Absolute encoder TRT
with PROFINET interface
Relevant data sheet TRT 12886

SUPREME SENSORING
TWK

Data sheet no.: TRT 12887 HE
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User manual

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1. Safety instructions

1.1 Scope

This user manual is valid exclusively for the following absolute encoders with PROFINET interface:

- TRTxx-xxxxxxxx4096x4xT01
- TRTxx-xxxxxxxxC4xT01

1.2 Documentation

The following documents must be observed:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number TRT 12887
- The connection assignment enclosed with the device
- Assembly instructions TZY10206 enclosed with the device

1.3 Proper use

The TWK-ELEKTRONIK GmbH absolute encoders 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 speci fied 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 TRT optoelectronic absolute encoders are designed for direct connection to the industrial Ethernet system PROFINET. 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).

The TRT PROFINET absolute encoder offers the class 2 encoder profile familiar from the CRD profibus absolute encoder as well as the functionality according to Encoder Profil 4.2 (as of hardware version 2). Besides the 26 bit position value the encoder supports a 16 bit velocity signal in the dimension steps/gating time. The gating time is adjustable in the range of 10…1000 ms.

In the version with code type "S" the TRT offers a slew ring functionality. This converts the sensor shaft position value into the position of a slewing ring or a rotary table.

The slew ring encoder permits the adjustment of the number of teeths of the slew ring and of the encoder gear-wheel. In this way all gear ratios are possible and the encoder can be adapted to any slew ring by the user. The output values are the position of the slew ring in degrees (resolution adjustable) and his velocity in degree / time basis (time basis adjustable).

3. Installation

3.1 General information

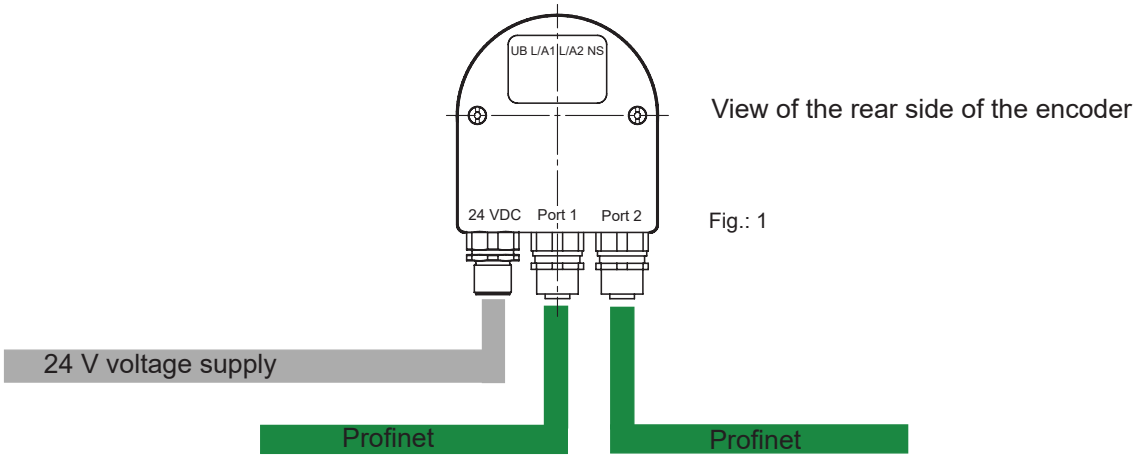
- During installation, observe the profinet assembly guideline PNO order No.: 8.071
- Use only certified profinet cables, connectors and switches (see "PROFINET Cabling and Interconnection Technology" PNO order No.: 2.252 and "Installation Guideline PROFINET Part 2: Network Components" PNO order No.: 2.252 p2)
- Hubs are not permissible.
- The cable length between two subscribers may be max. 100 m.
- The TWK TRT absolute encoder 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 Electrical connection

The " ...MT01" type absolute encoders 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. 12886 for connector assignment and ordering information.



View of the rear side of the encoder

Fig.: 1

3.3 Status LEDs

Four LEDs are housed in the absolute encoder's connecting cap. These have the following meaning:

UB (VB)	Link1 (L/A1)	Link2 (L/A2)	Status (NS)	Description
grün	grün	grün	grün/rot	
on				Operating voltage available
	on			Network connection established
		on		Network connection established
			green	Data exchange, device in operation and OK
			red, slow flashing (1 Hz)	Firmware download mode
			green flashing	Waits for connection with PROFINET controler
			red flashing (2 Hz)	Impermissible parameter or preset value
			fast red flashing (10 Hz)	Device error
			red	Connection to the PROFINET controller disrupted

Flashing codes

Errors which lead to encoder 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 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

3.4 Project planning

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

File name of the GSD file:
Profil C4 (Encoder-Profil 1.1) GSDML-V2.3-TWK-TRT-20200207.xml (The version and date may vary)
Profil E4 (Encoder-Profil 4.x) GSDML-V2.3-TWK-TRTE4-20200406.xml

File name of the bitmap: GSDML-0159-6300-TWK_TRTC4.bmp

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

4. Project planning with Simatic Step7

4.1 Simatic Manager

This chapter explains the procedure for integrating the TWK TRT absolute encoder into the PROFINET network of a Siemens S7 control system. The documentation is based on Step7 version 5.5.

4.1.1 Prerequisites

You have created a hardware configuration in accordance with your control system structure and a PROFINET sub-network.

This is shown here using the example of a CPU314C:

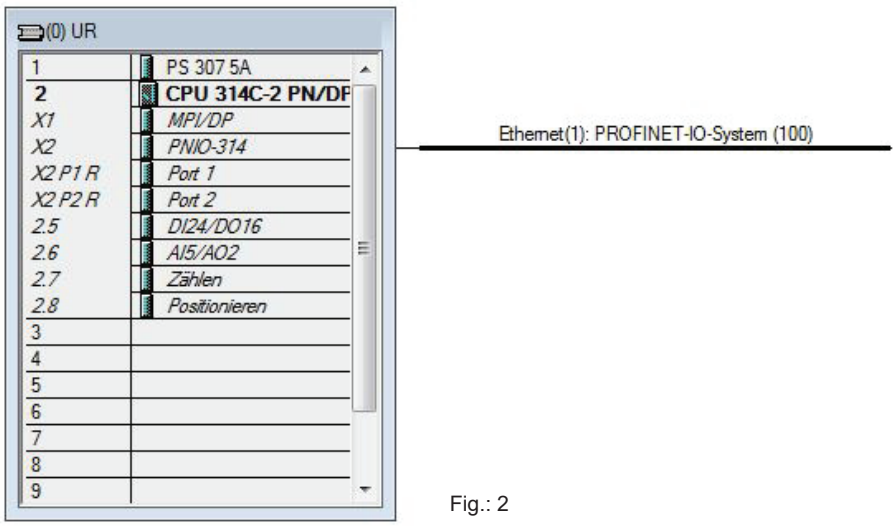


Fig.: 2

4.1.2 Installation of the GSD file

- Please download the GSD file and the encoder symbol from www.twk.de. Different GSD files for single- and multiturn encoders and for the different code types are available here (see also table on page 11)
- Under **Extras** in the hardware configuration, select **Install GSD files**.
- Set "from the directory" and "browse" to your GSD file. Click on "Install" (see Figure 4).
- The absolute encoder symbol is also installed automatically.

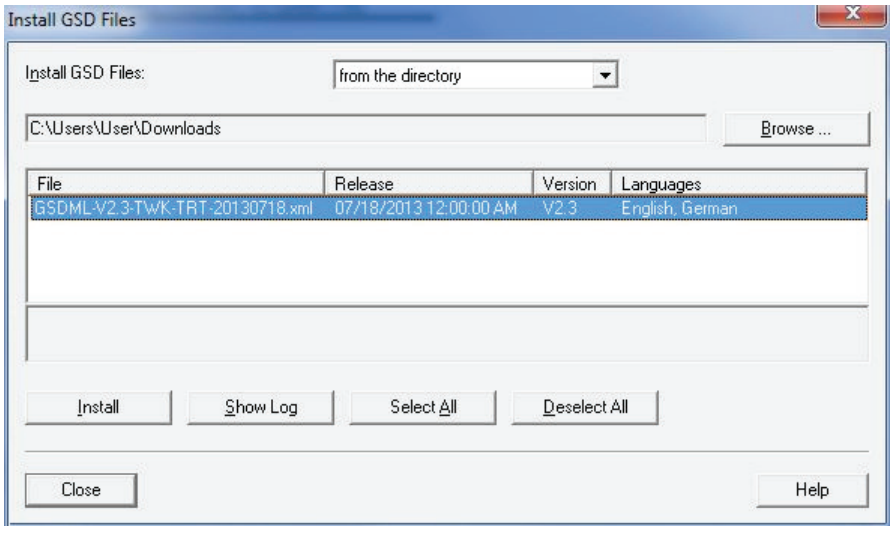


Fig.: 4

After installing the GSD file, the hardware catalogue is automatically updated. The TRT absolute encoder is located under **PROFINET, Further FIELD DEVICES, Encoders, TWK T series, TRT**.

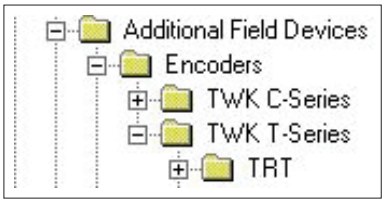


Fig.: 5

4.1.3 Installing the absolute encoder

Now drag the TRT encoder onto your PROFINET system using the mouse.

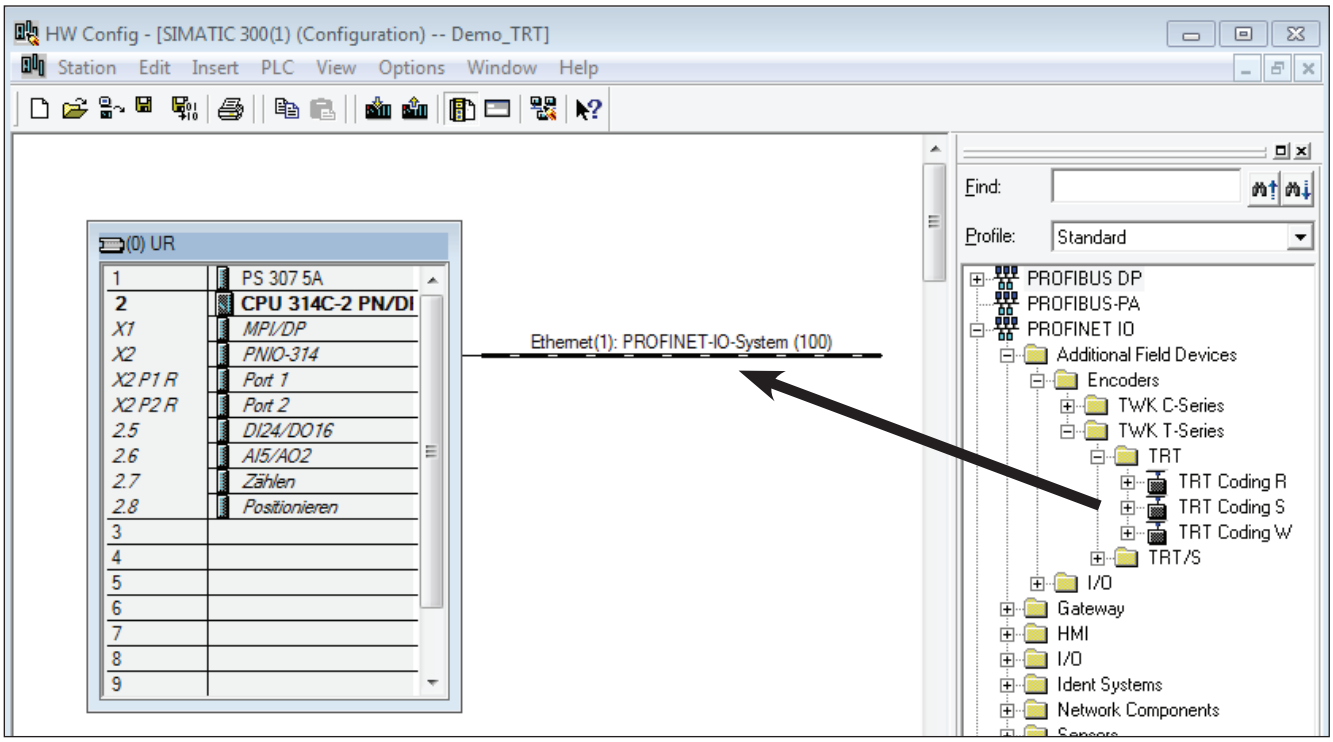


Fig.: 6

The absolute encoder's PROFINET interface is then installed together with its default values. The module corresponding to the absolute encoder then has to be installed.

