SUPREME SENSORING

TWK

Rotor hub sensor
Model NBT-D/S3
Interface: PROFIsafe/PROFINET

Document no.:
NBT 15982 BE
14.10.2024

USER MANUAL

PROFIsafe

PROFINET

SIL2 IEC 61508 FUNCTIONAL SAFETY SENSOR

PLd ISO 13849 FUNCTIONAL SAFETY SENSOR

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SAFETY INSTRUCTIONS

1. SAFETY INSTRUCTIONS

1.1 Scope

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

- NBT90-A360/0/0DS3-4-xxTxx
- NBT90-A0/360/0DS3-1-xxTxx
- NBT90-A0/0/360DS3-1-xxTxx

1.2 Documentation

The following documents must be observed:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number NBT15981
- The connection assignment TYxxxxx 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.

GENERAL INFORMATION

2. GENERAL INFORMATION

2.1 Description of functionality

The rotor hub sensor can detect position (0° - 360°) and speed of a continuously rotating shaft at moderate speeds up to 30 rpm. It behaves like a rotary encoder with a speed signal. Digital processing and predictive filter techniques yield a robust 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 and can be used as an alternative even in safety critical applications.

The sensor is based on our NBT inclinometer model series. In addition to the MEMS accelerometer, a MEMS gyroscope is used to precisely determine the angular velocity and rotation rate with a high refresh rate. The signals from the two sensors are also used to cross-check their functionality. This enhances the safety of the speed signals to SIL2 and PLd level without the need for redundant sensors.

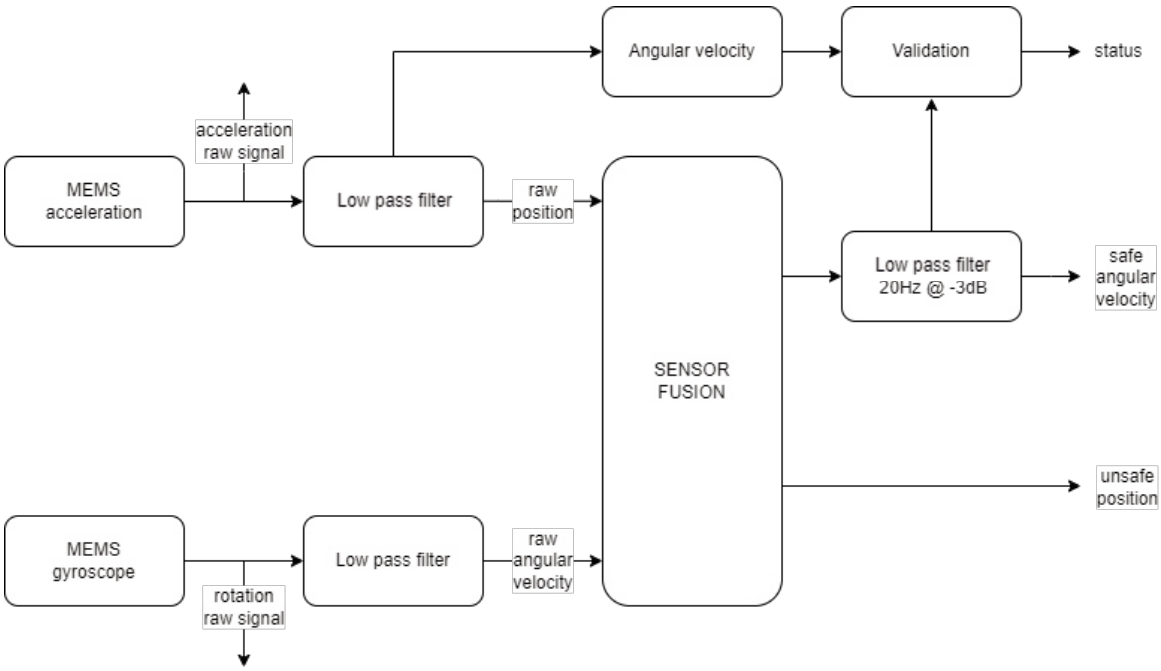
The sensor does not have to be positioned in the centre of the axis of rotation. The eccentricity is automatically determined by the sensor and used to correct the signal to gain a accurate position and speed signal for the shaft.

The six raw output signals of the sensors are available through a standard PROFINET module. The combined speed and position signal of the rotor hub are provided to the user via a PROFIsafe as well as a standard PROFINET module (see I/O data below).

The PROFINET interface according to IEC 61158 / 61784 or PNO specifications, order Nos. 2.712 and 2.722 version 2.44, and the PROFIsafe protocol according to "PROFIsafe – Profile for Safety Technology on PROFIBUS DP and PROFINET IO", order Nos. 3.092 and 3.192 version 2.4 and 2.6, are integrated.

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

Block diagram



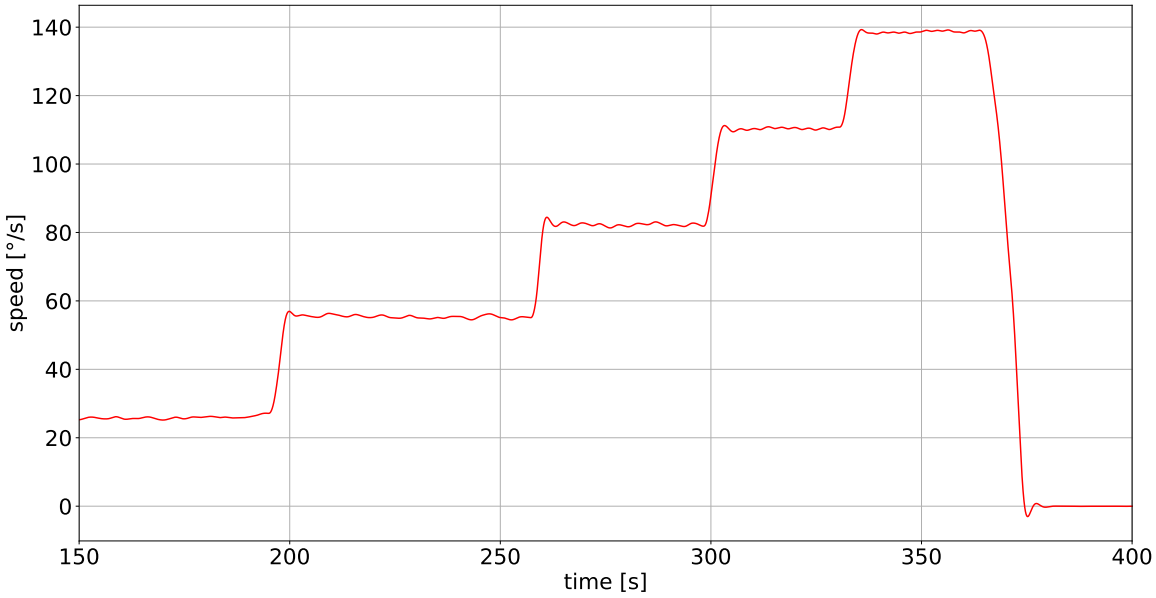
Functional diagram of the NBT rotor hub sensor. The MEMS gyroscope directly measures the angular velocity of the sensor. The accelerometer determines the position of the sensor. The change of the position signal is used to gain an independent measure of the sensor's angular velocity. Both signals are combined in a sensor fusion filter to yield a precise and robust value for the angular velocity and the position. The velocity is continuously checked for consistency, leading to an output signal which fulfils functional safety requirements without the need for redundant components. All filters can be adapted individually to the customers application.

