



# Manual

Encoders with EtherCAT interface

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# 1 Document

This document is the English translation of the original German version.

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Subject to errors and changes. The stated product features and technical data shall not constitute any guarantee declaration.

## 2 General Information



Please read this document carefully before working with the product, mounting it or starting it up.

### 2.1 Target Group

The device may only be planned, mounted, commissioned and serviced by persons having the following qualifications and fulfilling the following conditions:

- Technical training.
- Briefing in the relevant safety guidelines.
- Constant access to this documentation.

### 2.2 Symbols used / Warnings and Safety instructions



**DANGER**

#### Classification:

This symbol, together with the signal word **DANGER**, warns against immediately imminent threat to life and health of persons.

The non-compliance with this safety instruction will lead to death or severe adverse health effects.



**WARNING**

#### Classification:

This symbol, together with the signal word **WARNING**, warns against a potential danger to life and health of persons.

The non-compliance with this safety instruction may lead to death or severe adverse health effects.



**CAUTION**

#### Classification:

This symbol, together with the signal word **CAUTION**, warns against a potential danger for the health of persons.

The non-compliance with this safety instruction may lead to slight or minor adverse health effects.

**ATTENTION**

#### Classification:

The non-compliance with the **ATTENTION** note may lead to material damage.

<b>NOTICE</b>	<b>Classification:</b>
	Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation.

---

## 2.3 Transport / Storage

Inspect the delivery immediately upon receipt for possible damages due to the transport. If you do not mount the device immediately, store it preferably in its transport package.

Otherwise, make sure when storing the encoder that the shaft and the cable outlet are always free from any load.

The encoder must be stored at a dry and dust-free location and in compliance with the technical data, see chapter Technical Data.

## 3 Product Description

### 3.1 Technical Data

Maximum rotational speed	IP65 up to 70°C IP65 up to Tmax IP67 up to 70°C IP67 up to Tmax	9000 min <sup>-1</sup> , 7000 min <sup>-1</sup> (continuous op- eration) 7000 min <sup>-1</sup> , 4000 min <sup>-1</sup> (continuous op- eration) 8000 min <sup>-1</sup> , 6000 min <sup>-1</sup> (continuous op- eration) 6000 min <sup>-1</sup> , 3000 min <sup>-1</sup> (continuous op- eration)
Starting torque (at 20°C)	IP65 IP67	< 0.01 Nm < 0.05 Nm
Mass moment of inertia	Solid shaft version Hollow shaft version	3.0 x 10 <sup>-6</sup> kgm <sup>2</sup> 7.5 x 10 <sup>-6</sup> kgm <sup>2</sup> (MT) 6 x 10 <sup>-6</sup> kgm <sup>2</sup> (ST)
Permissible shaft load	radial axial	80 N 40 N
Protection level acc. to EN 60529	Housing side Shaft side	IP67 IP65, opt. IP67
Working temperature range		-40°C ... +80°C
Materials	Solid shaft/hollow shaft Flange Housing	Stainless steel Aluminum Die-cast zinc
Shock resistance according to EN 60068-2-27		2.500 m/s <sup>2</sup> , 6 ms
Vibration resistance according to EN 60068-2-6		100 m/s <sup>2</sup> , 55 ... 2000 Hz

Tab. 1: Mechanical characteristics for the Sendix 58xx encoders

### 3.2 Interface Description EtherCAT

EtherCAT is an industrial Ethernet technology characterized by performance, low costs, a flexible topology and easy handling. EtherCAT was completed in 2003, it is an international standard since 2007 and it is being promoted and developed further by the EtherCAT Technology Group. EtherCAT is an open technology: this means that everybody can implement and use it.

#### Operating principle

EtherCAT slave devices process the Ethernet frames during the cycle. Every participant takes the data intended for it and inserts its data in the same frame while the frame is already being forwarded. Therefore one single frame is generally sufficient per cycle, and the Ethernet bandwidth is used ideally.

Switches or hubs are not necessary. EtherCAT differs considerably from other Industrial Ethernet solutions. With EtherCAT, the slave devices take the data intended for them while the telegram is passing through the device. Input data is integrated in the telegram while it passes. This allows earliest possible processing of the frame, as the device must not wait until the whole frame has been received. Also sending takes place with a minimum offset of few bit times.

#### **Performance**

Its specific operating principle makes EtherCAT the fastest Industrial Ethernet technology.

