OPERATING INSTRUCTIONS

TMS/TMM22

Inclination sensor

SICK
Sensor Intelligence.

Described product

TMS/TMM22

Manufacturer

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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-duty vehicle 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 Overview

4.1 Properties of the TMS/TMM22

- Inclination sensors with measuring range of up to 360° (1-axis) or up to ± 90° (2-axis)
- Wear-free MEMS technology for consistently high precision and signal quality
- Measurement accuracy: ± 0.25°
- Analog interfaces 0 to 10 V and 4 to 20 mA available or customizable
- Enclosure ratings IP66, IP68 and IP69K
- Preset function for zeroing during installation
- Suitable for industrial use with temperature range from -40 °C to +80 °C

The TMS22 (single-axis) and TMM22 (dual-axis) inclination sensors enable cost-effective inclination measurement with high precision. The foundation for this is powerful MEMS technology, which scores points with a maximum error tolerance of ± 0.25° and excellent repeatability. The measured values are output via a linearized analog signal. In order to meet the highest requirements in terms of resistance for outdoor applications such as PV systems, the sensor electronics are embedded directly into the housing during injection molding. Therefore, TMS/TMM22 devices comply with the regulations according to enclosure rating IP66, IP68, IP69K. The compact design with a height of just 10.4 mm also makes nearly unlimited integration options possible.

4.2 Areas of application

- Photovoltaics and solar thermal energy
- Mobile agricultural and forestry machinery
- Vertical storage systems
- Crane and lifting technology
- Automated guided vehicle systems
- Construction machinery and special-purpose vehicles
- Wind power plants

5 Technical data

NOTE
This chapter contains an extract of the technical data. For full details, see the TMS/TMM22 product information (8026428).

5.1 Technical data for TMS/TMM22

General parameters	TMS22	TMM22
Number of measuring axes	1	2
Measuring range up to	360°	± 90°
Resolution	≤ 0.03°	≤ 0.015°
Error limits G	typ. 0.25°, max. 0.5° [1]	typ. 0.25°, max. 0.6° [1]
Repeatability standard deviation σ_r		
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 , enclosure type 1	
Electrical parameters		
Supply voltage	12 V DC ... 30 V DC	
Current consumption		
Analog / 010 V	< 50 mA @ 24 V	
Analog / 4...20 mA	< 50 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.

