

# Inclination sensor on MEMS technology

Interface: **PROFINET**

Model **NBT**



- **Certified PROFINET interface**
- **Number of measurement axes: 1 or 2**
- **Selectable measuring range:  $\pm 5^\circ$  to  $\pm 90^\circ$**
- **With preset function**
- **Housing: aluminium or stainless steel**
- **Protection type: up to IP69K**
- **Option: Filter measures for masking interference vibrations and interference shocks**

## Design and function

Registration of inclination in the gravitational field by means of MEMS sensors (Micro-Electro-Mechanical-System) with subsequent digitisation and linearisation via controllers.

The inclinometer (model NBT 65) has a stable aluminium housing (optionally stainless steel) and is highly-resistant to vibration and shock. Casting measures in the housing lead to the achievement of protection class IP 69K.

MEMS sensors are integrated circuits manufactured using silicon bulk micromechanical technology. Double capacities are formed with the aid of moveable micromechanical structures. If these structures are deflected in the case of acceleration, e.g. gravitational acceleration (**g**), this results in capacity changes, which are registered and further processed using measuring technology. The output voltage follows the function  $U \sim g \cdot \sin \alpha$ . In this case, the angle  $\alpha$  is the sensor's inclination angle measured against the **g** vector. These sensors measure precisely, have a long service life and are very robust. The measuring axes operate independently of each other.

The Profinet interface according to IEC 61158 / 61784 or PNO specifications order No. 2.712 and 2.722, version 2.3, is integrated into the inclinometer series NBT.

Real time classes 1 and 3 are supported, i.e. Real Time (RT) and Isochronous Real Time (IRT) plus the requirements of conformance class C. The integrated 2-fold switch enables the TWK PROFINET inclinometer to be used in star, tree and line network topologies.

An exhaustive description of integration into a PROFINET network can be found in the manual [NBT 14636](#).

## PROFINET properties

- Real Time (RT) and Isochronous Real Time (IRT)
- Device exchange without interchangeable medium or programming device
- Prioritised start-up (Fast Start Up)
- Media redundancy possible
- Firmware update via Profinet

# Inclinometer NBT

## General description

### Behaviour in the event of a measured value change due to averaging:

Dynamic, arithmetic averaging of the measured values is implemented in the inclinometer. This involves linear averaging over 1000 values, whereby a new value is recorded every millisecond. This results in a low-pass effect. In the event of an abrupt change in the measuring angle, the end value is reached after approx. 1 second. In the event of a linear change in the measuring angle, the relevant output signal follows after a delay of approx. 0.6 seconds. Other, e.g. shorter, values may be set depending on application conditions. However, the output signal then tends to have a higher noise factor.

### Behaviour in the case of lateral inclination:

The following must be observed for single-axis devices: If the inclination sensor is inclined in two axes simultaneously, the measuring axis is switched off if the sensor is inclined in another axis by more than 15° (transverse inclination). Switching off means that the output value of the measuring axis assumes the overflow value (+180°). The bit "Out\_of\_range" is set in the status word. This switch-off is necessary because the measuring accuracy decreases with increasing cross slope.

### Behaviour in the case of interference accelerations (shocks and vibrations):

In certain applications, in normal operating conditions, the following occur Acceleration due to jolts, blows, etc. or any subsequent oscillation processes resulting from it. These disturbances are limited in time and can cause the Exceed measuring range of internal MEMS sensor (2,2 g). In the event of such disturbances, the Position output value to -180° and in the status word the bit "Position\_not\_valid" is set. This causes the control that due to shock and vibration loads no inclination measurement is possible. The sensor does not interfere in this case. **This Behavior is not limited in time.**

As soon as there is no further interference acceleration due to shock and vibrations, regular inclination data are output again, and not -180°.

Depending on the current measuring range, interferences which reveal an amplitude of less than 2.2 g are interpreted by the NBT as a measuring range overshoot (the MEMS sensor is an acceleration sensor). In this case, the overflow value of +180° and the bit "Out\_of\_range" are output.

