to	360°	± 90°
Resolution	≤ 0.03°	≤ 0.015°
Measurement accuracy	typ. 0.25°, max. 0.5° [1]	typ. 0.25°, max. 0.6° [1]
Repeatability		
Analog / 0…10 V	30 mV [2]	
Analog / 4…20 mA	30 µA [2]	
Compensated cross sensitivity (dual axis)	-	typ. ± 0.5°, max. ± 0.9°
Temperature coefficient (zero point)	± 0.03°/K	
Limit frequency	2 Hz	
Sampling rate	400 Hz	
Operating temperature	-40 °C to +80 °C	
For UL: ambient temperature	Max. 75 °C , housing type 1	
Electrical parameters		
Supply voltage	12 V DC ... 30 V DC	
Current consumption		
Analog / 0…10 V	< 30 mA @ 24 V	
Analog / 4…20 mA	< 30 mA (+ I_{loop}) @ 24 V	
Mechanical parameters		
Connection type	Cable, 5-wire, with 5-pin M12 male connector Cable, 5-wire, with open ends	
Enclosure rating	IP66, IP67, IP68, IP69K	
Dimensions	38.8 mm x 30 mm x 10.4 mm	

1) In accordance with DIN ISO 1319-1, position of the upper and lower error limit depends on the installation situation, specified value refers to a symmetrical position, i.e. deviation in upper and lower direction is the same.
2) In accordance with DIN ISO 55350-13; 68.3% of the measured values are inside the specified area.

4.2 Technical data for TMS/TMM22 Basic

Table 3: Technical data for TMS/TMM22 Basic

	TMS22	TMM22
General parameters		
Number of measuring axes	1	2
Measuring range up to	360°	± 90°

	TMS22	TMM22
Resolution	≤ 0.01°	
Measurement accuracy	typ, 0.1°, max. 0.2° [1]	
Repeatability	typ. 0.04°, max. 0.12° [2]	
Compensated cross sensitivity (dual axis)	-	max. ± 0.3°
Temperature coefficient (zero point)	typ. ±0,0167 °/K	
Limit frequency	0.1 Hz ... 10 Hz, default: 2 Hz	
Sampling rate	400 Hz	
Operating temperature	-40 °C to +80 °C	
For UL: ambient temperature	Max. 70 °C , housing type 1	
Electrical parameters		
Supply voltage		
Analog / 010 V	12 V DC ... 32 V DC	
Analog / 4...20 mA	8 V DC ... 32 V DC	
Current consumption		
Analog / 010 V	< 45 mA @ 24 V	
Analog / 4...20 mA	< 45 mA (+ I_{loop}) @ 24 V	
Mechanical parameters		
Connection type	Cable, 5-wire, with 5-pin M12 male connector Cable, 5-wire, with open ends	
Enclosure rating	IP66, IP67, IP68, IP69K	
Dimensions	38.8 mm x 30 mm x 10.4 mm	

1) In accordance with DIN ISO 1319-1, position of the upper and lower error limit depends on the installation situation, specified value refers to a symmetrical position, i.e. deviation in upper and lower direction is the same.

2) In accordance with DIN ISO 55350-13; 68.3% of the measured values are inside the specified area.

4.3 Measuring axes

TMM

The measuring axes of the inclination sensors are factory-set as per the specifications in figure 1 and figure 2. Other settings are also possible on request. The programmable variants (TMS/TMM22 Basic) also offer the option of freely selecting the assignment of the measuring axes (X, Y and Z).