5.2 Measuring axes

TMM

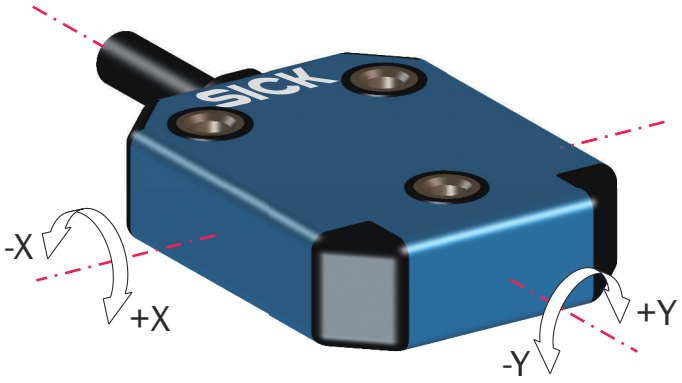


Figure 1: TMM22 measuring axis

TMS

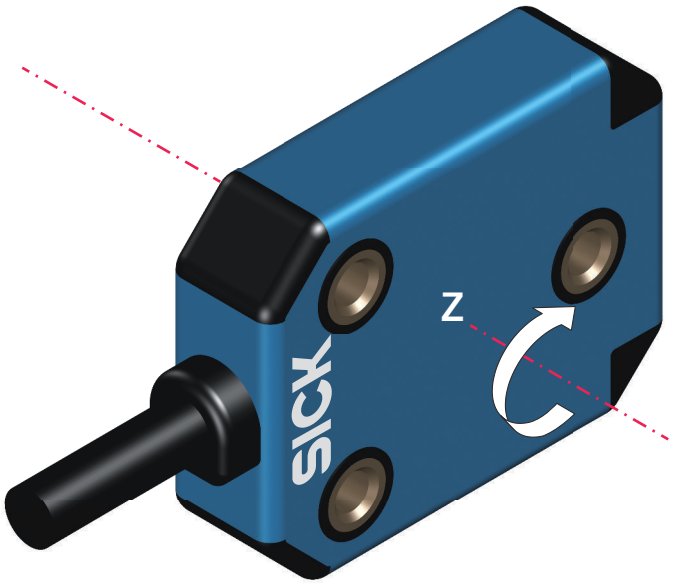


Figure 2: TMS22 measuring axis

5.3 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

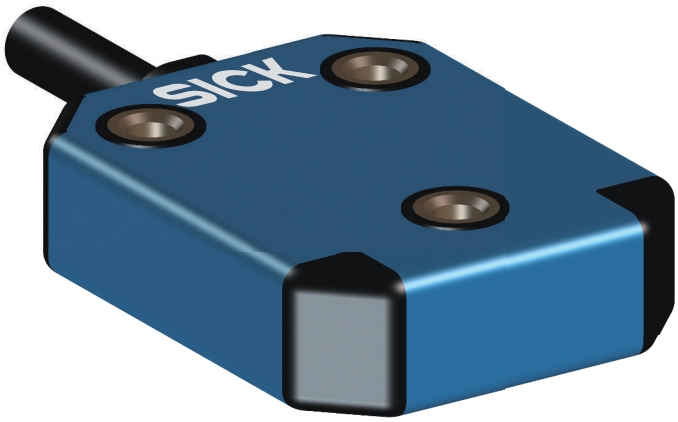


Figure 3: TMM zero point

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.

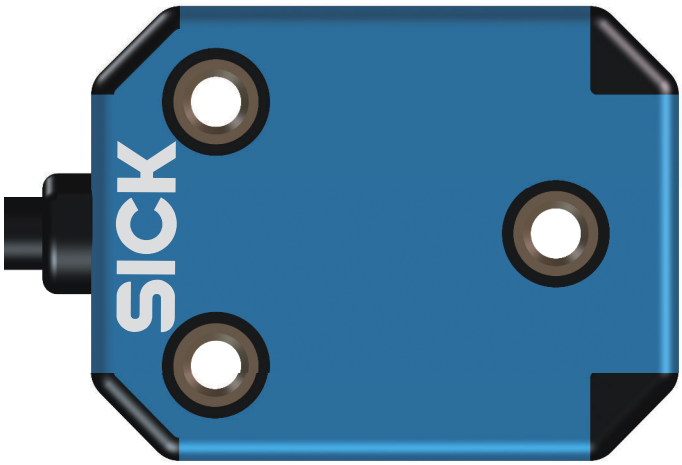


Figure 4: TMS zero point

6 Transport and storage

6.1 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.

6.2 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.

6.3 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.