## Measuring accuracy

Device with 1 or 2 axes,  $\pm 20^\circ$  measuring angle:

Accuracy:	$\pm 0.25^\circ$ (cross tilt $\pm 5^\circ$ ), otherwise $\pm 0.5^\circ$
Drift:	$\pm 0.3^\circ$ ; range [-10 °C to +60 °C] $\pm 0.5^\circ$ ; range [-40 °C to +85 °C]

Device with 1 axis,  $\pm 90^\circ$  measuring angle:

Accuracy:	$\pm 0.5^\circ$ (cross tilt $\pm 3^\circ$ ) $\pm 0.25^\circ$ within $20^\circ$ (cross tilt $\pm 3^\circ$ )
Drift:	$\pm 0.3^\circ$ ; range [-10 °C to +60 °C] for $\pm 60^\circ$ $\pm 0.4^\circ$ ; range [-40 °C to +65 °C] for $\pm 90^\circ$ $\pm 0.5^\circ$ ; range [-40 °C to +85 °C] for $\pm 60^\circ$ $\pm 0.6^\circ$ ; range [-40 °C to +85 °C] for $\pm 90^\circ$

# Inclinometer NBT

## Technical data

### Input data \*

- 2 byte status word
- 3x2 byte position data

### Output data \*

- 2 byte control word
- 2 byte preset word

### Electrical data

- Sensor system: MEMS acceleration sensor
- Operating voltage: 9 to 36 VDC
- No. measuring axes: 1 or 2
- Measuring range:  $\pm 5^\circ$  to  $\pm 90^\circ$  (selectable for example  $\pm 5^\circ$ ,  $\pm 10^\circ$  ....  $\pm 85^\circ$ ,  $\pm 90^\circ$  → see page 8)
- Resolution:  $0.01^\circ$
- Power consumption: < 3 W
- Current: approx. 90 mA (at 24V)
- Absolute accuracies:  $< \pm 0.5^\circ$  (see note on page 2)
- Repeatability:  $\pm 0.05^\circ$
- Noise:  $\pm 0.05^\circ$
- Zero error:  $\pm 0.5^\circ$
- Signal path: ascending values with CCW
- Reaction time: 1 s (for 100 % of the current end value, see note on page 2)

### PROFINET data

- MAC address: 00:0E:CF:XX:XX:XX  
The relevant, current MAC address is located on the model plate.
- Transfer technology: 100 Base-TX
- Transfer rate: 10 / 100 MBit/s
- Line length: Max. 100 m (between two subscribers)
- Minimum transmission cycle: 250  $\mu$ s

### Environmental data

- Temperature range: - 40 °C ... + 85 °C
- Storage temp. range: - 20 °C ... + 60 °C (due to packaging)
- Resilience
  - ☐ To shock: 200 m/s<sup>2</sup>; 11 ms, DIN EN 60068-2-27
  - ☐ To vibration: 100 m/s<sup>2</sup>; 10 ... 2000 Hz, DIN EN 60068-2-6
- Protection grade: IP 66 / IP 67  
IP 69K (option), IP 68 with cable outlet
- EMC standards: EN 61000-4-2 (ESD)  
EN 61000-4-4 (Burst)  
EN 61000-6-3(4) (Emission)  
(shielded cables must be used for power supply and PROFINET)
- Salt mist test: Test Kb according to IEC 60068-2-52
- Weight: Approx. 0.3 kg (aluminium), Approx. 0.65 kg (stainless steel)

### Electrical connection

- PROFINET: M12 connector D-coded 4-pin for bus in / bus out, socket or cable output via cable glands
- Supply: M12 connector A-coded 4-pin, pins or cable output via cable glands

### Cable output PROFINET (option)

- Cable type: PROFINET Type-C, 4 x 0,36 mm<sup>2</sup> (AWG22)
- Cable jacket: PUR, color: green
- Temperature range: - 40 °C to + 70 °C
- Outer diameter: 6.5 mm  $\pm$  0.2 mm
- Min. bend radius: 5 x d fixed installation, 10 x d freely movable