GENERAL INFORMATION

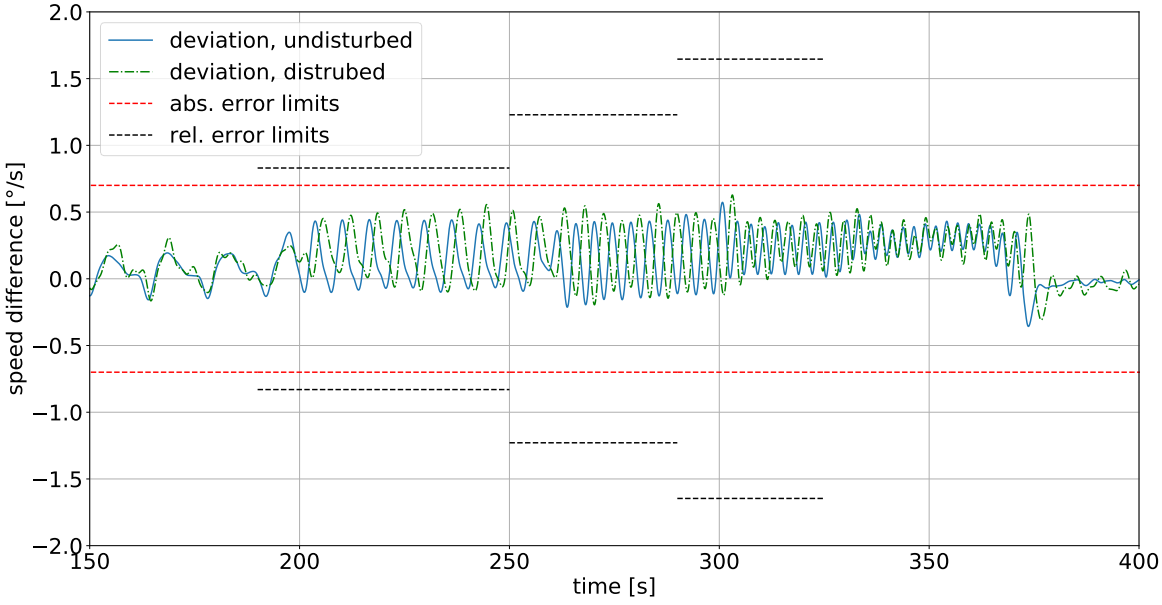
2.2 Performance testing

2.2.1 Measurements on test stand

The performance of the sensor was measured by comparing its output signal with the speed output of a high resolution magnetic rotation sensor mounted at the axis of the test setup. The test setup was run at several different speeds between 3.3 and 23 rpm (20 to 140 °/s). The speed profile is shown below:

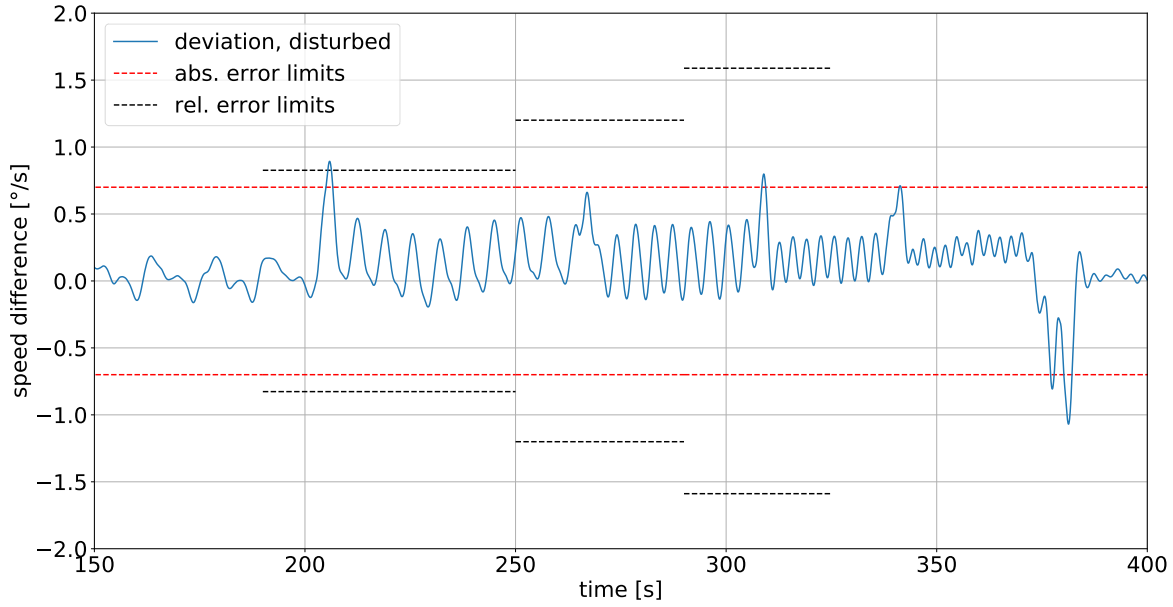


The difference of the two signals is used to estimate the accuracy of the sensor. The graph below shows the speed difference for an undisturbed rotation of the test stand and for a rotation where the test stand was disturbed by oscillations parallel to the rotation axis (“tower oscillations”, approx 1 m/s²). Additionally, structure borne noise (>1kHz) was induced by hammer strokes. In both cases the error signal (speed difference) stays well within the error limits of 0.7 °/s for low speeds (< 7.5 rpm) and 1.5 % for larger speeds (≥ 7.5 rpm) stated in the data sheet 15981.



GENERAL INFORMATION

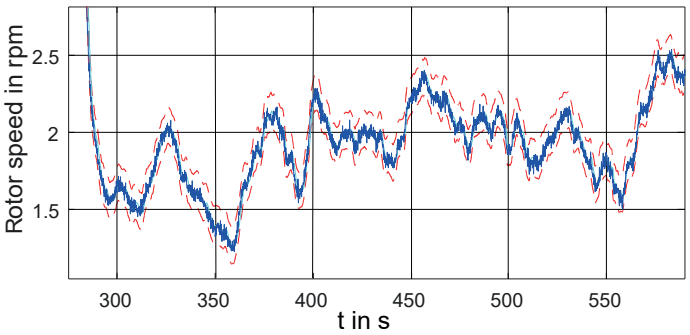
The system has also been tested in the presence of oscillations normal to the rotation axis in the horizontal plane. The speed profile for this test is identical to the one previously shown. Normal oscillations of 2 m/s² at a frequency of 0.33 Hz were added to the rotation. After a short reaction period after a sudden speed change the error signal again stays well within the specified limit. Residual oscillations are due to differences in the signal processing time of the two sensors.

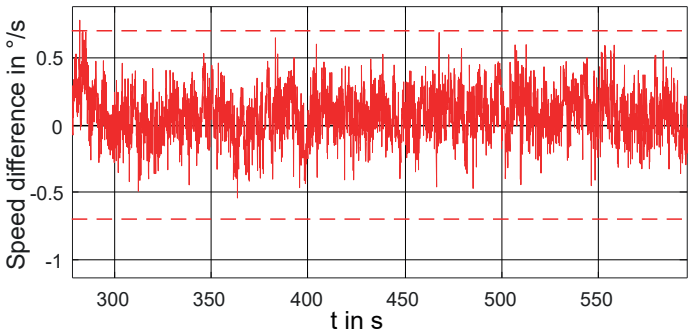


2.2.2 Performance on wind turbine

The measurement accuracy of the NBT-D/S3 sensor is demonstrated by measurements on a wind turbine with a rotor diameter of about 140 metres during normal operation. The following graphs show the measurement signal of the rotor hub sensor and the difference of the measured speed to the speed measured by a magnetic rotary encoder.

Slow rotation



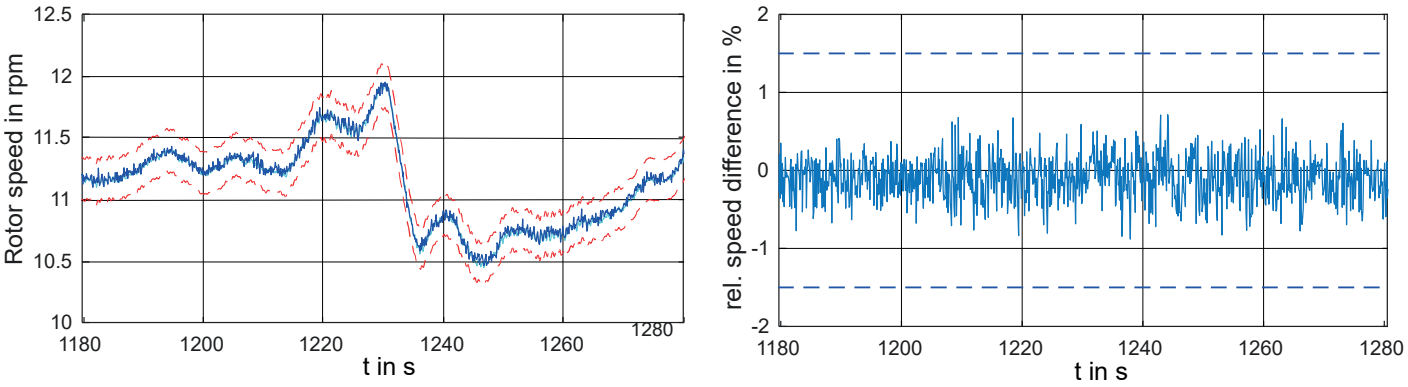


Left: Measured speed at approx 2 rpm (slow rotation). The dark blue line indicates the signal of the rotor hub sensor NBT-D/S3, the light blue line (behind the dark blue one) shows measurements with a magnetic rotary encoder. The red dashed lines show the error limits given in the data sheet 15981.