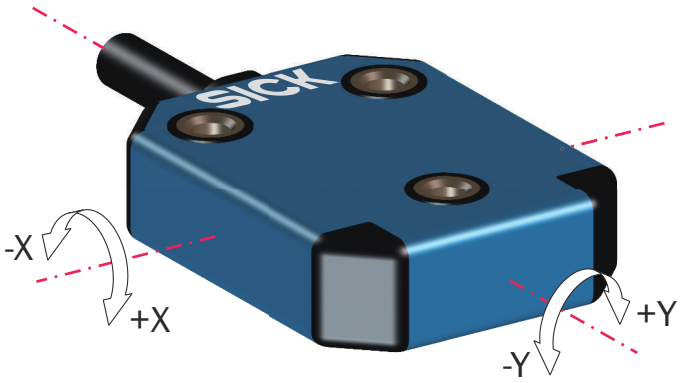

Figure 1: TMM22 measuring axis

TMS

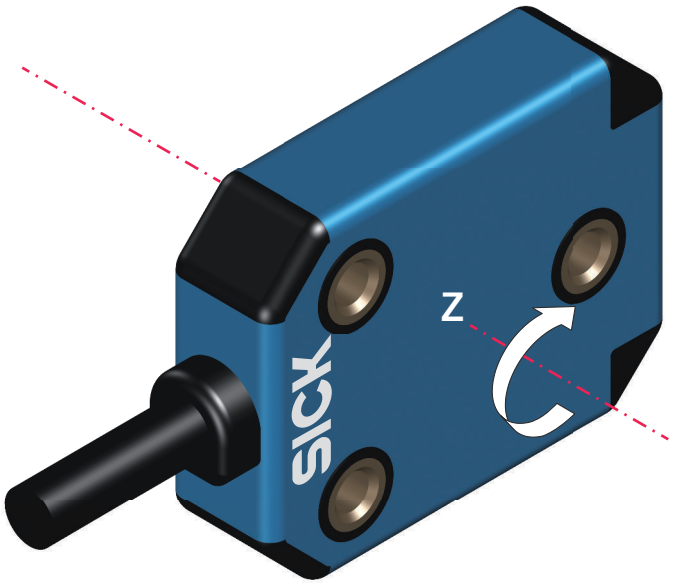

Figure 2: TMS22 measuring axis

4.4 Zero point

TMM

Sensor mounted horizontally. Both outputs give the following output signal in this position:

x-axis: 12 mA / 5 V

y-axis: 12 mA / 5 V

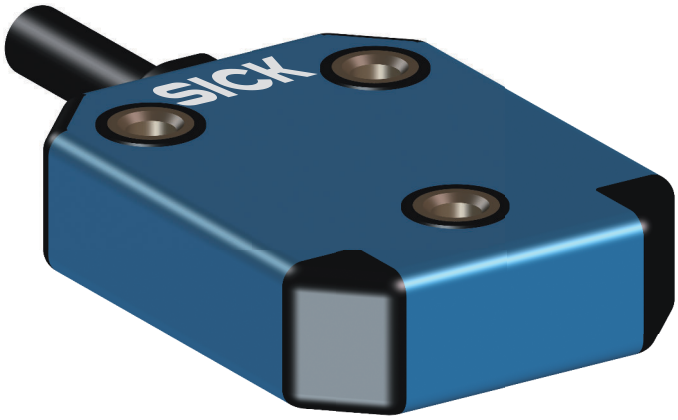

Figure 3: TMM zero point

TMS

Sensor mounted vertically. Cable points to the left.

The output of the z-axis outputs 4 mA / 0 V in this position. The second output is not used.

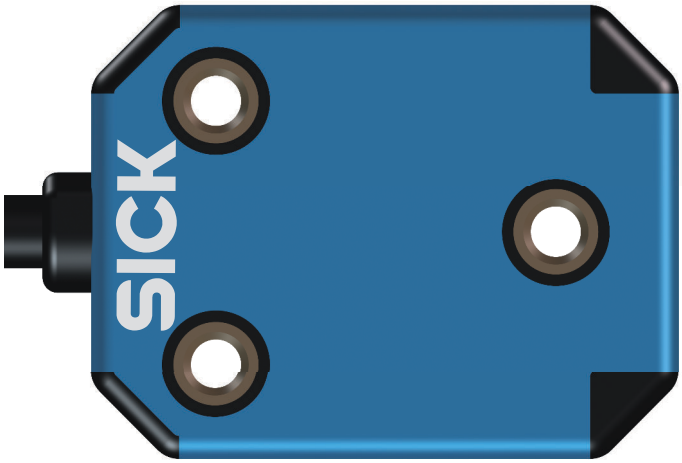

Figure 4: TMS zero point

In addition to the zeroing function via pin/stranded wire (see section 9.2), the programmable variants (TMS/TMM22 Basic) offer the option of freely parameterizing the zero point. Details: see "Parameterization", page 22

5 Transport and storage

5.1 Transport

For your own safety, please read and observe the following notes:

NOTE DAMAGE TO THE DEVICE DUE TO IMPROPER TRANSPORT.

- The device must be packaged for transport with protection against shock and damp.
- Recommendation: Use the original packaging as it provides the best protection.
- Transport should be performed by trained specialist staff only.
- The utmost care and attention is required at all times during unloading and transportation on company premises.
- Note the symbols on the packaging.
- Do not remove packaging until immediately before starting installation work.

5.2 Transport inspection

Immediately upon receipt in incoming goods, check the delivery for completeness and for any damage that may have occurred in transit. In the case of transit damage that is visible externally, proceed as follows:

- Do not accept the delivery or only do so conditionally.
- Note the extent of damage on the transport documents or on the transport company's delivery note.
- File a complaint.

NOTE

Complaints regarding defects should be filed as soon as these are detected. Damage claims are only valid before the applicable complaint deadlines.

5.3 Storage

Store the device under the following conditions:

- Recommendation: Use the original packaging.
- Do not store outdoors.
- Store in a dry area that is protected from dust.
- To allow any residual dampness to evaporate, do not package in airtight containers.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.

