

**EtherCAT®**   
**user manual**

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EtherCAT® ist eine eingetragene Marke und patentierte Technologie,  
lizenziiert durch die Beckhoff Automation GmbH, Deutschland.

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## 1. Safety instructions

### 1. Safety instructions

#### 1.1 Scope of validity

This user manual applies exclusively to the following rotary encoders with PROFI-safe 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 3. Installation instructions

**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.

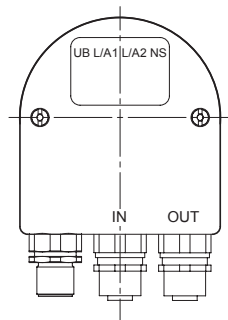
The EtherCAT specifications can be obtained from the EtherCAT Technology Group ETG ([www.ethercat.org](http://www.ethercat.org)).

**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/IEC 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. Installation instructions

#### 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 aktiv
		on		Network connection established
		flashing		Netzwerk aktiv
			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](http://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

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<sub>h</sub>, 6001<sub>h</sub> and 6002<sub>h</sub>. Failsafe storage of the modified parameters is carried out via the CoE parameter 1010<sub>h</sub>. 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 <sub>h</sub> ). Default value: 0  Scaling must be switched on to set the pre-set value (CoE parameter 6000 <sub>h</sub> ). Also see <a href="#">Chapter 5.4</a> . Additionally saving the pre-set (offset) value via object 1010 <sub>h</sub> is not necessary.
1 - 15	Not used	



5. Programming and diagnosis

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 <sub>h</sub> - 1FFF <sub>h</sub>
Manufacturer-specific parameters	Index 2000 <sub>h</sub> - 5FFF <sub>h</sub>
Standardised device parameters	Index 6000 <sub>h</sub> - 9FFF <sub>h</sub>

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
<b>Communication Profile Area</b>				
1000 <sub>h</sub>	VAR	device_type	Unsigned32	ro
1008 <sub>h</sub>	VAR	manufacturer_device_name	String	ro
1009 <sub>h</sub>	VAR	manufacturer_hardware_version	String	ro
100A <sub>h</sub>	VAR	manufacturer_software_version	String	ro
1010 <sub>h</sub>	RECORD	store_parameters		rw
1011 <sub>h</sub>	RECORD	restore_default_parameters		rw
1018 <sub>h</sub>	RECORD	identity_object		ro
1600 <sub>h</sub>	RECORD	receive_PDO_mapping		ro
1A00 <sub>h</sub>	RECORD	transmit_PDO_mapping		ro
1C12 <sub>h</sub>	RECORD	sync_manager_RxPDO_assign		ro
1C13 <sub>h</sub>	RECORD	sync_manager_TxPDO_assign		ro
<b>Manufacturer Specific Profile Area</b>				
2000 <sub>h</sub>	VAR	state_value	Unsigned16	ro
2001 <sub>h</sub>	VAR	control_value	Unsigned16	ro
<b>Standardised Device Profile Area</b>				
6000 <sub>h</sub>	VAR	operating_parameters	Unsigned16	rw
6001 <sub>h</sub>	VAR	measuring_units_per_revolution	Unsigned32	rw
6002 <sub>h</sub>	VAR	total_measuring_range_in_measuring_units	Unsigned32	rw
6003 <sub>h</sub>	VAR	preset_value	Unsigned32	rw
6004 <sub>h</sub>	VAR	position_value	Unsigned32	ro
6500 <sub>h</sub>	VAR	operating_status	Unsigned16	ro
6501 <sub>h</sub>	VAR	singleturn_resolution	Unsigned32	ro
6502 <sub>h</sub>	VAR	number_of_distinguishable_revolutions	Unsigned32	ro
6503 <sub>h</sub>	VAR	alarms	Unsigned16	ro
6504 <sub>h</sub>	VAR	supported_alarms	Unsigned16	ro
6509 <sub>h</sub>	VAR	offset_value	Unsigned32	ro

5. Programming and diagnosis

5.2 Communication parameters

5.2.1 Object 1000<sub>h</sub> - Device type

Index	Sub	Name	Data type	Access	Range/Value	Default
1000 <sub>h</sub>	00	device_type	Unsigned32	ro	0x20196	

