

**Inclination sensor NBT
with PROFINET interface**
Relevant data sheet NBT 14635

TWK ELEKTRONIK

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User manual

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POB 10 50 63 ■ 40041 Düsseldorf ■ Germany
Tel. +49/211/96117-0 ■ Fax +49/211/63 77 05
info@twk.de ■ www.twk.de

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1. Safety instructions

1.1 Scope

This user manual is valid exclusively for the following inclination sensor with PROFINET interface:

- NBTxx-xxx/x/xC1-x-xxTxx

1.2 Documentation

The following documents must be observed:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number NBT 14635
- The connection assignment enclosed with the device

1.3 Proper use

The TWK-ELEKTRONIK GmbH sensors and linear transducers are used to register angular or linear positions and make their measured value available in the form of an electrical output signal. As part of a system, they have to be connected to the downstream electronics and must only be used for this purpose.

1.4 Commissioning

- The relevant device may only be set up and operated in combination with this and the documentation specified under point 1.2.
- Protect the device against mechanical damage during installation and operation.
- Device commissioning and operation may only be undertaken by a specialist electrician.
- Do not operate the device outside of the limit values specified in the data sheet.
- Check all electrical connections before commissioning the system.

2. General information

The inclination sensors series NBT are one, two or three axis acceleration sensors based on MEMS (Micro-Electro-Mechanical-System) technology which work with the gravitational force.

Internally the sensor module is connected to the evaluation electronic which processes the measuring signal by filtering, linearisation and calibration and provides the measuring values via PROFINET protocol for the user.

The PROFINET interface according to IEC 61158 / 61784 or PNO specifications, order Nos. 2.712 and 2.722 version 2.3 is integrated.

The specifications can be obtained from the profibus user organisation (www.profibus.com).

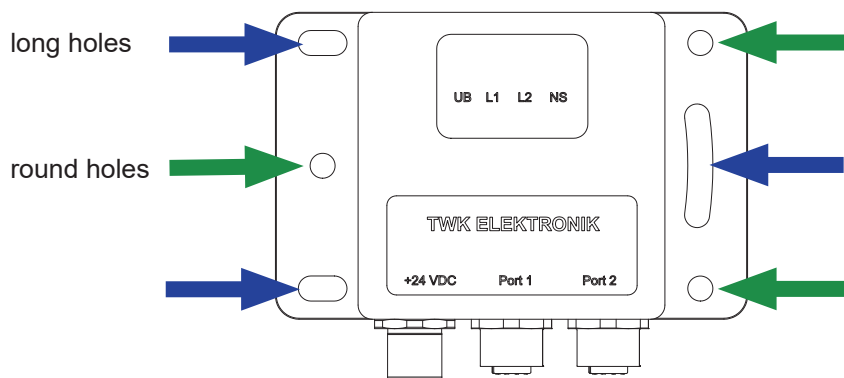
3. Installation

3.1 General information

- During installation, observe the profinet assembly guideline PNO order No.: 8.071 /3/
- Use only certified profinet cables, connectors and switches (see "PROFINET Cabling and Interconnection Technology" PNO order No.: 2.252 and "Installation Guideline PROFINET Part 2: Network Components" PNO order No.: 2.252 p2).
- Hubs are not permissible.
- The cable length between two subscribers may be max. 100 m.
- The TWK NBT inclination sensor possesses an integrated switch. This not only enables tree and star topologies but also the linear topology.
- Media redundancy protocol support enables the establishment of a redundant ring.
- The setting of addresses, the baud rate or terminating resistors on the device is not necessary.

3.2 Mounting

The mounting of the NBT can be done via the long holes or the round holes. When using the long holes a mechanical adjustment of the sensor is possible but some additional fixation is recommended to prevent a later shift of the sensor. The round holes don't permit any mechanical adjustment, but an adjustment by the application program of the PLC via PROFINET is possible in the range of ± 5 around the raw value after installation.



3.3 Electrical connection

The inclination sensors "NBT...C1T01" with connector output have separate connectors for the supply and the PROFINET system. Port 1 or port 2 are optionally available for the PROFINET connection. Due to the integrated switch, it is irrelevant which port is used.

Connection	Designation	Connector type
PROFINET	Port 1	M12x4 D-coded socket
PROFINET	Port 2	M12x4 D-coded socket
Voltage supply	24 VDC	M12x4 A-coded pins

Refer to data sheet No. [14635](#) for connector assignment and ordering information.

3.4 Status LEDs

The inclination sensor has four LEDs. These have the following meaning:

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	Interference accelerations to high or preset error
			Fast red flashing	Device error
			red	Connection to the PROFINET controller disrupted

In [Chapter 7](#) diagnosis you can find all diagnosis data of the NBT.

Flashing codes

Errors which lead to sensor system standstill (hard errors) are indicated by a flashing code on the part of the red NS LED. Following introductory flickering by the red LED, a specific number of flashing cycles are output for the cause of the error.

	Number of flashing cycles (Duration approx. 1 s)	Error cause
Flashing code 1	1	F stack error
Flashing code 2	2	CRC error ROM
Flashing code 3	3	RAM/XRAM error
Flashing code 5	5	Programme sequence error
Flashing code 6	6	Power consumption too high

3.5 Project planning

A device description file (GSD file) in the XML format GSDML and an image (bitmap) to integrate the inclination sensor into a project planning tool are available in the internet under www.twk.de

File name of the GSD file: GSDML-V2.32-TWK-NBT-20180124.xml (The version and date may vary depending on the status of the GSD file)

File name of the bitmap: GSDML-0159-8000-TWK_NBT.bmp

Project planning using the example of Step7 is explained in the following chapter.

