

USER MANUAL

PROFIsafe over PROFINET

for Absolute Encoder TRT/S3



1-800-366-5412 | 1-208-263-8541 | encoder.com | sales@encoder.com

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Encoder Products Company

464276 Highway 95 South
Sagle, Idaho 83860
USA

Phone: +1 (208) 263-8541

Fax: +1 (208) 263-0541

Email (Sales): sales@encoder.com

Website: encoder.com

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Table of Contents

1. SAFETY INSTRUCTIONS	5
1.1 Scope	5
1.2 Documentation	5
1.3 Proper use	5
1.4 Commissioning	5
2. GENERAL INFORMATION	6
2.1 Security	6
3. INSTALLATION	7
3.1 General information	7
3.2 Electrical connection	7
3.3 Status LED	8
3.4 Project planning	9
4. PROJECT PLANNING WITH SIMATIC STEP7	10
4.1 Step7, Safety Advance - TIA-Portal	10
4.1.1 Prerequisites	10
4.1.2 Installation of the GSD file	10
4.1.3 Installing the absolute encoder	11
4.1.4 Install module	12
4.1.4.1 Setting the PROFINET / PROFIsafe Address	14
4.1.4.2 IP-Address	14
4.1.4.3 Prioritized startup, media redundancy, update time and synchronization	14
4.1.5 Setting the absolute encoder (properties of the module)	15
4.1.5.1 Setting the I/O address	15
4.1.5.2 Parameterizing the absolute encoder	15
4.1.5.3 Setting the F parameters	15
4.1.6 Planning of "Device exchange without programming device" and "Automatic commissioning"	16
4.1.7 Assignment of the device name	17
4.1.8 Resetting to the factory settings	18
4.2 Application program	18
4.2.1 Remarks	18
4.2.2 F-Periphery-DB	19
4.2.3 Accessing the encoder in the F program	19
4.2.4 Example program	19
5. I/O DATA	25
5.1 Overview	25
5.1.1 Output code D and S	25
5.2 Status word	26
5.3 Position data	26
5.3.1 Data format coding D and S	26

5.4 Velocity 27

5.5 F input data. 27

5.6 Status data format 27

5.7 Preset value (reference value) 28

 5.7.1 Data format coding D and S 28

5.8 F output data. 28

6. PARAMETERIZATION 29

 6.1 Encoder parameter Class2 (encoder profile 1.1) 29

 6.1.1 Overview 29

 6.1.2 Description of the encoder parameters (encoder profile 1.1) 29

 6.2 Encoder parameter slewing ring function (code S). 30

 6.2.1 Overview 30

 6.2.2 Description of the slewing ring parameter (code S) 31

 6.3 F parameter 32

 6.3.1 Overview 32

 6.3.2 Description of the F parameters 32

7. DIAGNOSTIC 34

 7.1 Overview 34

 7.2 PROFINET alarms 34

 7.2.1 Additional alarms. 35

 7.3 Diagnostic data records. 36

8. REFERENCE DOCUMENTS 37

9. REVISION HISTORY 37

1. SAFETY INSTRUCTIONS

1.1 Scope

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

- TRTxx-xxxxxxx R4096S3xTxx (Multi-turn)
- TRTxx-xxxxxxx xS3xTxx (Single-turn)

1.2 Documentation

The following documents must be observed:

- The owner's system-specific operating instructions
- This user manual
- Datasheet number: TRT42/S3: **TRT16468**
- The connection assignment TYxxxxx enclosed with the device
- Assembly instructions **AN16169**

1.3 Proper use

The EPC 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 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 datasheet.
- Check all electrical connections before commissioning the system.

2. GENERAL INFORMATION

Model TRT/S3 is an electromagnetic rotary encoder with a PROFINET interface and PROFIsafe protocol. Thanks to additional internal monitoring measures, it is suitable for use in safety-technical applications up to SIL2 or PLd.

In addition to a safe position signal, these encoders also supply a safe speed signal. It offers the same parameterization and diagnostic options as the standard PROFINET and PROFIBUS rotary encoders.

Free module selection is possible. I.e. the TRT/S3 automatically adapts to the module selected in the project planning. Reprogramming of the encoder is not necessary.

The PROFINET interface according to IEC 61158 / 61784 or PNO specifications, order Nos. 2.712 and 2.722 version 2.42, 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. PROFIsafe V2 mode is supported.

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

The encoder model TRT/S3 offers a slewing ring functionality for safety applications. This translates the position value of the sensor shaft into the position of a slewing ring or a rotary table, with any transmission ratio between the slewing ring and the encoder pinion. When using the slewing ring function, the safety instructions in Chapter 5.1 must be observed.

2.1 Security

The user must ensure that the network in which the TRT/S3 is located is protected against unauthorized access from outside. Failure to do so may result in dangerous conditions on the system due to manipulation of the device software.

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 EPC 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

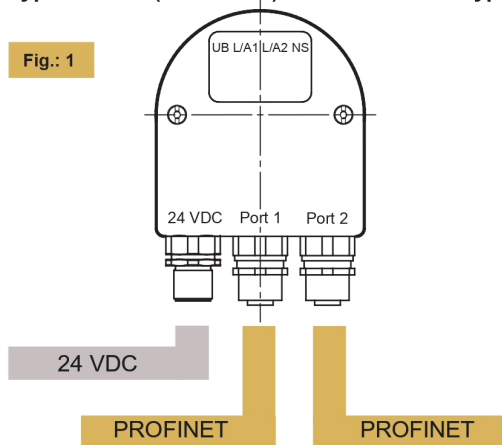
The “...MT01” or “...TT01” type absolute encoders have separate connectors for the supply and the PROFINET system. Port 1 or port 2 are optionally available for the PROFINET connection. Due to the integrated switch, it is irrelevant which port is used.

Connection	Designation	Connector type TRT42/S3	Connector type TRT58/S3
PROFINET	Port 1	M8, D-coded socket	M12, D-coded socket
PROFINET	Port 2	M8, D-coded socket	M12, D-coded socket
Voltage supply	24 VDC	M8, A-coded pins	M12, A-coded pins

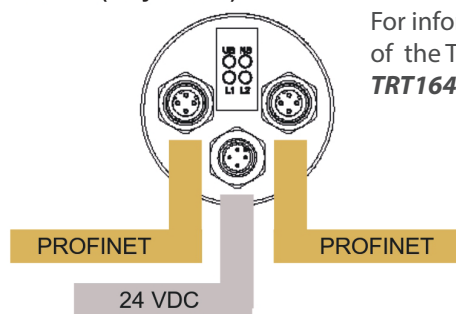
- Refer to datasheet: **TRT16468** (TRT42) for connector assignment and ordering information.

Type ...MT01 (not TRT42)

Fig.: 1



Type ...TT01 (only TRT58)



For information about the connection of the TRT42 please review datasheet **TRT16468**.