6 Mounting

6.1 Dimensional drawing

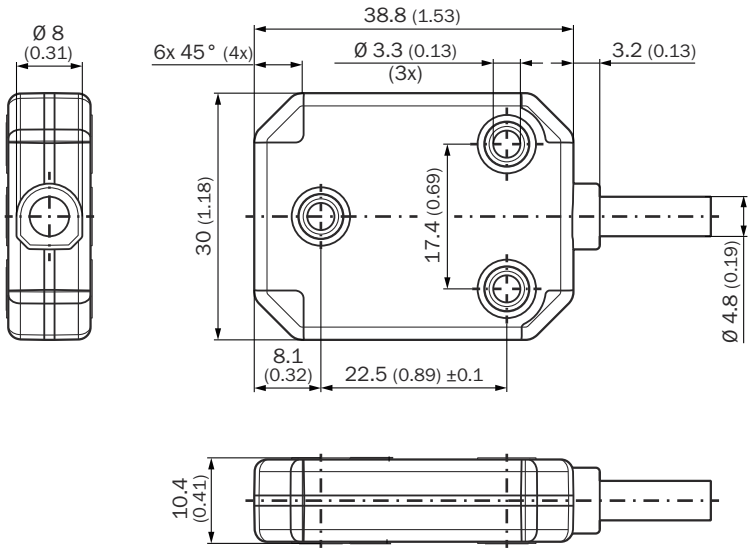

Figure 5: Dimensional drawing

6.2 Mounting instructions

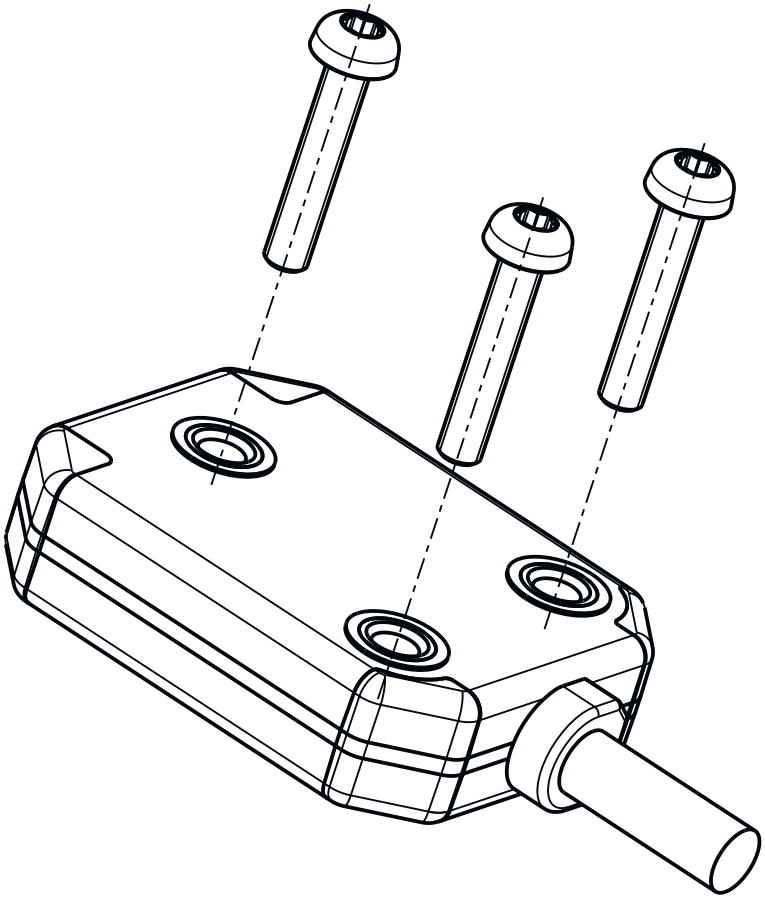

Figure 6: Mounting instructions

The TMS/TMM22 inclination sensors are fastened with 3 M3 screws. A tightening torque of 1.4 Nm must not be exceeded. Make sure that the mounting surface is as flat as possible to avoid mechanical stresses and to ensure good measurement results.

7 Connection

7.1 PIN and wire allocation

The TMS/TMM22 inclination sensors are equipped with a standard 5-pin M12 round male connector (A-coded) or with a cable with open strands, each of different lengths.

Connection TMS/TMM22 Eco

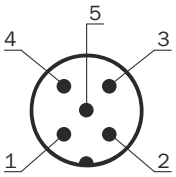

Table 4: Connection TMS/TMM22 Eco

PIN 5-pin M12 male connector	Wire colors, cable connection	Signal TMS	Signal TMM
1	Brown	V_S	V_S
2	White	z-axis	y-axis
3	Blue	GND	GND
4	Black	n.c.	x-axis
5	Gray	TEACH [1]	TEACH [1]

1) To activate the zero point setting, connect TEACH (pin 5) to GND (pin 3) for at least 1 second.

Connection TMS/TMM22 Basic

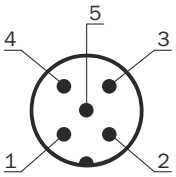

Table 5: Connection TMS/TMM22 Basic

PIN 5-pin M12 male connector	Wire colors, cable connection	Signal
1	Brown	V_S
2	White	OUT1
3	Blue	GND
4	Black	OUT2
5	Gray	TEACH [1]

1) To activate the zero point setting, connect TEACH (pin 5) to GND (pin 3) for at least 1 second.