5.2.2 Object 1008<sub>h</sub> - Manufacturer device name

Index	Sub	Name	Data type	Access	Range/Value	Default
1008 <sub>h</sub>	00	manufacturer_device_name	String	ro		

e.g. CRKxx12R12C1xx

5.2.3 Object 1009<sub>h</sub> - Manufacturer hardware version

Index	Sub	Name	Data type	Access	Range/Value	Default
1009 <sub>h</sub>	00	manufacturer_hardware_version	String	ro		

Contains the current manufacturer hardware version e.g.: "2.00"

5.2.4 Object 100A<sub>h</sub> - Manufacturer software version

Index	Sub	Name	Data type	Access	Range/Value	Default
100A <sub>h</sub>	00	manufacturer_software_version	String	ro		

Contains the current manufacturer software version e.g.: "3.00"

5.2.5 Object 1010<sub>h</sub> - Store parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1010 <sub>h</sub>	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<sub>h</sub> - Restore default parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1600 <sub>h</sub>	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 EEPROM and become immediately active. Following execution, the value is reset to "1".

5. Programming and diagnosis

5.2.7 Object 1018<sub>h</sub> - Identity Object

Index	Sub	Name	Data type	Access	Range/Value	Default
1018 <sub>h</sub>	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<sub>h</sub> - Receive PDO mapping

Index	Sub	Name	Data type	Access	Range/Value	Default
1600 <sub>h</sub>	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<sub>h</sub> - Transmit PDO mapping

Index	Sub	Name	Data type	Access	Range/Value	Default
1A00 <sub>h</sub>	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<sub>h</sub> - Sync manager channel 2 (process data output)

Index	Sub	Name	Data type	Access	Range/Value	Default
1C12 <sub>h</sub>	00	number_of_RxPDOs	Unsigned8	ro	1	
	01	receive_assign_object	Unsigned16	ro	0x1600	

5.2.11 Object 1C13<sub>h</sub> - Sync manager channel 3 (process data input)

Index	Sub	Name	Data type	Access	Range/Value	Default
1C13 <sub>h</sub>	00	number_of_TxPDOs	Unsigned8	ro	1	
	01	transmit_assign_object	Unsigned16	ro	0x1A00	

5. Programming and diagnosis

5.3 Manufacturer-specific parameters

5.3.1 Object 2000<sub>h</sub> - State value

Index	Sub	Name	Data type	Access	Range/Value	Default
2000 <sub>h</sub>	00	state_value	Unsigned16	ro	0...15	0

The object 2000<sub>h</sub> displays detailed parameterisation errors and information. An entry in state\_value is displayed by the highest-value bit in the object 6503<sub>h</sub> "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 <sub>h</sub> )	Re-write the parameter with permissible values
1	Impermissible value in the parameter „measuring_units_per_revolution“ (Object 6001 <sub>h</sub> )	Re-write the parameter with permissible values
2	Impermissible value in the parameter „total_measuring_range_in_measuring_units“ (object 6002 <sub>h</sub> )	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 <sub>h</sub> )	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<sub>h</sub> - Control value

Index	Sub	Name	Data type	Access	Range/Value	Default
2001 <sub>h</sub>	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 <sub>h</sub> ). Default value: 0 The scaling must be switched on to set the pre-set value (CoE parameter 6000 <sub>h</sub> ). Also see <a href="#">Chapter 5.4</a> . Additionally saving the pre-set (offset) value via the object 1010 <sub>h</sub> 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. Programming and diagnosis

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

5.4.4 Object 6003<sub>h</sub> - Preset

Index	Sub	Name	Data type	Access	Range/Value	Default
6003 <sub>h</sub>	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<sub>h</sub>.

Before changing the pre-set value, scaling must be switched on via object 6000<sub>h</sub> 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<sub>h</sub> - Position

Index	Sub	Name	Data type	Access	Range/Value	Default
6004 <sub>h</sub>	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. Programming and diagnosis

### 5.5 Standardised device diagnosis

#### 5.5.1 Object 6500<sub>h</sub> - Operating status

Index	Sub	Name	Data type	Access	Range/Value	Default
6500 <sub>h</sub>	00	operating_status	Unsigned16	ro	0,1,4	0

The object 6500<sub>h</sub> depicts the operating status of the absolute encoder. The bits have the same meaning as in the object 6000<sub>h</sub>.

#### 5.5.2 Object 6501<sub>h</sub> - Singleturn resolution

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

Specifies the maximum resolution which can be set.