\* Aus Sicht der Steuerung

# Inclinometer NBT

## Technical data

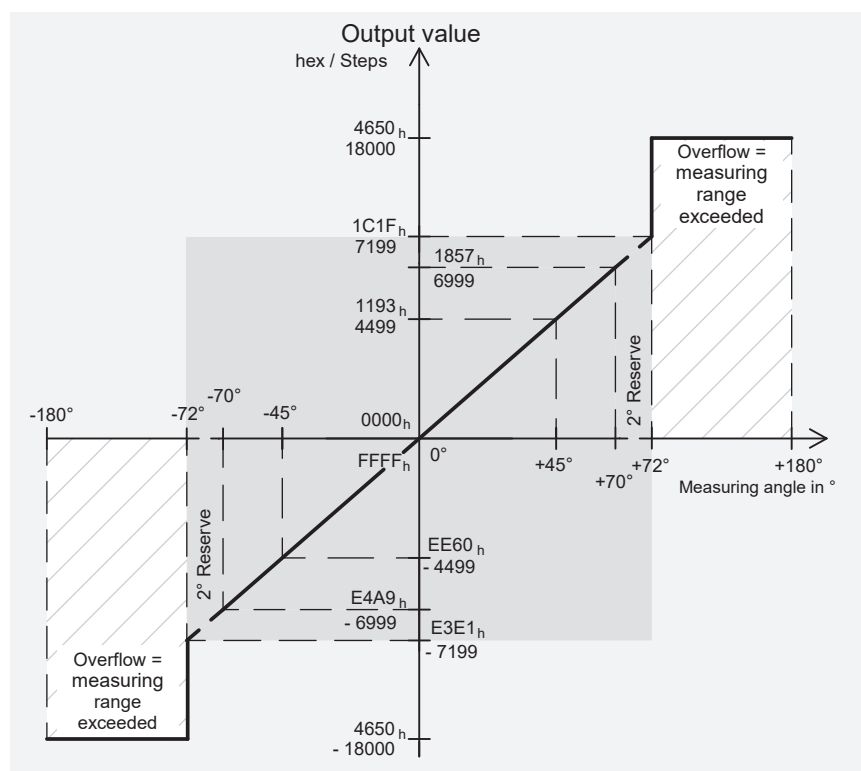
### Cable output power supply (option)

- Cable type: 2 x 0,75 mm<sup>2</sup>, shielded
- Cable jacket: PUR, color: gray
- Temperatur range: - 40 °C to + 80 °C fixed installation, - 5 °C to + 70 °C freely movable
- Outer diameter: 6 mm
- Min. bend radius: 6 x d fixed installation, 15 x d freely movable

## Characteristic curve

### Characteristic curve (example)

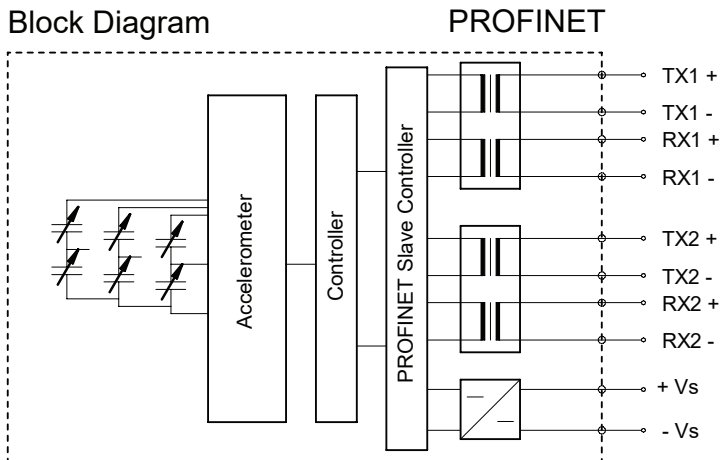
- Example:  $\pm 70^\circ \triangleq 2 \times 7000$  steps with resolution 0.01°
- Example:  $\pm 20^\circ \triangleq 2 \times 2000$  steps with resolution 0.01°
- Data format: Signed 16-bit.



When exceeding the selected range (eg  $\pm 70^\circ$ ), plus about 2° the output value is set to 4650<sub>hex</sub> (= 18,000<sub>dez</sub> = 180°) in order to signal the controller that the inclinometer is tilted out of the selected scale.

