TWK ELEKTRONIK

Absolut encoder with EtherCAT® interface

Accompanying data sheet TRK 12825 or CRK 11778

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user manual

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1. Safety instructions

1.1 Scope of validity

This user manual applies exclusively to the following rotary encoders with PROFIsafe interface:

- CRKxx-xxxxR4096C1M01
- TRKxx-xxxxxxR4096C1MK01

1.2 Documentation

The following documents must be noted:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number CRK11778 or TRK12825
- The pin assignment enclosed with the device
- Installation instruction TZY 10206 enclosed with the device

1.3 Proper use

TWK-ELEKTRONIK GmbH's rotary encoders and linear transducers are used to record rotary and linear positions, and make their measured values available as an electric output signal. As part of a system, they must be connected to the downstream electronics and must only be used for this purpose.

1.4 Commissioning

- The relevant device must only be set up and operated using this document and the documentation specified in point 1.2.
- Protect the device against mechanical damage during installation and operation.
- The device must only be commissioned and set up by a specialist electrician.
- Do not operate the device outside of the limit values which are specified in the data sheet.
- Check all electrical connections before commissioning the system.

2. General

The CRK electro-optical absolute encoders are designed for direct connection to the EtherCAT industrial Ethernet system. Use of the CANopen over EtherCAT message (CoE) enables parameters and diagnostic data to be handled as usual in the case of CANopen.

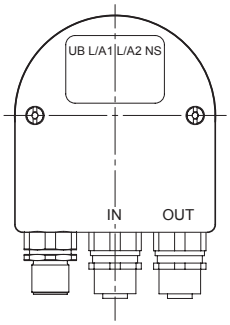
The EtherCAT specifications can be obtained from the EtherCAT Technology Group ETG (www.ethercat.org).

3. Installation instructions

3.1 Connection via M12 connector

The „...M01“ type absolute encoders have separate connectors for the supply and the EtherCAT system.

Device connectors:
- M12x4 D-coded socket: Bus in
- M12x4 D-coded socket: Bus out
- M12x4 A-coded pins: 24 V voltage supply



View of the rear of the encoder
(see data sheet CRK11778 for connector assignment)

3.2 EtherCAT wiring

The physical characteristics of the interface are based on the 100BASE-TX Ethernet standard in accordance with ISO/ I EC 8802-3.

As a result of this:

- The EtherCAT cable must at least meet the requirements according to CAT5.

- The max. cable length between two subscribers may be 100 m.

- Setting the baud rate is not possible/necessary.

In the case of EtherCAT, the network topology normally has a linear structure. However, tree structures or branch-off lines may also be implemented by means of bus modules with an integrated switch port.

In contrast to the EDP networks which are usual today, hubs are not permissible, and a standard switch is only permitted directly to the rear of the master (the first subscriber must then possess a MAC address).

For wiring purposes, we recommend pre-assembled data cables with M12 connectors moulded on at both ends. These can be ordered from us in various lengths (see data sheet CRK11778).

Terminating resistors are not necessary.

3.3 Addressing

Manually setting the subscriber address is not necessary. It is assigned automatically by the EtherCAT master in accordance with the physical sequence in the bus.

3.4 Status LEDs

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

UB (VB)	Link/ Activity1 (L/A1)	Link/ Activity2 (L/A2)	Status (NS)	Description
green	green	green	green/red	
on				Operating voltage available
	on			Network connection established
	flashing			Netzwerk activ
		on		Network connection established
		flashing		Netzwerk activ
			off	Initialisation
			green/ flashing 1 time	Safe-operational
			green/ normal flashing	Pre-operational
			green on	Operational
			red flashing	Impermissible parameter or pre-set value
			red on	No response from the master

Brief flickering on the part of the red status (NS) LED after switching on the voltage indicates the absolute encoder‘s booting process.

3.5 XML file

An XML file to integrate the absolute encoder into a project planning tool is available for download on our website www.twk.de (under documentation). This describes the features of the EtherCAT subscriber in the standardised XML format.

After integrating the XML file into the project planning tool (e.g. TwinCAT System Manager from Beckhoff), the absolute encoder can be integrated off-line into the bus. However, access to the parameters and diagnostic information (CANopen over EtherCAT) is only possible after reading these out (online) from the absolute encoder. See Chapter 6.

