



- SIL2 and Performance Level d
- Accelerometer for angular position and gyroscope for angular velocity
- Selectable measurement axes: x or y or z
- Angular measuring range: 360°
- Total angular velocity up to 25 rpm with accuracy of up to 0.5% of current velocity
- High vibration and shock resistance thanks to robust design and predictive filtering
- For use e.g. in rotor hubs of wind turbines for rotor position and speed
- TÜV certified



KEY INFORMATION OVERVIEW

DESIGN & FUNCTION

This sensor can precisely detect position (360°) and speed of a continuously rotating shaft like a wind turbine and behaves like a rotary encoder with a speed signal. Digital processing and predictive filter techniques yield a high position and speed accuracy even when the sensor is tilted or disturbed by vibrations.

No fixed shaft attachment is required. This enables simple and therefore inexpensive installation in a rotating application. The accuracy of the sensor is comparable to a rotary encoder can be used as an alternative even in safety critical applications.

The sensor is based on our NBT model series. In addition to the MEMS accelerometer, a MEMS gyroscope is used to determine the rotation rate with a high refresh rate.

The sensor does not have to be positioned in the centre of the axis of rotation. The eccentricity is automatically determined by the sensor and used to correct the signal to gain a high accuracy position and speed signal for the shaft.

The robust sensor has a stable aluminium housing (stainless steel optional). Electrical connection is carried out using M12 connectors. The protection class extends up to IP67.

FEATURES INTERFACE

Data output is realised via a PROFINET interface according to IEC 61158 / 61784 or PNO specifications order No. 2.712 and 2.722, version 2.3

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.

The PROFIsafe protocol is implemented according to the PROFIsafe Profile for Safety Technology version 2.4 (PNO Order No. 3.192).

An exhaustive description of integration into a PROFINET network can be found in the [NBT15982](#) manual.

- 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

TECHNICAL DATA

ELECTRICAL DATA

Sensor system	MEMS acceleration sensor and MEMS gyroscope
Operating voltage	9 bis 36 VDC
Power consumption	< 2 W
Current consumption	Approx. 60 mA @ 24 VDC
Measuring axes	z (x and y on request)
Zero error	± 1°
Noise	± 0.06° (position), typical ± 0.6 °/s (speed)
Signal path	CCW
Output code	Binary
Refresh time of output signal	up to 2 ms
Delay time of output signal	10 ms
Permitted tilt angle	up to 10°
Eccentricity (from rotation axis)	up to 1 m

POSITION DATA

Measuring range	360° (infinite rotation or reverse)
Resolution	0.01°
Accuracy	Approx. ± 2° (undisturbed)
Repeatability	Approx. ± 0.5° (undisturbed)
Data format	Unsigned 16 Bit

VELOCITY DATA

Measuring range	0 to 25 rotations per minute (rpm), 0 to 150 °/s
Resolution	0.01 °/s
Accuracy (@ 20 °C)	± 0.5 % @ 15 rpm (undisturbed, highest accuracy) < 0.12 rpm for velocities < 7.5 rpm (total range, including disturbances**) < 1.5 % for velocities ≥ 7.5 rpm (total range, including disturbances**)
Repeatability	Approx. ± 0,25 % @ 15 rpm (undisturbed)
Temperature drift	Slope ± 0.03 % typ.
Data format	Signed 16 Bit

INPUT DATA *

- 2 byte status word
- 3x2 byte MEMS accelerometer raw data (currently set to zero in safe module)
- 3x2 byte MEMS gyroscope raw data (only in unsafe module)
- 2 byte position data (currently set to zero at safe module)
- 2 byte speed data (functional safe value)**

OUTPUT DATA *

- 2 byte control word

PROFINET DATA

MAC address	88:A9:A7:BX:XX:XX The actual MAC address of the device is printed 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 µs

DIAGNOSIS LED

LED 1 (VS, green)	Operating voltage available
LED 2 (L1, green)	Link 1: Network connection established
LED 3 (L2, green)	Link 2: Network connection established
LED 4 (NS, green/red)	Device Status & error modes

* From the point of view of the control system

** Values were experimentally verified on a test stand in the presence of tower oscillations (1-2 m/s², 0.3 Hz) and typical structure born noise at several kHz, as well as during normal operation of a wind turbine (see handbook [NBT15982](#) for details).