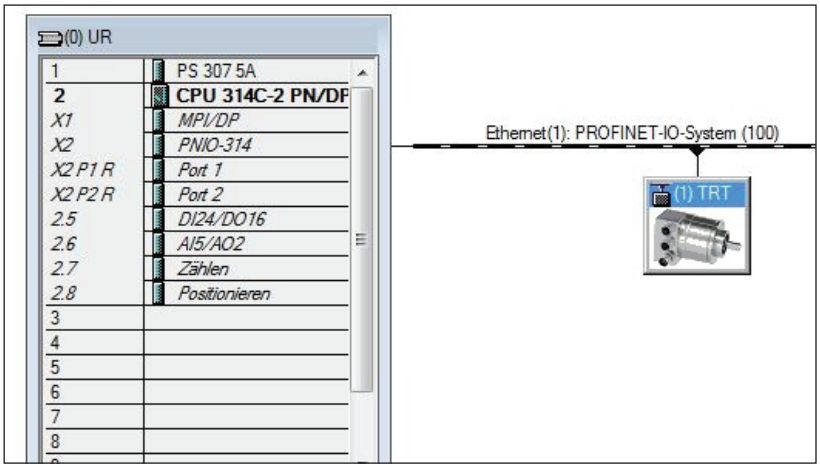


Fig.: 7

4.1.4 Installing the module

For the enoder TRT there are modules with differend resolutions and data formats available. The resolution and the data format is defined by the encoder type.

		Module	Resolution	Multiturn	Functionality
File GSDML-V2.3-TWK-TRT-yyyymmdd					
	Coding R				
		TRTxx-xxx4096R4096C4xTx	12	x	Position, speed, preset
		TRTxx-xxx4096RC4xTx	12		Position, speed, preset
		TRTxx-xxx8192R4096C4xTx	13	x	Position, speed, preset
		TRTxx-xxx8192RC4xTx	13		Position, speed, preset
		Available from HW version 2			
		TRTxx-xxx65536R4096C4xTx	16	x	Position, speed, preset
		TRTxx-xxx65536RC4xTx	16		Position, speed, preset
File GSDML-V2.3-TWK-TRTCodeS-yyyymmdd					
	Coding S				
		TRTxx-xxx8192S4096C4xTx	13	x	Slew ring position, slew ring speed, preset
File File GSDML-V2.3-TWK-TRTCodeW-yyyymmdd					
	Coding W				
		TRTxx-xxx4096W4096C4xTx	12	x	Position (2x integer16, separated single and multiturn data), speed, preset
		TRTxx-xxx8192W4096C4xTx	13	x	Position (2x integer16, separated single and multiturn data), speed, preset
Datei GSDML-V2.3-TWK-TRTE4-xxxxxxxx					
	Encoder Class 4 Modul				
		TRTxx-xxx4096R4096E4xTx	12	x	Contains one subslot for the modul access point (automatically plugged into subslot 1) and one subslot for the telegram.
		Submodule			
		Standard Telegramm 81	12	x	According to Encoder Profile 4.2 (see data format in chapter 5)

Now drag the module corresponding to your absolute encoder to slot one in the module list using the mouse.

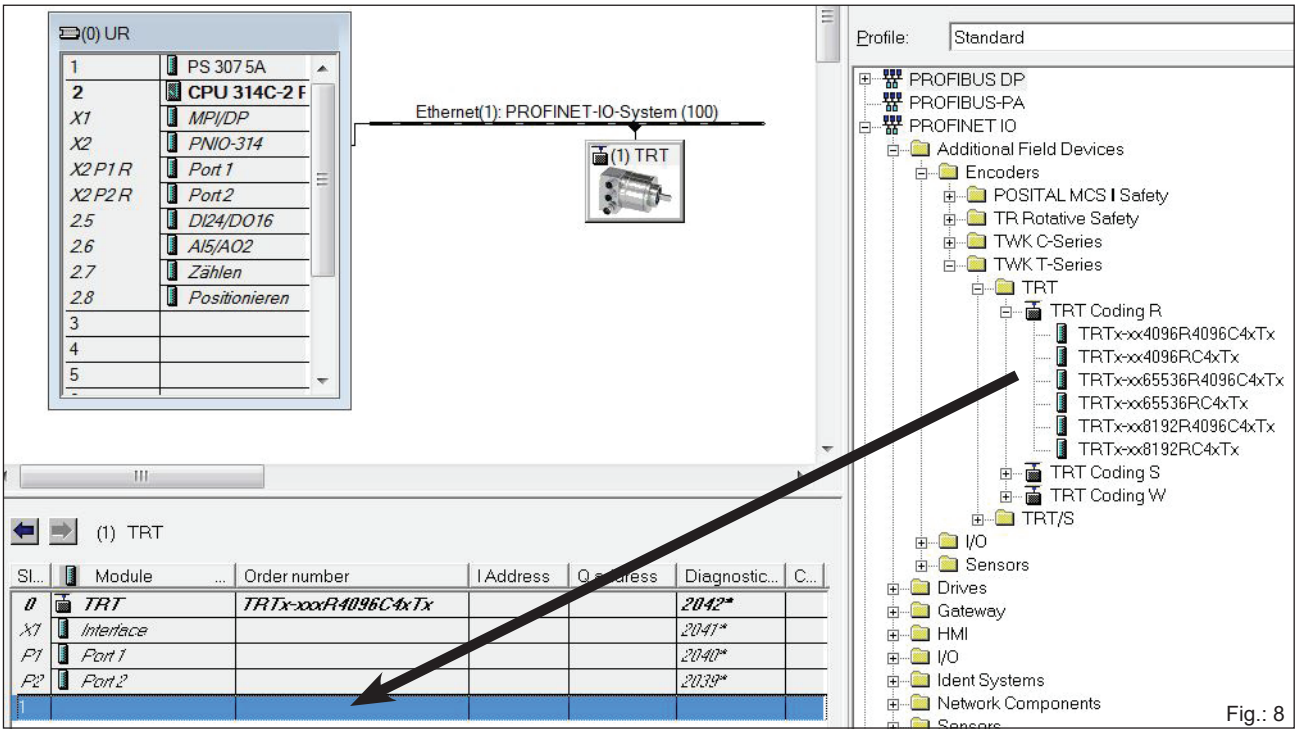


Fig.: 8

The network data can be set by double-clicking onto the absolute encoder symbol (see Chapter 4.1.5), and the I/O address plus the absolute encoder parameters can be set by double-clicking onto the line "Slot 1" (see Chapter 4.1.6).

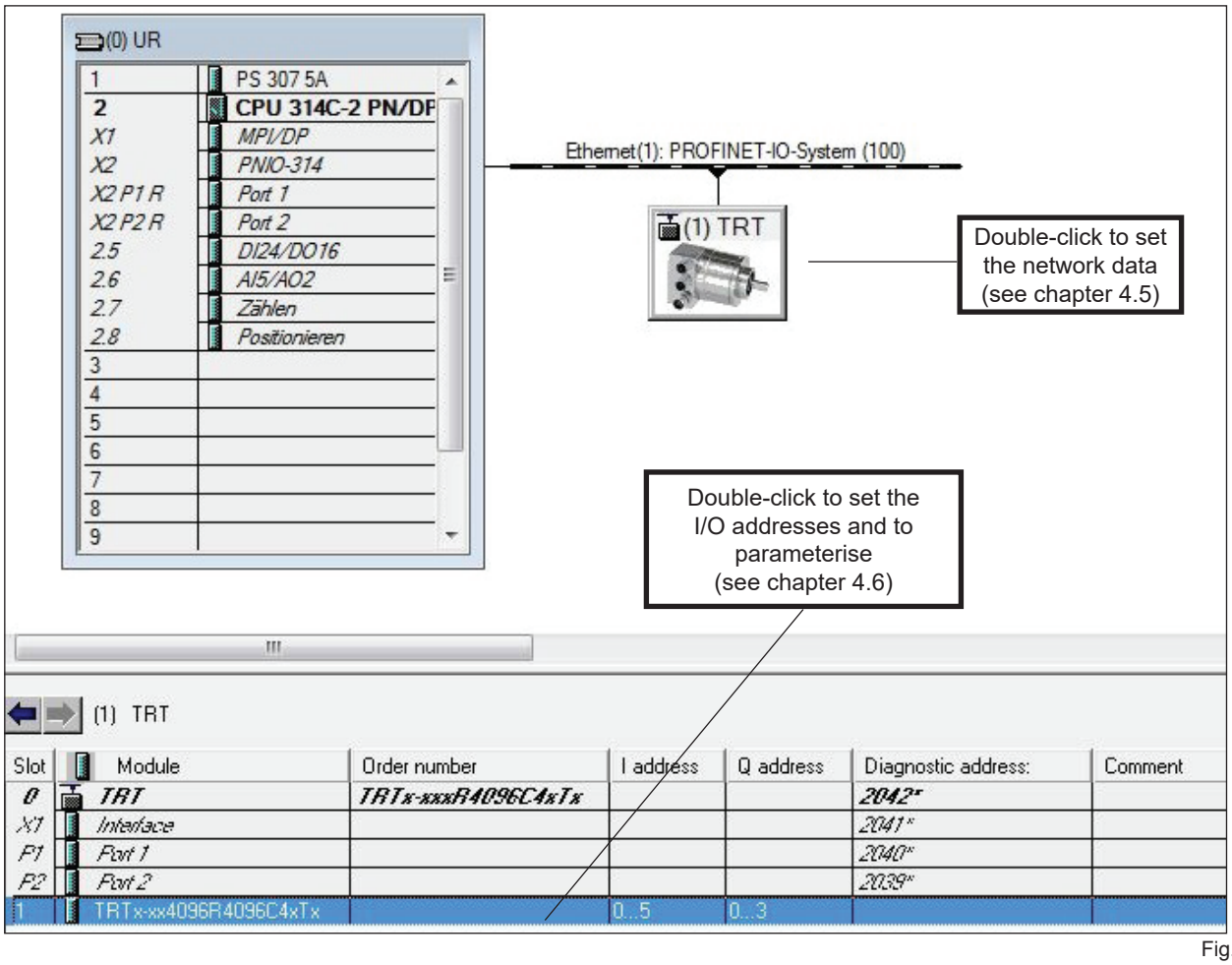


Fig.: 9

4.1.5 Setting the network data (TRT properties)

The following dialogue appears by double-clicking onto the absolute encoder symbol (or via the absolute encoder's context menu). Enter a name which is unique throughout the network to identify the device here. The controller expects this name when the device logs in. The default name is TRT. If only one TWK absolute encoder is contained in the network, this name can be retained.

The name assigned here must either be manually allocated to the absolute encoder (see Chapter 4.1.9) or it can be assigned automatically by the controller using the topology editor (see Chapter 4.1.8 Planning of "Device exchange without programming device" and "Automatic commissioning").

The device name is stored in the absolute encoder, where it is protected against zero voltage. An installed device can be exchanged with a mint condition device without a programming device or exchanging a memory card. The correct name is automatically assigned to the new absolute encoder by the controller. To do this, however, the prerequisites under Chapter 4.1.8 have to be met.

If the tick in front of "IP address assignment by IO controller" is set, the controller automatically assigns an IP address to the device which contacts it with this name. Manually setting an address as is usual in the case of previous field bus systems is not necessary.