4. Project planning

4.1 Simatic Step7 - TIA-Portal

This chapter explains the procedure for integrating the TWK NBT inclination sensor into the PROFINET network of a Siemens S7 control system with Step 7 Professional V14.

4.1.1 Prerequisites

You have installed and parameterized a F PLC under "Devices & networks" according to your equipment as well as a PROFINET subnet.

This is shown here using the example of a CPU1511F:

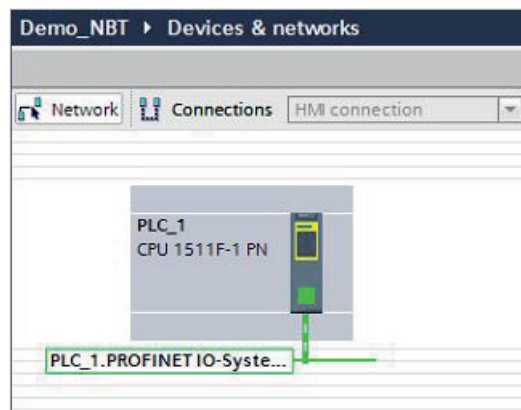


Fig.: 1

4.1.2 Installation of the GSD file

- In the main menu choose **Options, Install general station description file (GSD)**.
- Set the source path to your GSD file, check the GSD file and click on "Install" (see Figure 2).
- The inclination sensor symbol is also installed automatically, provided that it is in the same directory

Note: The GSD file and the sensor symbol (bitmap) are available for download under www.twk.de.

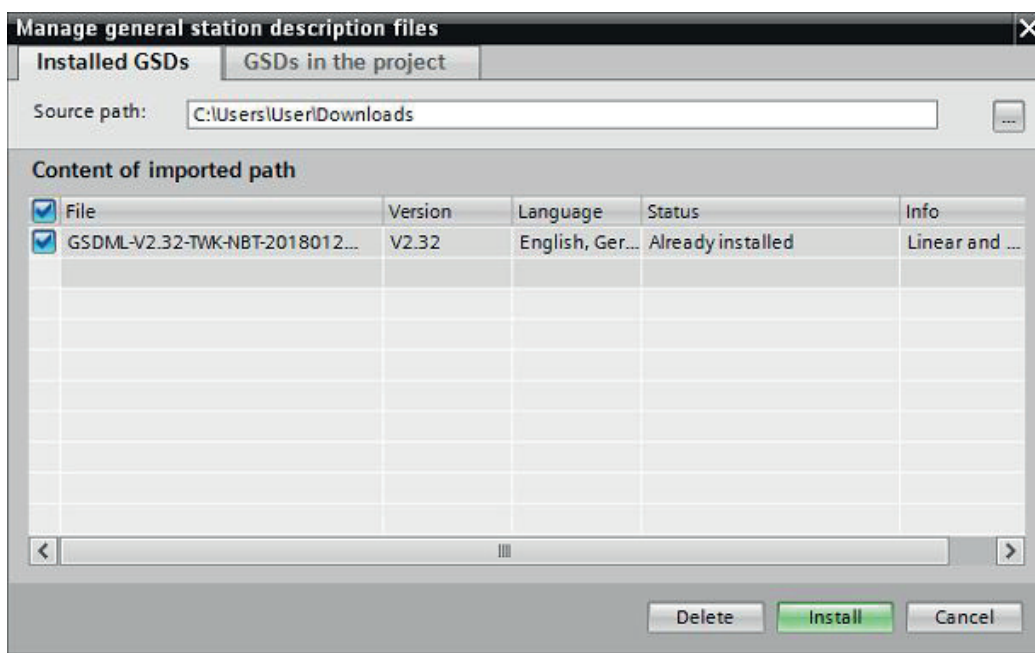


Fig.: 2

Project planning

After installing the GSD file, the hardware catalogue is automatically updated. The inclination sensor NBT is located in **Further FIELD DEVICES, PROFINET IO, Sensors, TWK-ELEKTRONIK GmbH, TWK N-Series, NBT**.

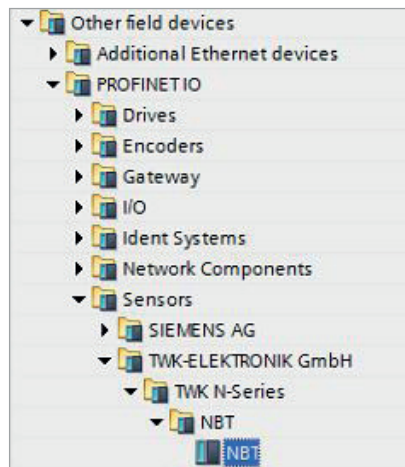


Fig.: 3

4.1.3 Installing the inclination sensor

Now drag the NBT from the hardware catalog in the netview of your project.