3.3 Status LED

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

UB	Link 1 (L1)	Link 2 (L2)	Status (NS)	Description
green	green	green	green/red	
on	on			Operating voltage available
	on			Network connection established
		on		Network connection established
			green	Data exchange, device in operation and OK
			green flashing	Network connection o.k. but no connection to a PROFINET controller
			red, slow flashing	Firmware download mode
			red flashing	Impermissible parameter or preset value, velocity too high or wrong module
			fast red flashing	Device error
			red	Connection to the PROFINET controller disrupted

In chapter 7 diagnosis you can find all diagnosis data of the encoder.

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 1	1	F stack error
Flashing code 2	2	CRC error ROM
Flashing code 3	3	RAM/XRAM error
Flashing code 5	5	Program 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.encoder.com

TRT/S3

File name of the GSD file: GSDML-V2.45-EPC-TRT42S3-xxxxxxx.xml

File name of the bitmap: GSDML-0159-6310-EPC_TRT42.bmp

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

4. PROJECT PLANNING WITH SIMATIC STEP7

4.1 Step7, Safety Advance - TIA-Portal

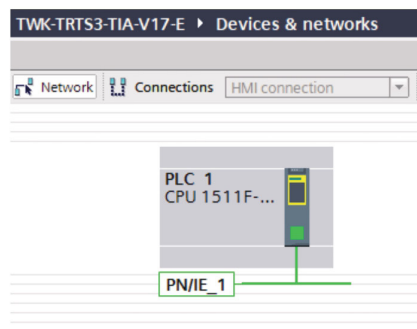
This chapter explains the procedure for integrating the EPC TRT/S3 absolute encoder into the PROFINET network of a Siemens S7 control system with Step 7 Professional V17 with Safety Advanced.

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 CPU1511F:

Fig.: 2

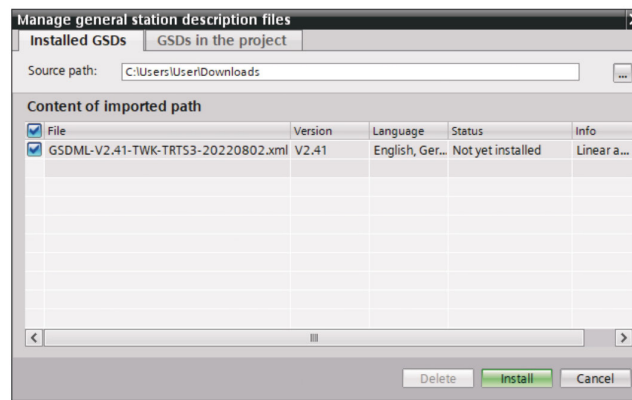


4.1.2 Installation of the GSD file

- 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 3).
- The absolute encoder symbol is also installed automatically, provided that it is in the same directory.

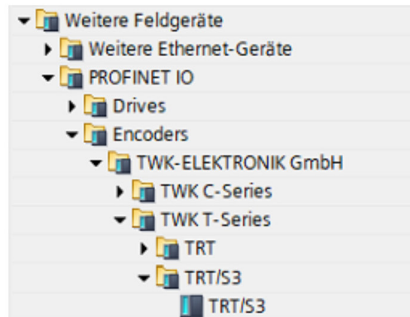
Note: The GSD file and the encoder symbol (bitmap) are available for download under www.encoder.com.

Fig.: 3



After installing the GSD file, the hardware catalogue is automatically updated. The TRT absolute encoder is located under **Further FIELD DEVICES, PROFINET IO, Encoders, EPC, EPC T series, TRT/S3**.

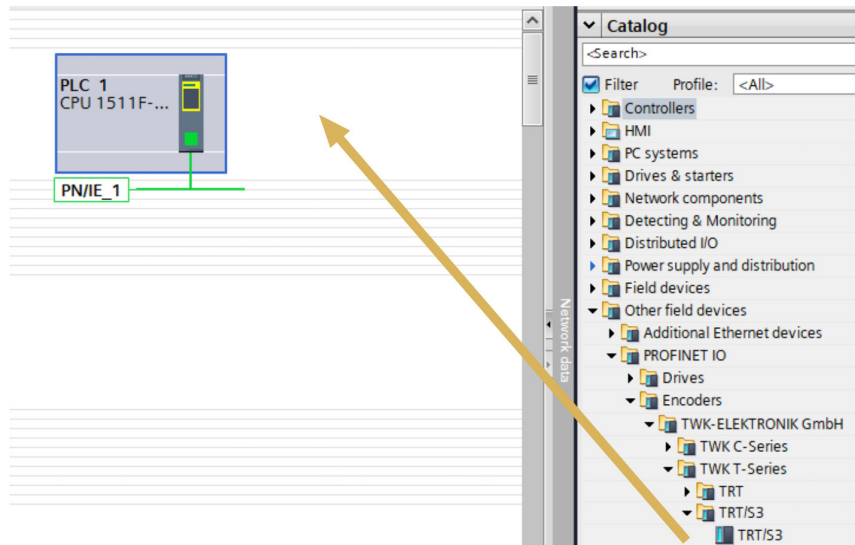
Fig.: 4



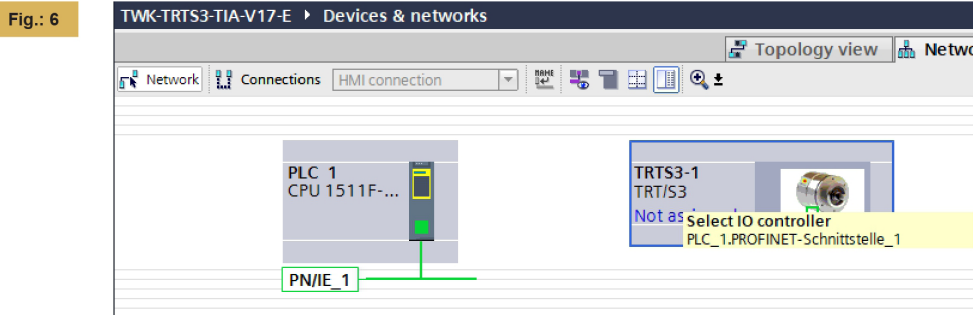
4.1.3 Installing the absolute encoder

Now drag the TRT/S3 encoder from the hardware catalog in the netview of your project.