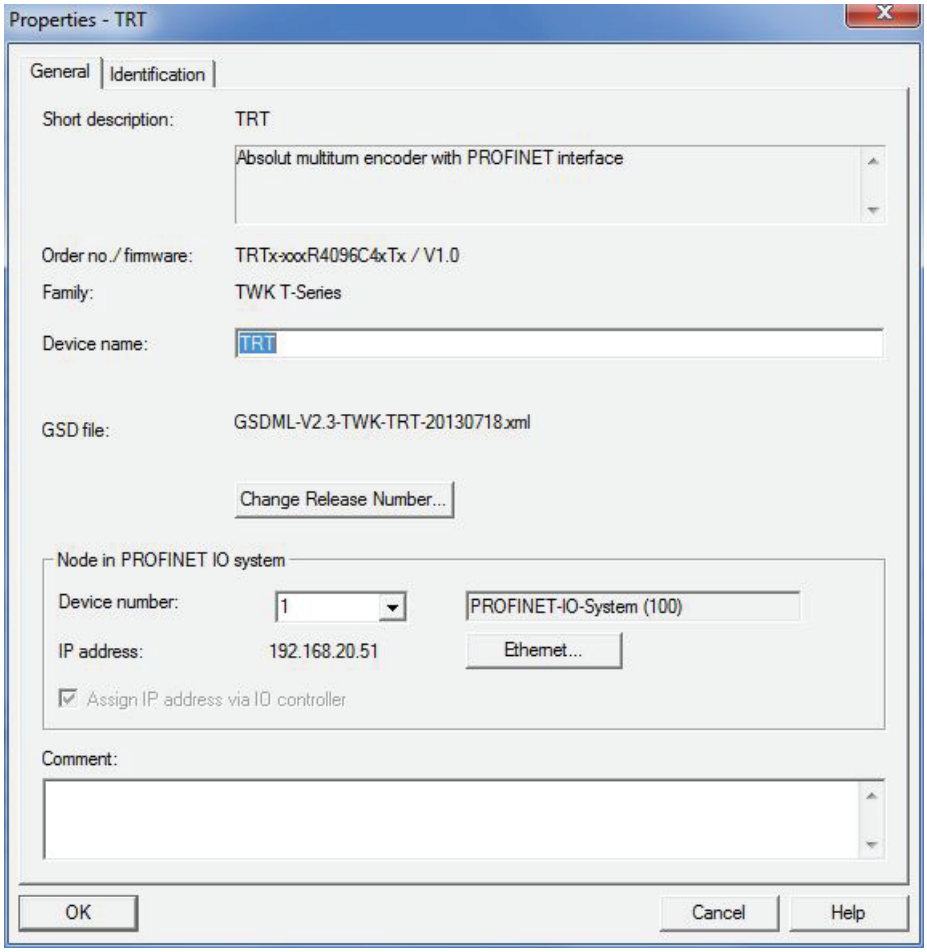


Fig.: 10

System and location codes can be specified for the absolute encoder in the "Identification" tab. These are stored in the S7 project.

4.1.6 Setting the absolute encoder (properties of the module)

4.1.6.1 Setting the I/O address

The dialogues for setting the I/O address and for setting the absolute encoder parameters can be accessed by double-clicking the installed module (slot 1 line) or via the module's context menu.

Set the input address for the position and velocity value and the output address for the preset value in the "Addresses" tab. (See Chapter 5 for the data format) The following figure shows the addresses tab for the module "TRTxx-xxx4096R4096C4xTx".

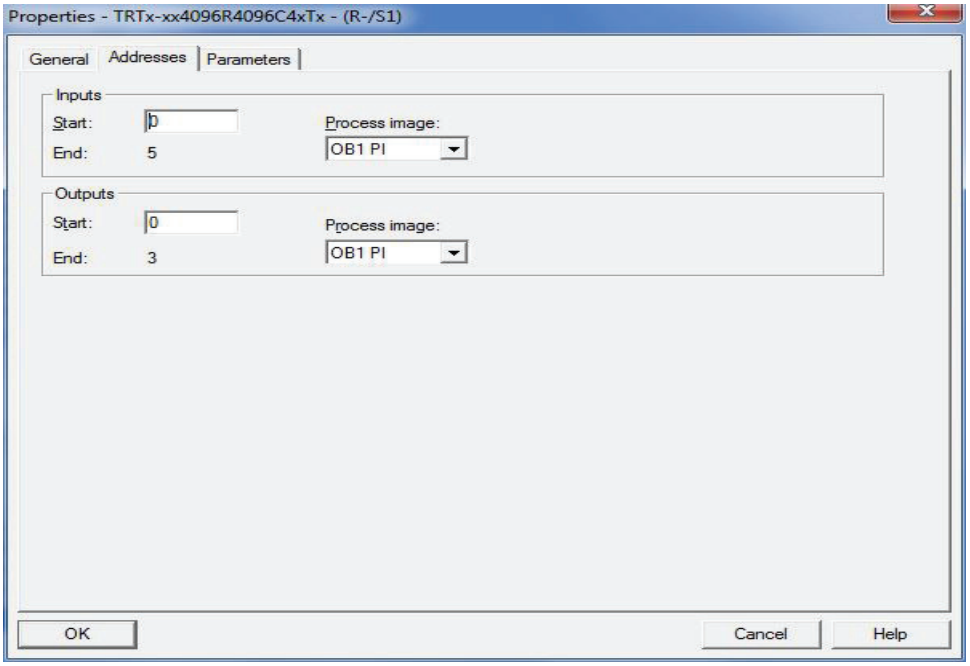


Fig.: 11

4.1.6.2 Parameterising the absolute encoder

The absolute encoder's parameters can be changed in the "Parameters" tab. An explanation of the parameters can be found in Chapter 6. The following figure shows the parameters tab for the module "TRTxx-xxx-4096R4096C4xTx".

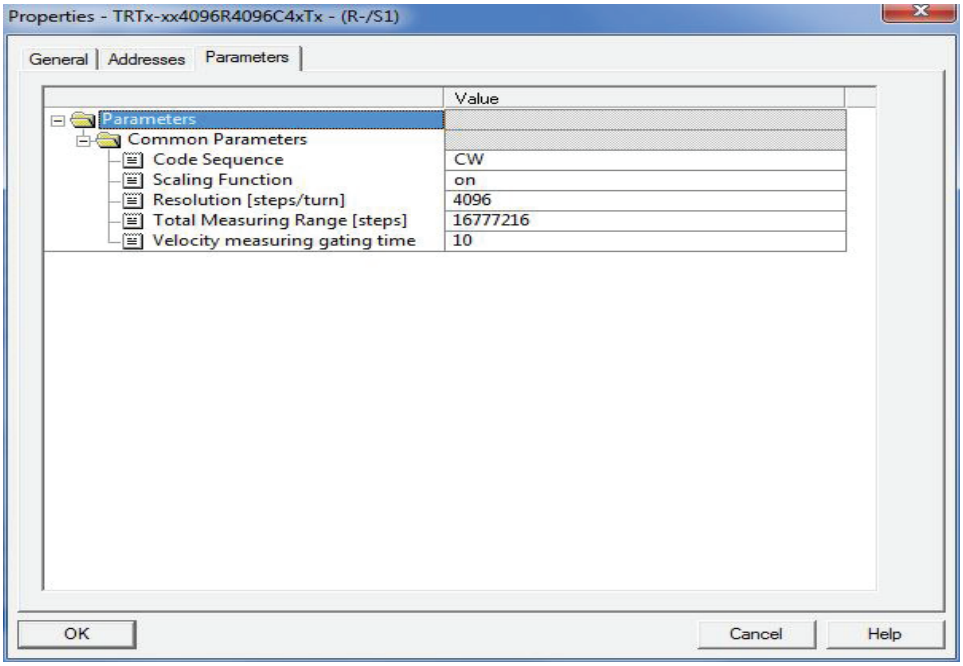


Fig.: 12

4.1.7 Setting real time mode and the updating time

The following dialogues are accessed via the PROFINET system's context menu:

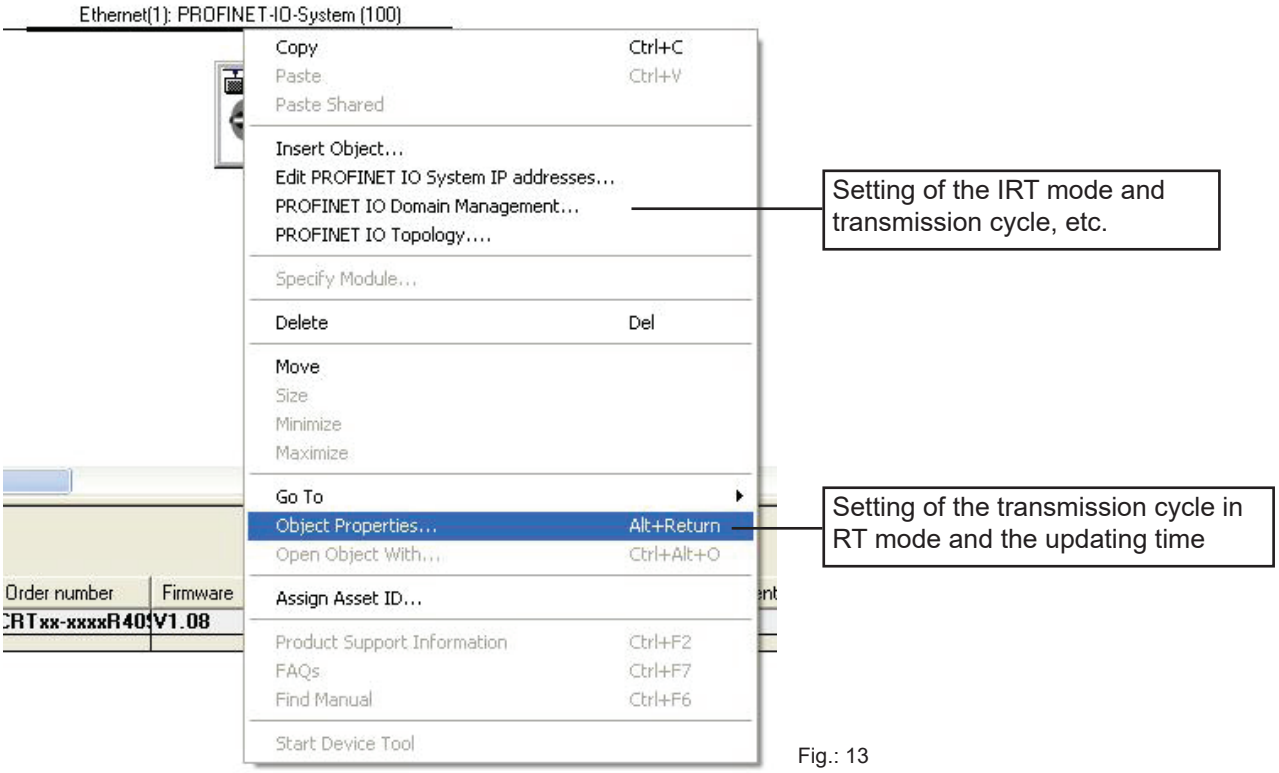


Fig.: 13

Set the transmission cycle and the desired updating time in the corresponding dialogue. Alternatively, the updating time can also be set via the interface's object properties. The default value is 2 ms for the updating time and 1 ms for the transmission cycle. The minimum updating time for the TRT is 250 µs.

4.1.8 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 absolute encoder 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 4.1.9) 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 TRT sup ports 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 (see Fig. 12) 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.

4.1.9 Assignment of the device name

If a PROFINET topology has not been defined as described in Chapter 4.1.8 or if the prerequisites for automatic commissioning are not met, the absolute encoder name must be assigned manually.

With the absolute encoder connected and the programming device connected to the control system, select "Target system -> Edit Ethernet subscribers" in the Simatic Manager to do this. Press the "Browse" button in the subsequent dialogue. All accessible PROFINET subscribers should now be shown as portrayed in the example in Figure 13.