## Electrical connection

### Block diagram



### PROFINET M12 connection assignment connector / cable output (Port1 und Port 2)

PIN	1	2	3	4
Signal	TX+	RX+	TX-	RX-
Colour*	yellow	white	orange	blue

### Supply M12 connection assignment connector / cable output

PIN	1	2	3	4
Signal	+ UB (+ 24 VDC)	—	- UB (0 VDC)	—
Colour	white	—	brown	—

## Diagnosis-LEDs

UB (VS)	Link 1 (L1)	Link 2 (L2)	Status* (NS)	Description
green	green	green	green/red	
on				Operating voltage available
	on			Network connection established
		on		Network connection established
			green	Data exchange, device in operation and OK
			green flashing	Network connection o.k. but no connection to a PROFINET controller
			red, slow flashing	Firmware download mode
			red flashing	There is an error message. See manual <a href="#">NBT 13912</a> Chapter 7
			Fast red flashing	Device error
			red	Connection to the PROFINET controller disrupted

\* The design form NBT65 has a bi-color LED, the NBT90 has separate LEDs for green and red

# Inclinometer NBT

## Order number

<b>NBT</b>	<b>90</b>	<b>- A</b>	<b>x / y / z</b>	<b>V</b>	<b>C1</b>	<b>- 1</b>	<b>- S</b>	<b>3</b>	<b>T</b>	<b>01</b>	→ Standardversion
											<b>Electrical and mechanical variants *:</b>
											01 Standard
											<b>Output interface:</b>
											T PROFINET
											<b>Electrical connections:</b>
											1 Connector (hybrid connector)
											2 Connector (1x PROFINET, 1x power supply)
											3 Connector (2x PROFINET, 1x power supply)
											x Cable length in m (for cable output)
											<b>Electrical connections***:</b>
											S Connector M12
											K Cable
											<b>Installation position</b> (See pages 11-12):
											1 TOP 1, 2, 3, 4, 5, 6
											<b>See below: Available types</b>
											<b>Profile:</b>
											C1 Standard Profinet
											<b>Behaviour during disturbance acceleration:</b>
											V Standard (see page 2)
											<b>Measuring ranges **</b> (See pages 11-12):
											± z° z-axis
											± y° y-axis
											± x° x-axis
											<b>See below: Available types. Other types on request.</b>
											<b>Housing material ***:</b>
											A Aluminium AlMgSi1
											V Stainless steel 1.4404 (only available in design form 65)
											<b>Design form:</b>
											65 See installation drawings on page 9 and 10
											90
											NBT Inclinometer with Profinet interface

## Available types

(Standard versions. Other measuring ranges and installation positions on request)

- NBTxx-A20/20/0 V C1-1-xx T01
- NBTxx-A90/0/0 V C1-2-xx T01

\* The basic versions according to the data sheet bear the number 01. Deviations are identified with a variant number and are documented in the factory.

\*\* The measuring ranges for the various measurement axes can be selected in 5° steps, whereby it must be noted that only 2 axes can be used at any one time. For the undesired axis please choose '0'. Accuracy differences may possibly arise in terms of the compatibility of the measuring ranges or the measuring angles. Please talk to one of our employees.

\*\*\* Aluminium housing with connector M12, stainless steel housing preferably with cable (D-sub connector for test purposes mounted).

## Inclinometer NBT

### Accessories, documentation, GSD file

#### Accessories (to be ordered separately)

##### ■ Straight mating connector

<b>STK4GP81</b>	for PROFINET In/Out (zinc die-cast nickel-plated), see data sheet <a href="#">STK14570</a>
<b>STK4GP110</b>	for PROFINET In/Out (stainless steel 1.4404), see data sheet <a href="#">STK14569</a>
<b>STK4GS60</b>	for the supply voltage (zinc die-cast nickel-plated), see data sheet <a href="#">STK14572</a>
<b>STK4GS104</b>	for the supply voltage (stainless steel 1.4404), see data sheet <a href="#">STK14571</a>

##### ■ Angled mating connector (only suitable for design form 90)

<b>STK4WP82</b>	for PROFINET in/out, see data sheet <a href="#">STK14676</a>
<b>STK4WS61</b>	for the supply voltage, see data sheet <a href="#">STK14675</a>