Fig.: 5



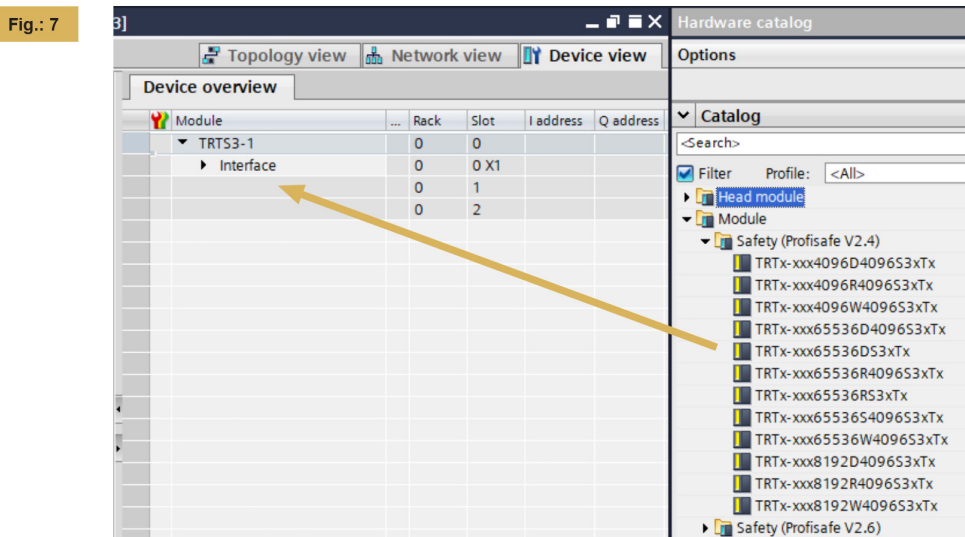
Next click on “Not assigned” and assign the inclination sensor to the PROFINET interface of your CPU or draw a network connection from the inclination sensor to the CPU port with your mouse.



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

4.1.4 Install module

To install the encoder module, change to the Device view of the TRT/S3 and drag the module corresponding to your encoder to the first free slot of the module list. It is also possible to use other modules. The TRT/S3 automatically adapts to the selected module.



The TRT/S3 offers two slots. A non-safe module can be installed on the second slot. This offers the possibility to use the position and speed value of the safety module in the standard program or a standard controller. The module in slot 2 must have the same resolution and code type as the safety module. It only has input data to which the data of the safety module is mirrored.

Note: For multi-turn encoders multi-turn modules (TRTx-...4096S3xTx) must be used and for single-turn encoders single-turn modules (TRTx-...D/RS3xTx). Please refer to the table on the next page.

The following modules are available for different resolutions and data formats as well as for single-turn and multi-turn. They are available with Profisafe protocol versions 2.4 and 2.6.

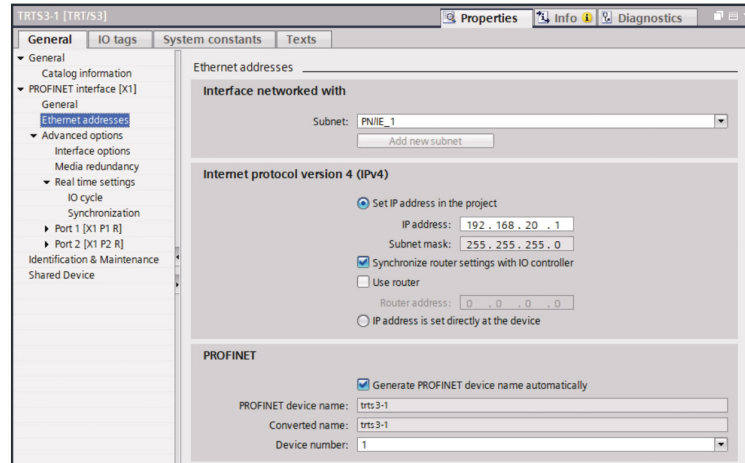
Module	Resolution	MT/ ST *	Funtionality
TRTx-xxx65536D4096S3xTx	16 bit	MT	Safe position (1x integer32), safe speed, preset (module not useable in Distributed Safety)
TRTx-xxx65536DS3xTx	16 bit	ST	Safe position (1x integer32), safe speed, preset (module not useable in Distributed Safety)
TRTx-xxx65536S4096S3xTx	16 bit	MT	Safe slewing ring position (integer32), safe slewing ring speed, preset

* MT = Multi-turn, ST = Single-turn

Setting the network data

Select the encoder in the Device view to show the properties of the PROFINET interface of the TRT/S3.

Fig.: 8



4.1.4.1 Setting the PROFINET / PROIsafe 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 TRTS3-1.

In the TRT/S3, the Profisafe address must be added to the 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). This must then be entered for F_Dest_Add under the F parameters (see chapter 4.1.6.3).

The name assigned here must either be manually allocated to the absolute encoder (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 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 4.1.7 have to be met.

4.1.4.2 IP-Address

Under “PROFINET interface - Ethernet addresses - Internet protocol version 4” the box 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.

4.1.4.3 Prioritized startup, media redundancy, update time and synchronization

Via the interface option Prioritized startup the startup time of the TRT/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 TRT/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 TRT/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 TRT/S3 can be set. The possible values depend on the setting of the send clock of the CPU. The minimal update time for the TRT/S3 is 250 µs.

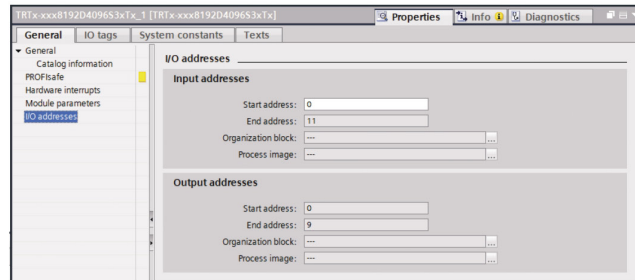
The desired real time class can be set under Synchronization. The TRT/S3 supports the classes RT and IRT.

4.1.5 Setting the absolute encoder (properties of the module)

4.1.5.1 Setting the I/O address

After switching to the device view of the TRT/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 (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).

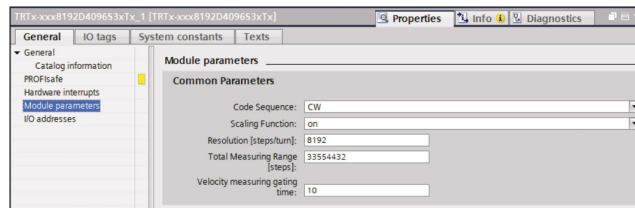
Fig.: 9



4.1.5.2 Parameterizing the absolute encoder

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

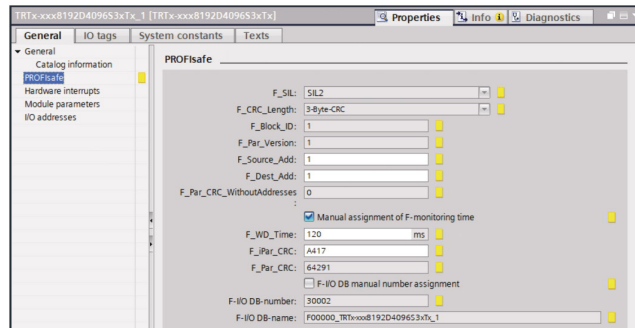
Fig.: 10



4.1.5.3 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.: 11



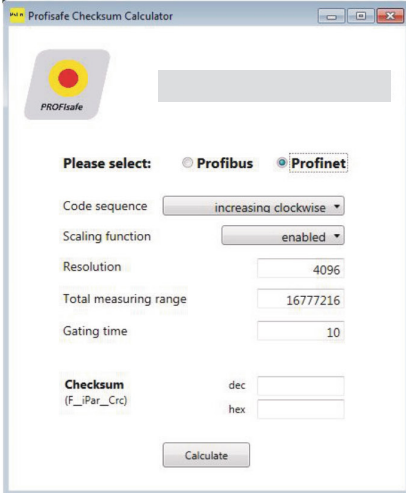
At the bottom of this window you can see the number and the symbolic name of the F-IO data block of this encoder assigned by Step7.