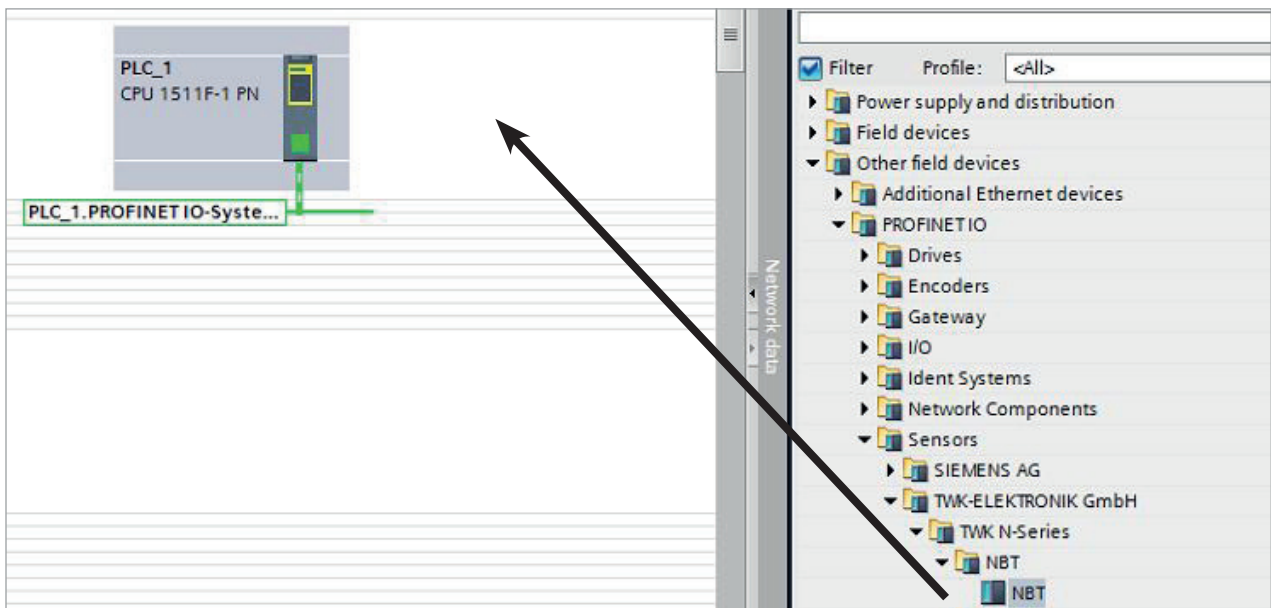


Fig.: 4

Afterwards click on "Not assigned" and assign the inclination sensor to the PROFINET interface of your CPU or draw a network connection from the inclination sensor to the CPU port with your mouse.

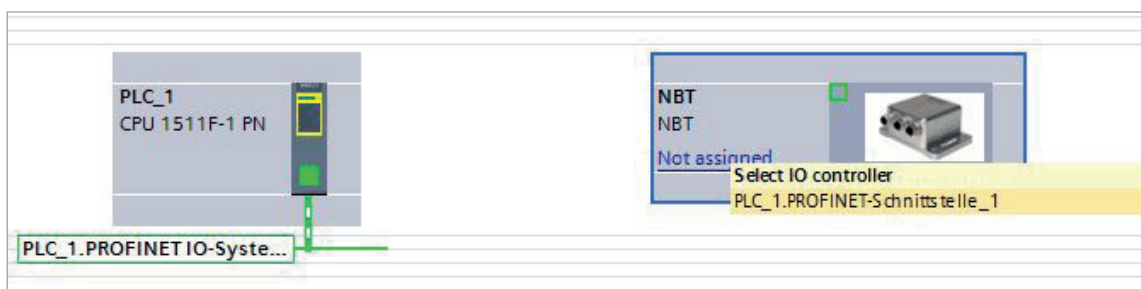


Fig.: 5

The PROFINET-Interface of the inclination sensor is now installed with its default values.

4.1.4 Install module

To install the inclination sensor module change to the **Device view** and drag the module "Inclination+status" to the first free slot of the module list.

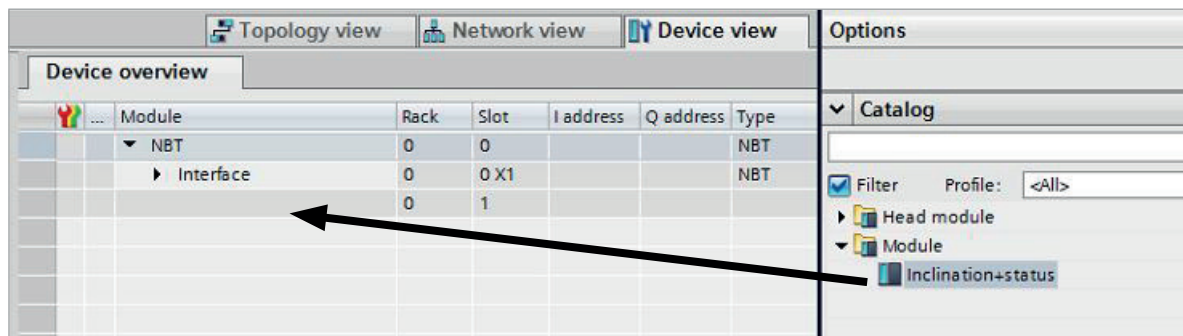


Fig.: 6

In the properties of the installed module we will set the I/O address and the sensor parameters later on.

4.1.5 Setting the network data

Select the inclination sensor in the Device view to show the properties of the PROFINET interface of the NBT.