TECHNICAL DATA**ENVIRONMENTAL DATA**

Operating temperature	- 40 °C ... + 70 °C
Storage temperature	- 20 °C ... + 60 °C (due to packaging)
Resilience	To shock 200 m/s ² ; 6 ms DIN EN 60068-2-27
	To vibration 100 m/s ² ; 10 ... 2000 Hz DIN EN 60068-2-6
Protection grade	IP67 (DIN EN 60529)
Weight	Approx. 0.3 kg (Aluminium) Approx. 0.65 kg (Stainless steel)

EMC STANDARDS

EN 61000-6-4:2006 + A1:2011	EMC Part 6-4: Generic standards-Emission standard for industrial environments
EN 61000-6-2:2005	EMC Part 6-2: Generic standards-Immunity for industrial environments
EN 61000-4-2:2009	EMC Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
EN 61000-4-3:2006 A1:2008 + A2:2010	EMC Part 4-3: Testing and measurement techniques - Radiated, radio frequency, electromagnetic field immunity test
EN 61000-4-4:2004	EMC Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
EN 61000-4-5:2006	EMC Part 4-5: Testing and measurement techniques - Surge immunity test
EN 61000-4-6:2009	EMC Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
EN 61000-4-8:2010	EMC Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test. Power frequency magnetic field immunity test: 30 A/m, test criterion A (± 16 digit), 100 A/m, test criterion B
EN 61000-4-29:2000	EMC Part 4-8: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests
IEC 61326-3-2:2018	Electrical equipment for measurement, control and laboratory use - EMC requirements Part 3-2: Immunity for safety-related systems and for equipment intended to perform safety related functions (functional safety) - industrial applications with specified electromagnetic environment

SAFETY DATA

According to DIN EN 61508	PFH = $5.27 \cdot 10^{-8}$ SFF = 97.3 % HFT = 0 SIL2
According to DIN EN ISO 13849-1	MTTFd = 100 years (calculated 180 years) DCavg = 96.7 % Category 2 Performance Level D
	Maximum operating life: 25 years

PROGRAMMABLE PARAMETERS (REFER TO HANDBOOK NBT15982 FOR DETAILS)

Firmware download	Sets NBT-D in the state „firmware download mode“
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PRODUCT CHARACTERISTICS

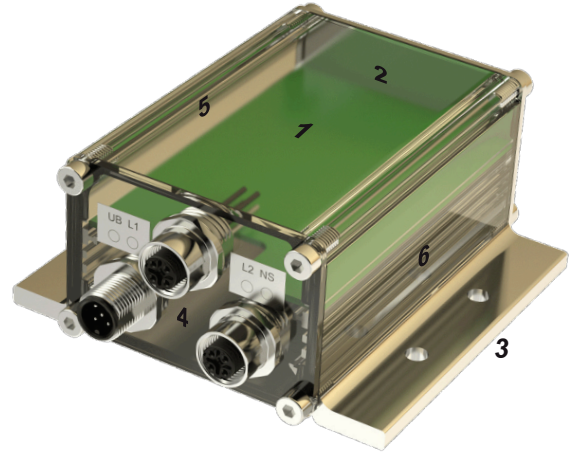
INSTALLATION POSITION AND MEASUREMENT AXES

The installation position TOP 1...6 of the rotor hub sensor determines, which face points upward when the zero transition $360^\circ \rightarrow 0^\circ$ occurs. For the three possible rotation axes are the following surfaces / installation positions fixed assigned. Other combinations are only available on request.

NBT 360 / 0 / 0 TOP4
NBT 0 / 360 / 0 TOP1
NBT 0 / 0 / 360 TOP1

The standard signal path is set to CCW (increasing angle values at rotation in direction „+“, see pictures below). It can be set to CW on request.

The definition of the rotation axis can be found below. The sensor does not have to be installed exact on the rotation axis. Further information on possible eccentricity can be found in the manual [NBT15982](#).