Once you have changed the rotary encoder parameters, the checksum must be recalculated using these so-called i parameters and must be entered under “F_iPar_CRC”. EPC provides you with the PsCRC program for calculating the F_iPar_CRC (see fig. 12).

It can be downloaded from the internet under www.encoder.com topic Documentation model PsCRC.

An explanation of all F parameters can be found in chapter 6.2.

Fig.: 12

The image shows a screenshot of a software application titled "Profisafe Checksum Calculator". The interface includes a logo with a red and yellow circle and the text "PROFIsafe". Below the logo, there is a section labeled "Please select:" with two radio buttons: "Profibus" and "Profinet", where "Profinet" is selected. The settings section includes: "Code sequence" with a dropdown menu set to "increasing clockwise"; "Scaling function" with a dropdown menu set to "enabled"; "Resolution" with a text input field containing "4096"; "Total measuring range" with a text input field containing "16777216"; and "Gating time" with a text input field containing "10". At the bottom, there is a "Checksum (F_iPar_CRC)" section with two input fields labeled "dec" and "hex", and a "Calculate" button.

4.1.6 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 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 4.1.8) 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 neighboring devices). The TRT/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.

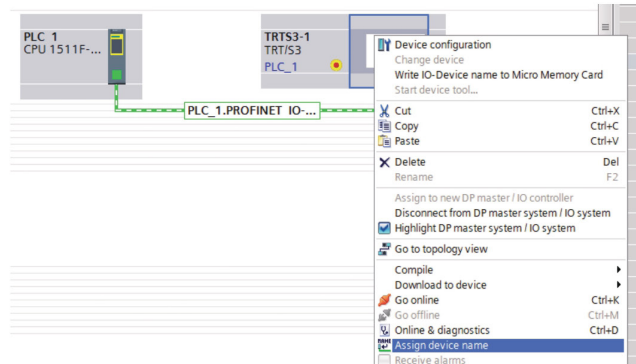
Now call the topology editor using the PROFINET system’s context menu and define all PROFINET connections between the subscribers.

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.

4.1.7 Assignment of the device name

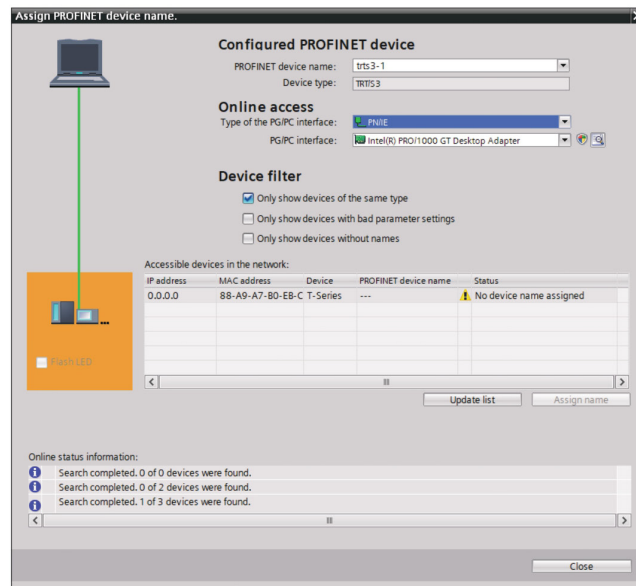
If a PROFINET topology has not been defined as described in chapter 4.1.7 or if the prerequisites for automatic commissioning are not met, the absolute encoder name must be assigned manually. With the absolute encoder connected and the programming device connected to the control system, select “Assign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

Fig.: 13



Subsequently the window “Assign PROFINET device name” appears, as shown in figure 14.

Fig.: 14



It can be seen that the absolute encoder device type “EPC 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.”

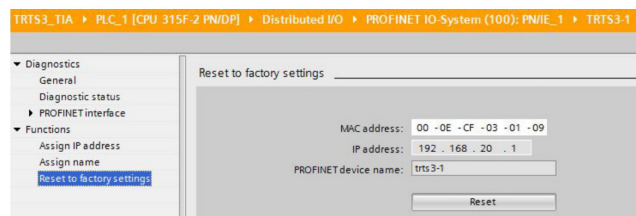
The device name is then stored in the absolute encoder, where it is protected against zero voltage.

The absolute encoder now logs onto the controller with its device name and is then provided with a valid IP address by the controller.

4.1.8 Resetting to the factory settings

After going online the online diagnosis is available via the context menu of the TRT/S3. Under “Functions” the function “Reset to factory settings” is available.

Fig.: 15



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

4.2 Application program

4.2.1 Remarks

For a detailed documentation for project planning and programming of F programs refer to SIMATIC S7 Distributed Safety - Project Planning and Programming, Programming and Operating Manual (A5E00109536-03) /7/ and SIMATIC S7 Distributed Safety Getting Started /8/ respectively SIMATIC Safety - Project Planning and Programming /9/ und SIMATIC Safety Getting Started /10/ when using Safety Advance in the TIA-Portal.

4.2.2 F-Periphery-DB

On translation of the hardware configuration, an F periphery DB is generated for the absolute encoder, 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 encoder necessary variables. It has the following appearance:
(A detailed description can be found in the documentation mentioned above)

Safety Advance

F00000_TRTx-xxx8192D4096S3xTx								
	Name	Data type	Offset	Start value	Retain	Visible in ...	Setpoint	Comment
1	Input							
2	PASS_ON	Bool	0.0	false		☒		1=ACTIVATE PASSIVATION
3	ACK_NEK	Bool	0.1	TRUE		☒		1=ACKNOWLEDGEMENT NECESSARY
4	ACK_REI	Bool	0.2	false		☒		1=ACKNOWLEDGEMENT FOR REINTEGRATION
5	IPAR_EN	Bool	0.3	false		☒		1=ENABLE I-PARAMETER ASSIGNMENT
6	Output							
7	PASS_OUT	Bool	2.0	TRUE		☒		1=PASSIVATION OUTPUT
8	QBAD	Bool	2.1	TRUE		☒		1=FAIL-SAFE VALUES ARE OUTPUT
9	ACK_REQ	Bool	2.2	false		☒		1=ACKNOWLEDGEMENT REQUEST
10	IPAR_OK	Bool	2.3	false		☒		1=NEW I-PARAMETER VALUES ASSIGNED
11	DIAG	Byte	3.0	16#0		☒		DIAGNOSTIC INFORMATION

4.2.3 Accessing the encoder in the F program

Important for the fail safe operation of the encoder 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.