#### 5.5.3 Object 6502<sub>h</sub> - Number of distinguishable revolutions

Index	Sub	Name	Data type	Access	Range/Value	Default
6502 <sub>h</sub>	00	number_of_distinguishable_revolutions	Unsigned16	ro	4096	

Specifies the maximum number of revolutions.

#### 5.5.4 Object 6503<sub>h</sub> - Alarms

Index	Sub	Name	Data type	Access	Range/Value	Default
6503 <sub>h</sub>	00	alarms	Unsigned16	ro		0

Bit	Meaning
0 - 14	Not used
15	Collective error (for further information, see object 2000 <sub>h</sub> state_value ( <a href="#">Chapter 5.3.1</a> ))

#### 5.5.5 Object 6504<sub>h</sub> - Supported alarms

Index	Sub	Name	Data type	Access	Range/Value	Default
6504 <sub>h</sub>	00	supported_alarms	Unsigned16	ro	8000	

Bit	Meaning
0 - 14	Not used
15	Collective error

#### 5.5.6 Object 6509<sub>h</sub> - Offset

Index	Sub	Name	Data type	Access	Range/Value	Default
6509 <sub>h</sub>	00	offset_value	Unsigned32	ro		0

See object 6003<sub>h</sub> pre-set ([Chapter 5.4.4](#))