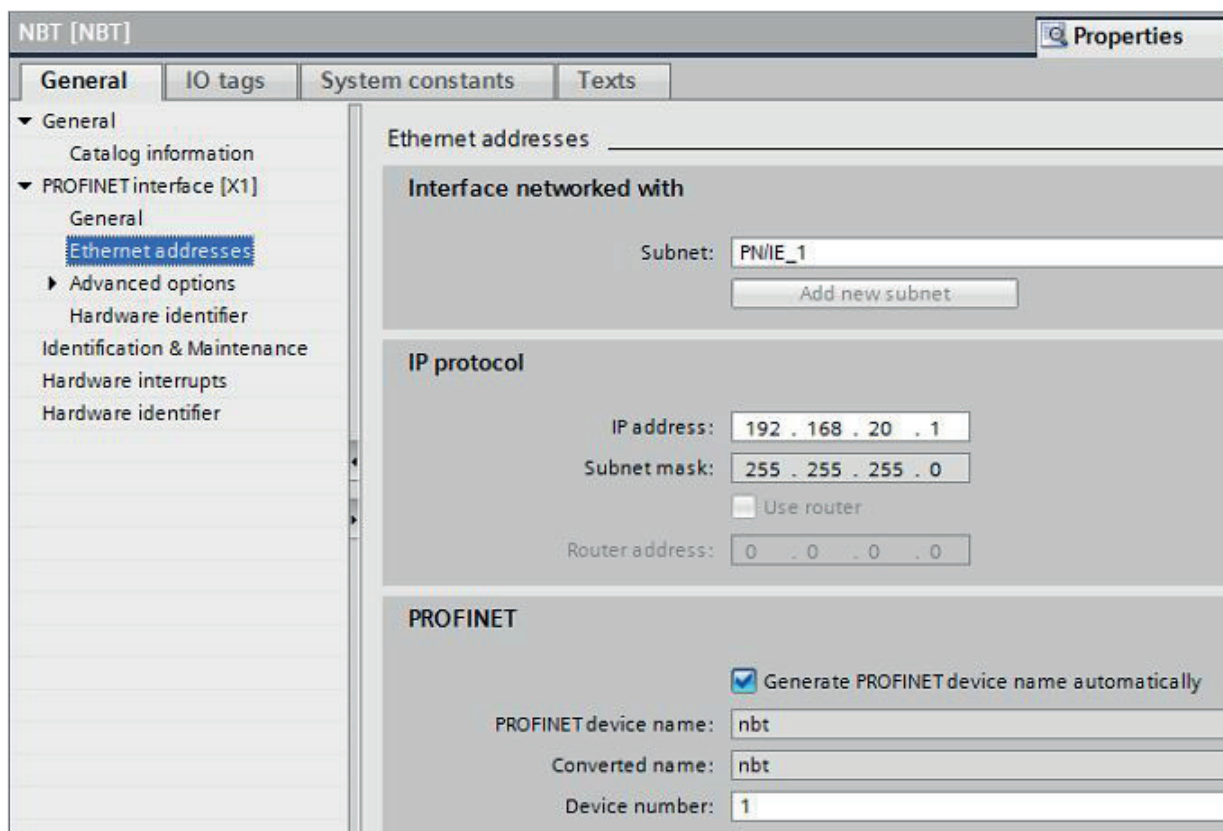


Fig.: 7

4.1.5.1 Setting the PROFINET / PROFIsafe address

Under "General" enter the **PROFINET name** which must be unique throughout the network to identify the device. If **Generate PROFINET device name automatically** is selected the name which is entered under **PROFINET interface - General** will be registered here. The default name is NBT.

The complete name assigned here must either be manually allocated to the inclination sensor (see [Chapter 4.1.8](#)) or it can be assigned automatically by the controller using the topology editor (see [Chapter 4.1.7](#) Planning of "Device exchange without programming device" and "Automatic commissioning").

The device name is stored in the inclination sensor, where it is protected against zero voltage. An installed device can be exchanged with a brand new device without a programming device or exchanging a memory card. The correct name is automatically assigned to the new sensor by the controller. To do this, however, the prerequisites under [Chapter 4.1.7](#) have to be met.

4.1.5.2 IP address

Under **PROFINET interface - Ethernet addresses - IP protocol** the boxes **Use IP protocol** and **Set IP address in the project** should be checked. Step7 automatically assigns an IP address when inserting the device in the project. Manually setting of the IP address is also possible.

4.1.5.3 Prioritized startup, media redundancy, update time and synchronisation

Via the interface option **Prioritized startup** the startup time of the NBT from power on until PROFINET I/O data exchange can be reduced from approx. 6s to 3s. However, this can only be achieved as of the second startup.

The NBT can be used as member (client) in a redundant ring. In case of a line topology one network cable from the last client to the controller (manager) is necessary only to achieve a redundant communication. Before setting the **media redundancy role** of the NBT a MRP domain has to be created and the MRP manager (normally the controller) to be assigned.

Under **PROFINET interface, Advanced options, Real time settings** the desired **Update time** of the NBT can be set. The possible values depend on the setting of the send clock of the CPU. The minimal update time for the NBT is 250 µs.

The desired real time class can be set under **Synchronisation**. The NBT supports the classes RT and IRT.

4.1.6 Setting the inclination sensor

4.1.6.1 Setting the I/O address

After switching to the device view of the NBT and selecting slot 1 in the device overview the properties of the module can be accessed.

Set the PLC addresses for the input data (status word and position) and for the output data (control word and preset value) under I/O addresses (see [Chapter 5](#) for the data format).