The access to the I/O data of the encoder is different and depends on the output code of the encoder and on the S7 software package. In Distributed Safety, the use of double words in the safety program is prohibited in this case, only word access to the 32 bit position and reference value is possible. This means the position and the reference value are divided into 2 words each and the evaluation has to be done separately. For this use encoder with output code “R” and “W” are provided.

In the safety program of TIA Safety Advanced, doublewords can be used now. Thus position and reference value in data type DINT32 can be treated in the same way as in the standard program. For this use encoder with output code “D” are provided. For a description of the data format see chapter 5.

4.2.4 Example program

The following example shows how to access the position and speed value as well as the F periphery DB of the Profisafe absolute encoder in the safety program. Setting a preset value and reading the diagnosis data is also demonstrated.

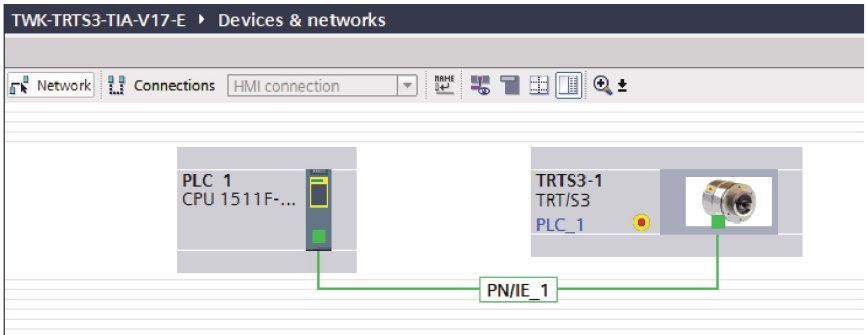
Only the programming steps which refer to the EPC absolute encoder are shown here. Knowledge regarding the programming and sequence of the failsafe S7 program is assumed. As an introduction to failsafe programming, we recommend „SIMATIC S7 Distributed Safety - Getting Started“ /8/ and „SIMATIC S7 Distributed Safety – Project Planning and Programming“ /7/ respectively SIMATIC Safety - Project Planning and Programming /9/ and SIMATIC Safety Getting Started /10/ when using Safety Advance under TIAPortal.

All program blocks of the following example can be found in the internet under www.encoder.com. The following documentation was created with TIA Portal V17 incl. Safety Advance and a CPU115F-1PN.

Devices required to operate the example program

- F CPU with PROFINET interface
- Profisafe encoder TRT/S3 with output code “D” (see “remarks to the program” on the next page)
- Step7 V17 with Safety Advanced V17

Hardware structure of the example program



Inputs and outputs used in the program

TWK-TRTS3-TIA-V15-EN > PLC_1 [CPU 1511F-1 PN] > PLC tags > Standard-Variablen-tabelle [76]

Standard-Variablen-tabelle								
	Name	Data type	Address	Retain	Access...	Write...	Visible...	Supervis...
1	TRT_ErrorPreset	Bool	%I1.0	☐	☒	☒	☒	
2	TRT_SpeedValue	Int	%IW2	☐	☒	☒	☒	
3	TRT_PositionsValue	Dint	%ID4	☐	☒	☒	☒	
4	Set_Preset	Bool	%Q1.0	☐	☒	☒	☒	
5	TRT_PresetValue	Dint	%QD2	☐	☒	☒	☒	
6	TrueFlag	Bool	%M0.0	☐	☒	☒	☒	
7	failsafestatus	Bool	%M0.1	☐	☒	☒	☒	
8	AckRequest	Bool	%M0.2	☐	☒	☒	☒	
9	Set_Preset_Pin	Bool	%M0.3	☐	☒	☒	☒	
10	Parameter_Enable	Bool	%M0.4	☐	☒	☒	☒	
11	UsrAck	Bool	%M0.5	☐	☒	☒	☒	
12	Limit1	Bool	%M0.6	☐	☒	☒	☒	
13	Diagnose_Request	Bool	%M11.0	☐	☒	☒	☒	
14	DataValid	Bool	%M11.1	☐	☒	☒	☒	
15	Busy	Bool	%M11.2	☐	☒	☒	☒	
16	Error	Bool	%M11.3	☐	☒	☒	☒	
17	LaddrValue	Hw_Any	%MW12	☐	☒	☒	☒	
18	PresetValue	Dint	%MD100	☐	☒	☒	☒	
19	Sensor_PresetValue	Dint	%MD104	☐	☒	☒	☒	
20	Speed_Data	Int	%MW108	☐	☒	☒	☒	

Remarks to the program

Access to the profisafe absolute encoder is carried out in a F program module (here FB100), which must be called up in a Fruntime group (F call-up module F CALL when using Distributed Safety). Calling the FB100 in the F CALL is not described here.

When using Distributed Safety it should be noted that access to double words is not permitted (see chapter 4.2.3). An example program for Distributed Safety is available on our homepage. The examples show how to carry out the comparison between the position and the threshold values although the position value consists of two words and the compare operation needs integer values.

The following listing contains only the for the handling of the encoder relevant part. Program blocks like F-CALL, clock OBs or peripheral data blocks are not listed.

OB1, NW 1 - 3: Load preset value, show F error messages with the DIAG byte

- ▼ **Block title:** Main program for TWK-PROFIsafe encoder TRT/S3
- ▼ TrueFlag, DIAG-Byte and calling FB ReadDiagData. Calling up the safety program is done in the F runtime group.

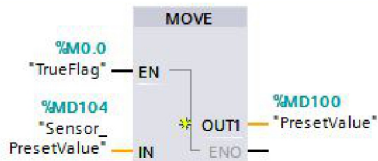
▼ **Network 1:**

Generate true flag



▼ **Network 2:**

The preset value is stored in the MD104.



▼ **Network 3:**

- ▼ Display of F error messages (here in help byte 1; in a real system, this should be further processed in the error message system). Polling the DIAG variable in the safety programme is not permissible. (Meaning of the individual bits in I7)



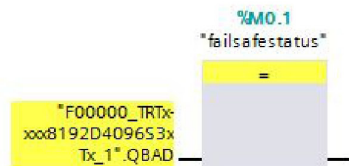
FB100, NW 1 - 3: Reading QBAD and Acknowledge

▼ Block title: TWK absolute encoder as a PROFISAFE subscriber

Comment

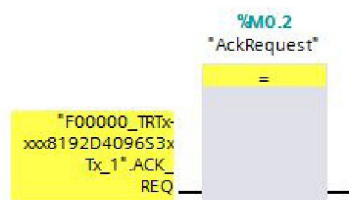
▼ Network 1:

- ▼ Polling of the failsafe status of the absolute encoder. In a real system this bit must be polled to introduce the fail safe state of the system. In case of QBAD = 1 the system has to go in the fail safe state.