7.2 Circuit diagrams

TMS/TMM22 circuit diagram with current output

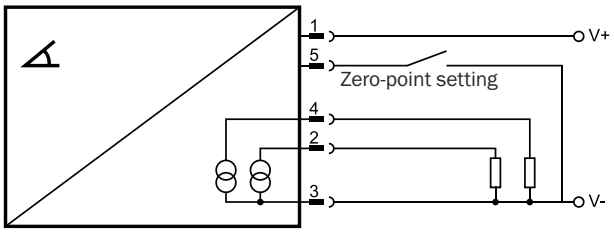

Figure 7: Current output

TMS/TMM22 circuit diagram with voltage output

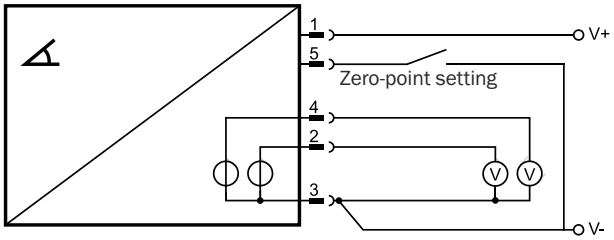

Figure 8: Voltage output

7.3 Length of cable and supply voltage

For sensors with current output, the required supply voltage increases by the voltage dip on the connected cable. The most significant voltage dip on the cable occurs when the maximum current of 20 mA is flowing, caused by the resistance of the cable (R_L). The partial resistances of the go and return line must also be taken into account. The sensors have been qualified up to a maximum length of cable of 30 meters according to standard EN 61326-1. Longer lengths of cable are technically possible, but were not evaluated taking into account EMC aspects.

Conductor resistance R_L can be calculated using the following formula:

R=p*l/A

Cross-sectional area of TMS/TMM22 cable: A = 0.34 mm^2

Specific conductor resistance of copper: ρ = 0.0171 ohm*mm^2/m

In general, this also applies: Conductor resistance R = 0.0503 ohm/m

All specified values refer to the recommended cable cross-section of 0.34 mm^2 / AWG 22.

This results in the following exemplary conductor resistances:

1 m length of cable: R = 0.05 ohm conductor resistance

10 m length of cable: R = 0.50 ohm conductor resistance

30 m length of cable: R = 1.51 ohm conductor resistance

The conductor resistance must be considered when designing the supply voltage.

7.4 Load resistance at current output

The set load resistance essentially determines the power loss in the sensor, based on the supply voltage. To keep the power loss low and to avoid the sensor overheating, a load resistor appropriate for the supply voltage should be used. The following table and corresponding diagram illustrate the relationship between supply voltage and permissible load resistance.

The minimum and maximum load resistances specified below should always be understood as the total resistance at the output. This total resistance comprises the load resistance and the resistance of the cable.

Table 6: Load resistance at current output

U_S [V]	Minimum load resistance R [Ω]	Maximum load resistance R [Ω]
8	0	100
12	0	300
18	200	600
24	200	900
30	200	1000
32	200	1050

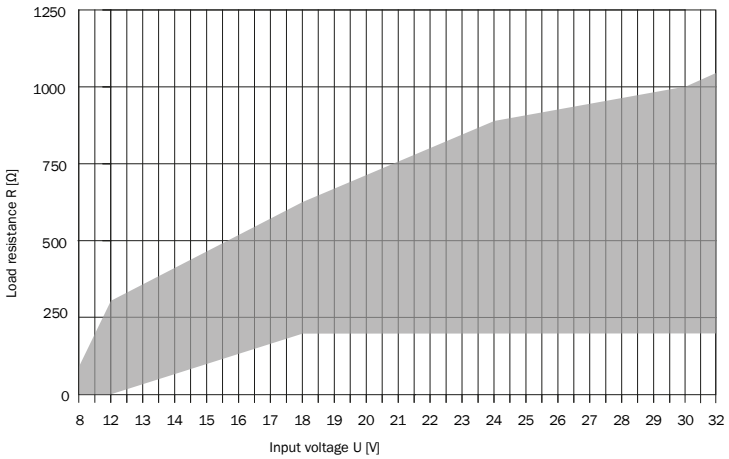

Figure 9: Permissible load resistances for current output

NOTICE

TMS/TMM22 Eco sensors have a limited supply voltage range of 12 to 30 V DC.

8 Description of operation

8.1 Axis assignment/Counting direction

TMS/TMM22 Eco

The TMM22 dual-axis sensor has a fixed assignment of the x- and y-axes. These run at right angles to each other in the sensor plane. Here, rotation around the axis of the cable describes the y-axis, while the x-axis runs through the long side of the sensor. The counting directions can be found in see figure 10, page 16. The axis of rotation of the TMS22 single-axis sensor runs vertically through the sensor surface and covers a complete rotation of 360°. The counting direction is clockwise (see figure 11, page 16).