4. Process data exchange

The absolute encoder transmits its position (4 bytes) and receives a control word (2 bytes) as process data objects (PDO). The data format is as follows:

4.1 Position data format (position_value)

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

The positions are depicted in Intel format (Little Endian).

The absolute encoder‘s counting direction, resolution and total number of steps can be changed via the CoE parameters 6000_h, 6001_h and 6002_h. Failsafe storage of the modified parameters is carried out via the CoE parameter 1010_h. See Chapter 5.2.5 and Chapter 5.4.

4.2 Control word data format (control_value)

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

Bit	Meaning	Comment
0	Set pre-set	A flank change from 0 to 1 sets the previously programmed pre-set value (CoE parameter 6003_h). Default value: 0 Scaling must be switched on to set the pre-set value (CoE parameter 6000_h). Also see Chapter 5.4. Additionally saving the pre-set (offset) value via object 1010_h is not necessary.
1 - 15	Not used	

5. Programming and diagnosis (CANopen over EtherCAT)

In the case of CANopen over EtherCAT, all parameters and diagnostic information are located in what is called the object directory. By specifying their index and sub-index, they can be modified or read there with the SDO (Service Data Object) message. The object directory is sub-divided into the following areas:

Communication parameters	Index 1000_h - $1FFF_h$
Manufacturer-specific parameters	Index 2000_h - $5FFF_h$
Standardised device parameters	Index 6000_h - $9FFF_h$

Refer to the following tables for a description of the individual parameters and diagnostic information.

5.1 Overview of the object directory

Index	Object	Name	Data type	Access
Communication Profile Area				
1000_h	VAR	device_type	Unsigned32	ro
1008_h	VAR	manufacturer_device_name	String	ro
1009_h	VAR	manufacturer_hardware_version	String	ro
$100A_h$	VAR	manufacturer_software_version	String	ro
1010_h	RECORD	store_parameters		rw
1011_h	RECORD	restore_default_parameters		rw
1018_h	RECORD	identity_object		ro
1600_h	RECORD	receive_PDO_mapping		ro
$1A00_h$	RECORD	transmit_PDO_mapping		ro
$1C12_h$	RECORD	sync_manager_RxPDO_assign		ro
$1C13_h$	RECORD	sync_manager_TxPDO_assign		ro
Manufacturer Specific Profile Area				
2000_h	VAR	state_value	Unsigned16	ro
2001_h	VAR	control_value	Unsigned16	ro
Standardised Device Profile Area				
6000_h	VAR	operating_parameters	Unsigned16	rw
6001_h	VAR	measuring_units_per_revolution	Unsigned32	rw
6002_h	VAR	total_measuring_range_in_measuring_units	Unsigned32	rw
6003_h	VAR	preset_value	Unsigned32	rw
6004_h	VAR	position_value	Unsigned32	ro
6500_h	VAR	operating_status	Unsigned16	ro
6501_h	VAR	singleturn_resolution	Unsigned32	ro
6502_h	VAR	number_of_distinguishable_revolutions	Unsigned32	ro
6503_h	VAR	alarms	Unsigned16	ro
6504_h	VAR	supported_alarms	Unsigned16	ro
6509_h	VAR	offset_value	Unsigned32	ro

5.2 Communication parameters

5.2.1 Object 1000_h - Device type

Index	Sub	Name	Data type	Access	Range/Value	Default
1000_h	00	device_type	Unsigned32	ro	0x20196	

5.2.2 Object 1008_h - Manufacturer device name

Index	Sub	Name	Data type	Access	Range/Value	Default
1008_h	00	manufacturer_device_name	String	ro		

e.g. CRKxx12R12C1xx

5.2.3 Object 1009_h - Manufacturer hardware version

Index	Sub	Name	Data type	Access	Range/Value	Default
1009_h	00	manufacturer_hardware_version	String	ro		

Contains the current manufacturer hardware version e.g.: “2.00”

5.2.4 Object $100A_h$ - Manufacturer software version

Index	Sub	Name	Data type	Access	Range/Value	Default
$100A_h$	00	manufacturer_software_version	String	ro		

Contains the current manufacturer software version e.g.: “3.00”

5.2.5 Object 1010_h - Store parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1010_h	00	largest_supported_subindex	Unsigned8	ro	1	
	01	save_all_parameters	Unsigned32	ro	1	

Writing “save” (hex: 0x65766173) in sub-index 1 leads to the failsafe saving of the parameters in the EEPROM. Following execution, the value is reset to “1”.