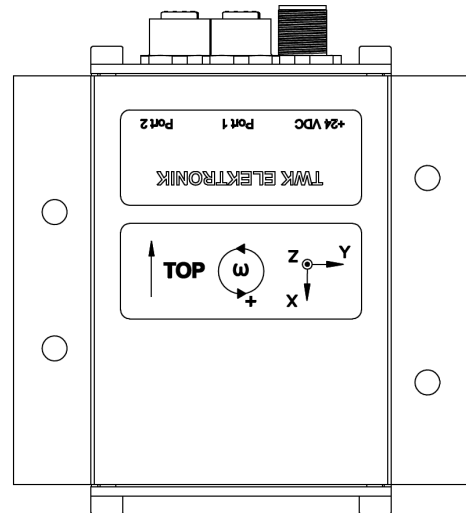


1: Top side	2: Back	3: Bottom
4: Front (connector side)	5: Left	6: Right

NBT90-A 360 / 0 / 0 D S3 - 4 - S3 T01



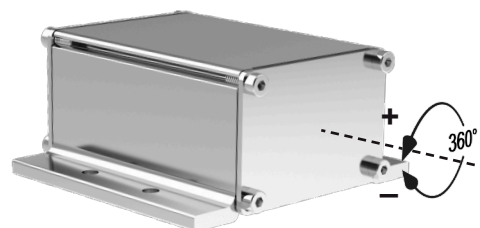
The definition of the measurement axes for the raw signals in the unsafe channel is indicated on the device. For the standard installation position, TOP4, and signal path CCW this is depicted below. The position signal is zero ($360^\circ \rightarrow 0^\circ$) in this configuration when the connectors point upwards.



NBT90-A 0 / 360 / 0 D S3 - 1 - S3 T01 (ON REQUEST)

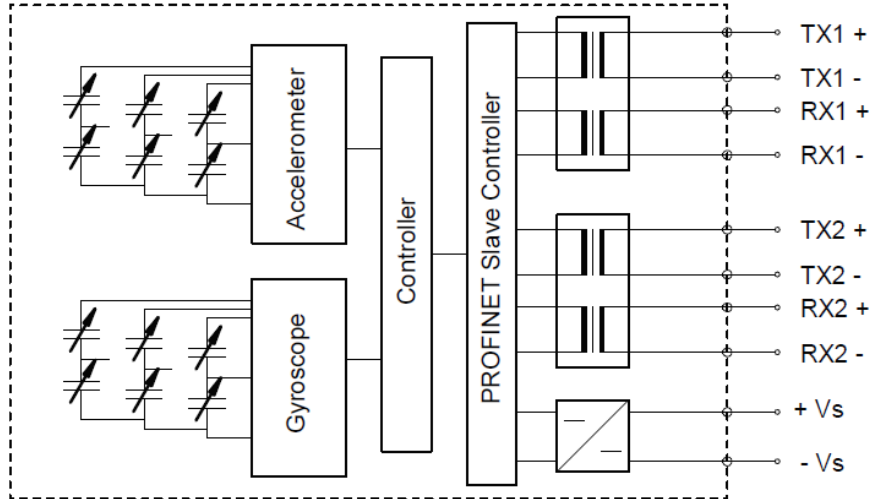


NBT90-A 0 / 0 / 360 D S3 - 1 - S3 T01 (ON REQUEST)



TECHNICAL DATA

PRINCIPAL CIRCUIT DIAGRAM



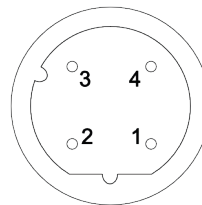
ELECTRICAL CONNECTION

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

PROFINET CONNECTOR, 2 X M12, D-CODED, SOCKET/FEMALE

PIN	Function
1	TX+
2	RX+
3	TX-
4	RX-

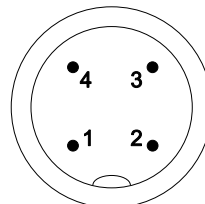


PROFINET CABLE OUTPUT (2X)

Colour*	Function
Yellow	TX+
White	RX+
Orange	TX-
Blue	RX-

SUPPLY CONNECTOR, M12, A-CODED, PINS/MALE

PIN	Function
1	+UB (+24 VDC)
2	not used
3	-UB (0 VDC)
4	not used



SUPPLY CABLE OUTPUT

Colour	Function
White	+UB (+24 VDC)
Brown	-UB (0 VDC)

REMARK

Only use shielded cable for power supply and PROFINET

* Industrial Ethernet cable colours according to ISO / IEC 8802-3.