7 Mounting

7.1 Dimensional drawing

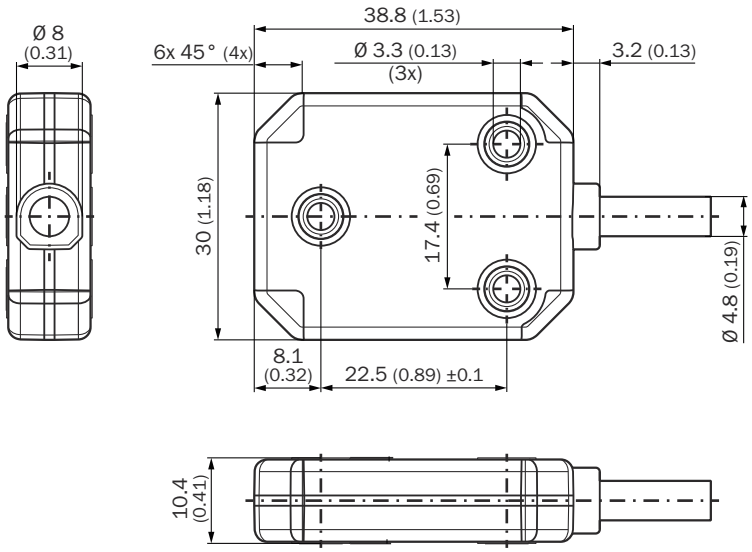


Figure 5: Dimensional drawing

7.2 Mounting instructions

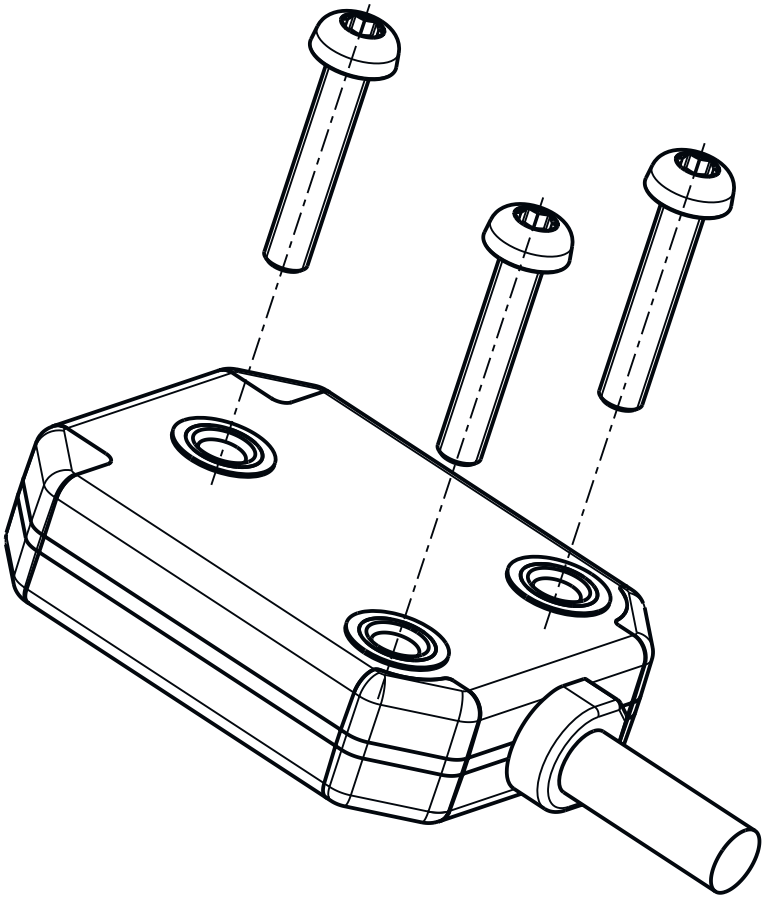


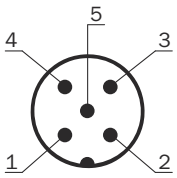
Figure 6: Mounting instructions

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.

8 Connection

8.1 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.



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.

8.2 Circuit diagrams

TMS/TMM22 circuit diagram with current output

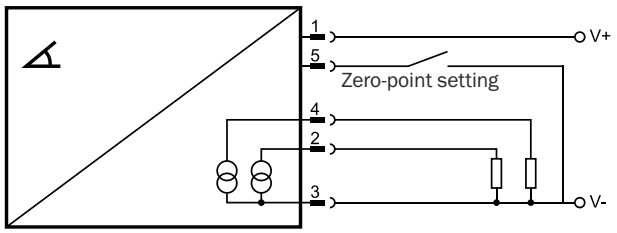


Figure 7: Current output

TMS/TMM22 circuit diagram with voltage output

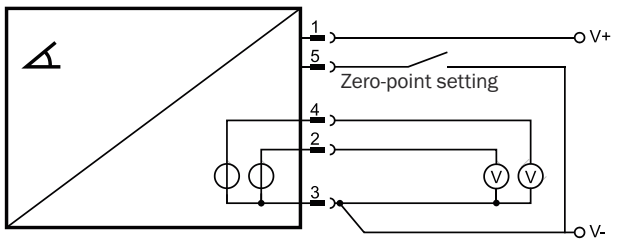


Figure 8: Voltage output

8.3 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.

8.4 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.

U_S [V]	Minimum load resistance R [Ω]	Maximum load resistance R [Ω]
12	0	350
18	200	600
24	200	900
30	200	1100