5.2.6 Object 1011_h - Restore default parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1600_h	00	largest_supported_subindex	Unsigned8	ro	1	
	01	load_default_parameters	Unsigned32	ro	1	

By writing “load” (hex: 0x64616F6C) in sub-index 1, the parameters’ default values are loaded into the EE-PROM and become immediately active. Following execution, the value is reset to “1”.

5.2.7 Object 1018_h - Identity Object

Index	Sub	Name	Data type	Access	Range/Value	Default
1018_h	00	largest_supported_subindex	Unsigned8	ro	4	
	01	vendor_id	Unsigned32	ro	0x10D	
	02	product_code	Unsigned32	ro	0x1000	
	03	revision_number	Unsigned32	ro	0x00010001	
	04	serial_number	Unsigned32	ro	XXXX XXXX	

5.2.8 Object 1600_h - Receive PDO mapping

Index	Sub	Name	Data type	Access	Range/Value	Default
1600_h	00	largest_supported_subindex	Unsigned8	ro	1	
	01	receive_mapping_object	Unsigned32	ro	0x20010010	

The encoder receives the control byte index 0x2001 as PDO.

5.2.9 Object $1A00_h$ - Transmit PDO mapping

Index	Sub	Name	Data type	Access	Range/Value	Default
$1A00_h$	00	largest_supported_subindex	Unsigned8	ro	1	
	01	transmit_mapping_object	Unsigned32	ro	0x60040020	

The encoder transmits the position value index 0x6004 as PDO.

5.2.10 Object $1C12_h$ - Sync manager channel 2 (process data output)

Index	Sub	Name	Data type	Access	Range/Value	Default
$1C12_h$	00	number_of_RxPDOs	Unsigned8	ro	1	
	01	receive_assign_object	Unsigned16	ro	0x1600	

5.2.11 Object $1C13_h$ - Sync manager channel 3 (process data input)

Index	Sub	Name	Data type	Access	Range/Value	Default
$1C13_h$	00	number_of_TxPDOs	Unsigned8	ro	1	
	01	transmit_assign_object	Unsigned16	ro	0x1A00	

5.3 Manufacturer-specific parameters

5.3.1 Object 2000_h - State value

Index	Sub	Name	Data type	Access	Range/Value	Default
2000_h	00	state_value	Unsigned16	ro	0...15	0

The object 2000_h displays detailed parameterisation errors and information. An entry in state_value is displayed by the highest-value bit in the object 6503_h “Alarms” (Chapter 5.5.4). The red status LED also flashes in addition to the current green status. (Also see Chapter 3.4)

The bits have the following meanings:

Bit	Meaning	Remedy
0	Impermissible bits set in the parameter „operating_parameters“ (object 6000_h)	Re-write the parameter with permissible values
1	Impermissible value in the parameter „measuring_units_per_revolution“ (Object 6001_h)	Re-write the parameter with permissible values
2	Impermissible value in the parameter „total_ measuring_range_in_measuring_units“ (object 6002_h)	Re-write the parameter with permissible values
3	Due to a current error, the „save_all_parameters“ function has not been carried out	First rectify the error which was present prior to „save_all_parameters“. Then execute the command again.
4	Impermissible value in the parameter „preset“ (object 6003_h)	Re-write the parameter with permissible values
5	Error in the flash; the parameters have been set to default values	
6	Internal error	Switch power supply off/on
7 - 14	Not used	
15	Collective error	

5.3.2 Object 2001_h - Control value

Index	Sub	Name	Data type	Access	Range/Value	Default
2001_h	00	control_value	Unsigned16	ro	0,1	0

The bits have the following meanings:

Bit	Meaning
0	A flank change from 0 to 1 sets the previously programmed pre-set value (CoE parameter 6003_h). Default value: 0 The scaling must be switched on to set the pre-set value (CoE parameter 6000_h). Also see Chapter 5.4. Additionally saving the pre-set (offset) value via the object 1010_h is not necessary.
1 - 15	Not used

Access to the control word is only possible via a PDO. In the object directory, it is “read only”!