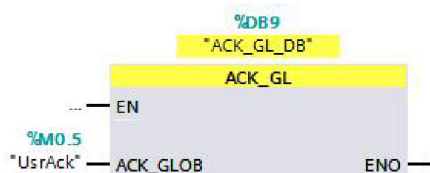
▼ Network 2:

Display necessary user acknowledgement

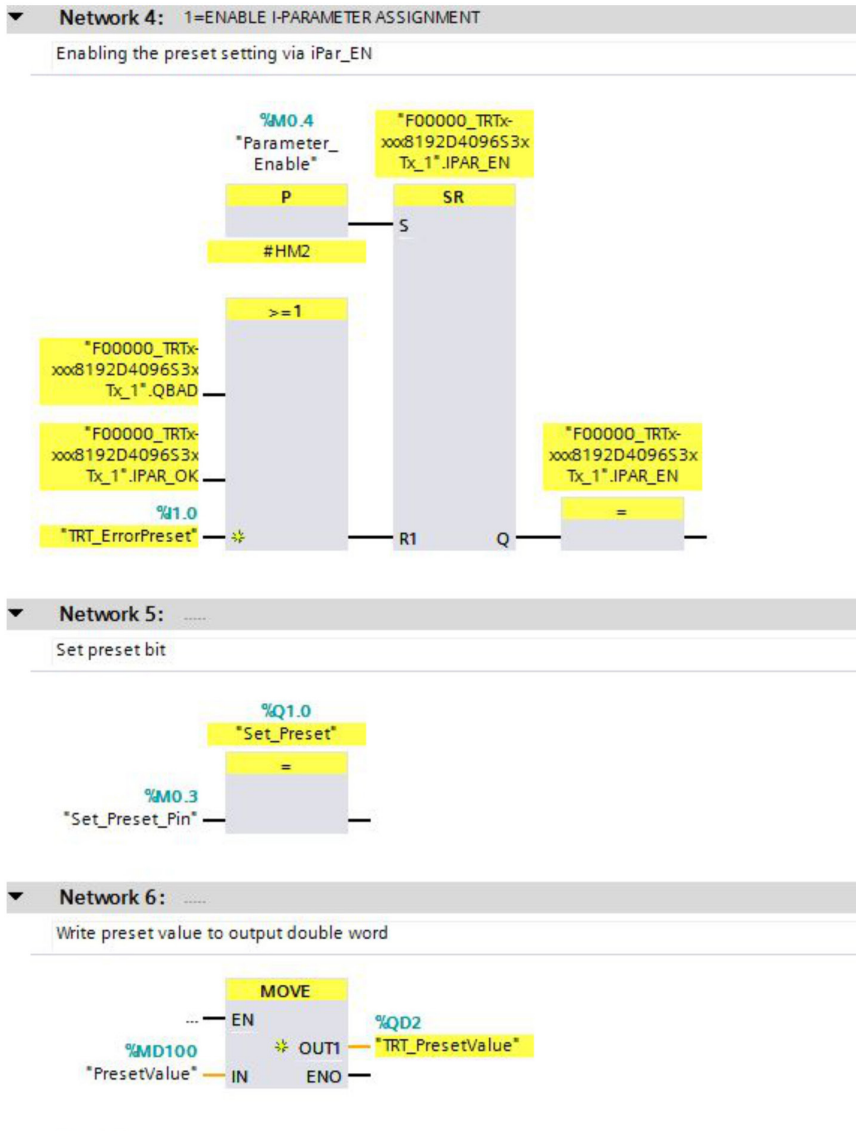


▼ Network 3:

Carry out user acknowledgement



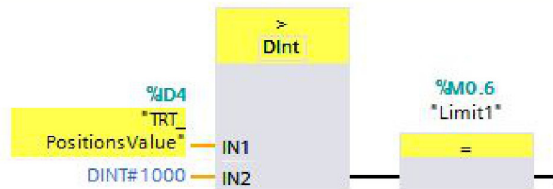
FB100, NW 4 - 6: Set reference value



FB100, NW 7 - 8: Accessing position and velocity

Network 7:

Example of a limit monitoring of the position value



Network 8:

Accessing the speed value



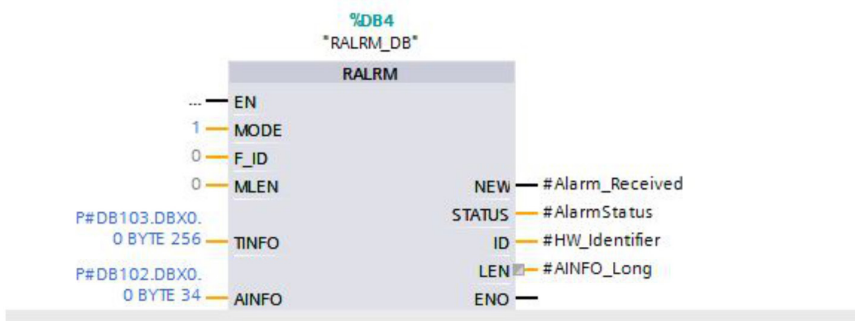
Evaluation of a PROFINET alarm

The SFB54 (RALRM) has to be called in an alarm OB. In the output ID it delivers the hardware identifier of the device that has triggered the alarm. In the data block to which AINFO points amongst others the alarm number can be read.

OB 82: NW 4

Network 4: Calling SFB54 (RALRM)

The SFB54 can only be called in the OB82.



5. I/O DATA

5.1 Overview

Note: The illustrations of the data formats below show the PROFIsafe protocol of PROFIsafe version V2.4. The PROFIsafe 2.6 protocol contains a 4-byte CRC instead of a 3-byte CRC. This results in a one-byte longer protocol length.

Safety note for slewing ring function (output code S)

It has to be ensured in the application, that the shaft is never turned x revolutions, where $x > r_{\text{safety}}$, in a state where the encoder is not connected to supply power. If in a non power state the Encoder shaft is turned for x revolutions, where $x > r_{\text{safety}}$ the output position is not valid, this is not detected by the encoder upon reconnecting it to supply power.

The allowed number of encoder shaft-turns r_{safety} in a situation when the encoder is not supplied with power can be calculated according to the following formula: $r_{\text{safety}} = 2048 - i$ (r_{safety} is rounded down to "full revolutions")

r_{safety} : allowed safety encoder revolutions in each direction without power supply to the encoder

i : gear ratio ($i = \text{slew gear} / \text{measure gear}$)

The smallest possible value for r_{safety} is 1024, due to the allowed range of the gear ratio i : $1 \leq i \leq 1024$. This means the safety area will always be in the range of $2047 \geq r_{\text{safety}} \geq 1024$ revolutions of the encoder shaft - depending on the gear ratio, when the encoder is not connected to power supply. While the encoder is powered on, there is no restriction on the number of revolutions. The above restrictions only apply when the encoder is powered off.