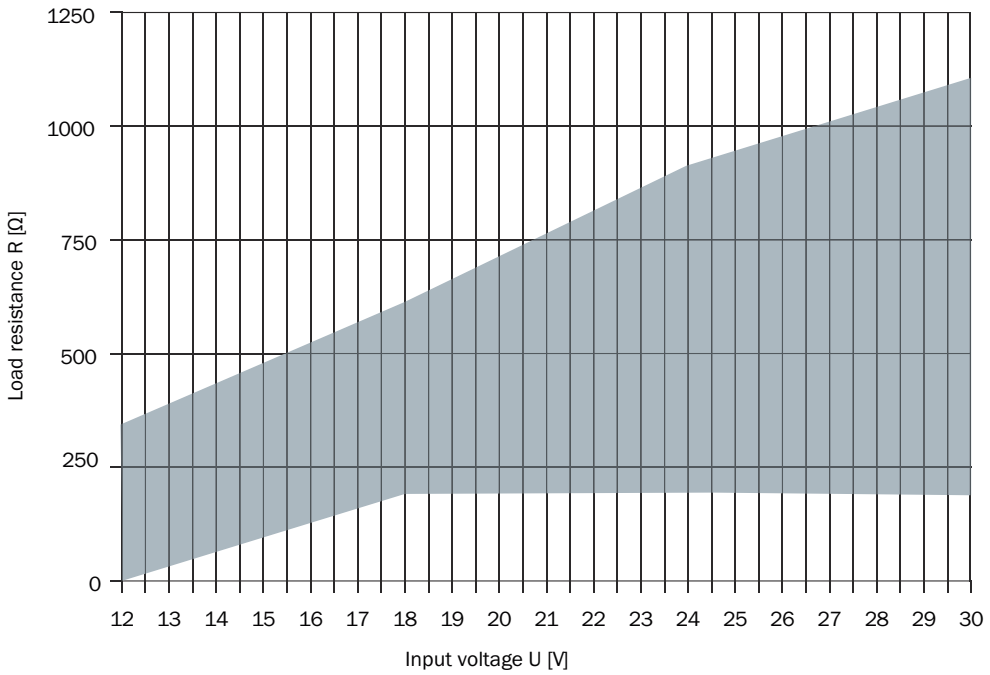


Figure 9: Permissible load resistances

9 Description of operation

9.1 Axis assignment/Counting direction

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 15. 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 15).

TMM

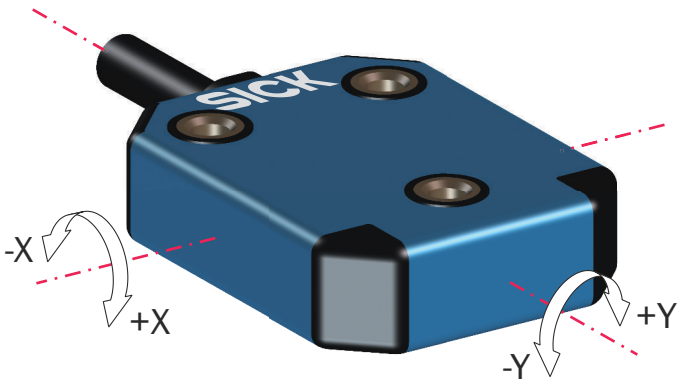


Figure 10: TMM22 measuring axis

TMS

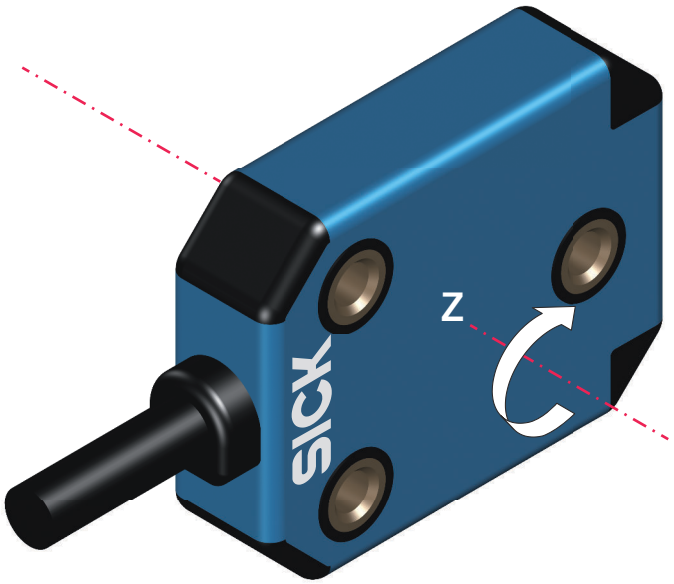


Figure 11: TMS22 measuring axis

9.2 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.

9.3 Signal filtering

TMx22E 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.