Right: Absolute difference between rotor hub sensor signal and magnetic encoder measurements. The red dashed lines indicate the error limit for slow rotations (< 7.5 rpm) of ±0.7 °/s .

GENERAL INFORMATION

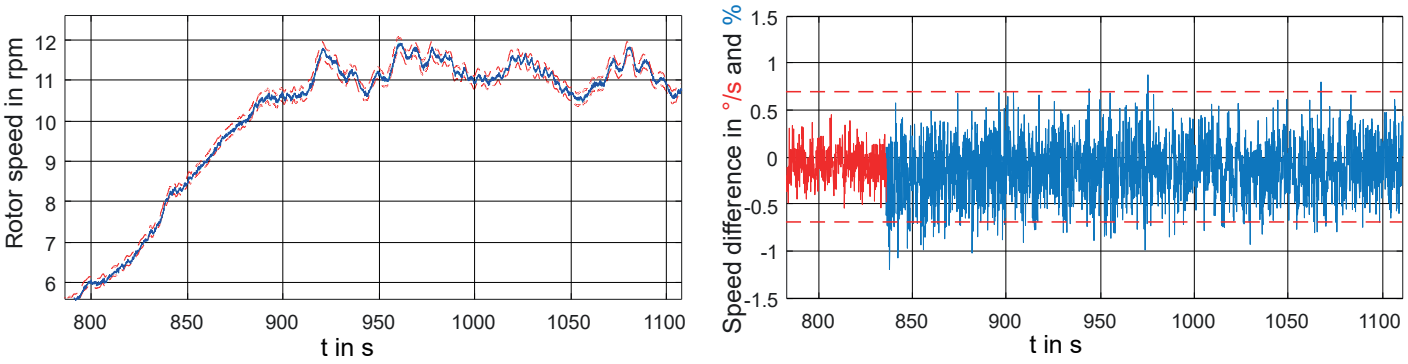
Fast rotation



Left: Measured speed at approx 11 rpm (fast rotation). The dark blue line indicates the signal of the rotor hub sensor NBT-D/S3, the light blue line (behind the dark blue one) shows the measurements with a magnetic rotary encoder. The red dashed lines indicate the error limits given in the data sheet 15981.

Right: Relative difference between rotor hub sensor signal and magnetic encoder measurements. The blue dashed lines indicate the error limit for fast rotations (≥ 7.5 rpm) of ±1.5 %.

Ramp up



Left: Measured speed during ramp up. The dark blue line indicates the speed measured by the rotor hub sensor NBT-D/S3, the light blue line (behind the dark blue one) shows the measurements with a magnetic rotary encoder. The red dashed lines show the error limits stated in this data sheet.

Right: Difference between rotor hub sensor signal and magnetic encoder measurements. The red dashed line indicates the error limits (±0.7 °/s) for low velocities and is valid for the red curve. For higher speeds (≥ 7.5rpm) the speed difference is given in relative units (blue curve). The state error limit of ±1.5 % coincides with the upper/lower boarder of the frame.

INSTALLATION

3. INSTALLATION

3.1 General information

- During installation, observe the PROFINET assembly guideline PNO order No.: 8.071 /3/ and the PROFIsafe Environmental Requirements related to PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO /6/.
- 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 sensor NBT-D/S3 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.
- Shared device functionally is supported from firmware version 3.1.0.
- The setting of addresses, the baud rate or terminating resistors on the device is not necessary.

3.2 Installation

For safety reason the mechanical installation of the NBT360/S3 has to be done in such a way, that an accidental displacement of the device is not possible.This means that a form-locked installation has to be done.

3.3 Electrical connection

The sensors "NBT...DS3…Txx" 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. Only use shielded cable for power supply and PROFINET.

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. 15981 for connector assignment and ordering information.

INSTALLATION

3.4 Status LEDs

The rotor hub 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 OK but no connection to a PROFINET controller
			red, slow flashing	Firmware download mode
			red flashing	See chapter 7.2
			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-D/S3.

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 rotor hub sensor into a project planning tool are available in the internet under www.twk.de.

File name of the GSD file: GSDML-V2.44-TWK-NBT-D-S3-20240710.xml
File name of the bitmap: . . . . . GSDML-0159-8100-TWK_NBTS.bmp
(Version and date may vary depending on the status of the GSD file)

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

PROJECT PLANNING

4. PROJECT PLANNING WITH SIMATIC STEP7

4.1 Step7, Safety Advance - TIA-Portal

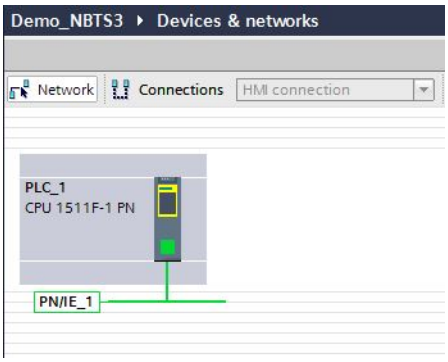
This chapter explains the procedure for integrating the TWK NBT-D-S3 rotor hub sensor into the PROFINET network of a Siemens S7 control system with Step 7 Professional V18 and Safety Advanced V18.

4.1.1 Prerequisites

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

This is shown here using the example of a CPU1511F:

Fig.: 1

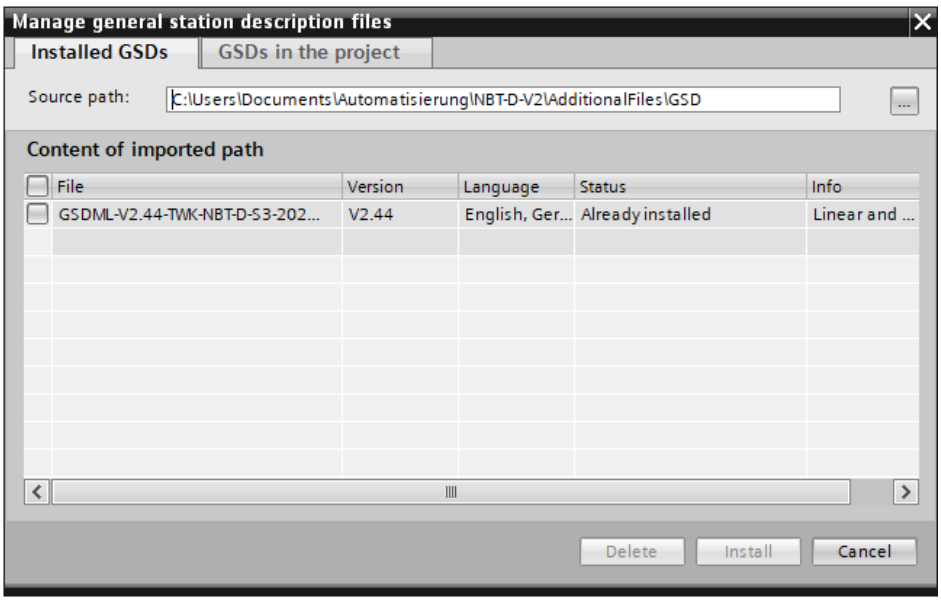


4.1.2 Installation of the GSD file

- 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.

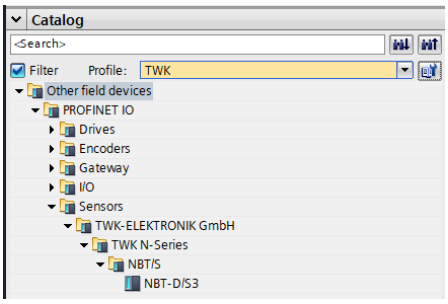
Fig.: 2



PROJECT PLANNING

After installing the GSD file, the hardware catalogue is automatically updated. The rotor hub sensor NBT-D/S3 is located in: **Other field devices, PROFINET IO, Sensors, TWK-ELEKTRONIK GmbH, TWK N-Series, NBT-D/S3.**