TMS/TMM22 Basic

The features described above also apply to the programmable variants (TMS/TMM22 Basic). The axis assignment can be changed for these, however. The X-, Y-, and Z-axes are available for this. The default counting direction is clockwise. This can be changed by the customer.

TMM

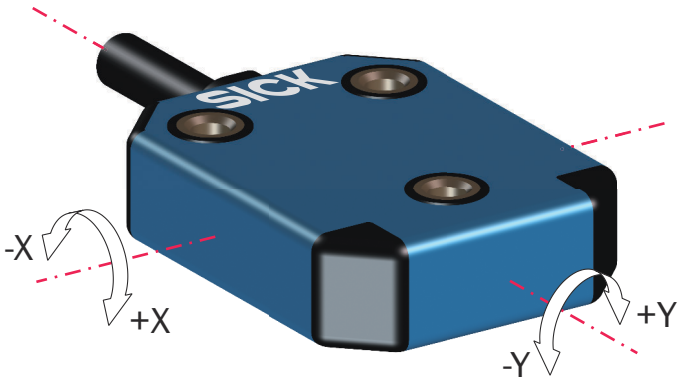

Figure 10: TMM22 measuring axis

TMS

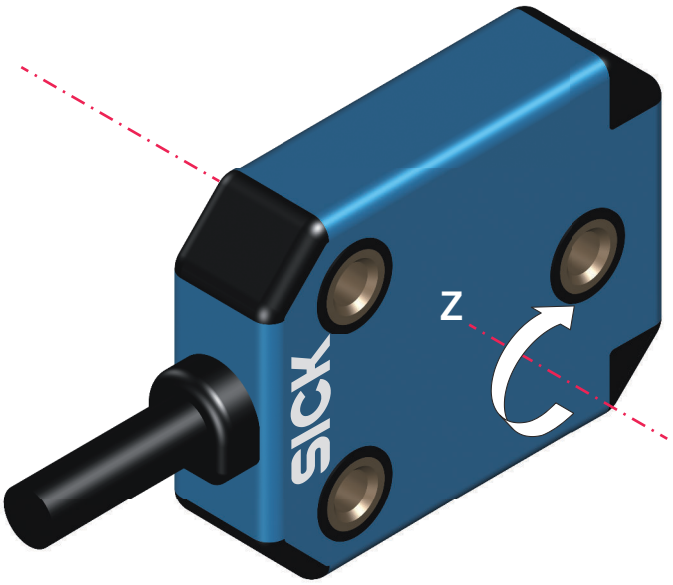

Figure 11: TMS22 measuring axis

8.2 Zero point adjustment

The zero points of the respective axes are predefined at the factory. For the TMM22, these are in the orientation where the sensor is mounted flat on a horizontal plane. Both the x- and y-axes are at 0 degrees in this position. The respective analog outputs give out 12 mA or 5 V as the output signal. With the TMS22, the zero point of the z-axis is in position when the sensor is mounted on a vertical plane and the cable points to the left. The analog output gives out 4 mA or 0 V.

To reset the zero point at any position, pin 5 or the gray sheathed wire (TEACH) must be contacted to pin 3 or the blue sheathed wire (GND) for at least 1 second. Successful zeroing is signaled by the green LED flashing twice. The two signals do not necessarily have to be separated again. However, it should be noted that before resetting to zero, they are separated for at least 250 ms. Otherwise, no resetting to zero is possible.

In normal operation, TEACH should be permanently set to U_S. Performing the zeroing process results in both outputs of the TMM22 giving out 12 mA or 5 V in the current position, while the output of the TMS22 is set to 4 mA or 0 V. It should be noted that the sensor must not be moved during the process.

The programmable variants (TMS/TMM22 Basic) also offer the option of setting the zero point to the current position via software and resetting it to the factory settings. It is also possible to deactivate zeroing via pin/stranded wire.

Changes to the settings of the measuring range and the analog output have a corresponding effect on the zero point setting.

8.3 Signal filtering

TMS/TMM22 inclination sensors support an option to make the angle value more insensitive to external vibration interference. Oscillation/Vibration interference up to 0.1 Hz can be suppressed with a factory-configurable 8th order low-pass filter. The default setting is a cut-off frequency of 2 Hz. This achieves an optimal ratio between signal filtering and response time. On request, the sensor can also be delivered with a different cut-off frequency.

For the programmable variants (TMS/TMM22 Basic), the cut-off frequency can be set in the range from 0.1 Hz to 10 Hz (in 0.1 Hz increments). It is also possible to deactivate the digital filter (not recommended).