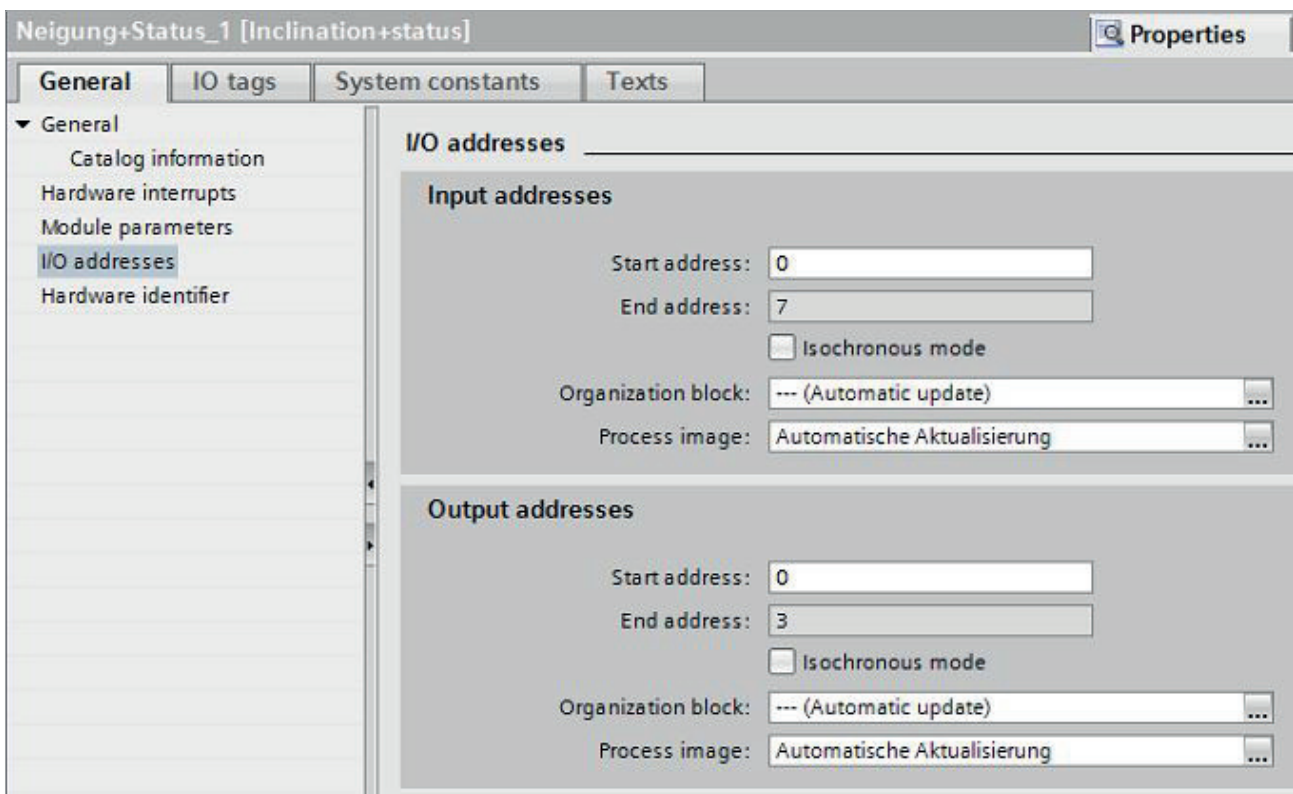


Fig.: 8

4.1.6.2 Parameterising the inclination sensor

The inclination sensor's parameters can be changed in the "Module parameters" tab. An explanation of the parameters can be found in [Chapter 6](#).

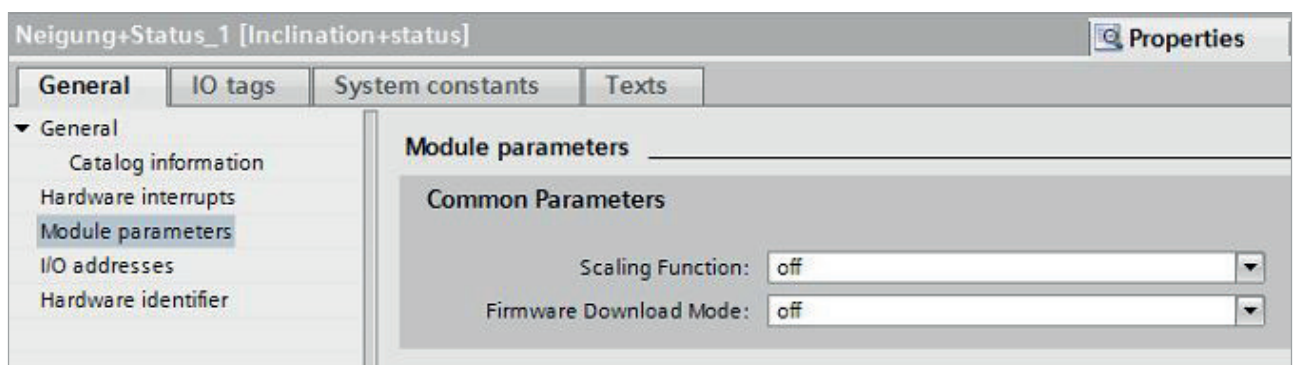


Fig.: 9

4.1.7 Planning of "Device exchange without programming device" and "Automatic commissioning"

If system restarting without the assignment of a new device name or the IP address is to be possible following the exchange of an installed sensor with a mint condition device, this must be taken into consideration during project planning. This also applies to "Automatic commissioning", in which the manual and, in the case of larger projects, time-consuming assignment of the device name (as described in Chapter 4.1.8) is avoided during commissioning.