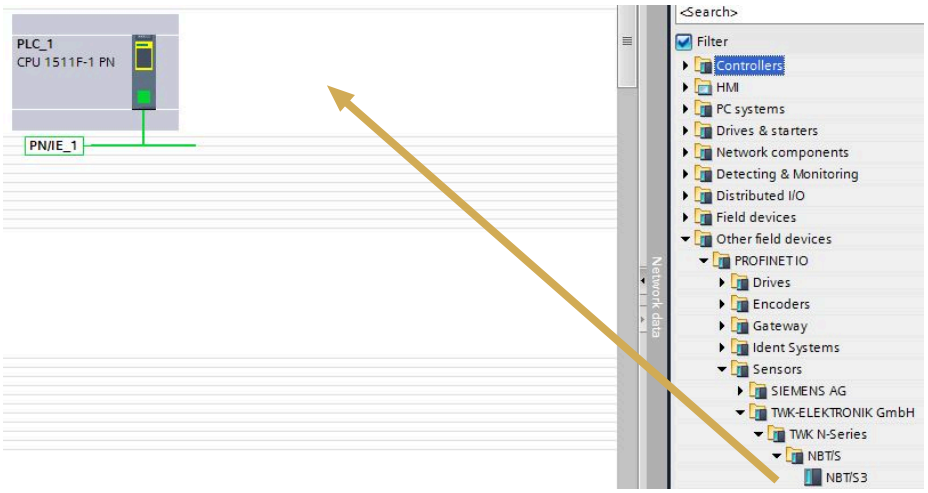
Fig.: 3



4.1.3 Installing the rotor hub sensor

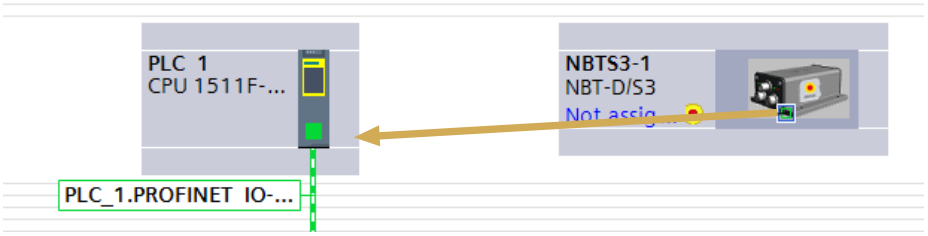
Now drag the NBT-D/S3 from the hardware catalog in the netview of your project.

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

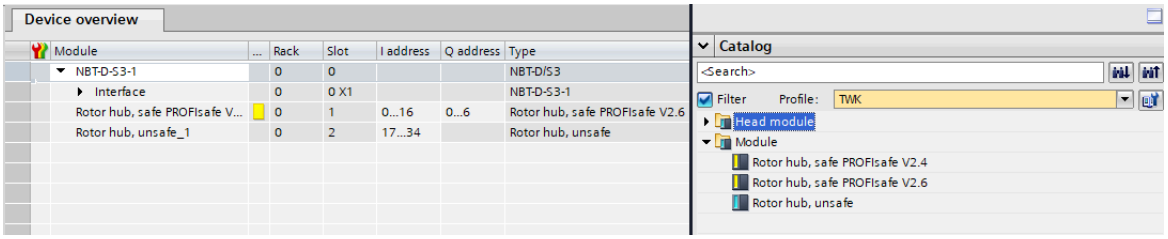


PROJECT PLANNING

4.1.4 Installing modules

The sensor includes a safe and and unsafe module. To install a module, change to **Device view** and drag the appropriate module to the first free slot of the module list.

Fig.: 6

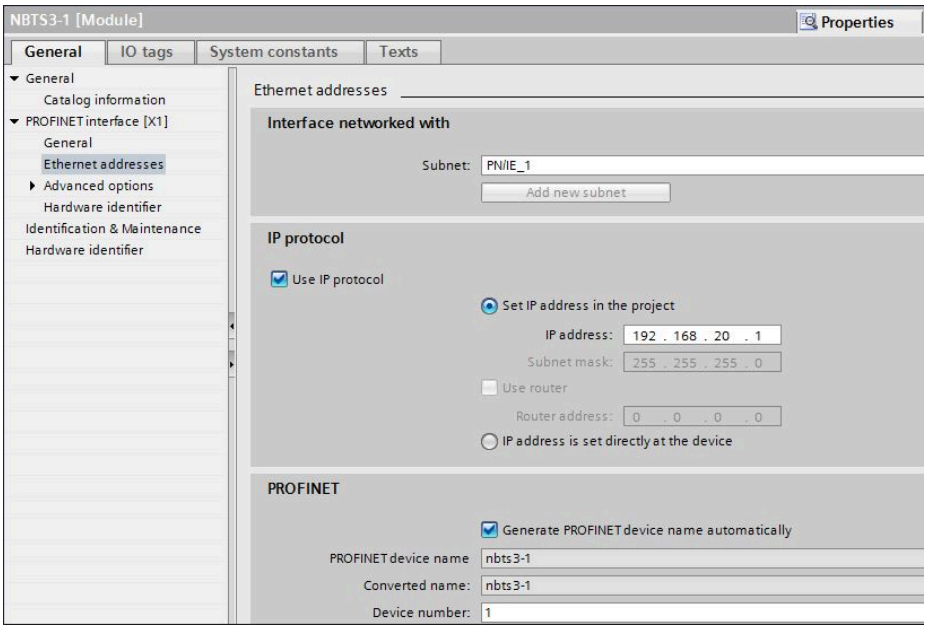


In the properties of the installed module we will set the I/O address and the sensor parameters later on.

4.1.5 Setting the network data

Select the rotor hub sensor in the Device view to show the properties of the PROFINET interface of the NBT-D/S3.

Fig.: 7



PROJECT PLANNING

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 NBTS3-1.

In the NBT-D/S3, the **PROFIsafe address** must be added to the PROFINET name. To do this, attach a number between 1 and 65,535 to the end (a special separator between the Profinet name and Profisafe address is not necessary). The attached number must then be entered for F_Dest_Add under the F parameters (see chapter 4.1.6.3).

The complete name assigned here must either be manually allocated to the rotor hub 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 rotor hub 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-D/S3 from power on until PROFINET I/O data exchange can be reduced from approx. 10s to 5s. However, this can only be achieved as of the second startup.

The NBT-D/S3 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-D/S3 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-D/S3 can be set. The possible values depend on the setting of the send clock of the CPU. The minimal update time for the NBT-D/S3 is 250 µs.

The desired real time class can be set under **Synchronisation**. The NBT-D/S3 supports the classes RT and IRT.

PROJECT PLANNING

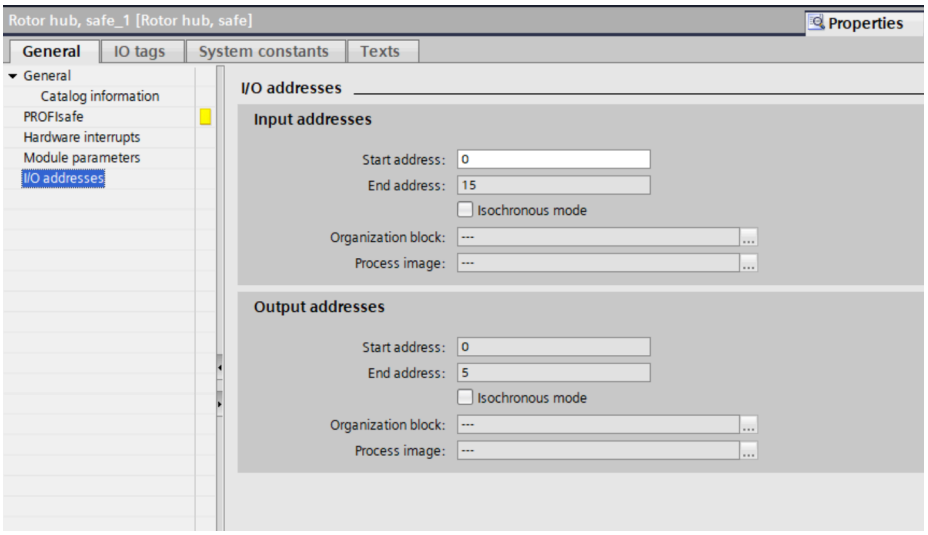
4.1.6 Setting up the rotor hub sensor

4.1.6.1 Setting the I/O address

After switching to the device view of the NBT-D/S3 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).

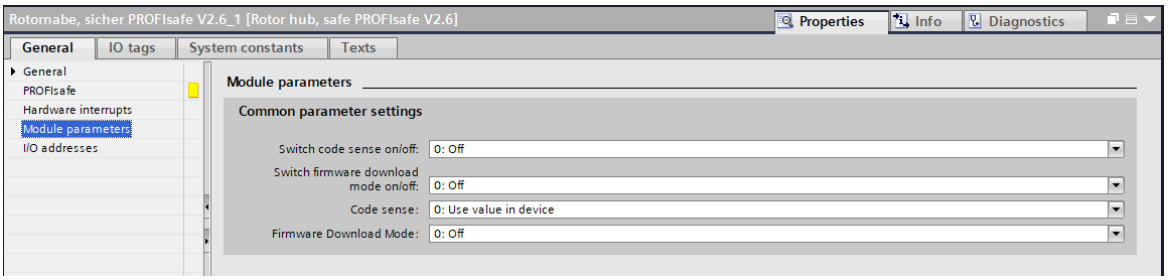
Fig.: 8



4.1.6.2 Parameterising the rotor hub sensor

The rotor hub sensor's parameters can be changed in the "Module parameters" tab. An explanation of the parameters can be found in chapter 6. After changing the sensor parameters the checksum has to be re-calculated and entered under the F-parameters (see next chapter).