5.1.1 Output code D and S

Input data: Device → Controller

Octet											
1	2	3	4	5	6	7	8	9	10	11	12
status word		velocity data		position data				F input data*			

Output data: Controller → Device

Octet									
1	2	3	4	5	6	7	8	9	10
control word		preset value				F output data*			

* with Profisafe V2.6 the length of the F input and output data is 5 bytes

5.2 Status word

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

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

16 bit status word

Bit	Name	Remarks/remedy
0	Error_Preset	Error during preset setting - The preset value has to be in the range of 0 ... total number of steps -1 - Set the preset value only during standstill of the shaft - Switch on scaling
1	Speed_Overflow	Speed measurement overflow
2-5		Not used
6	Supply_Error	Supply voltage out of range
7		Not used
8	Sync_Error	Synchronization error
9	Sensor_Error	Sensor error
10	Gear_Error	Gear error
11	Misc_Error	Miscellaneous hardware error
12		Not used
13	Slewing_Ring_Error	Error in slewing ring calculation
14		Not used
15	Device_Error	General device error

5.3 Position data

The position value is output as 1x 32 bit signed integer value in Motorola format (Big Endian). The resolution of the position value can be adjusted via the parameterization.

5.3.1 Data format coding D and S

Encoder with the output code D or S (TRTxx-xxxxxxxD/S4096S3xTxx) provide a position- und preset representation as double word (Integer32).

Octet 5								Octet 6								Octet 7								Octet 8							
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	0	0	0	0	0	0	0	0	0	0	0	0
position value* (single-turn)																position value* (multi-turn) or slewing ring position															

* At 12 bit resolution. With higher resolution correspondingly longer.

5.4 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.

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

The velocity 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 1ms.

The speed measurement resolution is independent of the resolution set for the position value (resolution parameter). The following position resolution is used for the speed calculation in the TRT/S3 (standard versions):

Model	Resolution used for speed calculation	Measuring range in rpm (with default gating time)
TRT/S3 (code type D)	16384 steps	-11.999...11.999
TRT/S3 (code type S)	programmable	denpending on programming

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

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

v = encoder output for speed value (for code type S, speed of the slewing ring)
 t = gating time in ms
 u = speed in rpm
 r = resolution used for speed calculation in steps (please refer to the table above)

Safety note: The user must avoid an overflow of the speed signal. The TRT/S3 indicates an overflow in his status bits. This bit has to be monitored in the safety program.

5.5 F input data

The F input data consist of the 1-byte F status and the 3 or 4 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).

5.6 Status data format

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

Bit	Name	Remark/remedy
0	Set_Preset	The preset value is activated on the rising edge.
1-15	Not used	

5.7 Preset value (reference value)

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.

The set reference value (preset value) function can only be executed while 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 set in the cyclical I/O data traffic by transferring the preset value in the output bytes (octets 3 - 6) and subsequently (or simultaneously) setting bit 0 of the control word (octets 1 - 2).

Before setting the preset value, the i parameterization must be enabled with the F control bit iPar_EN. The rotary encoder reports the completion of the process with the F status bit iPar_OK. If an error occurs on setting the preset value, e.g. due to a rotating rotary encoder shaft, this is reported via status bit 0 in the status word. In both cases, i.e. in the case of successful preset and in the event of an error, the iPar_EN bit must be reset. The rotary encoder then resets its iPAR_OK to zero. (See program example in chapter 4.2.4.)

The preset value is taken over with the rising edge of bit 0 of the control word. An offset value is calculated (from the current actual position 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.

5.7.1 Data format coding D and S

Encoder with the output code D or S (TRTxx-xxxxxxxD/S4096S3xTxx) provide a position- and preset representation as double word (Integer32).

Octet 3								Octet 4								Octet 5								Octet 6											
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 value* (single-turn)															
0	0	0	0	0	0	0	0	preset value* (multi-turn)																											

* At 12 bit resolution. With higher resolution correspondingly longer.

5.8 F output data

The F output data consist of 1 control byte and the 3 or 4 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 program example chapter 4.2.4).

6. PARAMETERIZATION

Parameterization 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. Changing the parameter of the encoder during cyclic I/O data exchange is not possible.

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

Record index	Data set
0xBF02	Encoder parameter
0x64	F parameter

6.1 Encoder parameter Class2 (encoder profile 1.1)

6.1.1 Overview

Byte	Data type	Designation	Default
1	BYTE	Operating mode	0x08
2-5	UINT32	Single-turn resolution [steps/turn]	65536
6-9	UINT32	Total measuring gear [steps]	268435456 or 65536 for single-turn
10-11	INT16	Gate time [ms]	10

6.1.2 Description of the encoder parameters (encoder profile 1.1)

Byte	Bit No.	Parameter	Value range	Default	Remark
1	0	Code path	0: clockwise (cw) 1: counter clockwise (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 resolution, the total number of steps and the preset.
	4-7	not used			
2-5		Resolution [steps/revolution]	1 - 65536	65536	To change this, the parameter „Scaling function“ must be set to „on“
6-9		Total number of steps [steps]	1 - 268435456 or 65536 for single-turn	268435456	To change this, the parameter „Scaling function“ must be set to „on“
10-11		Gating time [ms]	10 - 1000	10	

Notes:

Coding:

All values in Motorola format (Big Endian)

Total number of steps:

It must be noted that the number of revolutions is calculated in powers of 2^n internally in the encoder. Irrespective of this requirement, the user can program 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 2^n 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.

Checksum:

After changing the encoder parameters, the checksum must be recalculated and entered under the F-parameter "F_iPar_CRC". EPC provides the program PsCRC for calculating the F_iPar_CRC. You can download this program from the Internet at www.encoder.com, Documentation area, PsCRC.

6.2 Encoder parameter slewing ring function (code S)

6.2.1 Overview

Byte	Data type	Designation	Default
1	BYTE	Operation byte	0
2-3	UINT16	Number of teeth slewing ring	100
4-5	UINT16	Number of teeth encoder pinion	10
6-9	UINT32	Resolution position	36000
10-11	UINT16	Gate time	100
12-15	UINT32	Resolution for speed calculation	36000

6.2.2 Description of the slewing ring parameter (code S)

Byte	Bit No.	Parameter	Value range	Default	Remark
1	0	Code sense	0: clockwise (cw) 1: counter clockwise (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 slewing ring	1 - 65535	100	The number of teeth of the machines slewing ring has to be great or equal the number of teeth of the encoder pinion.
4-5		Number of teeth encoder pinion	1 - 65535	10	Number of teeth of the encoder pinion which gears in the slewing ring.
6-9		Resolution position [steps]	1 - 65536 x i	36000	Desired resolution of the slewing 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 - 65536 x i	36000	The resolution of the slewing ring used for the speed calculation (see notes)

Notes:

Coding:

All values in Motorola format (Big Endian)

Resolution position:

The maximum possible resolution of the slewing ring is 65536 steps x gear ratio i.

Example:

Gear ratio 1:4

=> max. resolution 8192 steps x 4 = 262144 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 262144 steps the maximum number of steps is output.