##### ■ Connecting cable - Profinet

<b>KABEL-xxx-114</b>	Industrial Ethernet data cable with M12 connectors, D-coded, moulded on at both ends. Standard lengths: 1, 2, 3 and 5 m (xxx = length in metres), see data sheet <a href="#">KBL14673</a>
<b>KABEL-xxx-118</b>	Industrial Ethernet data cable with M12 connector to RJ 45, IP 20 (xxx = length in metres), see data sheet <a href="#">KBL14655</a>

##### ■ Connecting cable - power supply

<b>KABEL-5-191</b>	With moulded M12 connector, A-coded, straight, 2. side open, length 5m, see data sheet <a href="#">KBL13411</a>
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#### Documentation, GSD file, etc.

The following documents plus the GSD file and bitmap can be found in the Internet under [www.twk.de](http://www.twk.de) in the documentation area, model NBT

- Data sheet No. NBT14635
- Manual No. [NBT14636](#)

# Inclinometer NBT

## Installation positions and axis assignment

**Installation position TOP 1... 6** of the 1- or 2-axis inclinometer must be taken into consideration on assignment or selection of the **measurement axes**. The installation positions specified below define the measurement axes and measuring range centre for x, y and z.

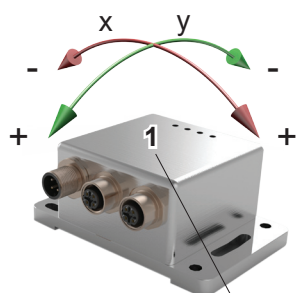
Which of housing surfaces 1 to 6 is to point upwards must be specified in the order number for the NBT (see figure on the right). The installation position is clearly marked on each device ('TOP'). This surface/edge must point upwards.

Only 2 of 3 axes are selectable. The installation position determines these axes.

Signal path: with the CW setting, the prefixes in the figures below specify the direction of rotation in which the output values increase positively during inclination measurement. This is accordingly reversed with the setting CCW.

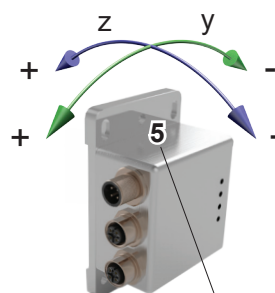
See page 6 for available types.