Fig.: 9

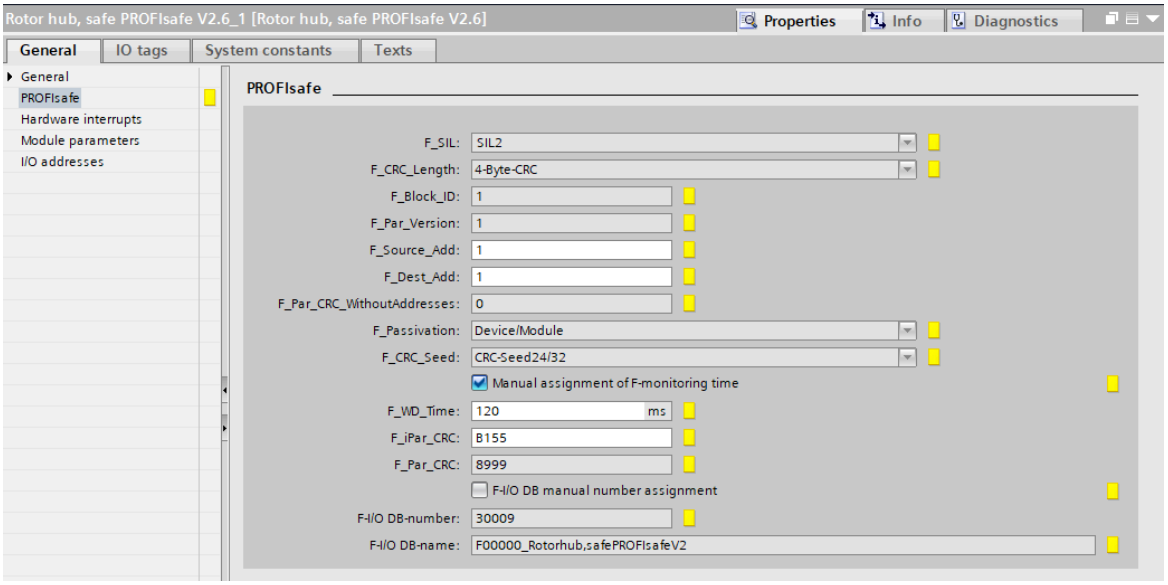


PROJECT PLANNING

4.1.6.3 Setting the F parameters

The F parameters must be set in the "PROFIsafe" tab. Here, you have to set the PROFIsafe address attached to the PROFINET name under "F_Dest_Add" and to specify a watchdog time corresponding to your system under "F_WD_Time" or you to take over the automatic setting. "F_Source_Add" is assigned automatically by the S7.

Fig.: 10



At the bottom of this window you can see the number and the symbolic name of the F-IO data block of this sensor assigned by Step7.

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-D/S3 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.

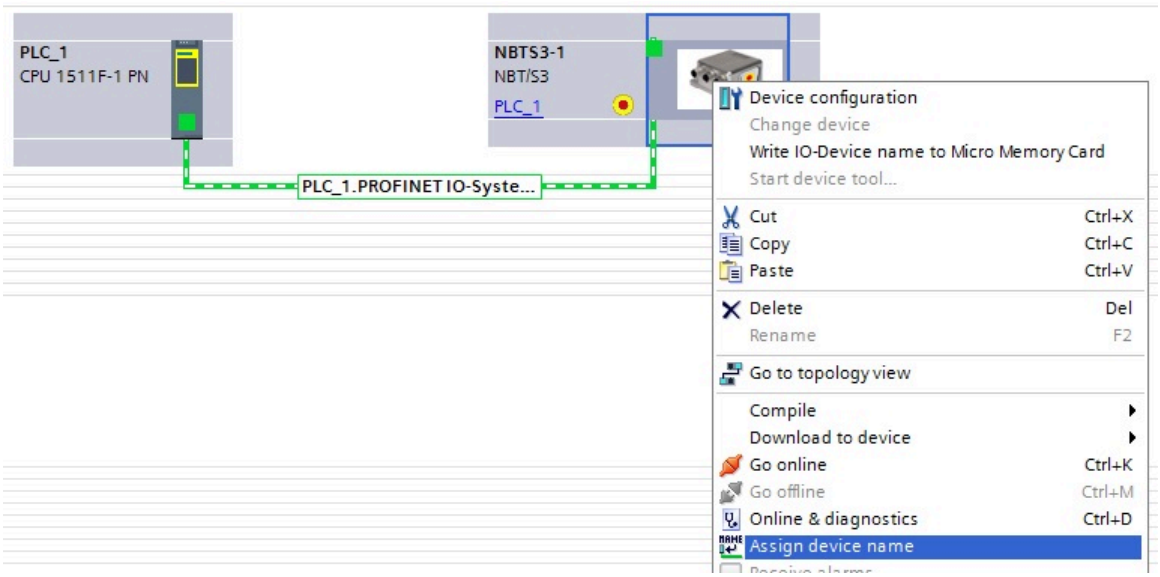
If the project is now loaded into the control system and the actual structure corresponds to the planned topology, all subscribers receive their planned names from the controller and device exchange succeeds without the reassignment of the device name.

PROJECT PLANNING

4.1.8 Assignment of the device name

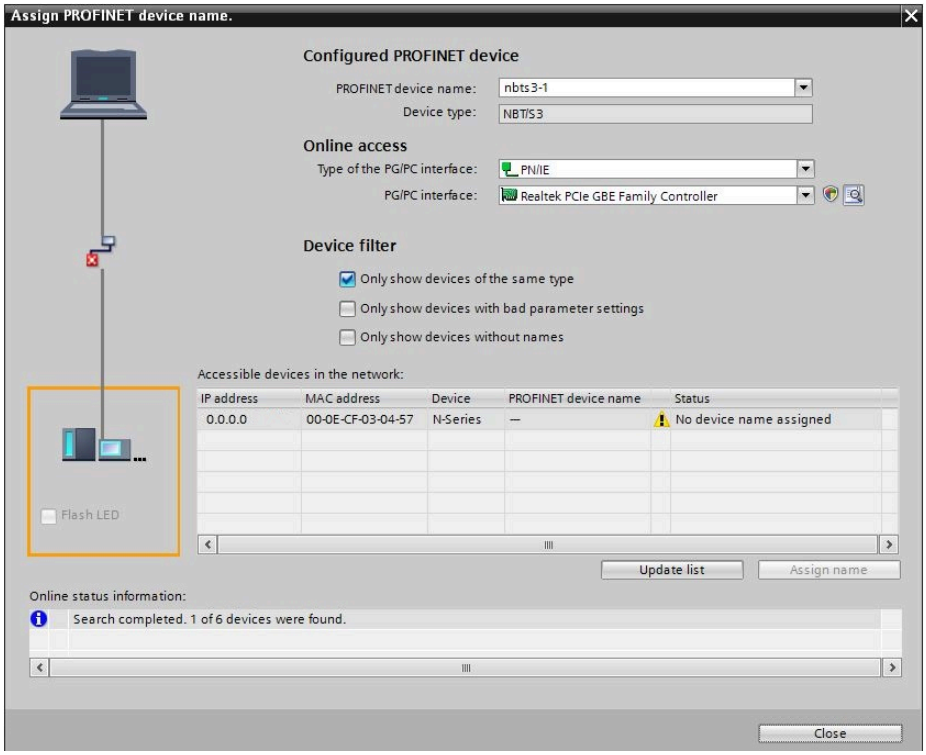
If a PROFINET topology has not been defined as described in chapter 4.1.7 or if the prerequisites for automatic commissioning are not met, the rotor hub sensor name must be assigned manually. With the rotor hub sensor connected and the programming device connected to the control system, select "Assign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

Fig.: 11



Subsequently the window "Assign PROFINET device name" appears (figure 12). After selecting the correct online connection the accessible devices will be displayed. This for example could look like shown in figure 11.

