SUPREME SENSORING
TWK

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Safety over EtherCAT®

SIL2 IEC 61508 FUNCTIONAL SAFETY SENSOR

PLd ISO 13849 FUNCTIONAL SAFETY SENSOR

user manual 16798
Manual for the slewing ring feature
Extension of user manual 13349

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1.1 Scope

This user manual is valid exclusively for encoders of the TRK series with slewing ring functionality. These can be identified by the output code „**S** – Binary, slewing ring function“ according to the order code.

1.2 Documentation

The following documents must be observed:

- The owner's system-specific operating instructions
- This user manual 16798
- The user manual 13349
- Data sheet for the specific device: TRK58 13348, TRK38 15899, TRK42 17023
  If a customer-specific variant is used, the associated data sheet applies.
- The connection assignment enclosed with the device
- Assembly instructions 16169

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

2 General information

2.1 Overview

This manual is intended as a supplement to the manual 13349 and contains additional information on the slewing ring functionality. The manual 13349 remains valid and the instructions must still be followed.

Devices for which the slewing ring functionality is available are identified by the specification "Output code: S" (binary, slewing ring function) in the order code.

The slewing ring function requires not only advanced software but also special hardware. Standard devices "Output code: B" (binary) cannot be upgraded with the slewing ring function afterwards. On the other hand, it is possible to parameterize and use a device with a slewing ring function like a device without.

The parameterization of the slewing ring function is carried out, like the other settings, via corresponding CoE (CANopen over EtherCAT) objects. The following new objects are now available for this purpose.

0x3100 safety_gear_configuration
0x31FE safety_gear_data_valid
0x31FF safety_gear_CRC_checksum

The object 0x3100, which contains the information about the number of teeth of the slew and measure gear and the desired measuring range, is located under the manufacturer specific objects.

As with other safety-relevant settings, object 0x3100 is protected by a CRC checksum. The correct checksum must be entered in object 0x31FF in order to activate the configuration with object 0x31FE. These safety features allow a device to be certified up to SIL2 (safety integrity level).

Due to the extended setting options, the procedure for initial configuration changes slightly compared to the standard devices.

This manual provides a complete description of the new objects, explains the setup procedure including the calculation of the checksum and shows configuration examples.

3 Manufacturer Specific Objects

This section introduces each object and provides a description of its function and properties. Here only the new objects are covered, which are additionally necessary for the slewing ring function. The previously existing objects can be found in manual 13349.

3.1 Object 3100 safety_gear_configuration

This object is for setting the safety gear parameters. Only valid for TRK/S3 devices with slewing ring function (Version "S" in order code number between singleturn and multiturn resolution).

Modifications in object 3100 will cause 31FE = "0" (must be set "A5" after modification). New CRC Checksum 31FF/01 must be calculated and transmitted to the device. Because the gear parameters belong to the safety-relevant settings, object 61FE is also set to 0 when these are changed.

Notes: i = slew_gear / measure_gear
Maximum gear ratio i =1024 [dez], Bigger values are not allowed.
Minimum gear ratio i =1 [dez], Smaller values are not allowed.

A plausibility check ensures that the valid flag 31FE cannot be set. Error code 0800 0022 - data not stored to device is transmitted if the plausibility check fails.

Adjustment of gear parameters

Index	Sub	Name	Data type	Access	Range/value	Default
3100	0	largest_supported_sub-index	Unsigned8	ro	0x03	-
	1	safety_slew_gear [teeth]	Unsigned32	rw	0x0 ... 0x FFFF FFFF	0x0
	2	safety_measure_gear [teeth]	Unsigned32	rw	0x0 ... 0x FFFF FFFF	0x0
	3	safety_measuring_range	Unsigned32	rw	0x0 ... 0x FFFF FFFF*	0x0

3100/01	safety_slew_gear	Number of teeth driving gear (slewing)
3100/02	safety_measuring_gear	Number of teeth of encoder tooth gear
3100/03	safety_measuring_range	Number of steps output for one turn of the slewing ring

*** Examples and conditions for object 3100/03:**

The encoder has a fixed value for the maximum resolution per revolution. A typical value is 65 536 steps per revolution of the encoder shaft. This information is part of the order code. The slewing ring function cannot circumvent this limitation.