The following prerequisites have to be met:

- The controller and the devices must support the function "Device exchange without interchangeable medium or programming device" (for the latter, at least the device itself and its neighbouring devices). The NBT supports this function.
- The function "Device exchange without interchangeable medium" must be activated in the controller. This is the default setting.
- The devices must be in delivery condition, i.e. they must not yet possess any device name.

Now call the topology editor using the PROFINET system's context menu and define all PROFINET connections between the subscribers.

If the project is now loaded into the control system and the actual structure corresponds to the planned topology, all subscribers receive their planned names from the controller and device exchange succeeds without the reassignment of the device name.

4.1.8 Assignment of the device name

If a PROFINET topology has not been defined as described in Chapter 4.1.7 or if the prerequisites for automatic commissioning are not met, the inclination sensor name must be assigned manually. With the inclination sensor connected and the programming device connected to the control system, select "Assign device name" in the context menu of the PROFINET.

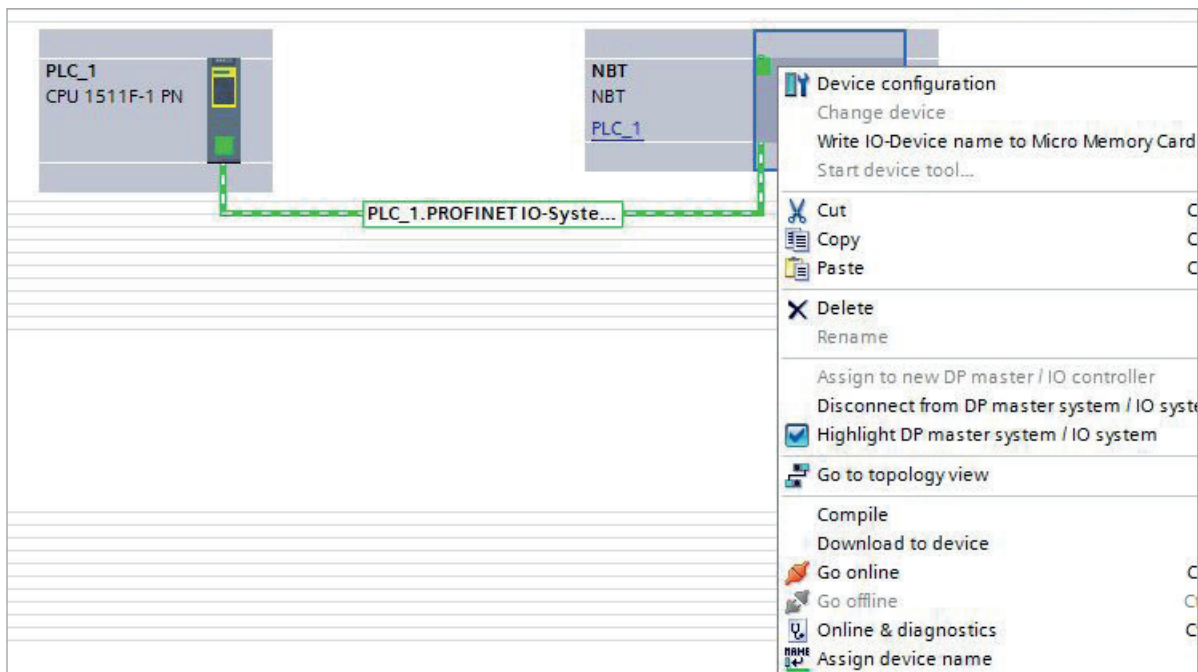


Fig.: 10

Subsequently the window "Assign PROFINET device name" appears. After selecting the correct online connection the accessible devices will be displayed. This for example could look like shown in figure 11.