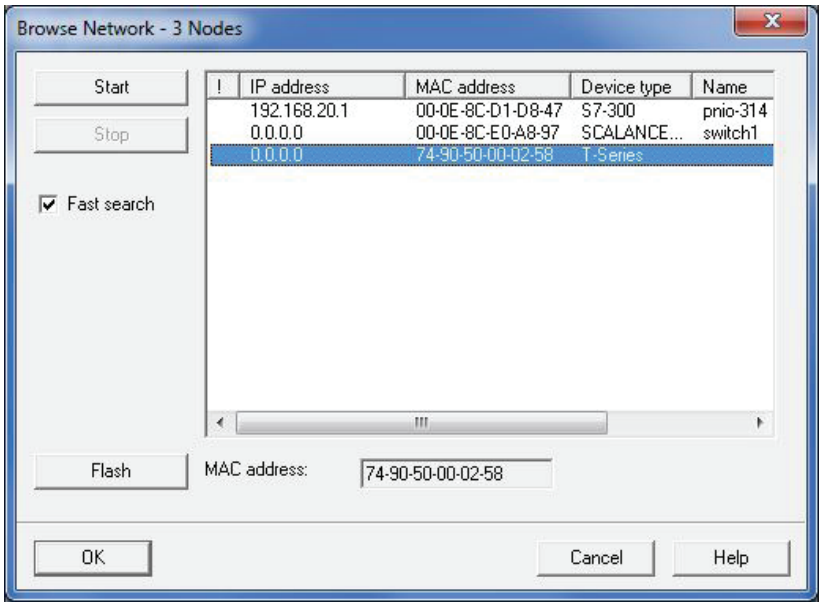


Fig.: 14

It can be seen that the absolute encoder device type "T series" does not possess either a valid IP address or a name. Now mark the absolute encoder and exit the dialogue with OK.

In the subsequent dialogue, enter a device name (the default setting is "TRT") and click onto the "Assign name" button. The device name is then stored in the absolute encoder, where it is protected against zero voltage.

The absolute encoder 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 absolute encoder, where it is protected against zero voltage.

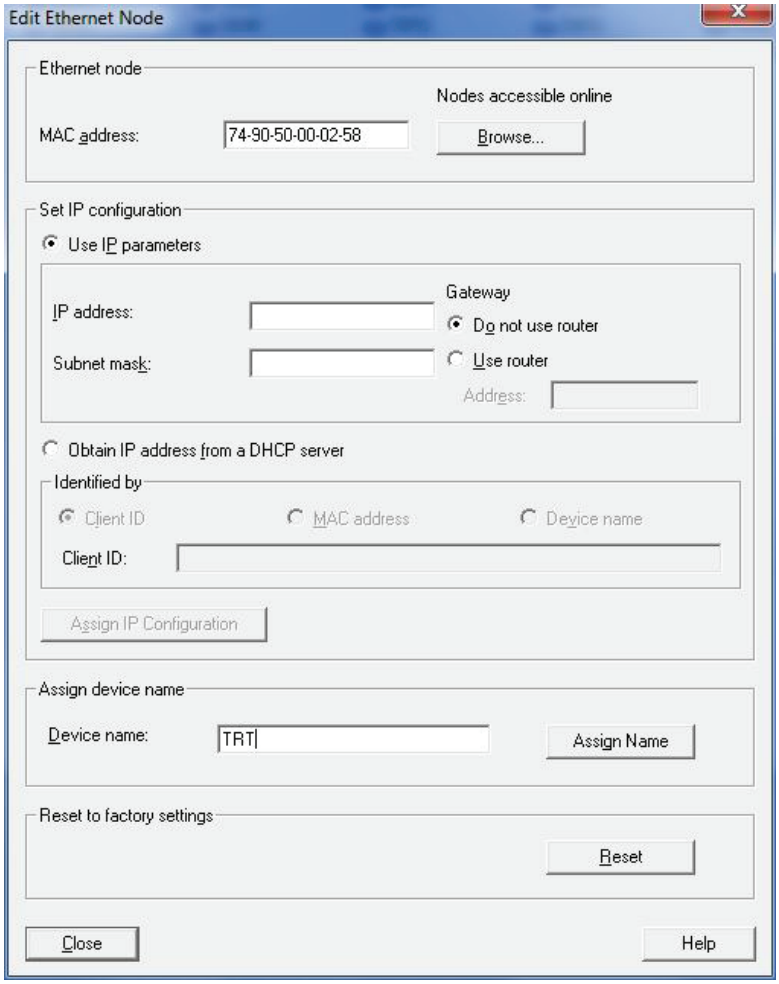


Fig.: 15

4.1.10 Resetting to the default settings

The absolute encoder can be reset to its delivery condition using the "Reset" button in the "Edit Ethernet subscribers" dialogue (Figure 14).

The following are reset	Delivery condition
Device name	Empty
IP-parameters	All 0
I&M0-revision counter	0

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 TRT restarts automatically with the name assigned during project planning.

4.2 TIA-Portal

This chapter explains the procedure for integrating the TWK TRT absolute encoder into the PROFINET network of a Siemens S7 control system with Step 7 Professional V13 in the TIA portal.

4.2.1 Prerequisites

You have created a hardware configuration in accordance with your control system structure and a PROFINET sub-network.

This is shown here using the example of a CPU314C:

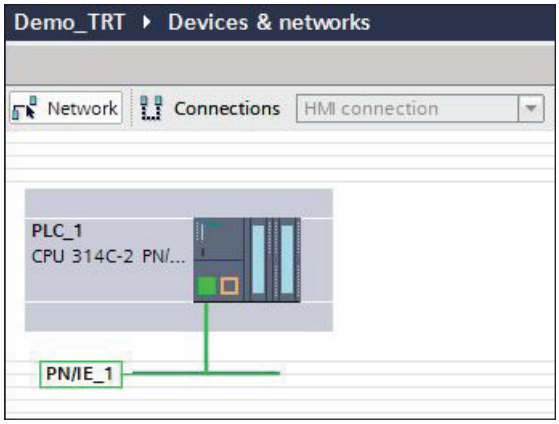


Fig.:16

4.2.2 Installation of the GSD file

- Please download the GSD file and the encoder symbol from www.twk.de. Different GSD files for single- and multiturn encoders and for the different code types are available here (see also table on page 11)
- 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 18).
- The absolute encoder symbol is also installed automatically, provided that it is in the same directory

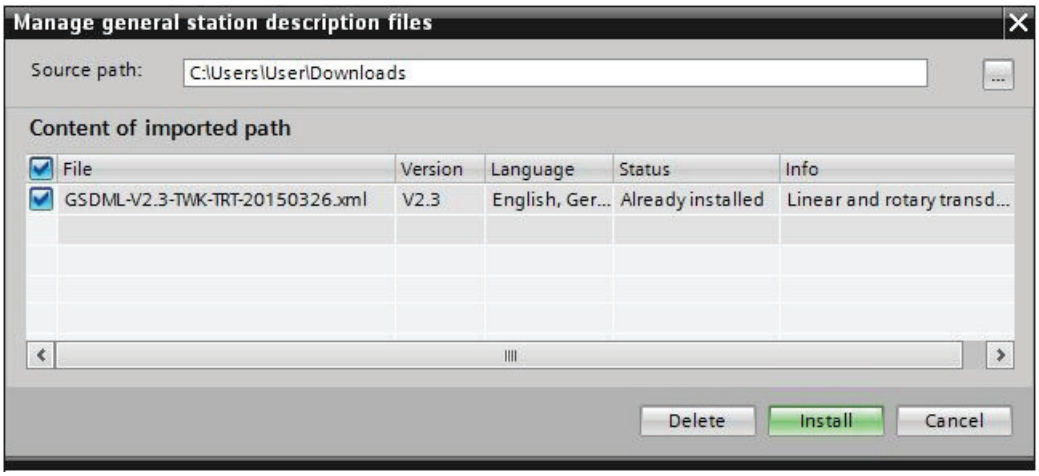


Fig.:18

After installing the GSD file, the hardware catalogue is automatically updated. The TRT absolute encoder is located under **Further FIELD DEVICES, PROFINET IO, Encoders, TWK-ELEKTRONIK GmbH, TWK T series, TRT**.

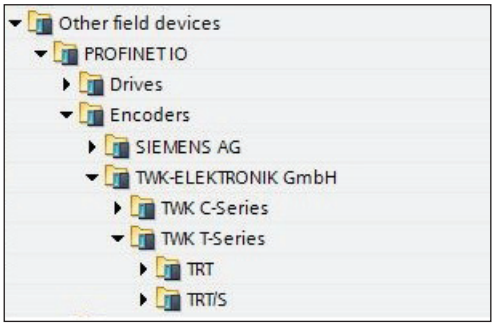


Fig.: 19

4.2.3 Installing the absolute encoder

Now drag the TRT encoder form the hardware catalog in the netview of your project.

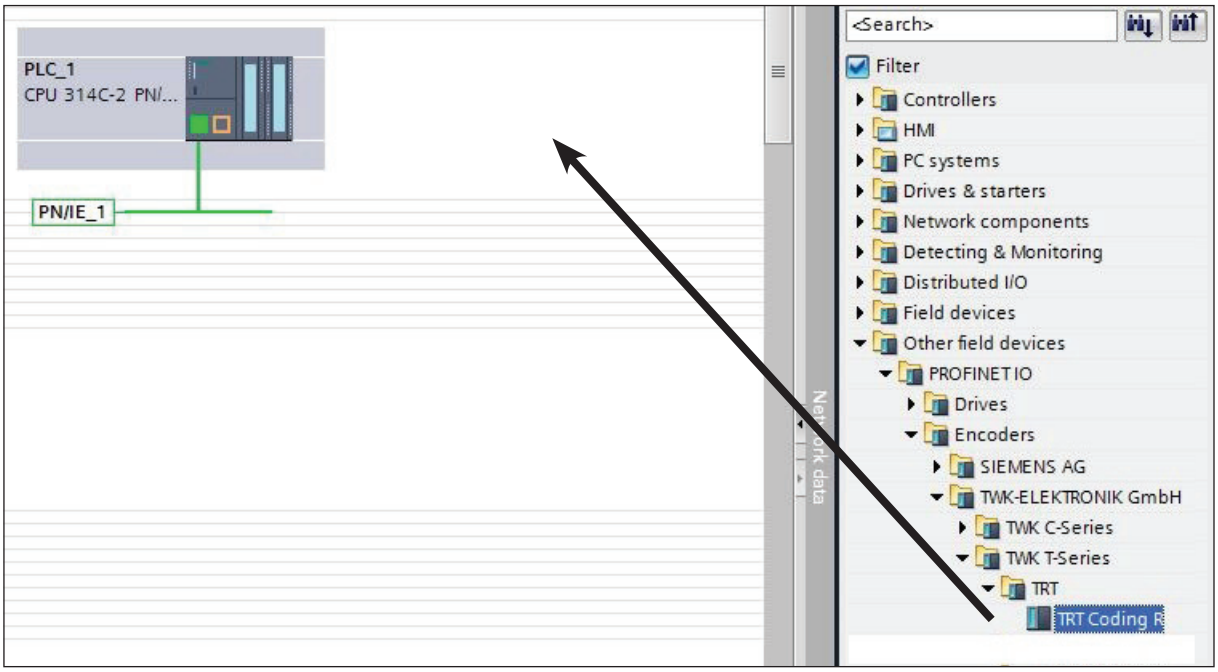


Fig.: 20

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

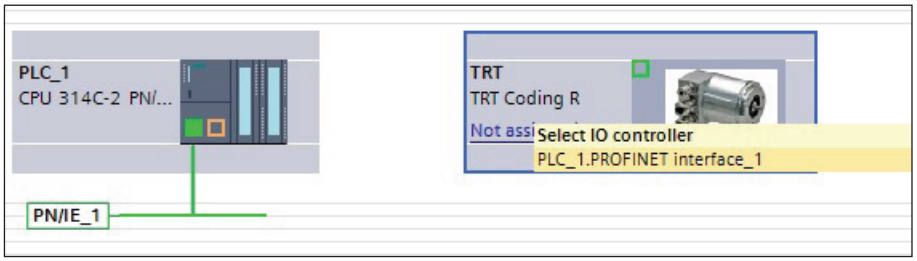


Fig.: 21

The encoder's PROFINET-Interface is now installed with its default values.