Fig.: 12



PROJECT PLANNING

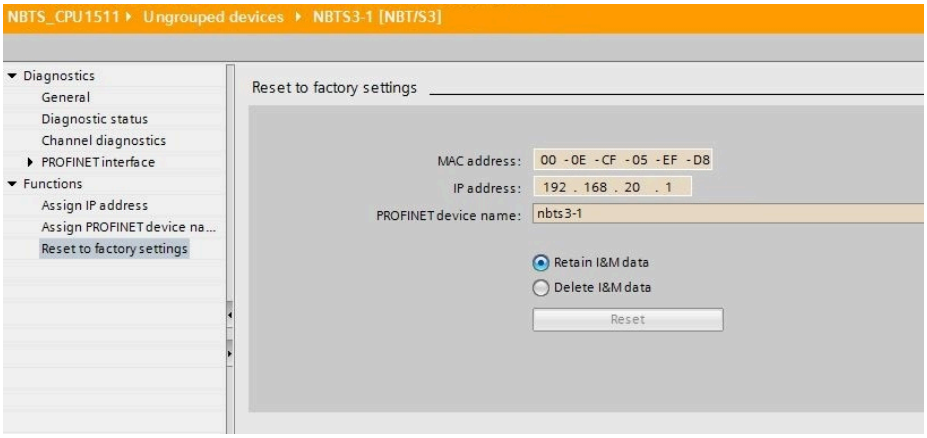
It can be seen that the rotor hub sensor device type "N series" does not possess either a valid IP address or a name. Now mark the sensor, check the name proposed at the top of the window and click on "assign name." The device name is then stored in the rotor hub sensor, where it is protected against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

The rotor hub 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 rotor hub 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-D/S3. Under "Functions" the function "Reset to factory settings" is available.

Fig.: 13



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-D/S3 restarts automatically with the name assigned during project planning.

PROJECT PLANNING

4.2 Application program

4.2.1 Remarks

For a detailed documentation for project planning and programming of F programs in Safety Advance refer to:

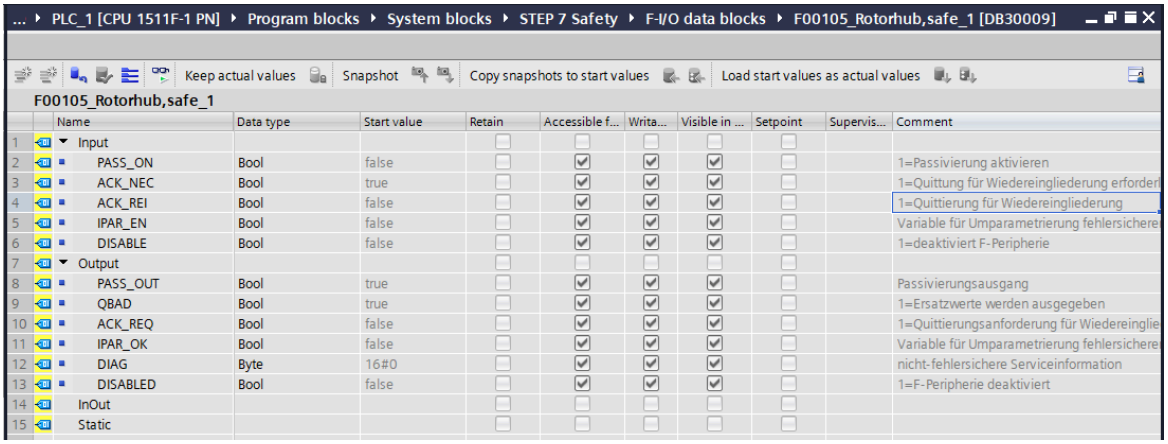
SIMATIC Safety - Project Planning and Programming /7/ and SIMATIC Safety Getting Started /8/

4.2.2 F periphery DB

On translation of the hardware configuration, an **F periphery DB** is generated for the rotor hub sensor, as for each other PROFIsafe subscriber. The automatically generated name consists of the I/O address and the module name.

The F periphery DB contains the for the operation of the sensor necessary variables. It has the following appearance: (A detailed description can be found in the documentation mentioned above)

Fig.: 14



	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Supervis...	Comment
1	Input									
2	PASS_ON	Bool	false		☑	☑	☑			1=Passivierung aktivieren
3	ACK_NEC	Bool	true		☑	☑	☑			1=Quittung für Wiedereingliederung erforderl
4	ACK_REI	Bool	false		☑	☑	☑			1=Quittierung für Wiedereingliederung
5	IPAR_EN	Bool	false		☑	☑	☑			Variable für Umparametrierung fehlersichere
6	DISABLE	Bool	false		☑	☑	☑			1=deaktiviert F-Peripherie
7	Output									
8	PASS_OUT	Bool	true		☑	☑	☑			Passivierungsausgang
9	QBAD	Bool	true		☑	☑	☑			1=Ersatzwerte werden ausgegeben
10	ACK_REQ	Bool	false		☑	☑	☑			1=Quittierungsanforderung für Wiedereinglie
11	IPAR_OK	Bool	false		☑	☑	☑			Variable für Umparametrierung fehlersichere
12	DIAG	Byte	16#0		☑	☑	☑			nicht-fehlersichere Serviceinformation
13	DISABLED	Bool	false		☑	☑	☑			1=F-Peripherie deaktiviert
14	InOut									
15	Static									

4.2.3 Accessing the rotor hub sensor in the F program

Important for the fail safe operation of the rotor hub sensor are: reintegration after communication or F periphery errors by the variables „ACK_REQ“ and "ACK_REI" or "ACK_GL", evaluation of the failsafe status by the variable "QBAD" and the evaluation of the diagnostic data by the variable "DIAG". All mentioned variables are provided by the F periphery DB. An example can be found in the following example program.

PROJECT PLANNING

4.2.4 Example program

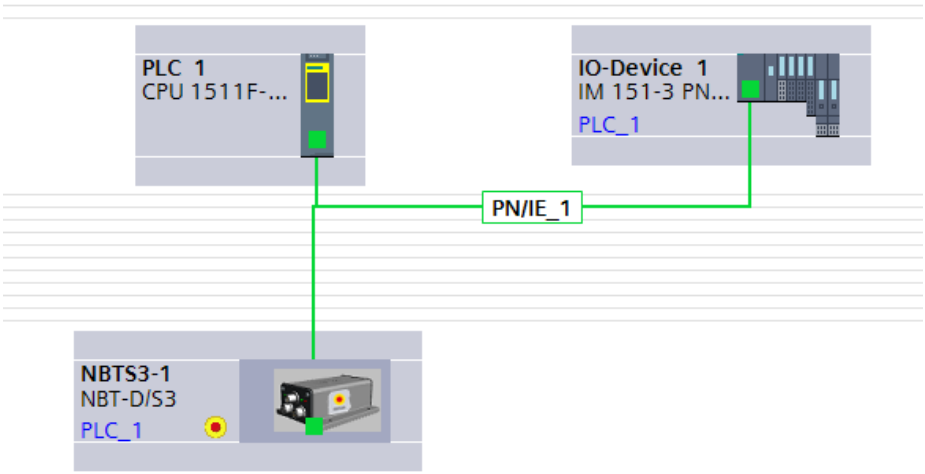
The following example shows how to access the angular velocity (speed) value and the F periphery DB of the PROFIsafe rotor hub sensor in the safety programme. Only the programming steps which refer to the TWK rotor hub sensor are shown here. Knowledge regarding the programming and sequence of the failsafe S7 programme is assumed. As an introduction to failsafe programming, we recommend "SIMATIC Safety - Project Planning and Programming " /7/ and "SIMATIC Safety Getting Started" /8/

Devices required to operate the example program

- F CPU with PROFINET interface
- PROFIsafe rotor hub sensor NBT-D/S3
- Optionally one digital input for the acknowledge and two digital outputs to monitor the acknowledge request and the failsafe status (here realized with a ET200S with IM151-3PN)
- Step 7 Professional V13 with Safety Advanced

Hardware structure of the example program

Fig.: 15



Inputs and outputs used in the program

IW	0	rotor hub sensor status word
IW	10	Speed (safe module)
I	35.0	Acknowledgement and reintegration
I	35.1	User action
QW	0	rotor hub sensor control word
Q	35.0	Acknowledgement requested
Q	35.1	Failsafe status
Q	35.3	Speed limit exceeded

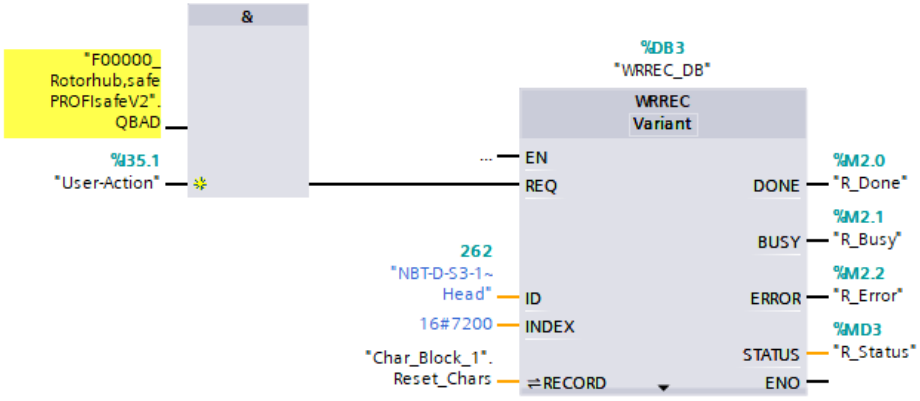
Remarks to the program

Access to the rotor hub sensor is carried out in an F programme module (here FB1), which must be called up in F-runtime group. Calling the FB1 is not described here.