Object 3100/03 describes the number of steps for one revolution of the slewing ring. An upper limit results from the maximum number of steps for one revolution of the encoder shaft multiplied by the transmission ratio i.

$$[3100/03] \leq 65\,536 \times [3100/01] / [3100/02] = 65\,536 \times i$$

If we have a transmission ratio of i=8 for example, one revolution of the slewing ring can be resolved with a maximum of 8*65 536=524 288 steps. This is the maximal available resolution, smaller values are also valid.

3.2 Object 31FE safety_gear_data_valid

This parameter is reset (= 0x0) each time a "safety relevant parameter" is accessed. Entering 0xA5 switches the configuration to valid. In the case of an invalid value (not 0 or 0xA5) in the safety_gear_data_valid or incorrect setting of the checksum, write access is rejected.

Attention:
The flag is automatically reset by writing to the safety position data in safety_gear_configuration Object 3100.

Index	Sub	Name	Data type	Access	Range/value	Default
31FE	0	safety_gear_data_valid	Unsigned8	rw	0 / 0xA5	0xA5

3.3 Object 31FF safety_gear_CRC_checksum

This object contains the CRC checksum of the parameters stored in object 3100.

Activating (writing 0xA5 to) the valid flag in object 31FE is only possible, if and only if the checksum in object 31FF is valid for the settings currently stored in object 3100.

The checksum can be calculated by the external “SafetyCRC” program available for download on www.twk.de.

Instructions for this software can be found in the general EtherCAT manual 13349 and additional information in this manual in chapter 4.2.

Index	Sub	Name	Data type	Access	Range/value	Default
31FF	0	largest_supported_sub_index	Unsigned8	ro	0x01	0xA1
	1	safety_gear_CRC_checksum	Unsigned16	rw	0 … 0xFFFF	0x76E9

4 Instructions for use

4.1 Parameterization procedure

For the objects 3100 to be writable, the device must be in the PreOP state.

Modifications to objects 3100 will reset the valid flags 31FE and 61FE.

- Set device state to preoperational
- Fill objects 3100/01, 3100/02, 3100/03 with the desired parameters
- calculate the CRC checksum for the gear parameters and write it to object 31FF/01
- activate the valid flag 31FE by writing 0xA5=165 into this object
- activate the valid flag 61FE by writing 0xA5=165 into this object
  (suitable entry for the checksum in the object 61FF required)

In order to deactivate the slewing ring function and achieve an encoder behavior exactly as a normal binary encoder, all parameters of 3100 (sub1, sub 2 and sub 3) have to be set to zero.

After modifying the gear parameters it has to be ensured that a "safe all" command via Object 1010 sub1 is executed. Otherwise after switching the supply power off and back on, the settings are reset to the last saved status.

After modifying any safety gear parameter, the output position is undefined within the code range of the output resolution (object 0x3100/3). By setting a preset value (object 0x6100/2) a defined initial position is set.

This parameter is verified by the checksum of the profile specific parameters.

4.2 Safety notes

The encoder can determine an absolute position of the shaft in the range of 4096 turns. The working range of the slewing ring function is split in two areas, positive and negative relative to its zero position.

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:

$$r_{safety} = 2048 - i$$

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= slew gear / measure gear)

Safety Note:
It has to be ensured in the application, that the shaft is never turned x revolutions, where x > r_{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_{safety} the output position is not valid, this is not detected by the encoder upon reconnecting it to supply power.

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 $2047 \geq r_{safety} \geq 1024$ revolutions of the encoder shaft- depending on the gear ratio, when the encoder is not connected to power supply.

Remark: 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.