4.2.4 Install module

To install the encoder module change to the **Device view** and drag the module corresponding to you encoder to the first free slot of the module list.

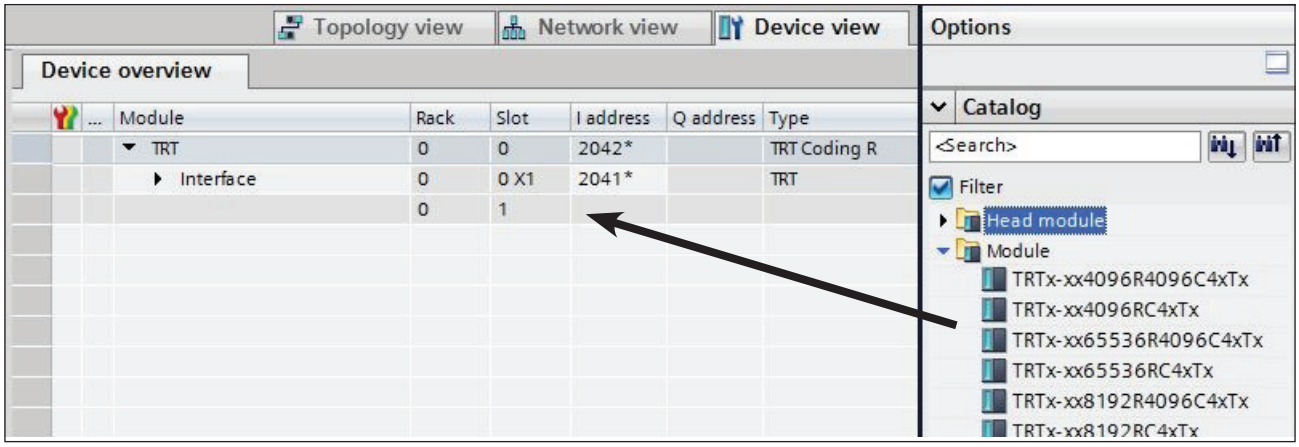


Fig.: 22

For the enoder TRT there are modules with differend resolutions and data formats available. The resolution and the data format is defined by the encoder type. See chapter 4.1.4.

When using the GSD file GSDML-V2.32-TWK-TRTE4-xxxxxx for encoders with profile E4 (encoder profile 4.x, Class4), only the Class4 module is available.

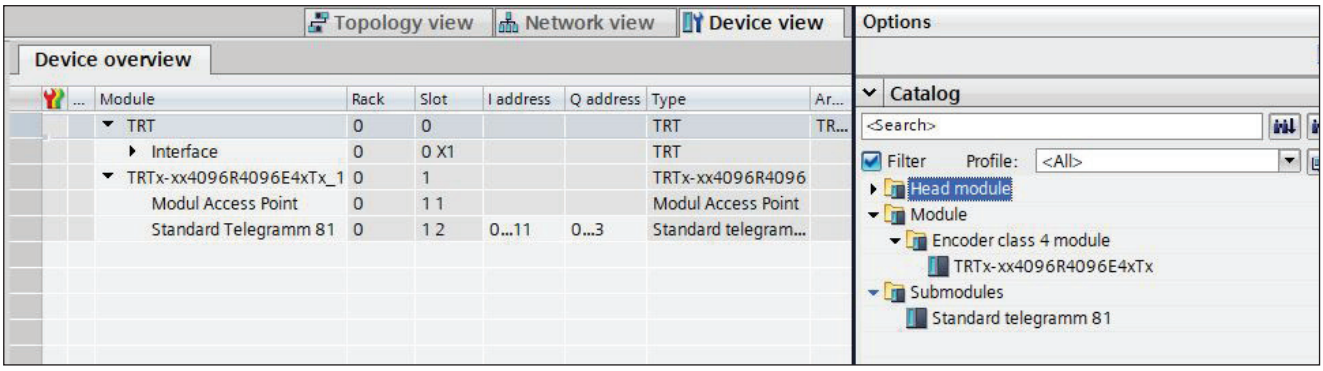


Fig.: 22.1

Here, after inserting the module, the submodule (currently only the standard telegram 81 is available) must also be installed under the module Access Point.

In the properties of the installed module you can then set the I/O address and the encoder parameters (see next chapter).

4.2.5 Setting the network data

Select the encoder in the Device view to show the properties of the PROFINET interface of the TRT.

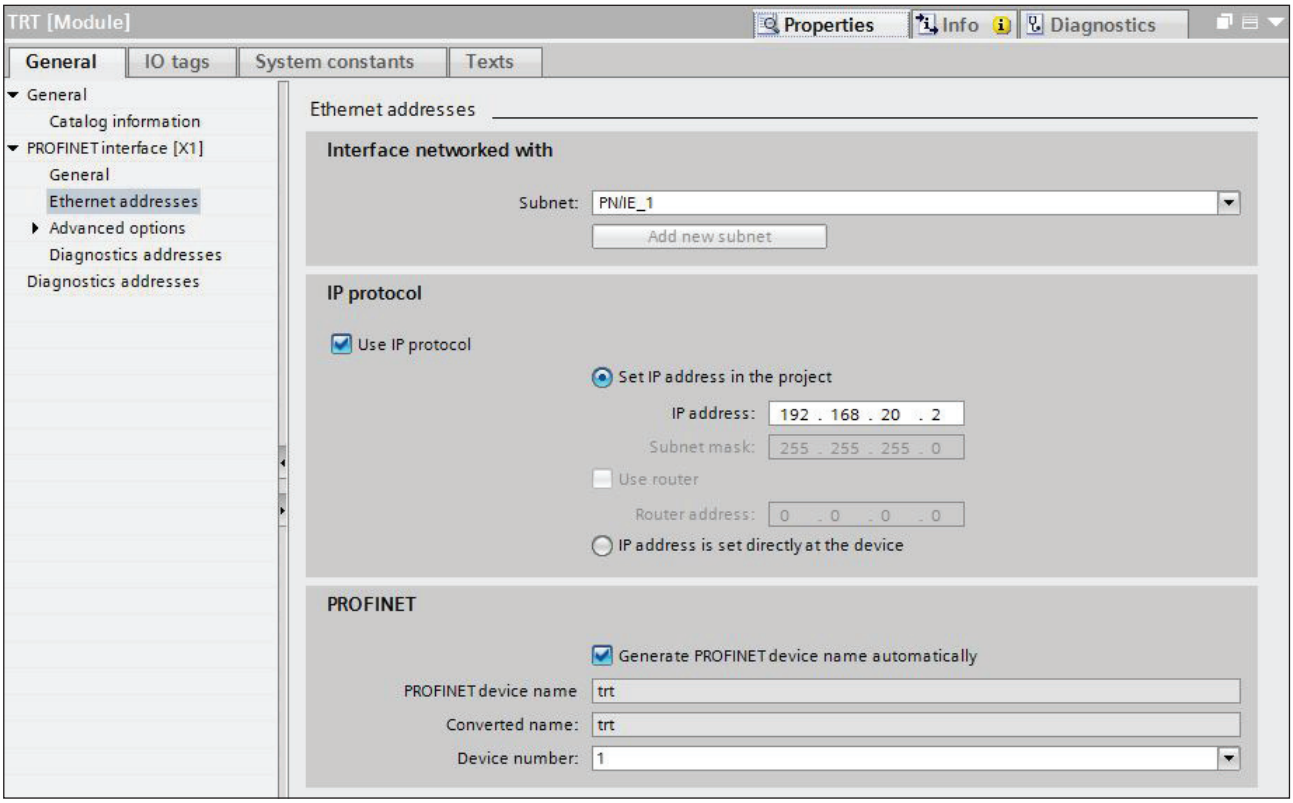


Fig.: 23

4.2.5.1 Setting the PROFINET

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 TRT.

The name assigned here must either be manually allocated to the absolute encoder (see Chapter 4.2.8) or it can be assigned automatically by the controller using the topology editor (see Chapter 4.2.7 Planning of "Device exchange without programming device" and "Automatic commissioning").

The device name is stored in the absolute encoder, 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 absolute encoder by the controller. To do this, however, the prerequisites under Chapter 4.2.7 have to be met.

4.2.5.2 IP-Adresse

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.

4.2.5.3 Prioritized startup, media redundancy, update time and synchronisation

Via the interface option **Prioritized startup** the startup time of the TRT 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 TRT 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 controler (manager) is necessary only to achieve a redundant communication. Bevor setting the **media redundancy role** of the TRT a MRP domain has to be created and the MRP manager (normally the controler) to be assigned.

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

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

4.2.6 Setting the absolute encoder (properties of the module)

4.2.6.1 Setting the I/O address

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

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

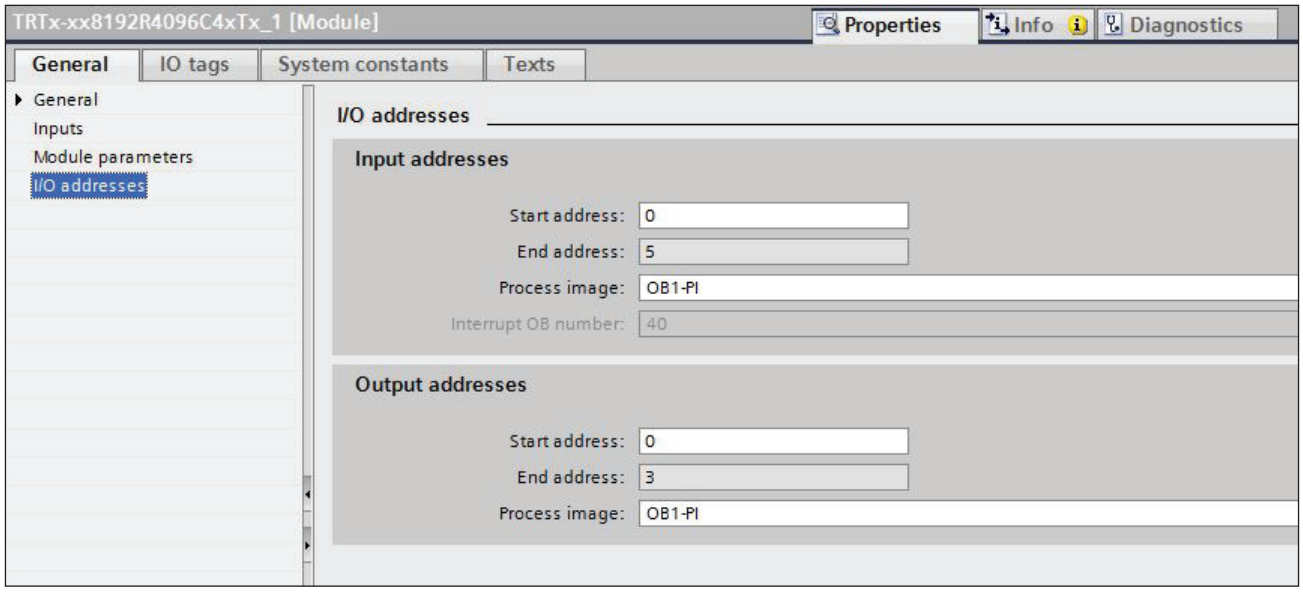


Fig.: 24

4.2.6.2 Parameterising the absolute encoder (Encoder Class2)

The absolute encoder's parameters can be changed in the "Module parameters" tab. An explanation of the parameters can be found in Chapter 6.