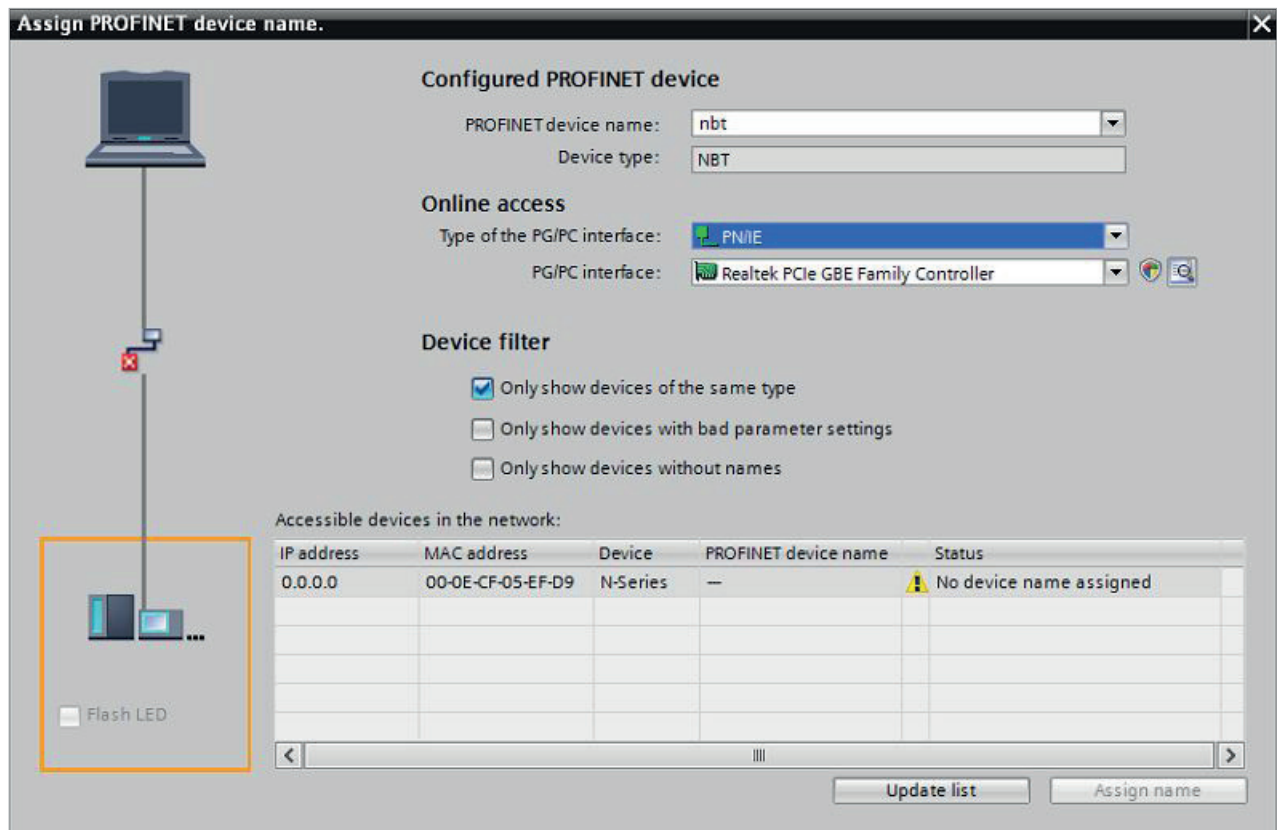


Fig.: 11

It can be seen that the inclination sensor device type "N series" does not possess either a valid IP address or a name. Now mark the sensor, check the name proposed at the top of the window and click on "assign name." The device name is then stored in the inclination sensor, where it is protected against zero voltage.

The inclination sensor now logs onto the controller with its device name and is then provided with a valid IP address by the controller. This is also stored in the inclination sensor, where it is protected against zero voltage.

4.1.9 Resetting to the factory settings

After going online the online diagnosis is available via the context menu of the NBT. Under "Functions" the function "Reset to factory settings" is available.

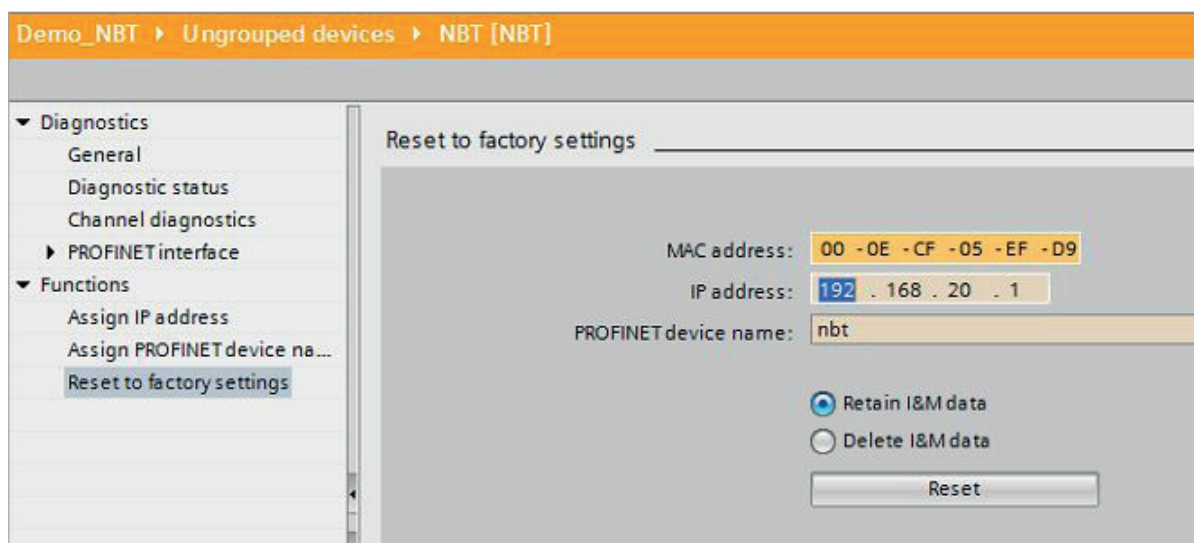


Fig.: 12

Project planning

The following data will be reset as follows:

The following are reset	delivery condition
Parameters	see Chapter 6.1 for default values
Device name	empty
IP-parameters	All 0
I&M0-revision counter	0
I&M1-3	empty (only when choosing "Delete I&M data")

After resetting, the connection to the Profinet controller is closed and the NS LED lights up red. After switching the voltage off/on, the connection can be re-established by assigning the device name.

If the connections have been defined using the topology editor, the NBT restarts automatically with the name assigned during project planning.

5. I/O data

5.1 Overview

Input data: Device -> Controller

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8
status word		position x axis		position y axis		position z axis	

Output data: Controller -> Device

Octet 1	Octet 2	Octet 3	Octet 4
control word		preset value	

5.2 Input data

5.2.1 Status word

The status word contains error bits which have to be evaluated in the user program of the PLC.

Octet 1								Octet 2							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit status word															

Bit	Name	Remarks/remedy
0	Out of range	The position is out of range or the cross tilt is too high
1	Position not valid	Because of too high interference accelerations the position value is not valid
2	Error_preset	Error when setting the preset value. The preset value must not deviate more than $\pm 5^\circ$ from the actual raw position.
3 - 15	not used	

5.2.2 Position data

The NBT has a 3 axis MEMS sensor. But only 2 of these can be output. The value of third axis is always 0. Which axis is used for a measuring task is selected via the order code.