5.4 Standardised device parameters

Those parameters marked with "rw" in this chapter can be set by the user. To store the parameters in a failsafe manner in the encoder's EEPROM, the "save" command must then be executed under the object 1010_h. See Chapter 5.2.5

5.4.1 Object 6000_h - Operating parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
6000_h	00	operating_value	Unsigned32	rw	0,1,4,5	0

Bit	Name	0	1	
0	Code sense	CW		Ascending position value on clockwise rotation of the shaft, viewed in the direction of the shaft
			CCW	Ascending position value on counter-clockwise rotation of the shaft, viewed in the direction of the shaft
1	Not used			
2	Scaling	off		The absolute encoder operates with the default values of the resolution, total number of steps and pre-set (offset) parameters. Editing of the parameters is blocked.
			on	The absolute encoder operates with the values last stored for the parameters. Editing of the parameters is enabled.
3 - 31	Not used			

5.4.2 Object 6001_h - Measuring units per revolution

Index	Sub	Name	Data type	Access	Range/Value	Default
6001_h	00	measuring_units_per_revolution	Unsigned32	rw	1...4096 (8192*)	4096

This parameter can be used to set the absolute encoder's resolution in steps per revolution.
Before changing the resolution, scaling must be switched on via object 6000_h bit 2.

5.4.3 Object 6002_h - Total measuring range in measuring units

Index	Sub	Name	Data type	Access	Range/Value	Default
6002_h	00	total_measuring_range_in_ measuring_units	Unsigned32	rw	1...16777216 (33554432*)	16777216

This parameter can be used to set the absolute encoder's total number of steps. The total number of steps is the product of the resolution and the number of revolutions.

Before changing the resolution, scaling must be switched on via object 6000_h bit 2.

Note: It must be noted that internal calculation of the number of revolutions within the encoder is carried out in powers of 2. Irrespective of this requirement, the user can programme the desired total number of steps and the desired resolution according to the application. If necessary, the absolute encoder makes use of the next highest power of 2 during calculation. In this case, the values are designated as the actual resolution or the actual total number of steps and are displayed as the parameter value.

Example: Desired total number of steps: 20,480
Desired resolution: 4096

*The values in brackets are valid for encoders with 13 Bit resolution

Desired number of revolutions:	5
Next highest 2^n revolution number:	8
The following results from this:	
Actual total number of steps:	32,768
Actual resolution:	4096

5.4.4 Object 6003_h - Preset

Index	Sub	Name	Data type	Access	Range/Value	Default
6003_h	00	preset_value	Unsigned32	rw	0 ... total No. of steps - 1	

This parameter can be used to set the absolute encoder's position value to any arbitrary value within its total number of steps. The value entered here is output directly as the new position value. The difference between the displayed and the internal position value is stored as the offset in object 6509_h.

Before changing the pre-set value, scaling must be switched on via object 6000_h bit 2.

The pre-set value can also be set via the PDO "control_value" in the I/O data traffic. See Chapter 5.3.2

5.4.5 Object 6004_h - Position

Index	Sub	Name	Data type	Access	Range/Value	Default
6004_h	00	position_value	Unsigned32	ro	0 ... total No. of steps - 1	

This value is the position value and is output via the PDOs. (See Chapter 4)

5.5 Standardised device diagnosis

5.5.1 Object 6500_h - Operating status

Index	Sub	Name	Data type	Access	Range/Value	Default
6500_h	00	operating_status	Unsigned16	ro	0,1,4	0

The object 6500_h depicts the operating status of the absolute encoder. The bits have the same meaning as in the object 6000_h.

5.5.2 Object 6501_h - Singleturn resolution

Index	Sub	Name	Data type	Access	Range/Value	Default
6501_h	00	singleturn_resolution	Unsigned32	ro	4096 (8192*)	

Specifies the maximum resolution which can be set.

5.5.3 Object 6502_h - Number of distinguishable revolutions

Index	Sub	Name	Data type	Access	Range/Value	Default
6502_h	00	number_of_distinguishable_revolutions	Unsigned16	ro	4096	

Specifies the maximum number of revolutions.