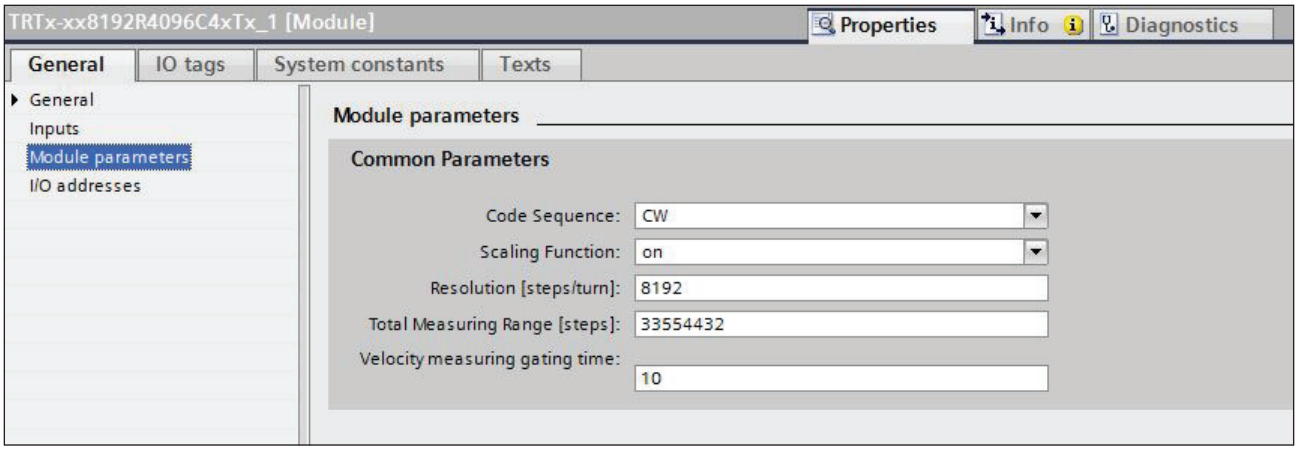


Fig.: 25

4.2.6.3 Parameterising the absolute encoder (Encoder Class4)

Slot 1.1, Access Point module provides access to the module parameters of the Class4 encoder. An explanation of the parameters can be found in chapter 6.2.

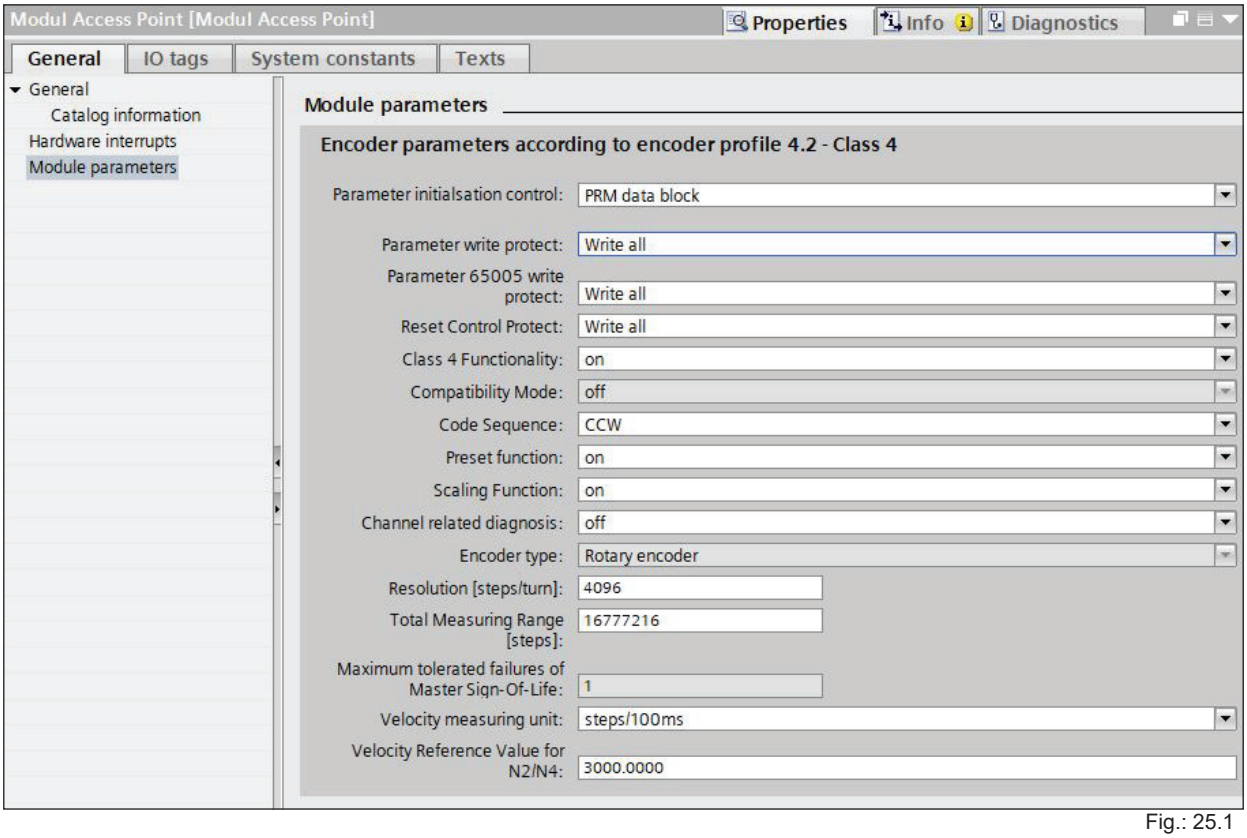


Fig.: 25.1

4.2.7 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 absolute encoder 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 Chapter4.2.8) 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 TRT sup ports 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.

4.2.8 Assignment of the device name

If a PROFINET topology has not been defined as described in Chapter 4.2.7 or if the prerequisites for automatic commissioning are not met, the absolute encoder name must be assigned manually.With the absolute encoder connected and the programming device connected to the control system, select "Assign device name" in the context menu of the PROFINET.

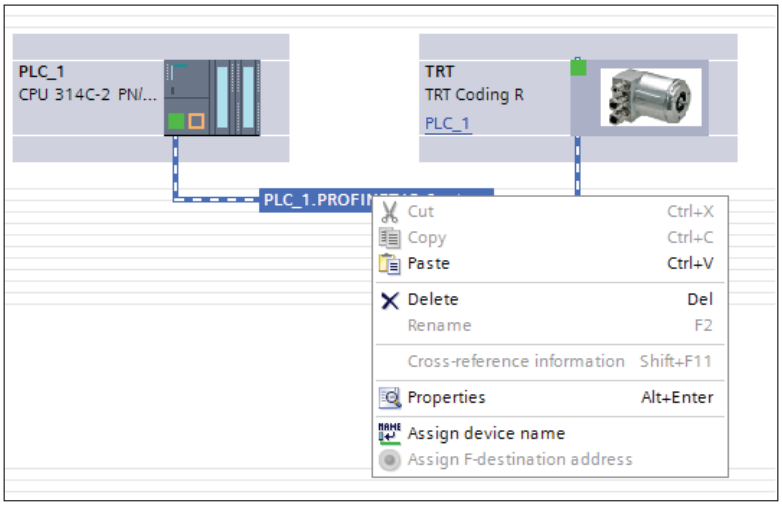


Fig.: 26

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 27.

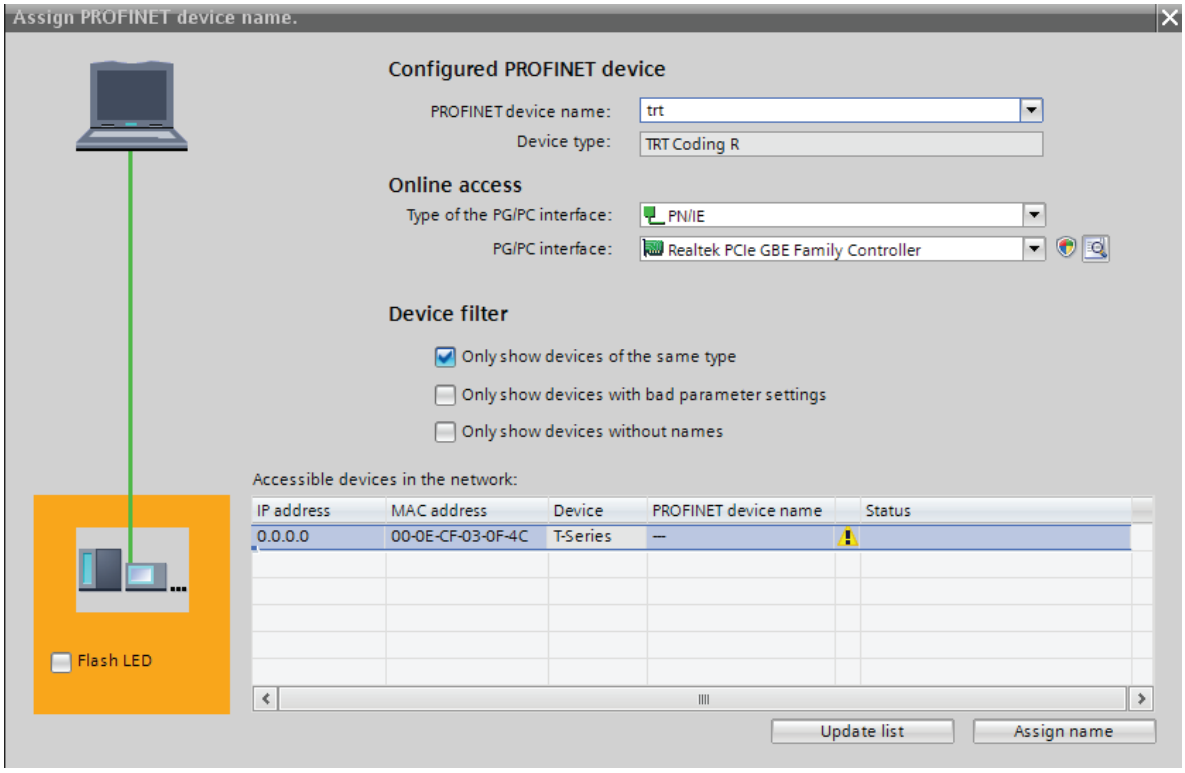


Fig.: 27

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

The absolute encoder 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 absolute encoder, where it is protected against zero voltage.

4.2.9 Resetting to the factory settings

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

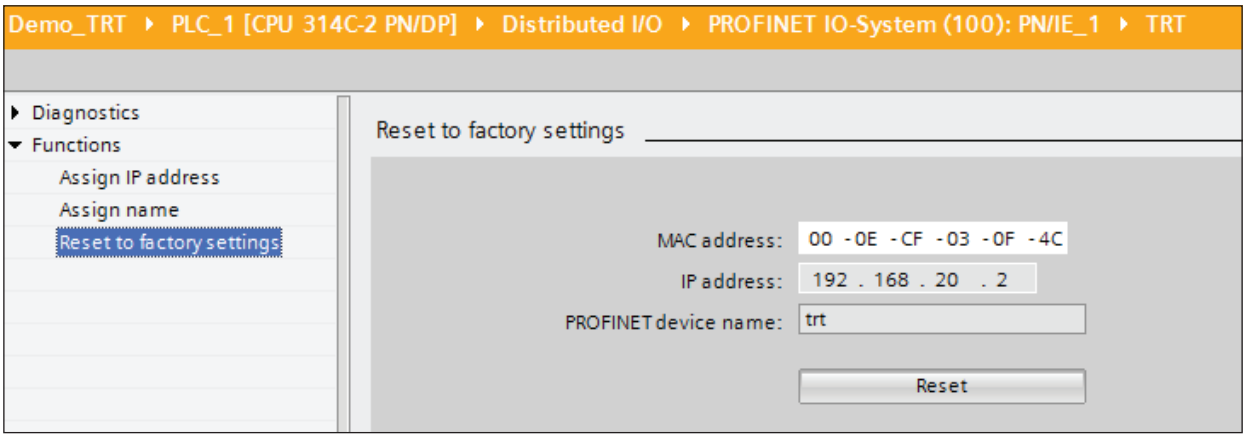


Fig.: 28

The following encoder data will be reset as follows:

The following are reset	Delivery condition
Device name	Empty
IP-parameters	All 0
I&M0-revision counter	0

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 TRT restarts automatically with the name assigned during project planning.

4.3 Application programme

All of the program modules in the following examples can be found in the internet under www.twk.de.

Note: **TWK-ELEKTRONIK GmbH provides no guarantee for the correct functioning of the example programmes shown here!**

4.3.1 Position value and preset

Once the absolute encoder has started up on the PROFINET, the absolute encoder's position value can be read-in as a double word and the preset can be set as a double word under the input address assigned in Chapter 4.2.6.1 (See Chapter 5 for the data format).