The inclination value is output as a 16 bit signed integer value in Motorola format (Big Endian) for each axis. The resolution is $0,01^\circ$.

Octet 3,5,7								Octet 4,6,8							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inclination of axis x,y,z in $0,01^\circ$															

5.3 Output data

5.3.1 Control word

Octet 1								Octet 2							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16 bit control word															

Bit	Name	Remarks
0	Set_Preset_X	Sets the x axis to the preset value. The preset value is accepted with the raising edge of the signal.
1	Set_Preset_Y	Sets the y axis to the preset value. The preset value is accepted with the raising edge of the signal.
2	Set_Preset_Z	Sets the z axis to the preset value. The preset value is accepted with the raising edge of the signal.
3 - 15	not used	

5.3.2 Preset value

Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
preset value															

To adapt the inclination sensor to the mounting conditions the measured value can be adjusted by $\pm 5^\circ$. For this purpose the preset value has to be transferred in the output octets 3 and 4. Afterwards or at the same time the preset bit (Set_Preset_X/Y/Z) has to be set in the control word. The preset value is accepted with the raising edge of the control bit.

The preset setting is only possible when the scaling function is switched to on (see [chapter 6](#)).

The preset value has to be entered as a 16 bit signed integer value in Motorola format (Big-Endian). The resolution is the same as the resolution of the position value $0,01^\circ$.

Example:

	<u>output value</u>	<u>angle</u>	<u>deviation from raw value</u>
Situation after installation	-147	-1,47°	0°
After preset setting with preset value 200	200	2,00°	3,47°

6. Parameterisation

Parameterisation of the inclination sensor is carried out using the acyclical PROFINET services. In the case of the Simatic S7 control system, this is carried out during starting as default.

Attention: Never change the parameterisation whilst a system or machine is in operation! A complete function test has to be performed after each parameter change before returning to normal operation.

Record index	Data set
0xBF02	Inclination sensor parameter

6.1 Inclination sensor parameter

6.1.1 Overview

Byte	Data type	Designation	Default
1	BYTE	Operating mode	0x0

6.1.2 Description of the inclination sensor parameters

Byte	Bit No.	Parameter	Value range	Default	Remark
1	0-2	not used			
	3	Scaling	off, on	off	Switches on the scaling function of the axis. Preset setting is only possible when scaling is on. By switching of the scaling, the preset respectively the offset value will be deleted.
	4-6	not used			
	7	FW download mode	off, on	off	Sets the sensor in the firmware download mode. Afterwards the sensor waits for the transfer of the new firmware via the Profinet interface.

7. Diagnostic

7.1 Overview

The inclination sensor NBT provides diagnostic data in 3 different ways.

- LEDs (see [Chapter 3.4](#))
- PROFINET alarms (see Chapter 7.2)
- Diagnostic data (see Chapter 7.3)

7.2 PROFINET alarms

The following alarms are send via the PROFINET alarm mechanism. In the PROFINET controler they are displayed in plain text and partially with a help text.

Erro no. (hex)	Error text	Reaction	Status-LED (NS)	Remarks/remedy
0x001A	Internal communication error (TPS-1)			Please switch power off/on or change the device
0x1100	Device error		fast red flashing (10 Hz)	Please switch power off/on or change the device.
0x1150	Supply voltage out of range		red flashing (1 Hz)	Please check the supply voltage and switch power supply off/on.
0x1160	Wrong Record Index on startup		red flashing (1 Hz)	Please check your GSD file.
0x1170	Sensor not ready		red flashing (1 Hz)	Please switch power off/on or change the device.
0x1180	Preset error	Status word: Error_preset	red flashing (1 Hz)	The Preset Value has to be in the range of $\pm 5^\circ$ around the actual position of the axis. In the module parameters Scaling has to be switched to on. It is not allowed to set two axis at the same time.

7.3 Diagnostic data records

The following diagnostic records are available in the NBT. They can be read out with the PROFINET acyclic read services

Record index	Data set
0xAFF0	I&M0 data (according to I&M-specification version 1.2 /9/)
0xBF02	Parameter data (see Chapter 6)

8. Scope of delivery

The scope of delivery includes: - Inclination sensor with PROFINET interface
- Connection assignment TY XXXXX (depending on the device variant)

Available for download on www.twk.de are:

- the corresponding datasheet
- this user manual
- the certificates
- GSD file and bitmap

9. Literature

- /1/ PROFIsafe-Profile for Safety Technology, Order No. 3.092 und 3.192, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /2/ PROFINET - Interface nach IEC 61158 / 61784 bzw. PNO-Spezifikation, Order No. 2.712 und 2.722, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /3/ PROFINET Installation guideline, Order No. 8.071, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /4/ PROFINET Cabling and Interconnection Technology, Order No.: 2.252, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /5/ Installation Guideline PROFINET Part2: Network Components, Order No.: 2.252 p2, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /6/ PROFIsafe - Environmental Requirements related to PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO (IEC 61784-3-3), Order No. 2.232, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
- /7/ SIMATIC Safety - Project Planning and Programming (A5E02714440-AC) - <http://support.automation.siemens.com>
- /8/ SIMATIC Safety - Getting Started (A5E02714463-01) - <http://support.automation.siemens.com>
- /9/ Profile Guidelines Part 1: Identification & Maintenance Functions, Order No. 3.502, www.profibus.com