Step response of an 8th-order low pass filter for different cut-off frequencies

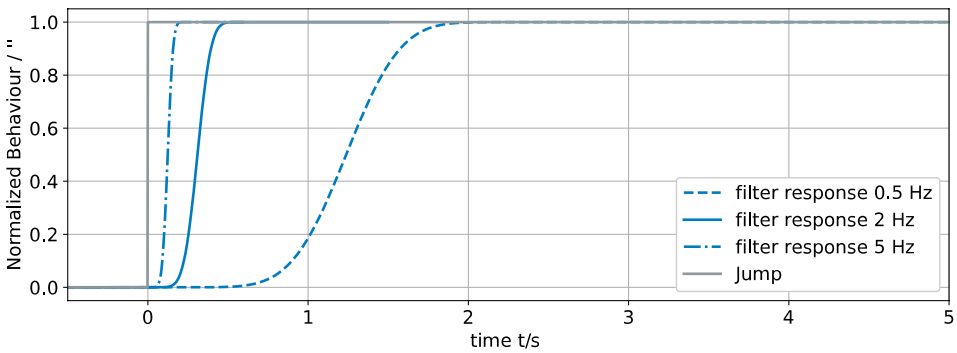

Figure 12: Pulse response of the filter

Amplitude response of an 8th-order low pass filter for different cut-off frequencies

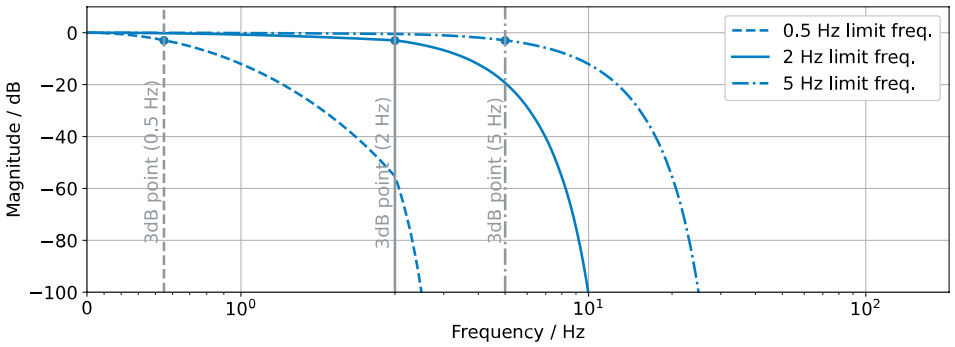

Figure 13: Amplitude curve of the filter

Input filtering

To achieve optimum accuracy for the analog outputs, we recommend using an analog or digital filter (e.g., average filter) before recording the measured values.

8.4 Status LED

For visualization of the operational status, the sensor has a green and a red LED. These are placed in the front two corners. With the help of the LEDs, the following statuses can be displayed:

Green LED

If the green LED lights up continuously, the sensor is in a fault-free operating mode. Two flashes of the green LED indicate that zero point setting was (see "Zero point adjustment", page 18) successful. It then again lights up permanently.

The green LED flashes quickly and continuously to indicate that the sensor is in programming mode see "Parameterization", page 22.

Red LED

The red LED indicates that there is a fault. As long as this LED is flashing, the outputs are automatically deactivated. This is the case, for example, if the supply voltage is below or above the permissible voltage. As soon as the error is no longer present, the red LED goes out and the outputs are reactivated. In the event of a critical error, the LED lights up permanently. In this case, please contact SICK Support.

NOTE

Short circuit to ground/short circuit to the supply voltage of the outputs cannot be detected by the sensor. The green LED therefore remains lit in this case.

8.5 Output diagram

The TMS/TMM22 inclination sensors feature a linearized analog output signal. The signal paths are listed below as examples for four variants.