In the following example, bytes 0 to 5 have been selected as the absolute encoder's I/O address.

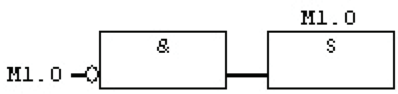
OB 1: Display position value and set preset

OB1 : "Main Program Sweep (Cycle)"

Comment:

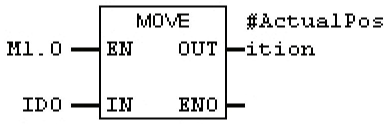
Network 1: Generate one flag

Comment:



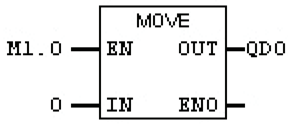
Network 2 : Read actual position

Comment:



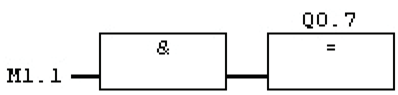
Network 3 : Load preset value (0 here)

Comment:



Network 4 : Set preset bit

Comment:



4.3.2 Reading diagnostic data

On occurrence of a PROFINET device diagnostic alarm, OB 82 is run through in S7. Amongst other aspects, the trigger for the diagnostic alarm can be ascertained in this. The diagnostic data can then be read-out with SFB52.

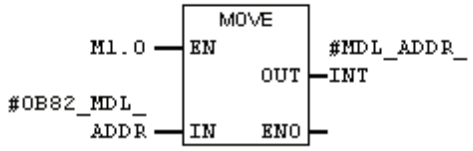
The events which trigger a diagnostic alarm in the absolute encoder can be found in Chapter 7.2.

The following example shows how this can be implemented in Step7. The absolute encoder again has the I/O address (logical basic address) 0 in this case. The control system transfers the logical basic address of the device which has transmitted the diagnostic alarm in the local variable #OB82_MDL_ADDR.

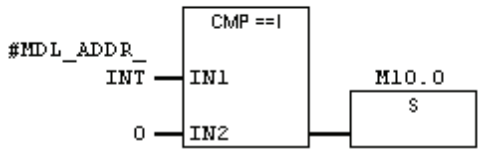
Note: In addition to the diagnostic data, the other data records listed in Chapter 7 can also be read-out with SFB 52.

OB 82: Evaluation of the local OB 82 data and initialisation of the read job

```
OB82 : Title:
OB82 is run through as soon as an assembly/module submits a diagnostic request
or sends an alarm
Network 1: Conversion to integer format
Comment:
```

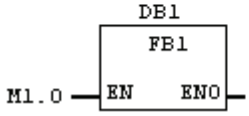



```
Network 2 : Set diagnostic requirement
Absolute encoder with logical basic address 0
```



OB 1: Calling the FB 1 to read the diagnostic data

```
Network 5 : Read data record with SFB52
Comment:
```



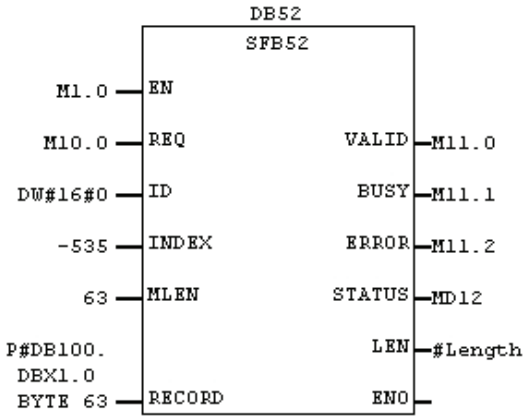
FB 1: Reading the diagnostic data with the SFB52 RDREC

FB1 : Diagnostic data read

The data are stored in DB100 as of byte 1.

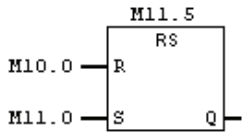
Network 1: Call SFB52 (RDREC)

ID = record index
Here: -535 dec. = FDE9 hex. - encoder diagnostic data record (63 bytes)



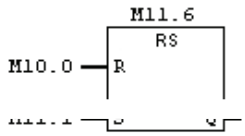
Network 2 : Data valid

Indicates whether the last read process was successful and the data are valid



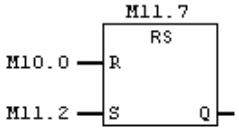
Network 3 : Busy

Indicates whether the last read process was initialised



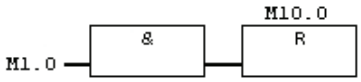
Network 4 : Error

Indicates whether the last read process was incorrect.



Network 5 : Reset diagnostic requirement

Comment:



4.3.3 Writing parameters

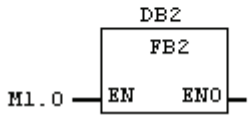
On starting the PROFINET, the parameters set in the hardware configuration are transferred to the TRT and are stored in the absolute encoder's flash memory. However, the S7 user programme enables these to be changed during operation. Each change also leads to storage in the flash memory. Note the following when changing the parameters from the user programme.

Attention! The new parameters are immediately valid!
This function must not be executed without extensive tests during system or machine operation.

OB1: Calling FB2 for writing the parameter data

Network 6 : Write data record with SFB53

Comment:



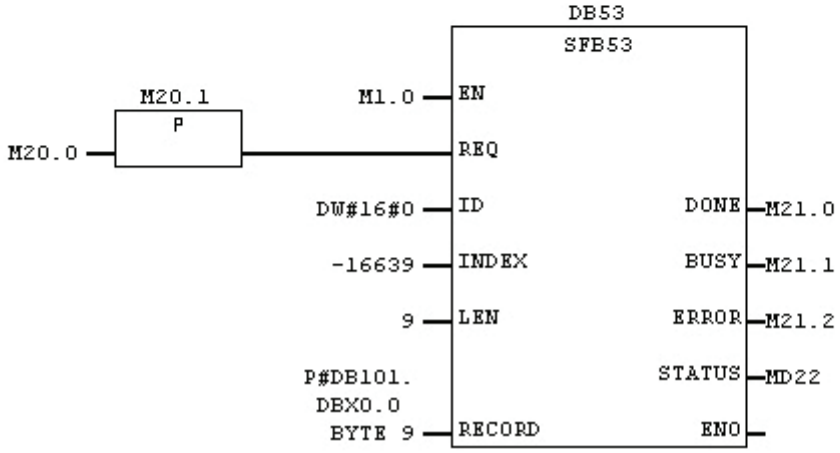
FB2: Writing the data record with the SFB53 WRREC

FB2 : Write data record

```
Writes parameter data

ATTENTION!!!
The new parameters are immediately valid.
This function must not be executed without extensive tests during system or
machine operation.
```

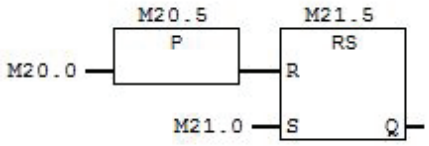
Network 1 : Call SFB53 (WRREC)

```
ID: Initial address of the I address range of the desired encoder

Index - data record number (record index):
BF01 = -16,639 dec. (9 bytes) - parameter data

LEN - length of the data to be transferred

Record - source DB of the data
```



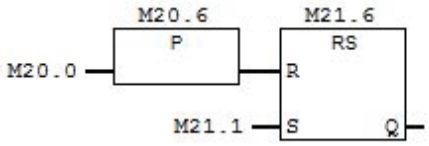
Network 2 : Valid

Indicates whether the last write process was successfull



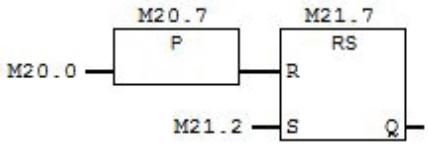
Network 3 : Busy

Indicates whether the last write process was initialised.



Network 4 : Error

Indicates whether the last write process was incorrect.



5. Data format

5.1 Overview

5.1.1 Encoder Profile 1.1 (Profile C4)

Input data: Device -> Controler

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6
MSB	position data		LSB	MSB velocity	LSB

Output data: Controler -> Device

Octet 1	Octet 2	Octet 3	Octet 4
MSB	preset data		LSB

5.1.2 Encoder Profile 4.2 (Profile E4)

5.1.2.1 Telegram 81

Input data: Device -> Controler

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8	Octet 9	Octet 10	Octet 11	Octet 12
ZSW2_ENC		G1_ZSW		position data G1_XIST1				position data G1_XIST2			

Output data: Controler -> Device

Octet 1	Octet 2	Octet 3	Octet 4
STW2_ENC		G1_STW	

5.2 Position data

5.2.1 Data format coding R

The position value is output as a 32-bit unsigned integer value in Motorola format (Big Endian). The factory setting of the resolution of the position value is 4096, 8192 or 65536 steps / turn. It can be adjusted via the parameterization.

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	position data[1] (singleturn)											
0	0	0	0	0	0	0	0	position data*																							
position data G1_XIST1																															

* For a resolution of 12 bit. With higher resolution correspondingly longer.

Note: The position value G1_XIST1 is always 32 bits long. At the end of the physical measuring range of the encoder, the revolutions are counted up in the encoder software. Thus the zero crossing of the position value is always only at the end of the full 32-bit value. It should be noted, however, that this value is lost in the event of a voltage drop.

5.2.2 Data format coding W

The rotary encoders with code type W (TRTxx-xxxxxxxW4096C4xTxx) reveal deviating position and preset value representation. In these models, the number of revolutions (multiturn part) is output in the first word and the steps of the single-turn part in the second word

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	number of turns												0	0	0	0	steps*											

* For a resolution of 12 bit. With higher resolution correspondingly longer.

5.2.3 Data format slew ring encoder (coding S)

The slew ring encoder converts the sensor shaft position into the slewing ring position which is displayed here. Therefore the gear ratio has to be set by the parameters "number of teeths slew ring" and the "number of theeth encoder pinion". The parameter "Resolution position" defines the resolution of the displayed slew ring position (see chapter 6**).**

The position value is output as a 32-bit unsigned integer value in Motorola format (Big Endian).

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
slew ring position																															

5.3 Velocity

The velocity value is determined via the cyclically read-in of the position data. The dimension is steps per gating time. The gating time (time interval for determining the change of position) is adjustable in the range of 10 - 1000 ms. The default value is 10 ms.

Octet 5								Octet 6							
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 velocity															

The speed value is output as a 16-bit signed integer value in Motorola format (Big-Endian). The following applies to the prefix:

positive for increasing position
negative for decreasing position

The refresh rate of the velocity signal is independent from the selected gating time always 1 ms. The resolution for speed measurement of the standard encoder is independent of the resolution set for the position value (parameter resolution). For devices with 12 or 13 bit resolution it is based on 4096 otherwise on 65536 steps per revolution.

The slew ring encoder shows the speed value of slew ring here. The resolution can be set independently from the resolution of the position via the parameter "resolution for speed" (see chapter 6).

The steps/gating time unit can be converted to rpm as follows:

$$u = \frac{v \times 60000 / t}{r}$$

v = encoder output for speed value
t = gating time in ms
u = speed in rpm
r = resolution in steps (4096 or 16384)

5.4 Setting the reference value (preset value) (Profile C4)

In certain cases, setting the reference value is unavoidable in order to compare the machine position values and the absolute position of the absolute encoder. The reference value is the position value which is displayed at the reference point. The user must note that the reference value must lie within the range of 0 to (total number of steps - 1). This particularly has to be taken into consideration when changing the total number of steps. In cyclical I/O data traffic, the reference value is transferred by setting bit 31 (octet 1, bit 7) of the output byte with the lowest value.

The set reference value (preset value) function should only be executed whilst the absolute encoder shaft is stationary! Setting the reference value is only possible when scaling is switched on (see Chapter 6)!

The preset value is taken over with the ascending flank of bit 31. An offset value is calculated (from the current actual position value and the reference value) by the absolute encoder in this case. This is stored in the absolute encoder, where it is protected against zero voltage, with the result that the new position is correctly output again even following voltage failure.