ELECTRICAL CONNECTION

CABLE OUTPUT PROFINET (OPTIONAL)

Cable type PROFINET Type-C, 4 x 0.36 mm² (AWG22)
 Cable jacket. PUR, colour: green
 Temperature range - 40 °C bis + 70 °C
 Outer diameter 6.5 mm ± 0.2 mm
 Min. bend radius 5 x d fixed installation, 10 x d freely movable

CABLE OUTPUT POWER SUPPLY (OPTIONAL)

Cable type 2 x 0.75 mm², shielded
 Cable jacket. PUR, colour: green
 Temperature range - 40 °C bis + 70 °C fixed installation, - 5 °C bis + 70 °C freely movable
 Outer diameter 6 mm
 Min. bend radius 6 x d fixed installation, 15 x d freely movable

ORDER CODE FORMAT

NBT **90 -** **A** **360 /** **0 /** **0** **D** **S3** **- 4 -** **S** **3** **T** **01** **STANDARD VERSION**

NBT	Inclination sensor / rotor hub sensor with PROFINET interface		
90	Design form	90	Design form 90 mm
A	Housing material	A	Aluminium (see page 8)
360	Measuring axis x	0 360	Please enter 360 here when x is the desired axis (with TOP4)
0	Measuring axis y	0 360	Please enter 360 here when y is the desired axis (with TOP1)
0	Measuring axis z	0 360	Please enter 360 here when z is the desired axis (with TOP1)
D	Measuring version	D	With gyroscope for measuring angular velocity
S3	Profile	S3	SIL2 / PLd certified according to this data sheet
4	Installation position	1 4	Defines which face points upward (TOP) when the zero transition 360° → 0° occurs (see page 4)
S	Electrical connection	S K	Connector M12 Cable
3	Electrical connection	1 2 3 X	1 x connector (Hybrid connector) 2 x connector (1 x PROFINET, 1 x power supply) 3 x connector (2 x PROFINET, 1 x power supply) Cable length in m (for cable output)
T	Output	T	PROFINET
01	Electrical and mechanical variants*	01	Standard

* Standard versions according to this data sheet are labeled 01. Variations are identified with a variant number and are documented by TWK.

ACCESSORIES (TO BE ORDERED SEPARATELY)
MATING CONNECTORS

Order number, Datasheet	Type	Design & wire fixing	Housing-material	Cable \varnothing & wire size	Shielding & IP grade
STK4GP81 , STK14570	M12-D 4-pole, male	Straight, screws	Zinc die-cast nickel-plated	5 – 8 mm $\leq 0.75 \text{ mm}^2$	On housing IP67
STK4GP110 , STK14569	M12-D 4-pole, male	Straight, screws	Stainless steel 1.4404	5.5 – 8.6 mm $\leq 0.75 \text{ mm}^2$	On housing IP67
STK4GS60 , STK14572	M12-A 4-pole, female	Straight, screws	Zinc die-cast nickel-plated	6 – 8 mm $\leq 0.75 \text{ mm}^2$	On housing IP67
STK4GS104 , STK14571	M12-A 5-pole, female	Straight, screws	Stainless steel 1.4404	4 – 6 mm $\leq 0.75 \text{ mm}^2$	On housing IP67
STK4WP82 , STK14676	M12-D, 4-pole, male	Angled, screws	Die-cast zinc nickel-plated	5 – 8 mm $\leq 0.75 \text{ mm}^2$	On housing IP67
STK4WS61 , STK14675	M12-A 4-pole, female	Angled, screws	Polyamid (PA)	4 – 6 mm $\leq 0.75 \text{ mm}^2$	- (due to PA) IP67

CONNECTING CABLE - PROFINET

KABEL-xxx-114 Industrial Ethernet data cable with M12 connectors, D-coded, moulded on at both ends,
xxx = length in meters, standard lengths: 1, 2, 3, 5, 10, 15 and 20 m, see data sheet [KBL14673](#)

KABEL-xxx-118 Industrial Ethernet data cable with M12 connector to RJ 45, IP 20,
xxx = length in meters, standard lengths: 2, 3, 5, 10, 15 and 25 m, see data sheet [KBL14655](#)

CONNECTING CABLE - POWER SUPPLY

KABEL-xxx-191 With moulded M12 connector, A-coded, straight, 2. side open,
xxx = length in meters, standard lengths: 2, 5, 10, 15, 20 and 25 m, see data sheet [KBL13411](#)