Depending on the gear ratio resolutions up to 0.001° can be achieved. The following applies:

Parameter „Resolution position“	Slewing ring resolution
360	1°
3600	0.1°
36000	0.01°
360000	0.001°

Resolution for speed calculation:

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

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

Parameter „Resolution for speed calculation“	Slewing ring speed
360	1° / gate time
3600	0.1° / gate time
36000	0.01° / gate time
360000	0.001° / gate time

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

6.3 F parameter

6.3.1 Overview

Overview			
Octet	Data type	Description	Default
1	Unsigned8	F_Prm_Flag1	
2	Unsigned8	F_Prm_Flag2	
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	7100
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	Remark
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 (V2.4) 2: 4 byte CRC (V2.6)	Depending on Profisafe version	Checksum of the process data (CRC2)
6	F_CRC_Seed	0: CRC-Seed16 1: CRC-Seed24/32	Depending on Profisafe version	Starting value of the CRC calculation
7	Not used			

Octet 2: F_Prm_Flag2				
Bit No.	Parameter name	Value range	Default	Remark
0	F_Passivation	0	0	Not supported
1-2	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

Octet 3-14				
Octet	Parameter name	Value range	Default	Remark
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 encoder is a F device with PROFIsafe address type 1, i.e. the F_Dest_Add has to be unique networkwide and CPUwide.
7-8	F_WD_Time	10-10000	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 encoder is 120 ms (for 4 ms actualisation time).
9-12	F_iPar_CRC	1-0xFFFF FFFF	0x1BBC	CRC checksum on the iParameters (encoder parameters). A checksum calculation program is available for download on www.encoder.com menu documentation.
13-14	F_ParCRC (CRC1)	0-65535		CRC checksum on the F parameters. Is generated from the SIMATIC manager.

7. DIAGNOSTIC

7.1 Overview

The encoder provides diagnostic data in 3 different ways.

- LEDs (see chapter 3.3)
- PROFINET alarms (see chapter 7.2 below)
- Diagnostic data (see chapter 7.3)

All alarms which lead to the failsafe status can only be reset via power off/on of the encoder. An automatical re-integration after a device fault is therefore not possible.

7.2 PROFINET alarms

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

Error no. (hex)	Error text	Reaction	LED failure type	Remarks/remedy
0x001A	Internal communication error (TPS-1)	Input and F data = 0	System failure	Please switch power off/on or change the device
0x0040	Mismatch of safety destination address (F_Dest_Add)	Diagnostic data: F parameter error	Parameterization failure	
0x0041	Safety destination address not valid (F_Dest_Add)	Diagnostic data: F parameter error	Parameterization failure	
0x0042	Safety source address not valid (F_Source_Add)	Diagnostic data: F parameter error	Parameterization failure	
0x0043	Safety watchdog time value is 0 ms (F_WD_Time)	Diagnostic data: F parameter error	Parameterization failure	
0x0044	Parameter „F_SIL“ exceeds SIL from specific device application	Diagnostic data: F parameter error	Parameterization failure	
0x0045	Parameter „F_CRC_Length“ does not match the generated values	Diagnostic data: F parameter error	Parameterization failure	
0x0046	Version of F-Parameter set incorrect (F_Par_Version)	Diagnostic data: F parameter error	Parameterization failure	
0x0047	F parameter CRC error (CRC1-Fault)	Diagnostic data: F parameter error	Parameterization error	
0x0048	Error in F parameter set	Diagnostic data: F parameter error	Parameterization failure	
0x004B	Inconsistent iParameters (iPar-CRC error)	Diagnostic data: F parameter error	Parameterization failure	Please check the value of the F parameter F-iPar-CRC
0x1100	Device error	Diagnostic data: device error F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device

0x1110	Preset error	Diagnostic data: Preset error Status word: Error-Preset	Parameterization failure	The preset value has to be in the range of 0 ... total number of steps - 1. Setting the preset is only allowed when the shaft is in standstill. Scaling has to be on.
0x1120	Velocity measuring range exceeded	Diagnostic data: velocity error F status word, TRT/S3: FV_activated	Parameterization failure	Please reduce the velocity or decrease the gating time and switch power off/on
0x1140	Parameter error	Diagnostic data: Parameter error	Parameterization failure	The value of the measuring range has to be in the range of resolution... (resolution x max. number of turns (4096)).
0x1150	Supply voltage out of range	F status word: FV_activated, Device_Fault	System warning	Please check the supply voltage and switch power off/on.
0x1160	Wrong Record Index on startup	F status word: FV_activated, Device_Fault	Parameterization failure	Please check your GSD file.
0x1170	Sensor not ready	F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device

7.2.1 Additional alarms

Erro no. (hex)	Error text	Reaction	LED failure type	Remarks/remedy
0x1102	Synchronization error	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1105	Sensor error	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1106	Gear error	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1151	Operating temperature exceeded/undershot		System warning	Please switch off power until the ambient temperature is within the permissible range again.
0x1190	Other hardware error	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1191	Error in temperature sensor	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1200	Error in slewing ring calculation	Input data = 0, F status word: FV_activated, Device_Fault	System failure	Please switch power off/on or change the device
0x1210	Not supported module or module combination		Parameterization failure	Please change the module or the module combination

7.3 Diagnostic data records

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

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

8. REFERENCE DOCUMENTS

1. PROFIsafe-Profile for Safety Technology, Order No. 3.092 und 3.192, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
2. PROFINET - Interface nach IEC 61158 / 61784 bzw. PNO-Spezifikation, Order No. 2.712 und 2.722, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
3. PROFINET Installation guideline, Order No. 8.071, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
4. PROFINET Cabling and Interconnection Technology, Order No.: 2.252, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
5. Installation Guideline PROFINET Part2: Network Components, Order No.: 2.252 p2, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
6. PROFIsafe - Environmental Requirements related to PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO (IEC 61784-3-3), Order No. 2.232, PROFIBUS Nutzerorganisation e. V., Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
7. SIMATIC S7 Distributed Safety - Project Planning and Programming, Programming and Operating Manual (A5E00109536-03) - <http://support.automation.siemens.com>
8. SIMATIC S7 Distributed Safety Getting Started (A5E00320725-01) - <http://support.automation.siemens.com>
9. Profile Guidelines Part 1: Identification & Maintenance Functions, Order No. 3.502, www.profibus.com
10. SIMATIC Safety - Project Planning and Programming (A5E02714440-AC) - <http://support.automation.siemens.com>
11. SIMATIC Safety - Getting Started (A5E02714463-01) - <http://support.automation.siemens.com>

9. REVISION HISTORY

Version	Date	Reason for change
TRT 12846 RE	05.10.2026	creation

Contact addresses

Do you have any questions about this product?
EPC Technical Support will be happy to help you.

Encoder Products Company

464276 Highway 95 South
Sagle, Idaho 83860
USA

Phone: +1 (208) 263-8541

Fax: +1 (208) 263-0541

Email (Sales): sales@encoder.com

Website: encoder.com