If the output actual position value is equal to the reference value, resetting can be carried out using bit 31, as preset mode is ended.

On inputting an incorrect preset value, control bit 31 has to be set to zero before inputting the correct preset value in order to rectify the error. The preset value can therefore be reset by setting control bit 31 to 1.

5.4.1 Data format coding R

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	preset value* (singleturn)											
	0	0	0	0	0	0	0	preset value* (multiturn)																							

Preset Control Bit

5.4.2 Data format coding W

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	preset value number of turns												0	0	0	0	preset value steps*											

Preset Control Bit

5.4.3 Data format slew ring encoder (coding S)

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	preset value slew ring																														

Preset Control Bit

* For a resolution of 12 bit. With higher resolution correspondingly longer.

6. Parameterisation

Parameterisation of the absolute encoder 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, but can also be carried out during I/O data traffic via the user programme.

Attention: Never change the parameterisation whilst a system or machine is in operation!

The data record number (record index) of the parameter data is: 0xBF01.

6.1 Parameter Encoder Profile 1.1

Byte	Bit No.	Parameter	Value range	Default	Remark
1		Operating mode			
	0	Code sense	0: clockwise (cw) 1: counter clock-wise (ccw)	clockwise (cw)	Ascending values on rotation clockwise (CW) or counter clockwise (CCW). (When looking towards the shaft)
	1-2	Not used			
	3	Scaling function	0: off 1: on	on	Enables/disables scaling of the position value via the resolutioin, the total number of steps and the preset.
	4-7	Not used			
2 - 5		Resolution [steps/revo-lution]	1 - 4096* or 4096* for coding W	4096*	To change this, the parameter "Scaling function" must be set to "on"
6 - 9		Total number of steps [steps]	1 - 16,777,216*	16,777,216*	To change this, the parameter "Scaling function" must be set to "on"
10 - 11		Gate time [ms]	10 - 1000	10	Time basis of the speed measurement (see notes)

* The maximum values depend on the encoder type. The values specified here apply to an encoder with 12 bit resolution.

Notes:

Coding:

All values in Motorola format (Big Endian)

Resolution

The resolution of encoders with **coding W** is not changeable and factory set to 4096 respectivly 8192 for the 25 bit encoder.

Total number of steps:

It must be noted that the number of revolutions is calculated in powers of 2n internally in the encoder. Irrespective of this requirement, the user can programme the desired total number of steps and the desired resolution according to the application. During calculation, the absolute encoder uses the next highest power of 2n if necessary. In this case, the values are designated as the effective resolution or the effective total number of steps and are displayed as the output values.

Example :	Desired total number of steps:	20,480
	Desired resolution:	4096
	Desired number of revolutions:	5
	Internal absolute encoder calculation	
	Effective total number of steps:	32,768
	Effective resolution:	4096
	Calculated number of revolutions:	8

(Note: The above notice is to be taken into consideration in the case of non-reversible operation. In the listed example, position 0 is only reached after 32,767 steps and not after 20,479 steps as desired.)

Gate time:

The steps/gate time unit can be converted to rpm as follows:

$$u = \frac{v \times 60000 / t}{4096}$$

v = encoder output for speed value
t = gate time in ms
u = speed in rpm

6.2 Parameter Encoder Profile 4.2

Parameter	Value range	Parameter description
Parameter initialsation control	PRM data block / internal memory	Controls whether the encoder parameters are initialized by the Profinet Controller during startup (PRM data block) or by the internal memory of the encoder
Parameter write protect	Write all / read only / write controller / write Supervisor	Controls the write access via the acyclic communication
Parameter 65005 write protect	Write all / read only	The parameter 65005 contains the bits (param. initialization, param. write protect and reset control protect)
Reset control protect	Write all / read only	Controls the write access on parameter 972 (drive reset).
Class 4 functionality	on / off	Enables the scaling, the preset function and the code sequence
Compatibility mode	off	Not supported
Code sequence	CW / CCW	CW (clockwise): ascending values on rotation clockwise CCW (counter clockwise): descending values on rotation clockwise (viewed looking at the shaft)
Preset function	off / on	Enables the preset function for G1_XIST1
Scaling function	off / on	Enables the scaling
Channel related diagnosis	off / on	Not supported
Encoder type	Rotary encoder	
Resolution [steps/turn]	1 ... 16384	Steps per turn (360°)
Total measuring range [steps]	1 ... 67.108.864 or 16384 for single turn encoder	Results from set resolution times desired number of revolutions. The maximum value is 16384 x 4096.
Maximum tolerated failures of Master Sign-Of-Life	0...255	Not supported

Velocity measuring unit	steps/s (100ms, 10ms), rpm, N2/N4 normalised	
Velocity reference value for N2/N4	3000.0000	Specifies the 100% value for the N2/N4 output

6.3 Parameter of the slew ring encoder (coding S)

Byte	Bit No	Parameter	Value range	Default	Remark
1	0	Code sense	0: clockwise (cw) 1: counter clock-wise (ccw)	clockwise (cw)	Ascending values on rotation clockwise (CW) or counter clockwise (CCW). (When looking towards the shaft)
	1-7	Not used			
2 - 3		Number of teeth slew-ing ring	1 - 65535	100	The number of teeth of the ma-chines slew ring has to be great or equal the number of teeth of the encoder pinion.
4 - 5		Number of teeth enco-der pinion	1 - 65535	10	Number of teeth of the encoder pinion which gears in the slew ring
6 - 9		Resolution position [steps]	1 ... 8192 x i	36000	Desired resolution of the slew ring position (see notes).
10 - 11		Gate time [ms]	10 - 1000	100	Time basis of the speed measurement
12 - 15		Resolution for speed calculation [steps]	1 ... 8192 x i	36000	The resolution of the slew ring used for the speed calculation (see notes).

t = Gear ratio *Number of teeth slewing ring* to *Number of teeth encoder pinion (Note: 1 ≤ i ≤ 32).*

Notes:

Coding:

All values in Motorola format (Big Endian)

Resolution position:

The maximum possible resolution of the slew ring is 8192 steps x gear ratio i.

Example:

Gear ratio 1:4

=> max. resolution 8192 steps x 4 = 32768 steps

To get a position value in degree you can set the parameter resolution position to:

- 360 steps for a resolution of 1°
- or 3600 steps for a resolution of 0,1°

If you enter 32768 steps the maximum number of steps is output.

Depending on the gear ratio slew ring resolutions up to 0,001° can be achieved. The following applies:

Parameter "Resolution position"	Slew ring resolution
360	1°
3600	0,1°
36000	0,01°
360000	0,001°

Note:
Resolution position
≤ 8192 x gear ratio

Resolution for speed calculation:

The resolution of the slew ring used for the velocity calculation can be adjusted independendly of the parameter "Resolution position".

To get a speed value in degree/time one of the following values should be entered for the parameter "Resolution for speed calculation":

Parameter "Resolution for speed calculation"	Slew ring speed
360	1° / Torzeit
3600	0,1° / Torzeit
36000	0,01° / Torzeit
360000	0,001° / Torzeit

Note:
Resolution for speed
≤ 8192 x gear ratio

All intermediate values are possible.

Gate time:

The steps/gate time unit can be converted to rpm as follows:

$$u = \frac{v \times 60000 / t}{r}$$

v = encoder output for speed value
t = gate time in ms
u = speed in rpm
r = resolution for speed calculation

7. Diagnosis

7.1 Overview

The encoder TRT gives diagnosis information in 3 different ways:

- LED (see chapter 3.3)
- PROFINET alarms (see below)
- Diagnosis records (see below)

7.2 PROFINET alarms

The following alarms are send via the PROFINET alarm mechanisme. In the PROFINET controler they are shown in plain text with further help texts.

Error no.. (hex)	Error text	Encoder reaction	Status LED (NS)	Remarks/remedy
0x1100	Sensor error	Diagnosis data: Sensor error	red flashing (10 Hz)	Please switch power off/on
0x1111	Preset error	Diagnosis data: Preset error	red flashing (1 Hz)	The preset value has to be in the range of 0 to total steps - 1 or 0 to resolution position - 1 for the slew ring encoder. Setting is only possible when scaling is on (only standard encoder).
0x1120	Velocity range exceeded	Diagnosis data: speed error Speed value = 0	red flashing (1 Hz)	Please reduce the speed or reduce the value for the gating time. Switch power off/on afterwards.
0x1140	Parameter error	Diagnosis data: Parameter error	red flashing (1 Hz)	**Standard encoder:** The value for the total steps has to be in the range of: resolution ... (resolution x max. number of turns) **Slew ring encoder:** - gear ratio smaller than 1 or to high - resolution not possible for this gear ratio

7.3 Diagnosis data

The data records listed in the table below are available for diagnosis for the TRT. These can be read out using the acyclical read services.

Record Index	Data record
0xAFF0	I&M0 data (according to I&M specifications version 1.2)
0xBF01	Parameter data (see chapter 6)
0xFDE9	Diagnosis data (see below)

7.3.1 Diagnosis data of Encoder Class 2 Profil

Diagnosis data in data record 0xFDE9					
Byte	**Datatyp**	**Diagnostic function**	**Default (values in hex)**	**Diagnostic alarm**	**Remark**
1 8	BYTE	Reserved	00		
9	BYTE	Operating status	08	No	CW, Scaling on
10	BYTE	Encoder typ	01	No	Absolute multiturn encoder
11 - 14	UINT32	Maximum resolution	0000.1000*	No	Maximum possible steps/ turn of the present encoder
15 - 16	UINT16	Maximum measuring range	1000 or 1 for singleturn encoder	No	4096 revolutions
17	UINT8	Additional alarm messages	00	No	Not supported
18 - 19	UINT16	Supported alarm messages	0000	No	Not supported
20 - 21	UINT16	Warning messages	0000	No	Not supported
22 - 23	UINT16	Supported warning messages	0000	No	Not supported
24 - 25	UINT16	Profile version	0101	No	Current encoder profile version
26 - 27	UINT16	Software version	xx.xx	No	Current firmware version
28 - 31	UINT32	Operating time	FFFF.FFFF	No	Not supported
32 - 35	UINT32	Offset value	0000.0000	No	Current internally calculated offset value
36 - 39	UINT32	Manufacturer offset value	0000.0000	No	Not supported
40 - 43	UINT32	Resolution	0000.1000*	No	Currently set resolution (only for standard encoder)
44 - 47	UINT32	Total number of steps	01.000.0000* or 1000* for singleturn encoder	No	Current total number of steps (only for standard encoder)
48 - 57	BYTE	Serial number		No	Serial number of the device
58 - 59	BYTE	Reserved	0000	No	
60 - 63	BYTE	Manufacturer specific diagnostic data	00000000	Yes	See below

* Depending on the encoder type.

Diagnosis

Manufacturer-specific diagnosis data

Byte	Bit	Error message	Profinet alarm	Red LED	Help (see Profinet alarms)
60	0 - 7	reserved			
61	0 - 7	reserved			
62	0	Flash memory error	yes	Rapid flashing (10 Hz)	
	1 - 7	Not used			
63	0 - 1	Not used			
	2	Parameter error	yes	Flashing (1 Hz)	
	3	Not used			
	4	Not used			
	5	Not used			
	6	Preset error	yes	Flashing (1 Hz)	
	7	Velocity error	yes	Flashing (1 Hz)	

8. Scope of delivery

The scope of delivery includes:
- Absolute encoder 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 PNO certificate
- example programmes
- GSD file and bitmap

Annex A: absolute encoder terms

Parameter	Explanation
Resolution - steps/360°	The resolution specifies the number of steps per revolution (360°).
Measuring range	The measuring range specifies the maximum number of revolutions. The revolutions must be specified in powers of 2^n.
Total number of steps	The total number of steps arises as follows: total number of steps = resolution x measuring range
Code path	The code path specifies the direction of rotation in which the encoder's output code ascends. Depending on the direction of rotation, a distinction is made between: CW - clockwise direction of rotation CCW - counter clockwise direction of rotation (when looking towards the shaft)
Reference value/preset	The reference value is the value which appears as the encoder's actual position value according to the preset function. It lies in the value range from 0 to total number of steps -1.