DOCUMENTATION
DOCUMENTATION

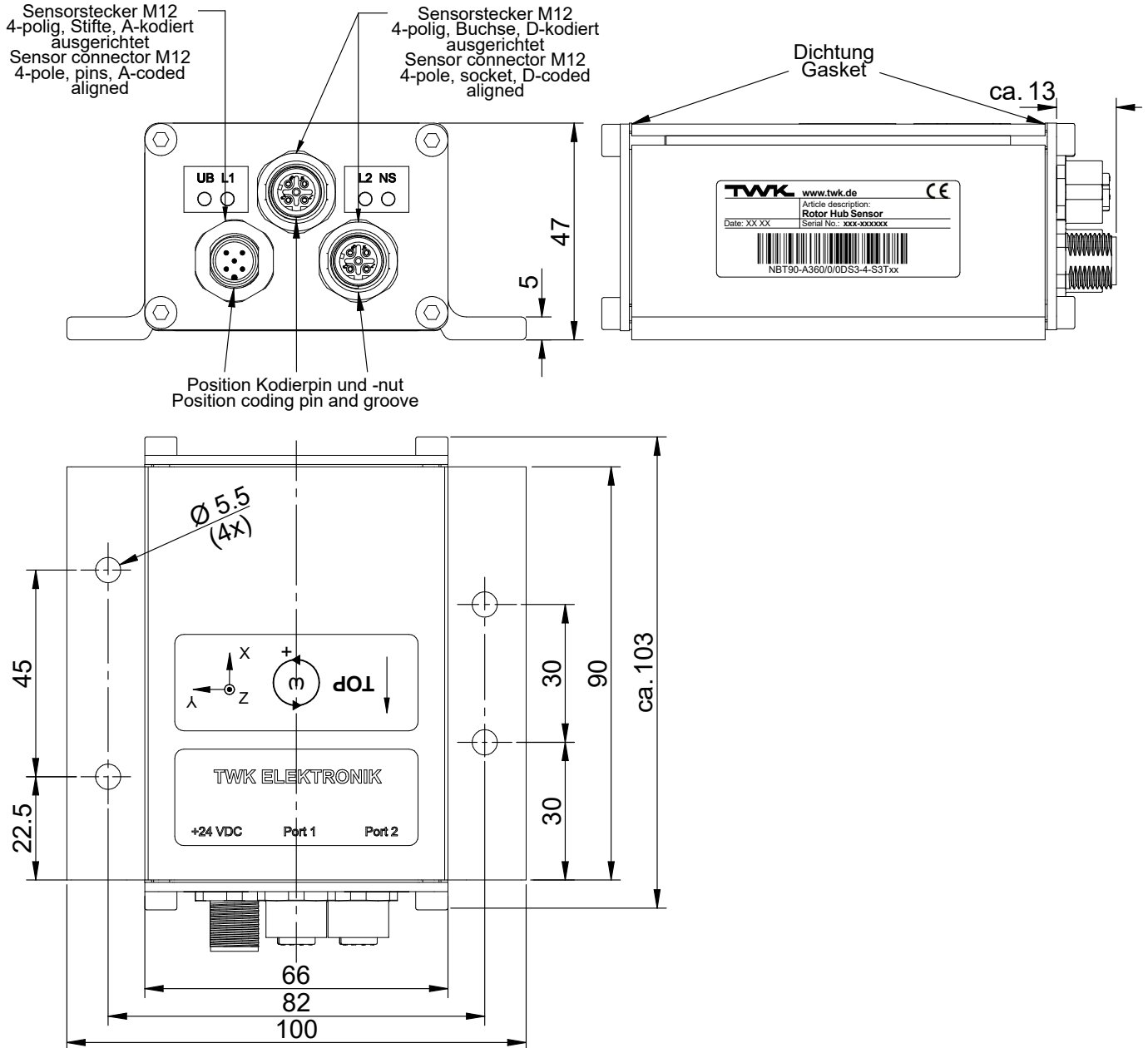
The following documents plus the GSD file and bitmap can be found in the Internet under www.twk.de/en in the documentation area, model NBT-D/S3.

Data sheet	NBT15981
Manual	NBT15982
Certificate PROFINET	NBT14715
Certificate PROFIsafe	NBT14717
Certificate TÜV	NBT16273
GSD files	GSD files NBT-D/S3
Declaration of Conformity	ZE16569
Safety Library (VDMA/Sistema)	Safety Library NBT/S3
Reach compliant	QS15286
RoHS compliant	QS13284
Installation instructions	AN16169

INSTALLATION DRAWINGS

DESIGN FORM 90, ORDER NUMBER: E. G. NBT90-A 360 / 0 / 0 D S3 - 4 - S3 T01

Dimensions in mm



MATERIALS USED

- Aluminium housing Aluminium 3.3206
- Aluminium front plates..... Aluminium 3.3316
- Connectors Brass, nickel plated or diecast zinc, nickel plated
- Sealing rings PTFE / NBR