### Installation position top 1



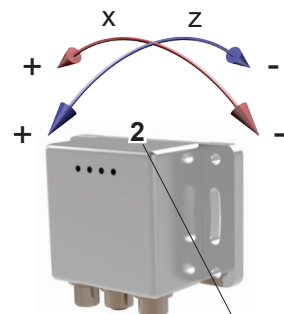
NBT65 - A xx/xx/0 C1 - 1 - S3 T01

### Installation position top 5



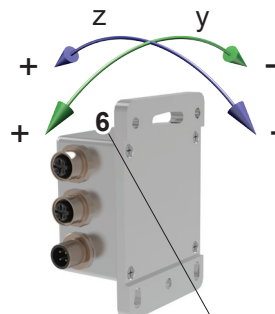
NBT65 - A 0/xx/xx C1 - 5 - S3 T01

### Installation position top 2



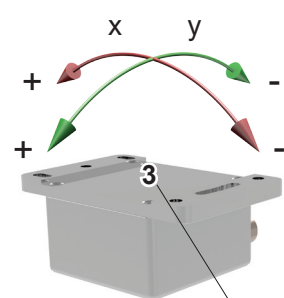
NBT65 - A xx/0/xx C1 - 2 - S3 T01

### Installation position top 6



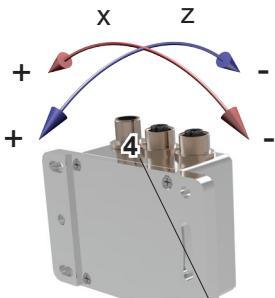
NBT65 - A 0/xx/xx C1 - 6 - S3 T01

### Installation position top 3



NBT65 - A xx/xx/0 C1 - 3 - S3 T01

### Installation position top 4



NBT65 - A xx/0/xx C1 - 4 - S3 T01

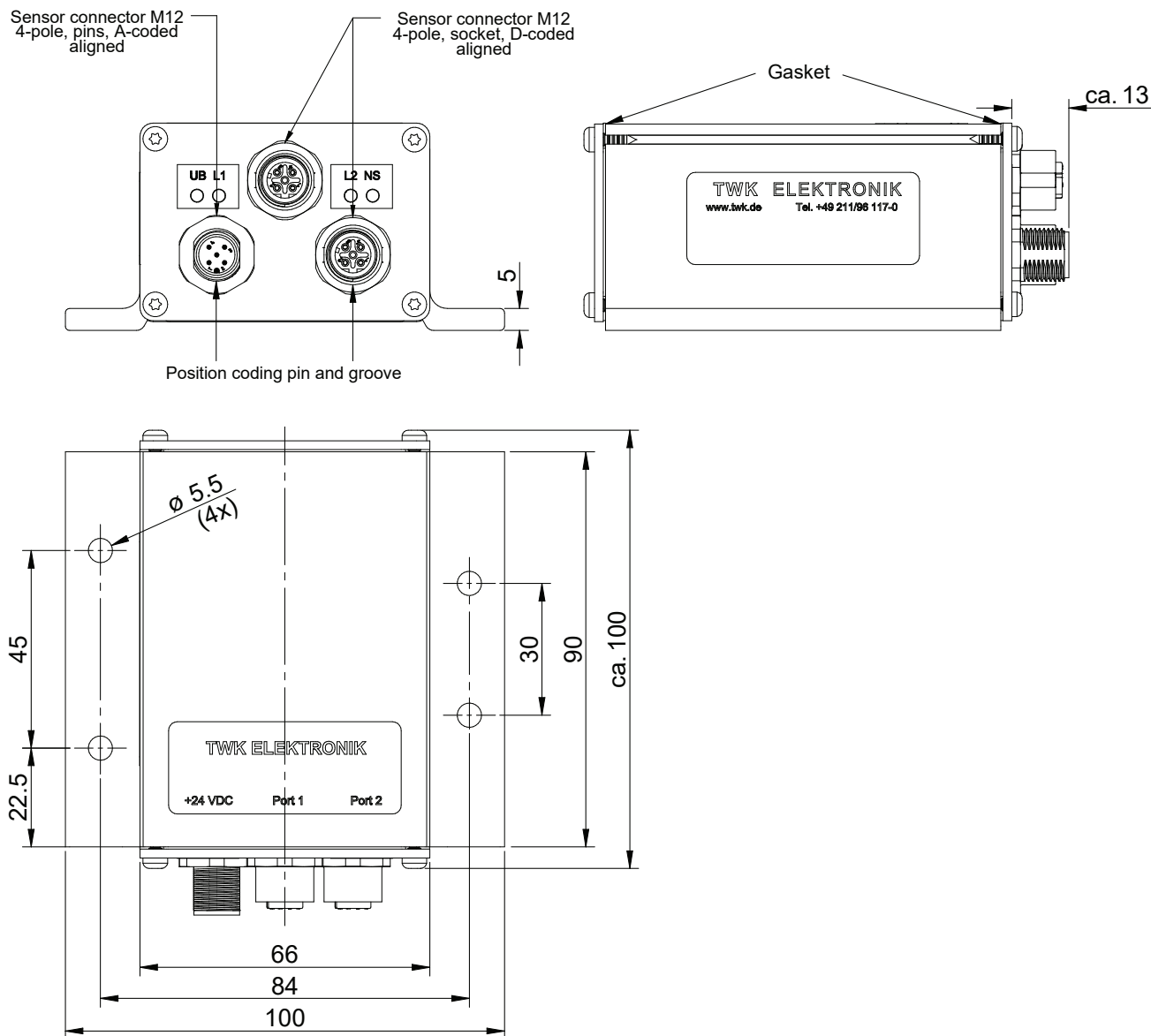


# Inclinometer NBT

## Installation drawings

Design form 90, order number: NBT90-Axx/xx/xxVC1-x-S3T01 - standard design form

### Dimensions in mm



### Materials used

Aluminium housing:	AlMgSi0.5 (EN AW 6060)
Aluminium front panels:	AlMg3
Plug:	zinc die-cast nickel-plated
Sealing rings:	Silicone