5.5.4 Object 6503_h - Alarms

Index	Sub	Name	Data type	Access	Range/Value	Default
6503_h	00	alarms	Unsigned16	ro		0

Bit	Meaning
0 - 14	Not used
15	Collective error (for further information, see object 2000_h state_value (Chapter 5.3.1))

5.5.5 Object 6504_h - Supported alarms

Index	Sub	Name	Data type	Access	Range/Value	Default
6504_h	00	supported_alarms	Unsigned16	ro	8000	

Bit	Meaning
0 - 14	Not used
15	Collective error

5.5.6 Object 6509_h - Offset

Index	Sub	Name	Data type	Access	Range/Value	Default
6509_h	00	offset_value	Unsigned32	ro		0

See object 6003_h pre-set (Chapter 5.4.4)

*The values in brackets are valid for encoders with 13 Bit resolution

6. TwinCAT system manager

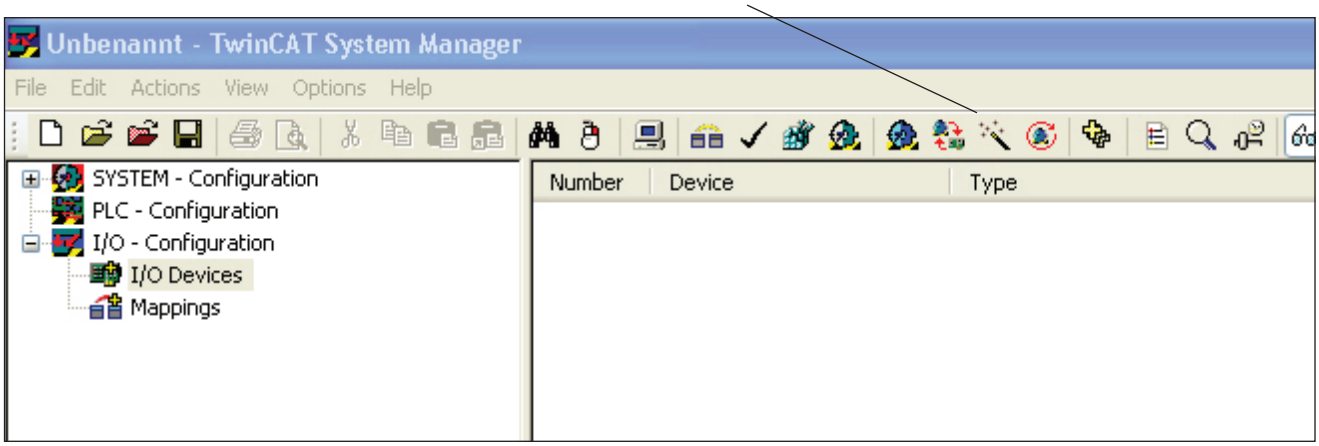
6.1 Installation der XML-Datei

- Copy the downloaded XML file to the **..\Twincat\Io\Ethercat** directory
- Start the TwinCAT system manager

6.2 Online commissioning

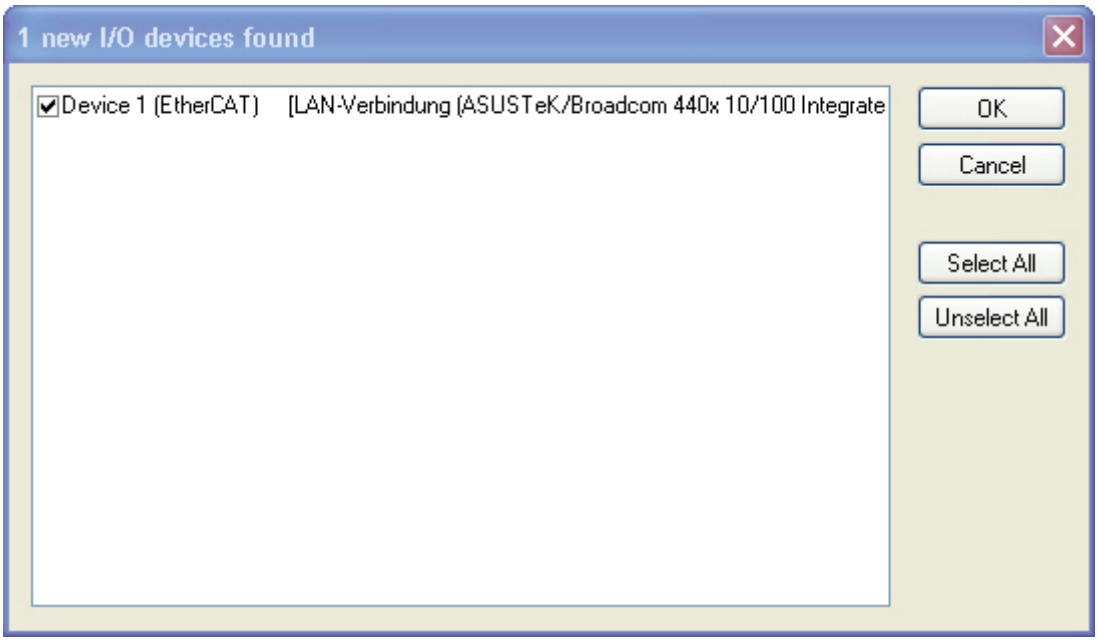
If the system is connected and capable of running, reading-in the bus structure online is the simplest option. This procedure is described here examplarily for the encoder CRK.