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

6. TwinCAT System Manager

6. TwinCAT system manager

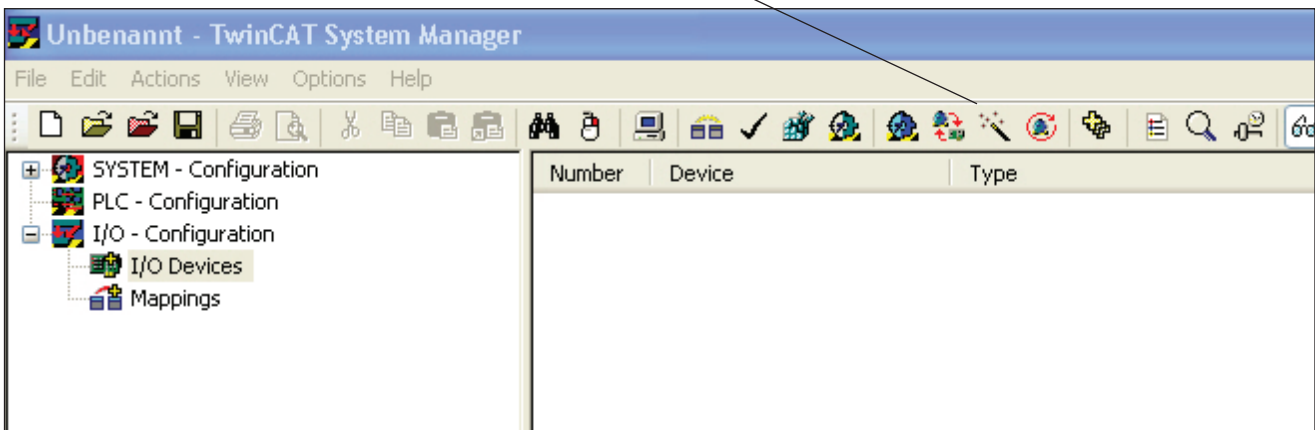
6.1 Installation der XML-Datei

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

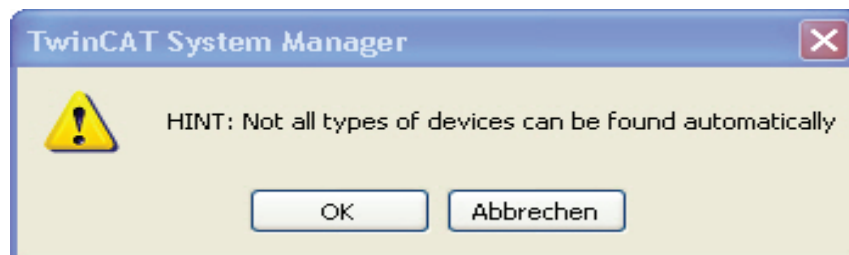
6.2 Online commissioning

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

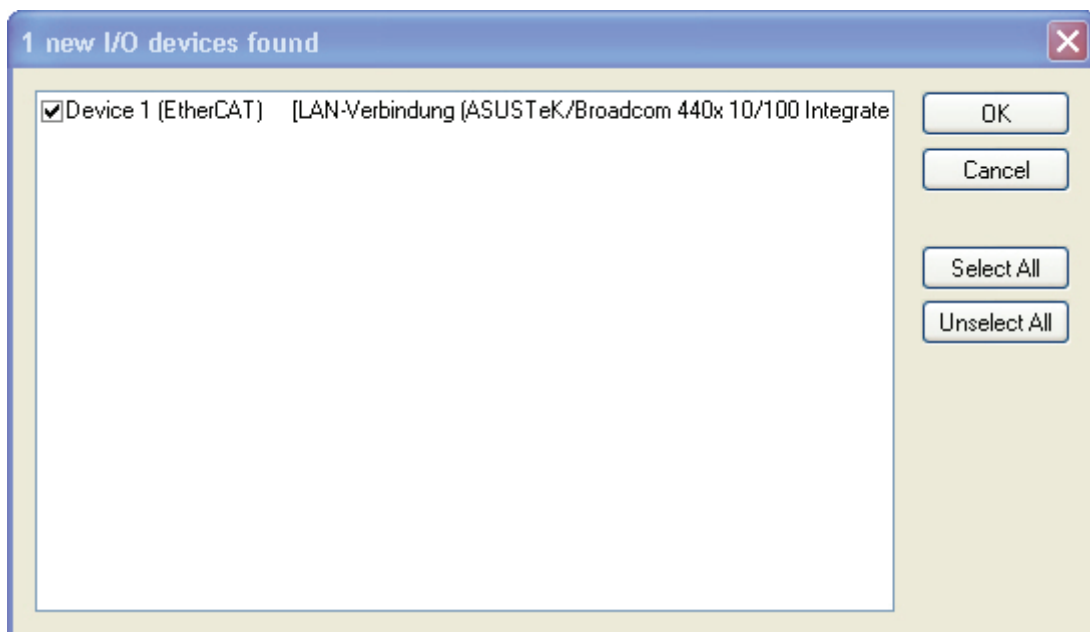
Create a new project, mark "I/O devices" and click onto the "wand".



Confirm the following note with OK.



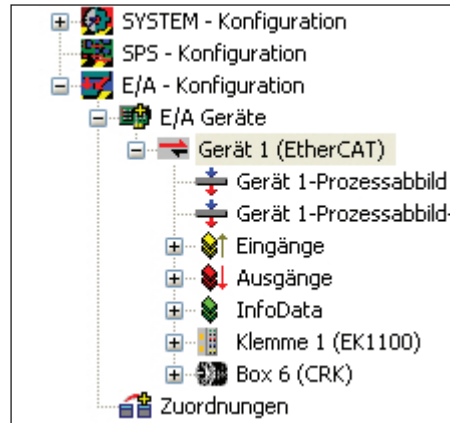
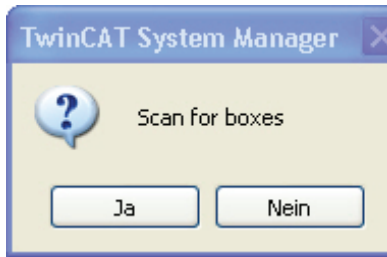
TwinCAT should then locate your network card. Confirm this with OK.