4 Instructions for use

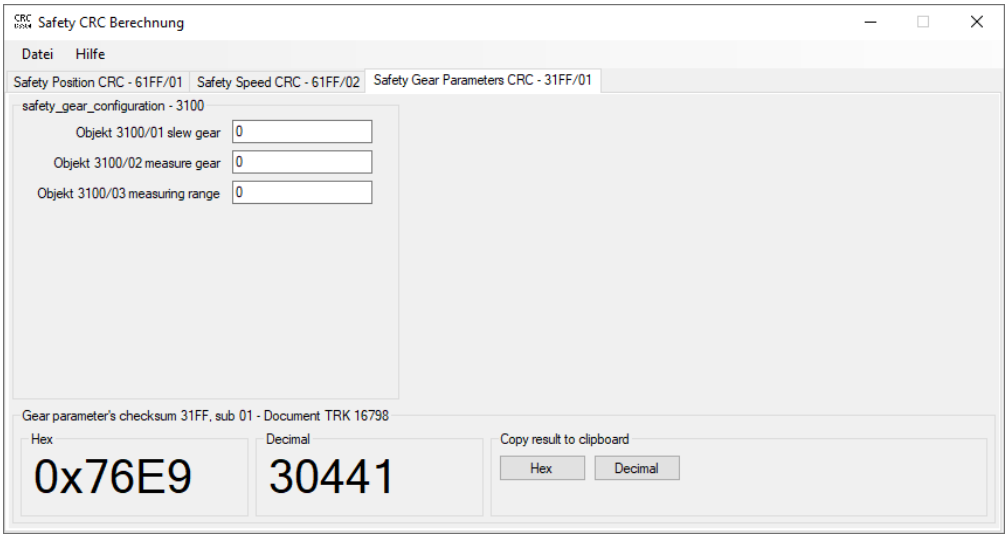
4.3 SafetyCRC Program

For the calculation of the CRC checksum the program "SafetyCRC" is provided. This program can be used for different devices. Please make sure that the correct settings are loaded. Load the appropriate xml file via the file load function.

By default, some xml files are delivered directly with the program. You can find them in the program path in the subfolder "Data". Otherwise we offer the xml files for download on our homepage www.twk.de or for special customer variants of the devices on request.

To verify if the SafetyCRC program is configured correctly, please compare it with the following picture. Exactly one tab must be displayed for each of the entries:

0x61FF/01: Safety Position CRC
0x61FF/02: Safety Speed CRC
0x31FF/01: Safety Gear Parameters CRC



Enter your desired settings in the respective fields. The CRC checksum is automatically calculated and displayed in decimal and hexadecimal notation in the lower part of the screen.

4.4 Sample Configurations

To illustrate the possibilities, some sample configurations are shown here. The free choice of parameters allows to cover different applications with the same device.

Example 1: slewing functionality off – Default values

In the factory settings, the slewing ring functionality is deactivated. The individual parameters are set to 0.

0x3100/01:	0	Number of teeth driving gear (slewing)
0x3100/02:	0	Number of teeth of encoder tooth gear
0x3100/03:	0	Number of steps output for 1 turn of the slewing ring

In this mode, the device behaves like a device without a slewing ring function, i.e. like a normal mutiturn encoder with resolution and measuring range according to article number.

Example 2: singleturn settings

By suitable choice of parameters it is possible to obtain the behavior of a singleturn encoder.

0x3100/01:	1
0x3100/02:	1
0x3100/03:	65 536

With these settings a transmission ratio of 1:1 is set and one revolution is sampled with 65 536 steps. With this configuration the encoder behaves like a pure singleturn device.

Example 3: slewing ring functionality

The main application of the slewing ring function is the automatic conversion between the position of the slewing ring gear and the measuring gear.

0x3100/01:	128
0x3100/02:	16
0x3100/03:	524 288

These parameters describe a transmission ratio of 128:16 or 8:1. The maximum resolution of 524 288 (8 * 65 536) is chosen.

Example 4: slewing ring functionality

A major advantage of our slewing ring function is that it is not limited to specific gear ratios.

0x3100/01:	451	Number of teeth driving gear (slewing)
0x3100/02:	85	Number of teeth of encoder tooth gear
0x3100/03:	5953	Number of steps output for 1 turn of the slewing ring

The gear ratio is approximately 5,3 (451:85) and is not a problem. The encoder can be adapted very easily to the installation situation and thus enables a flexible and process-safe application. The PLC is freed up and not overloaded with complicated conversions between the position of the encoder and the slewing ring. Especially in case of non-integer gear ratios in combination with an endless rotation, the conversion is not trivial.