TMM22E-Pxx090

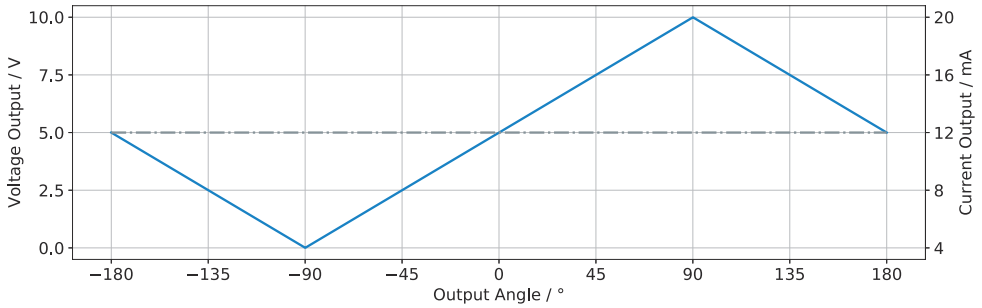

Figure 14: TMM22E-Pxx090 output diagram

TMM22E-Pxx045

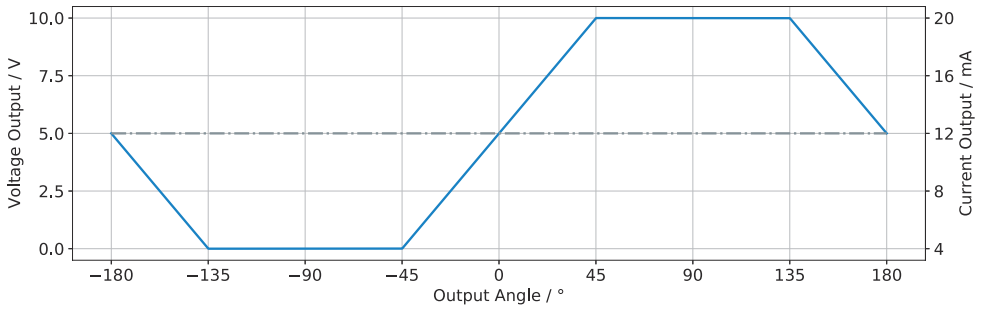

Figure 15: TMM22E-Pxx045 output diagram

TMS22E-Pxx360

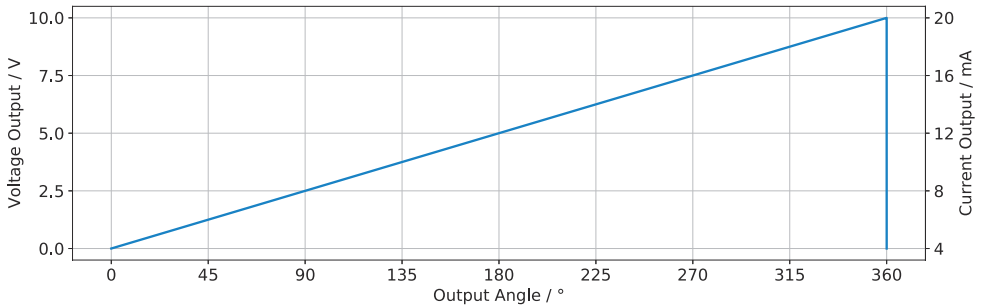

Figure 16: TMS22E-Pxx360 output diagram

TMS22E-Pxx180

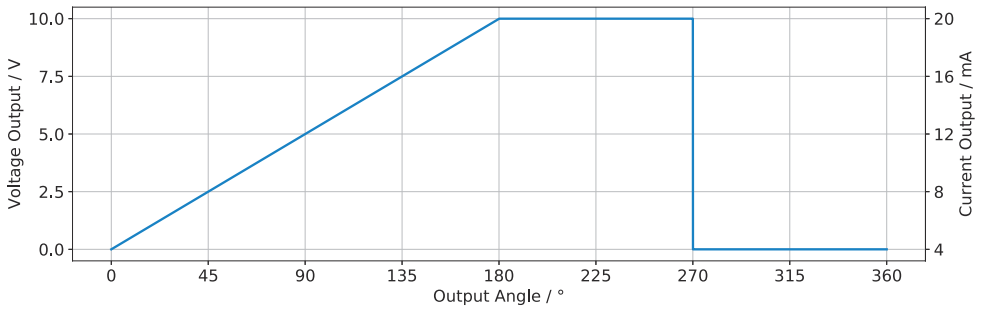

Figure 17: TMS22E-Pxx180 output diagram

Output limiting

By default, the outputs are limited to the selected minimum and maximum values of the analog outputs (default: 4...20 mA or 0...10 V). The sensors also offer the option of selecting two further output limitations:

Linear

- If “Linear” is selected, the signal rises or falls linearly to 1 V / 1 mA above or below the limits.

Jump

- If “Jump” is selected, the signal immediately jumps by 1 V or 1 mA when the limit is reached.

NOTE

No negative voltages are output at the voltage output. For the “Step” and “Linear” options, the difference between the supply voltage and the maximum output voltage must be at least 3 V.

8.6 Resolution

8.6.1 TMS/TMM22 Eco

The TMS/TMM22 Eco inclination sensors feature a digital sensor core with a resolution of 16 bits per axis. The output signal is generated via a 14 bit DAC transducer. This results in a resolution depending on the measuring range, as shown in see figure 18, page 21.

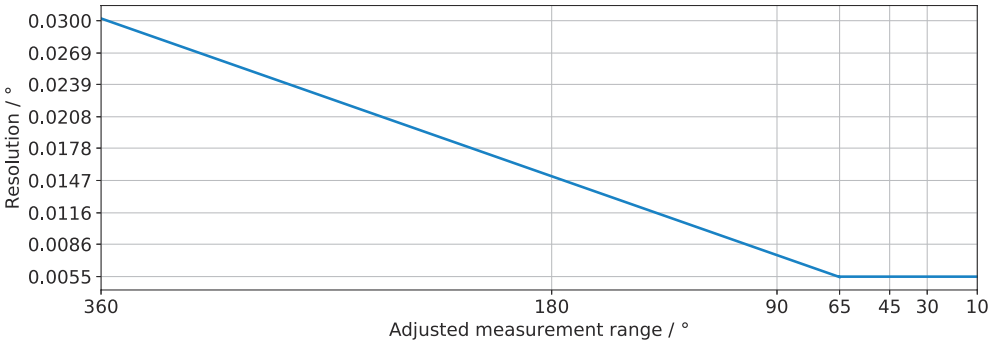

Figure 18: Resolution vs. set measuring range

Examples:

TMM22E-Pxx090: Resolution 0.015°

TMS22E-Pxx360: Resolution 0.03°

8.6.2 TMS/TMM22 Basic

The TMS/TMM22 Basic inclination sensors feature a digital sensor core with a resolution of 16 bits per axis. The output signal is also generated via a 16 bit DAC transducer. This results in a constant total resolution of 16 bits.