Step response of 8th order low-pass filter with 2 Hz cut-off frequency

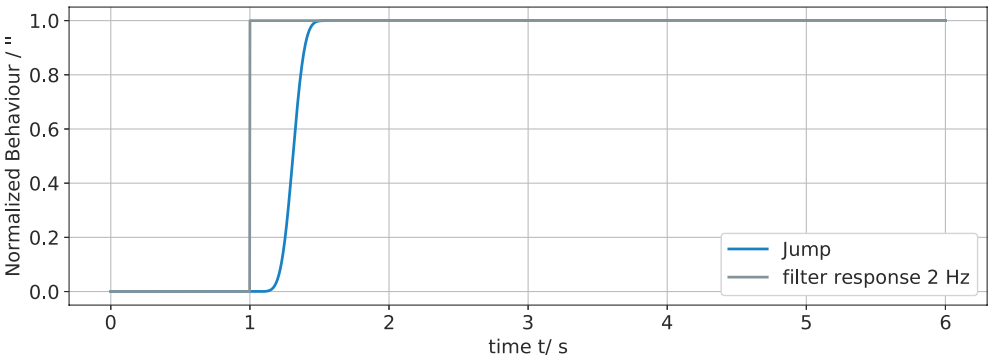


Figure 12: Pulse response of the filter

Amplitude response of 8th order low-pass filter with 2 Hz cut-off frequency

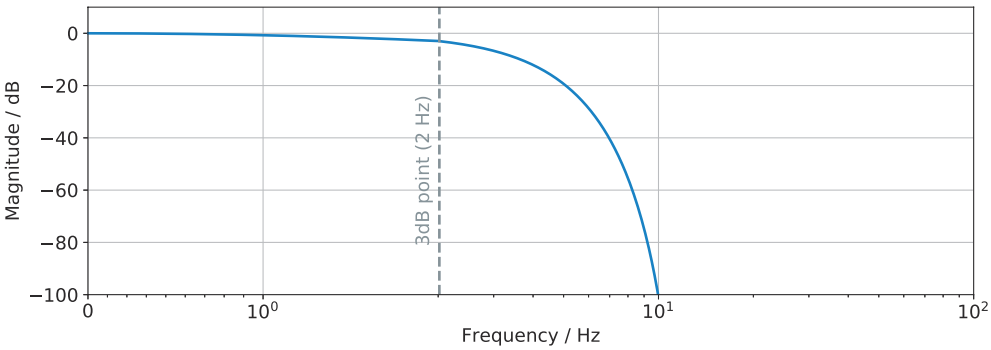


Figure 13: Amplitude characteristic of the filter

9.4 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 16) successful. It then again lights up permanently.

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 less than 12 V DC or greater than 30 V DC. As soon as the fault 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.