Create a new project, mark “I/O devices” and click onto the “wand”.



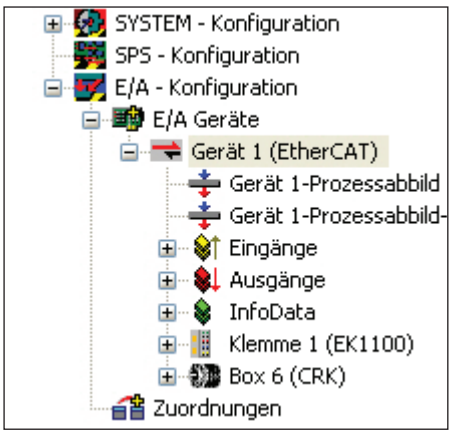
Confirm the following note with OK.

TwinCAT should then locate your network card. Confirm this with OK.



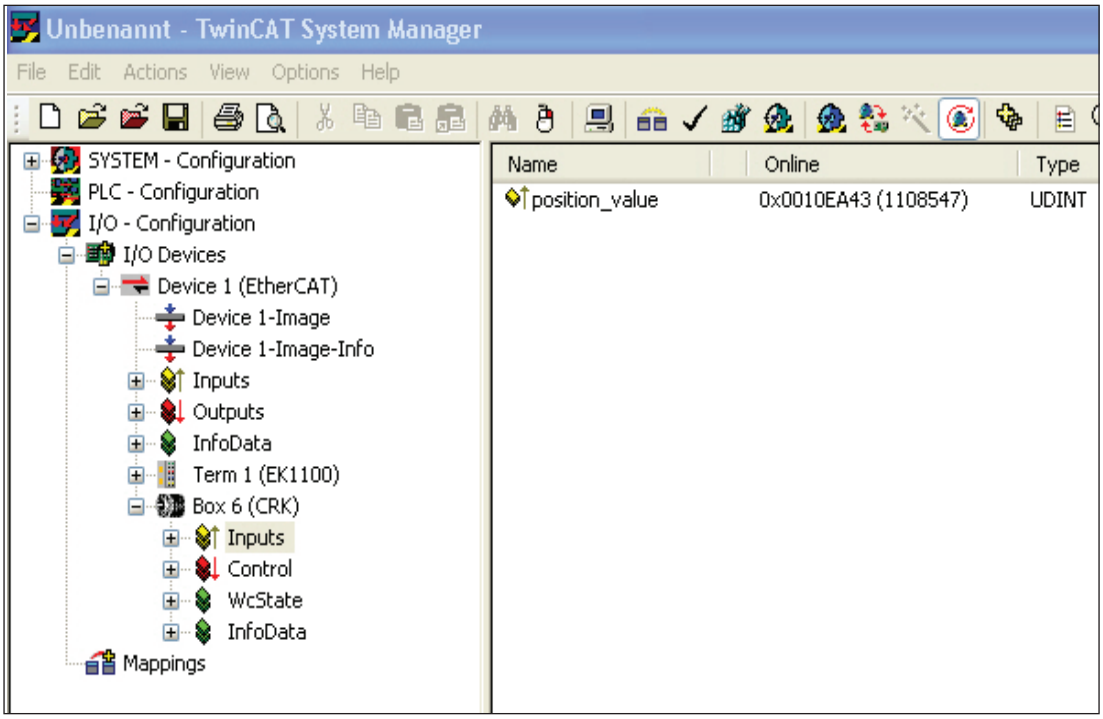
6. TwinCAT System Manager

After confirming the following dialogue with “Yes”, all connected devices should be located. In this case, the EtherCAT master (device 1), a Beckhoff bus terminal with I/O modules and the TWK CRK absolute encoder.