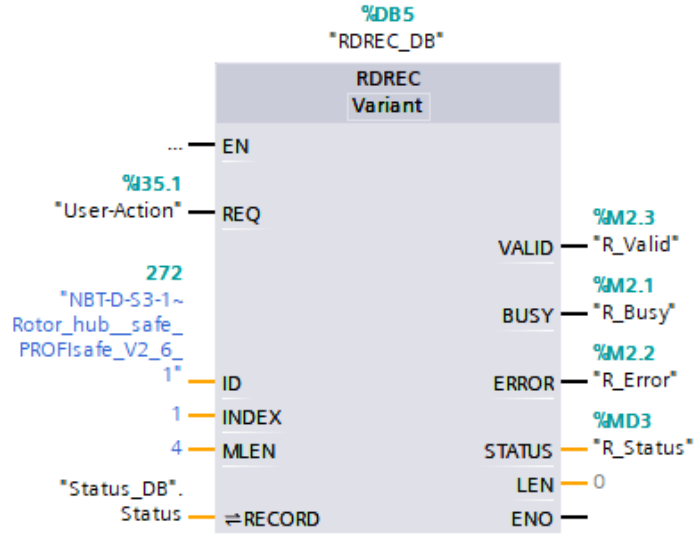
The following listing contains only the for the handling of the rotor hub sensor relevant part. Program blocks like clock OBs or peripheral data blocks are not listed.

PROJECT PLANNING

Example 1: Reset the sensor after a device error

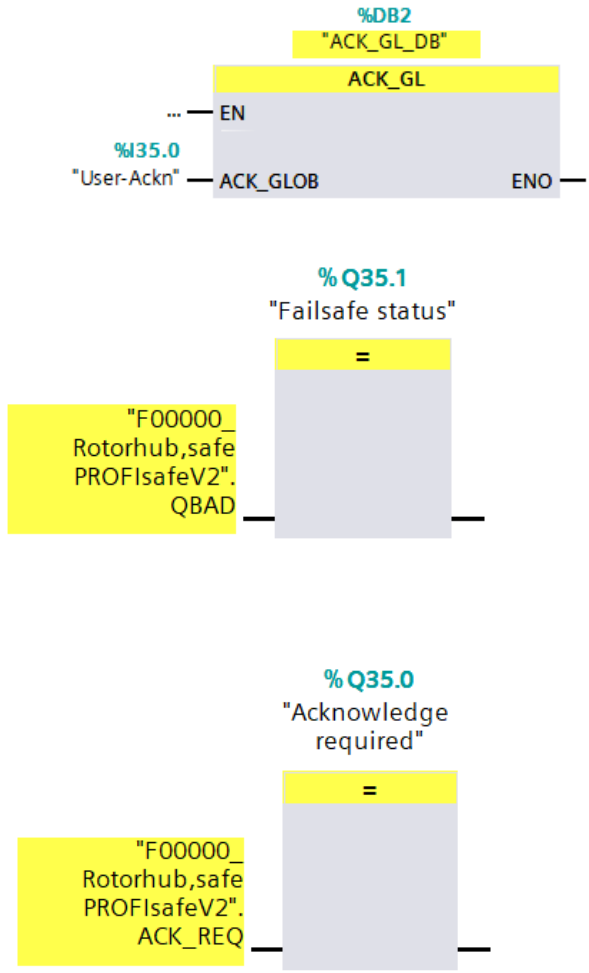


Example 2: Read the status word from safe module

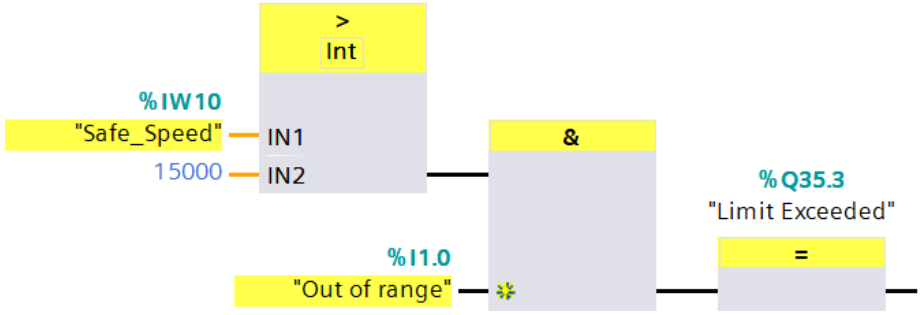


PROJECT PLANNING

Safety Examples 1-3: Acknowledge and reading QBAD



Safety Example 4: Evaluation of the rotor hub speed value



I/O DATA

5. I/O DATA

5.1 Overview

Module „Rotor hub, safe“

Input data: Device → Controller

Octet															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
status word		Acceleration x axis (currently always 0)		Acceleration y axis (currently always 0)		Acceleration z axis (currently always 0)		Position (currently always 0)		Speed		F data			

Output data: Controller → Device

Octet					
1	2	3	4	5	6
control word		F data			

Module „Rotor hub, unsafe“

Input data: Device → Controller

Octet																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
status word		Acceleration x axis		Acceleration y axis		Acceleration z axis		Rotation rate x axis		Rotation rate y axis		Rotation rate z axis		Position		Speed	

5.2 Input data

Module „Rotor hub, safe“

Signal	No. of Bytes	Data type	Scaling
Status word	2	Word	See below
Acceleration x axis	2	Integer	2700 digit / g (raw value, unsafe)
Acceleration y axis	2	Integer	2700 digit / g (raw value, unsafe)
Acceleration z axis	2	Integer	2700 digit / g (raw value, unsafe)
Position	2	Integer	0.01° / digit (unsafe)
Safe Speed	2	Integer	0.01 °/s / digit (safe)
F data	4	Word	According to PROFIsafe specification

I/O DATA

Module „Rotor hub, unsafe“

Signal	No. of Bytes	Data type	Scaling
Status word	2	Word	See below
Acceleration x axis	2	Integer	2700 digit / g (raw value)
Acceleration y axis	2	Integer	2700 digit / g (raw value)
Acceleration z axis	2	Integer	2700 digit / g (raw value)
Rotation rate x axis	2	Integer	8.75 millidegree / s / digit (raw value)
Rotation rate y axis	2	Integer	8.75 millidegree / s / digit (raw value)
Rotation rate z axis	2	Integer	8.75 millidegree / s / digit (raw value)
Position	2	Unsigned integer	0.01° / digit
Speed	2	Integer	0.01° / s / digit

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															

Byte	Name	Remarks/remedy
0	Out of range	The rotation rate is too high
1	Position not valid	Not used
2	reserved	
3	Synchronisation monitor failure	Synchronisation monitor has caused the device to go into a safe state. If this is only due to a temporary external disturbance, device can be reseted to leave the safe state (see …)
4	Device error	Restart device. If error persits device needs to be exchanged
5	Supply voltage out of range	Check supply voltage

I/O DATA

5.2.2 Sensor data

The inclination / rotation values of the three axis and the position/speed signal are output as a 16 bit signed integer value in Motorola format (Big Endian). The resolution is described in the table above.

Octet n								Octet n+1							
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 x, y, z axis Rotation rate x, y, z axis Position Speed															

5.2.3 F input data

The 4-byte F input data consist of the 1-byte F status and the 3-byte CRC checksum. Their content is defined in the Profisafe profile /1/. The status of the F status bit must be evaluated in the F application program (see program example in chapter 4.2.4).

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 status word															

5.3.2 Module “Rotor hub, unsafe”

Currently there is no output data available from this module

5.3.3 F output data

The 4-byte F output data consist of 1 control byte and the 3-byte CRC checksum. Their content is defined in the PROFIsafe profile /1/. The F control bits are made available by the F control system and must be implemented in the F application program (see programme example chapter 4.2.4).