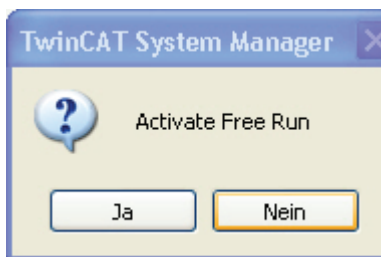


6. TwinCAT System Manager

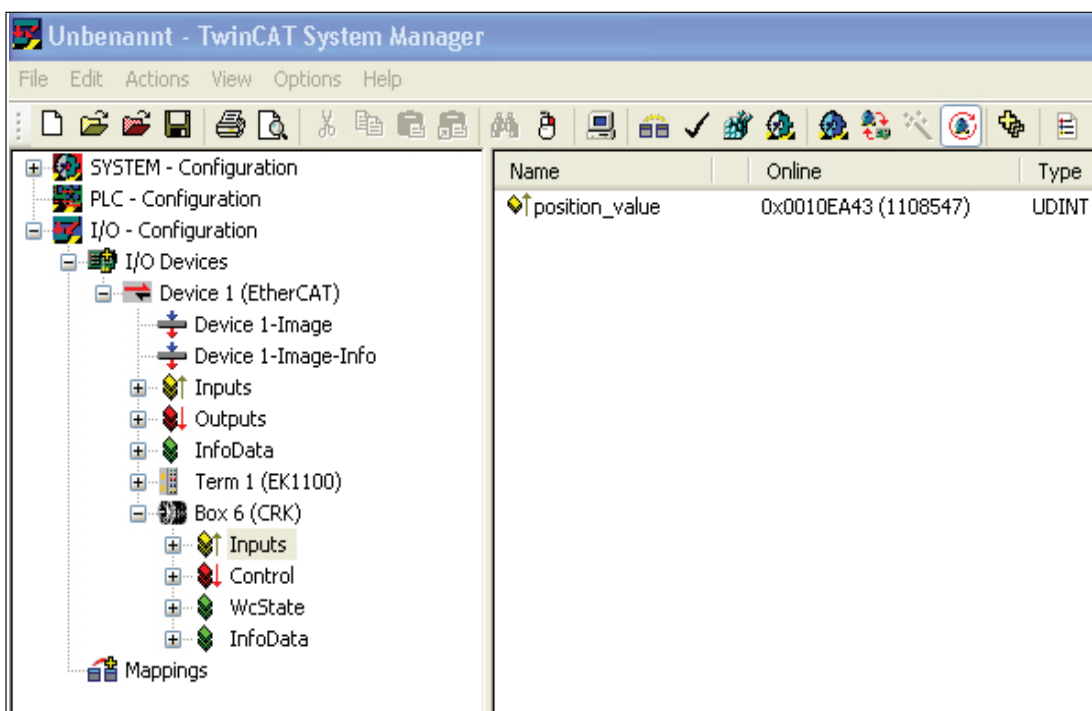
After confirming the following dialogue with “Yes”, all connected devices should be located. In this case, the EtherCAT master (device 1), a Beckhoff bus terminal with I/O modules and the TWK CRK absolute encoder.



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

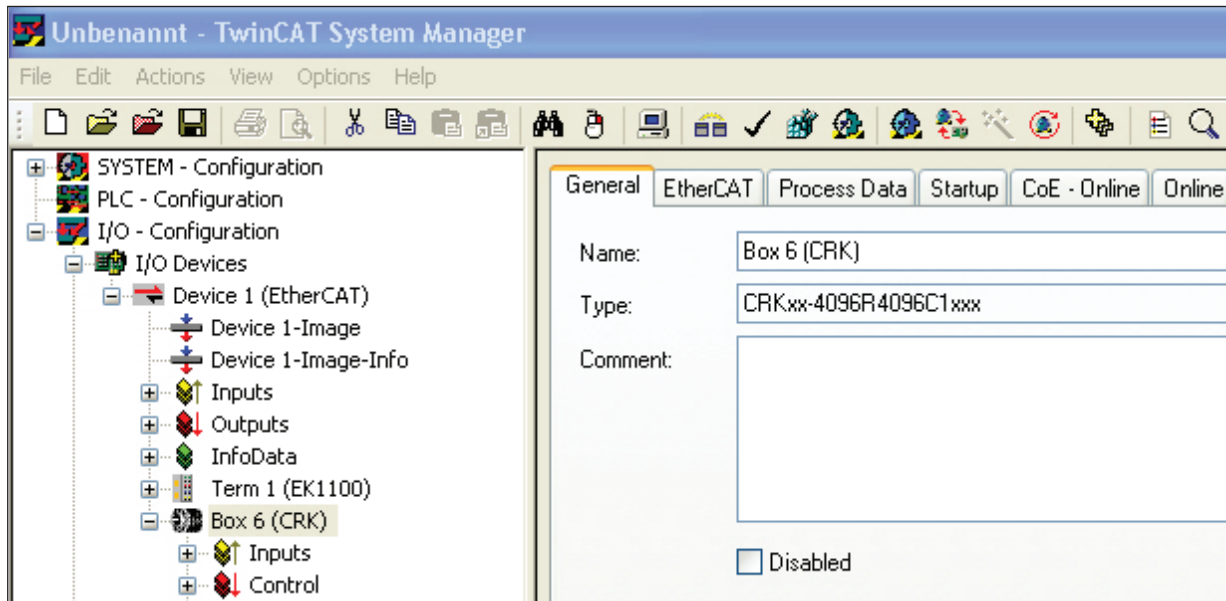


Clicking onto the CRK’s “Inputs” displays the absolute encoder’s input data.



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<sub>n</sub>.