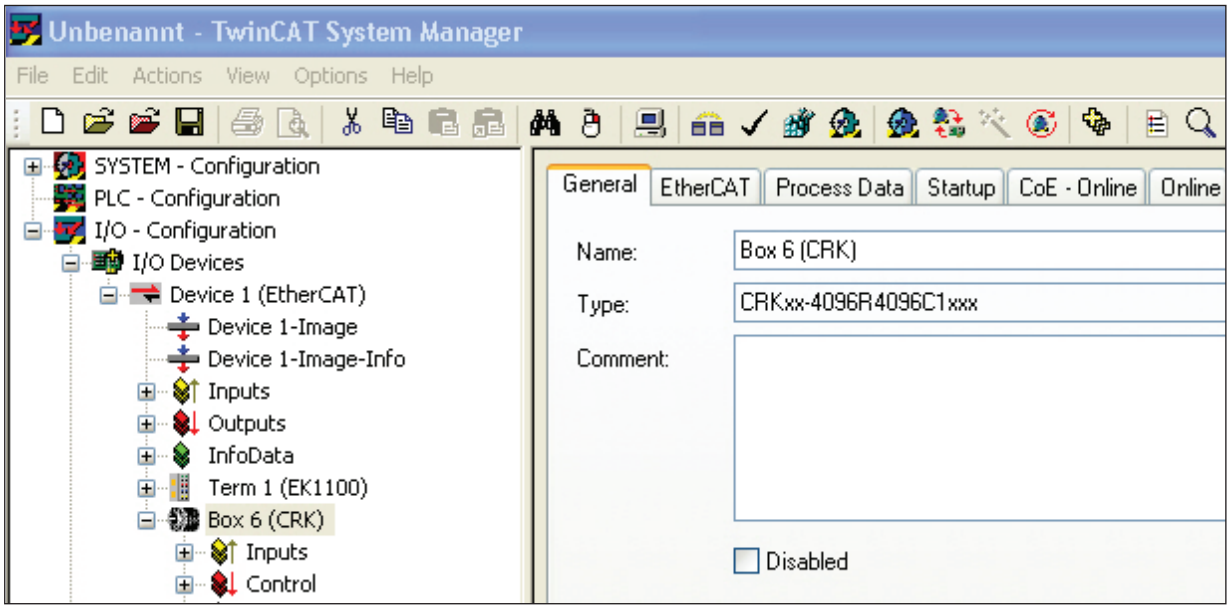
If the so-called free run is now also activated, the I/O data are cyclically exchanged and can be monitored in the TwinCAT.

Clicking onto the CRK’s “Inputs” displays the absolute encoder’s input data.