9.5 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

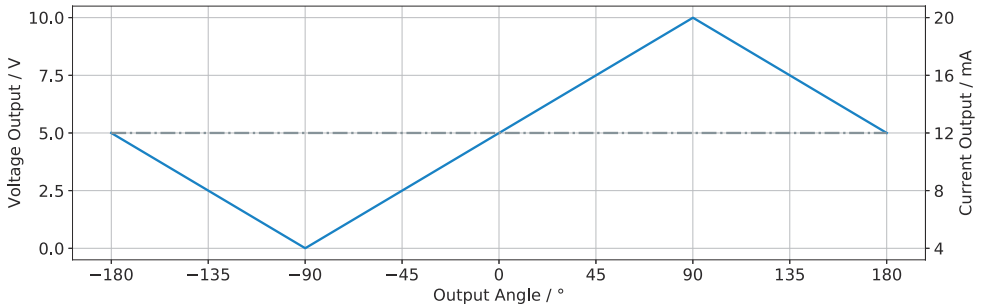


Figure 14: TMM22E-Pxx090 output diagram

TMM22E-Pxx045

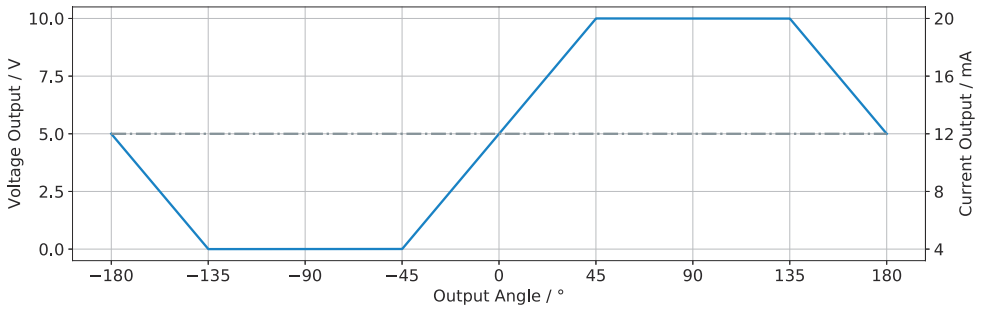


Figure 15: TMM22E-Pxx045 output diagram

TMS22E-Pxx360

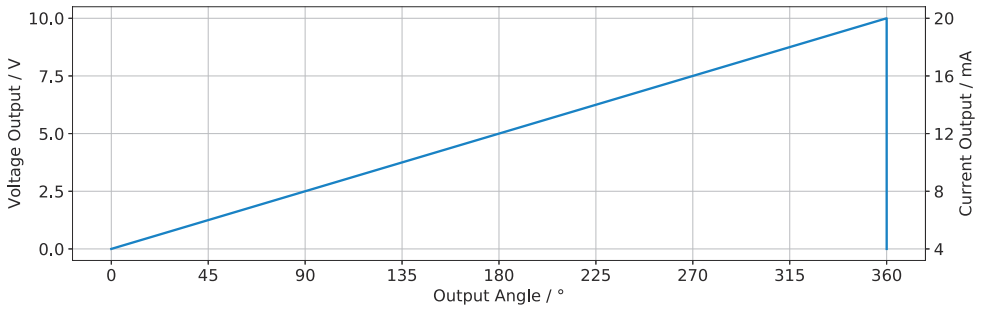


Figure 16: TMS22E-Pxx360 output diagram

TMS22E-Pxx180

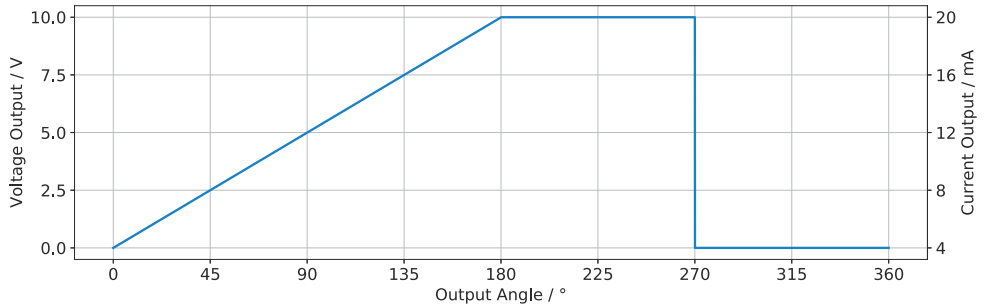


Figure 17: TMS22E-Pxx180 output diagram

9.6 Resolution

The TMS/TMM22 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 19.

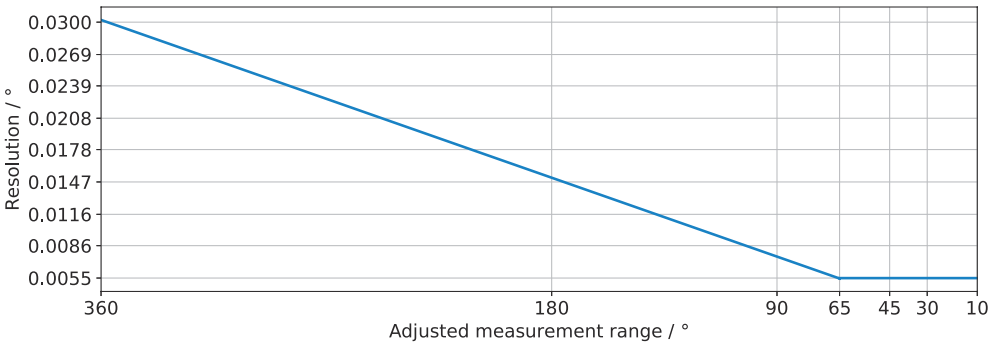


Figure 18: Resolution vs. set measuring range

Examples:

TMM22E-Pxx090: Resolution 0.015°

TMS22E-Pxx360: Resolution 0.03°

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