Signal	No. of Bytes	Data type	Scaling
Control word	2	Word	Currently not available
F data	4	Word	According to PROFIsafe specification

6. PARAMETERISATION AND COMMANDS

Parameterisation of the rotor hub 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. Changing the parameter of the NBT-D/S3 during cyclic I/O data exchange is not possible.

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
0x1000	Rotor hub sensor parameter
0x64	F parameter

6.1 Rotor hub sensor parameter

6.1.1 Overview

Byte	Data type	Designation	Default
0-1	BYTE	Version	0x0
2	BYTE	Operating mode	0x0
3	BYTE	Code sense	0x0
4	BYTE	Firmware download mode	0x0
5-15	BYTE	Reserved	0x0

6.1.2 Description of the rotor hub operating modes

Byte	Bit No.	Parameter	Value range	Default	Remark
2	0	Switch code sense enabled	off (0x00), on (0x01)	off	Allows the modification of the code sense with byte 3
	1	FW download mode	off (0x00), on (0x01)	off	Enables the firmware download mode selection with byte 4.
	2-7	Reserved			

PARAMETERISATION AND COMMANDS

6.1.3 Description of the rotor hub code sense byte

Byte	Value.	Meaning
3	0x00	Use value from device
	0x01	Clockwise (CW)
	0x02	Counterclockwise (CCW)

6.1.4 Description of the rotor hub firmware download byte

Byte	Value.	Meaning
4	0x00	Firmware download mode off
	0x01	Firmware download mode on. Afterwards the sensor waits for the transfer of the new firmware via the PROFINET interface.

6.1.5 iPar CRC

After changing of one of the rotor hub sensor parameters, the checksum F_iPar_CRC has to be changed.

Use case	Setting	F_iPar_CRC
Default	All bytes equal 0x00	0xB155 (45397 dez)
Set code sense to CW	Byte 2: 0x01 Byte 3: 0x01	0x5F36 (24374 dez)
Set code sense to CCW	Byte 2: 0x01 Byte 3: 0x02	0xBBCF (48079 dez)
Activate FW download mode	Byte 2: 0x02 Byte 1: 0x01	0x05D4 (1492 dez)

6.2 Rotor hub records

Record	Modul	R/W	Size	Command	Precondition	Function
0x0001	Safe	R	2 bytes			Device status (equal to status word in cyclic data)
0x1000	Safe	W	16 bytes	(See above)		Edit sensor parameters
0x7010	Head Safe Unsafe	R	16 bytes			Customer part number
0x7200	Head	W	5 bytes	RESET	Error state	Device reset is executed
0x7300	Head	W	4 bytes	TRIP	Speed < 1 rpm	Set speed output to 25 rpm for 10 s, then device reset is executed

PARAMETERISATION AND COMMANDS

6.3 F parameter

6.3.1 Overview

Overview			
Octet	**Data type**	**Description**	**Default**
1	Unsigned8	F_Prm_Flag1	See 6.3.2
2	Unsigned8	F_Prm_Flag2	See 6.3.2
3-4	Unsigned16	F_Source_Add	0
5-6	Unsigned16	F_Dest_Add	1
7-8	Unsigned16	F_WD_Time	120
9-12	Unsigned32	F_iPar_CRC	15283 ($3BB3_{hex}$)
13-14	Unsigned16	F_Par_CRC	—-

6.3.2 Description of the F parameters

Octet 1: F_Prm_Flag1				
Bit no.	**Parameter name**	**Value range**	**Default**	**Remarks**
0	F_Check_seqNr	0: NoCheck	NoCheck	Fixed to „No Check“
1	F_Check_iPar	0: NoCheck	NoCheck	Fixed to „No Check“
2-3	F_SIL	1: SIL2	SIL2	Fixed to „SIL2“
4-5	F_CRC_Length	0: 3-Byte-CRC (V2 Mode)	3-Byte_CRC	Checksum of the process data (CRC2)
6-7	Not used			

Octet 2: F_Prm_Flag2				
Bit no.	**Parameter name**	**Value range**	**Default**	**Remarks**
0-2	Not used			
3-5	F_Block_ID	0-7	1	1 = F parameter block contains F_iPar_CRC
6-7	F_Par_Version	1: V2-Mode	1	Parameter version

PARAMETERISATION AND COMMANDS

Octet 3-14				
Octet	**Parameter name**	**Value range**	**Default**	**Remarks**
3-4	F_Source_Add	1-65534		Automatically assigned by the SIMATIC manager
5-6	F_Dest_Add	1-65534	1	Must correspond to the PROFIsafe address set in the PROFINET name. The NBT-D/S3 is a F device with PROFIsafe address type 1, i.e. the F_Dest_Add has be unique netwide and CPU-wide.
7-8	F_WD_Time	90-10000	120	Monitoring time in the failsafe slave. Within the monitoring time, a valid, current safety message must be received from the F CPU. Otherwise, the device goes to the safe state. Set the monitoring time long enough to ensure not only that the communication functions tolerate telegram delays, but also that the fault response is triggered quickly enough if a fault occurs (e.g. interruption of the communication connection). The minimum watchdog time for the NBT-D/S3 is 120 ms (for 4 ms actualisation time).
9-12	F_iPar_CRC	1-0xFFFF FFFF	15283 ($3BB3_{hex}$)	CRC checksum on the iParameters (rotor hub sensor parameters). After changing the rotor hub sensor parameters this default value has to be changed to: For FW download mode = "on" to BA0Chex. For Scaling = "on" to D3BDhex
13-14	F_Par_CRC (CRC1)	0-65534		CRC checksum on the F parameters. Is generated from the SIMATIC Manager.

DIAGNOSTIC

7. DIAGNOSTIC

7.1 Overview

The rotor hub sensor NBT-D/S3 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 controller 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)	Input and F data = 0		Switch power off/on or change the device
0x0040	Mismatch of the safety desination address (F_Dest_Add)	Input and F data = 0	red flashing (1 Hz)	
0x0041	Safety destination address not valid (F_Dest_Add)	Input and F data = 0	red flashing (1 Hz)	
0x0042	Safety source address not valid (F_Source_Add)	Input and F data = 0	red flashing (1 Hz)	
0x0043	Safety watchdog time is 0 ms(F_WD_Time)	Input and F data = 0	red flashing (1 Hz)	
0x0044	Parameter „F_SIL“ exceeds SIL from specific device application	Input and F data = 0	red flashing (1 Hz)	
0x0045	Parameter „F_CRC_Length“ does not match the generated values	Input and F data = 0	red flashing (1 Hz)	
0x0046	Version of F parameter set incorrect (F_Par_V ersion)	Input and F data = 0	red flashing (1 Hz)	
0x0047	F parameter CRC error (CRC1-Fault)	Input and F data = 0	red flashing (1 Hz)	
0x0048	Error in F parameter set	Input and F data = 0	red flashing (1 Hz)	
0x004B	Inconsistent iParameters (iPar-CRC error)	Input and F data = 0	red flashing (1 Hz)	Check value of i-Par-CRC

DIAGNOSTIC

0x1100 0x1101	Device error	F status word: FV_activated, Device_Fault	fast red flashing (10 Hz)	Switch power off/on or change the device
0x1102	Sensor synchronisation error	F status word: FV_activated, Device_Fault	fast red flashing (10 Hz)	Check for excess external acceleration, switch power off/on or change the device
0x1104	Device error	F status word: FV_activated, Device_Fault	fast red flashing (10 Hz)	Switch power off/on or change the device
0x1140	Parameter error	F status word: FV_activated, Device_Fault	red flashing (1 Hz)	Switch power off/on or change the device
0x1150	Supply voltage out of range	F status word: FV_activated, Device_Fault	red flashing (1 Hz)	Check the supply voltage and switch power supply off/on
0x1160	Wrong Record Index on startup	F status word: FV_activated, Device_Fault	red flashing (1 Hz)	Pleace check your GSD file
0x1170	Sensor not ready	F status word: FV_activated, Device_Fault	red flashing (1 Hz)	Switch power off/on or change the device
0x1190	Mounting position	F status word: FV_activated, Device_Fault	red flashing (1 Hz)	Mount sensor in correct position and perform power cycle

7.3 Diagnostic data records

The following diagnostic records are available in the NBT-D/S3. 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)

LITERATURE, REVISION HISTORY

8. 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 guidline, 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

9. REVISION HISTORY

Version	Date	Change
NBT 15982 AE	22.07.2021	First version
NBT 15982 BE	30.08.2024	New functionality for firmware V 3.1.0

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