9 Parameterization

9.1 TMS/TMM22 Basic

Use version 2021.2 or higher of the SOPAS Engineering Tool (SOPAS ET) software to parameterize the device and for service and diagnostic purposes. SOPAS ET can be used to set parameters and also visualize measured values.

Prerequisites

- A computer with the SOPAS ET software installed on it, and a free USB 2.0 compatible port
- PGT-15 PC programming device (available as accessory)

NOTE
The current version of the SOPAS ET software can be downloaded from www.sick.com/SOPAS_ET. You will also find the respective system requirements for installing SOPAS ET there.

Establishing a connection

- Connect the sensor to the PGT-15 via the male connector or the terminal.
- Connect the PGT-15 to the free USB port on the computer.
- Start SOPAS ET.

DANGER
To use SOPAS ET with the device, a device description file (SDD file) is required.
The current version of the SDD file is available for download on the product page:
www.sick.com/tms_tmm22

Install the SDD file via the device catalog in SOPAS ET. When the installation has finished, select the device from the device catalog and add it to a project. A connection to the device is established via the communication interface. Activate the connection for data transmission (online).

Adjustable parameters

- **Activating/deactivating an output channel**
  The sensor has two analog outputs. If only one output is required, deactivate the second one accordingly.
- **Direction of rotation** (see "Axis assignment/Counting direction", page 16)
  The direction of rotation of the axes may be opposite depending on the installation orientation.
- **Axis assignment** (see "Axis assignment/Counting direction", page 16)
  It is possible to assign the analog outputs to different measuring axes depending on the installation orientation.
- **Analog output**
  The current or voltage output is factory set to the maximum output range. Restrict this if necessary.
- **Measuring range**
  Adjust the factory-set measuring range if necessary.
- **Filter settings** (see "Signal filtering", page 18)
  Activate or deactivate the digital filter. Optionally define the cut-off frequency when the digital filter is activated.

- **Preset** (see "Zero point adjustment", page 18)
  Once installed, the sensor can be set to zero using the Teach-in button. Zero corresponds to 0° in the measuring range diagram. It is also possible to restore the factory-calibrated zero point. Deactivate zeroing via stranded wire/pin if required.
- **Output limitation** (see "Output diagram", page 19)
  Choose between the factory-activated limitation or the alternatives “Linear” and “Step”.

Visualizing the sensor data

In addition to the 3D display of the current position of the sensor, the output values, angle, acceleration and yaw rate can be visualized in a diagram accessed via the “Sensor data” button. This function is particularly useful for selecting the correct cut-off frequency of the digital filter.

You can also save and export this data using the “Diagnostic report” button. This enables your SICK contact person to provide you with tailored application advice.

Diagnostics

The sensor saves and outputs the following diagnostic data:

- Temperature (current/total time)
- Supply voltage (current/total time)
- Acceleration histogram showing the current, minimum and maximum acceleration of the three axes over the total time
- Operating hours counter/power-up counter
- Overview of the factory settings compared to the settings currently saved in the sensor

Saving the settings

The configured parameters are initially only displayed in SOPAS ET.

Transferring the settings to the sensor: Send the settings to the sensor using the “Save” button (top right). Then check the function of the sensor with the new settings.

Resetting the sensor to factory settings: Run the “Restore factory settings” command (ellipsis menu → Device).

10 Annex

10.1 Conformities and certificates

You can obtain declarations of conformity, certificates, and the current operating instructions for the product at www.sick.com. To do so, enter the product part number in the search field (part number: see the entry in the “P/N” or “Ident. no.” field on the type label).

10.2 Compliance with EU directives

EU declaration of conformity (extract)

The undersigned, representing the manufacturer, herewith declares that the product is in conformity with the provisions of the following EU directive(s) (including all applicable amendments), and that the standards and/or technical specifications stated in the EU declaration of conformity have been used as a basis for this.

10.3 Compliance with UK statutory instruments

UK declaration of conformity (extract)

The undersigned, representing the following manufacturer herewith declares that this declaration of conformity is issued under the sole responsibility of the manufacturer. The product of this declaration is in conformity with the provisions of the following relevant UK Statutory Instruments (including all applicable amendments), and the respective standards and/or technical specifications have been used as a basis.

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