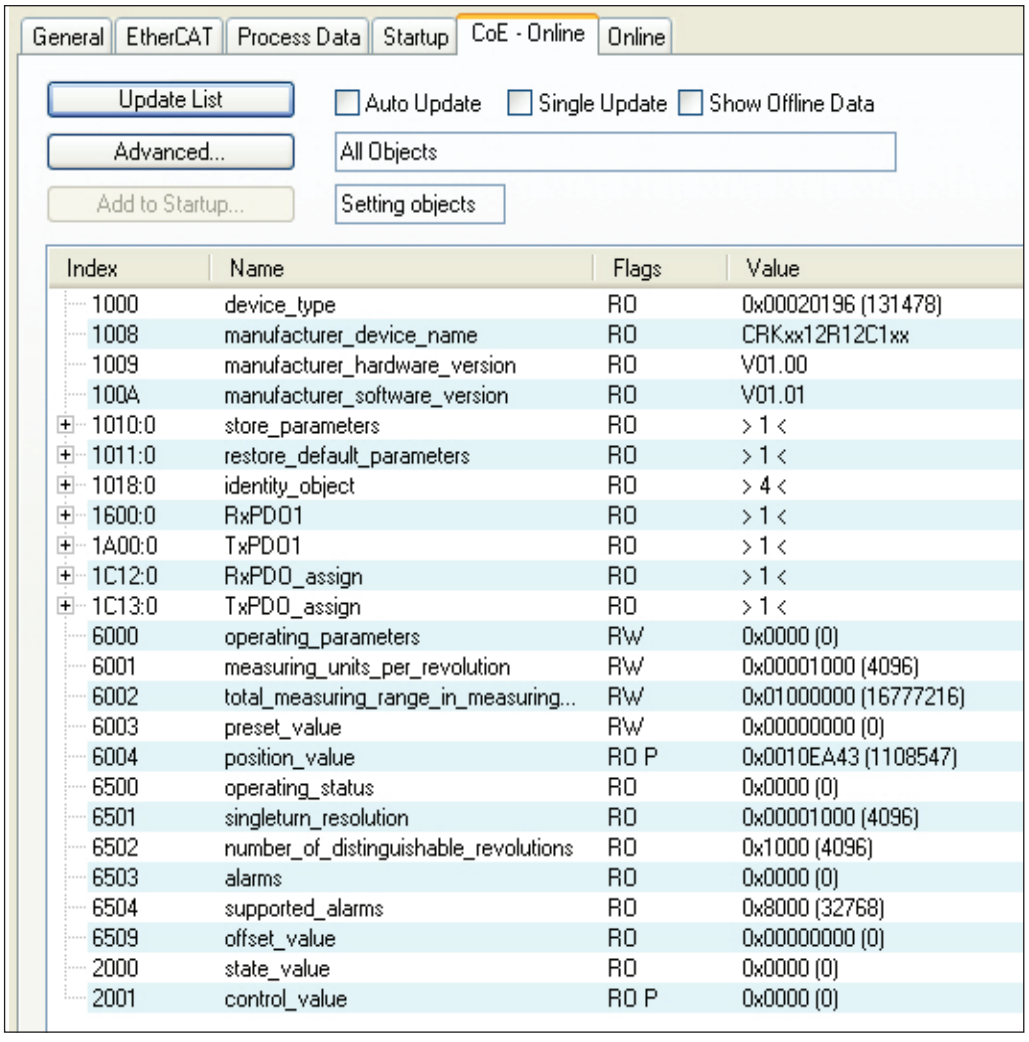


6. TwinCAT System Manager

If you click onto the CRK itself instead, the following screen's register takes you to the absolute encoder's configuration and parameterisation.



The CoE online register accesses the parameter and diagnostic data. All parameters identified with "RW" can be changed. The description of the parameters can be found in Chapter 4. After changing the parameters, do not forget to save them in a failsafe manner via parameter 1010_h.



Index	Name	Flags	Value
1000	device_type	RO	0x00020196 (131478)
1008	manufacturer_device_name	RO	CRKxx12R12C1xx
1009	manufacturer_hardware_version	RO	V01.00
100A	manufacturer_software_version	RO	V01.01
1010:0	store_parameters	RO	> 1 <
1011:0	restore_default_parameters	RO	> 1 <
1018:0	identity_object	RO	> 4 <
1600:0	RxPDO1	RO	> 1 <
1A00:0	TxPDO1	RO	> 1 <
1C12:0	RxPDO_assign	RO	> 1 <
1C13:0	TxPDO_assign	RO	> 1 <
6000	operating_parameters	RW	0x0000 (0)
6001	measuring_units_per_revolution	RW	0x00001000 (4096)
6002	total_measuring_range_in_measuring...	RW	0x01000000 (16777216)
6003	preset_value	RW	0x00000000 (0)
6004	position_value	RO P	0x0010EA43 (1108547)
6500	operating_status	RO	0x0000 (0)
6501	singleturn_resolution	RO	0x00001000 (4096)
6502	number_of_distinguishable_revolutions	RO	0x1000 (4096)
6503	alarms	RO	0x0000 (0)
6504	supported_alarms	RO	0x8000 (32768)
6509	offset_value	RO	0x00000000 (0)
2000	state_value	RO	0x0000 (0)
2001	control_value	RO P	0x0000 (0)