#### **Topology**

EtherCAT supports up to 65,535 participants with a totally freely selectable topology:

line, junction, tree, star – in any combination. The fast Ethernet physics allow up to 100m between two participants. Fiber optics are used for longer distances. Connecting and disconnecting devices and segments during operation and line redundancy thanks to a ring topology complete the flexibility.

## **3.3 Supported Standards and Protocols**

### **Supported Standards and Protocols**

CAN over EtherCAT: CoE

### **Implemented encoder profile**

CiA 406 Work Draft Version 3.2.10 of February 18, 2011

### **Conformity to**

EN 61000-4-2:2001

EN 61000-4-3:2006

EN 61000-4-4:2005

EN 61000-4-5:2007

EN 61000-4-6:2008

EN 61000-4-7:2004

EN 61000-6-4:2007

EN 61000-6-2:2006

The firmware and XML file versions at the date of release of this documentation are:

- Firmware-Version V3.4, visible under TwinCAT through Object 0x100A.
- KueblerEtherCAT.xml in Version 8, visible in the file as a tag <Vendor FileVersion="8">

## 4 Installation

### 4.1 Electrical Installation

#### 4.1.1 General Information for the Connection

<b>ATTENTION</b>	<b>Destruction of the device</b>
	Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again.

<b>NOTICE</b>	<b>General safety instructions</b>
	<p>Make sure that the whole plant remains switched off during the electrical installation.</p> <ul style="list-style-type: none"> <li>• Make sure that the operating voltage is switched on or off simultaneously for the device and the downstream device.</li> <li>• Electrostatic discharges at the contacts of the connector or at the cable ends could damage or destroy the device. Take appropriate precautionary measures.</li> <li>• Use a PELV supply voltage source according to EN 60204-1 with the proper operating voltage and the maximum permissible output current.</li> </ul>

#### 4.1.2 Information for EMC-Compliant Installation

##### Requirements for cables

- Use exclusively shielded twisted-pair cables to connect the encoder.
- Comply with the max. permissible connection cables length.

##### Wiring

When wiring the facility, pay attention to proper cable routing.

- Separate the wiring into power groups such as motor/power supply lines and signal and data lines.
- Route the signal and data lines as close as possible to ground surfaces (frames, metal rails, cabinet sides) and not parallel to motor and power supply lines or other lines carrying high interference levels.
- Make sure that no other users with high interference levels such as frequency converters, solenoid valves, contactors, are connected to the encoder power supply.

<b>NOTICE</b>	<b>Use a traction relief</b>
	Mount all cables with traction relief and check the supply voltage on the device.

### Shielding and equipotential bonding

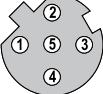
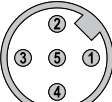
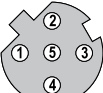
- Apply the cable shield on a large contact area - ideally 360°. Use shield terminals to this purpose.
- Shield terminals are available depending on the cable diameter, order code 8.0000.4G06.0312 or 8.0000.4G06.0718).
- Pay attention to proper cable shield fastening.
- Preferably connect the shield on both sides with low impedance with the protective earth (PE), e.g. on the encoder and/or on the evaluation device. In the event of potential differences, the shield must only be applied on one side.
- If shielding is not possible, appropriate filtering measures must be taken.
- If the protective earth should only be connected to the shield on one side, the facility manufacturer / operator must make sure with suitable means that no short-time overvoltages can appear on the signal and supply voltage lines.

### 4.1.3 Terminal Assignment

The encoder has three connectors, two of them are the two Ethernet ports. This documentation refers to them as Port IN and Port OUT.

The central connector is the power supply connector.



Interface	Type of connection	Connector					Pin arrangement
		3x M12 connector, 4-pole					
			Bus Port IN				
B	2	Signal	TxD+	RxD+	TxD-	RxD-	
		Pin	1	2	3	4	
			Voltage supply				
		Signal	+ V	-	0 V	-	
		Pin	3	2	1	4	
			Bus Port OUT				
		Signal	TxD+	RxD+	TxD-	RxD-	
		Pin	1	2	3	4	

Connector	Signal	Function	Strand color
Bus Port IN / OUT	TxD+	Transmit Data +	YE
	TxD-	Receive Data -	OG
	RxD+	Transmit Data +	WH
	RxD-	Receive Data -	BU
Voltage supply	+ V	10 ... 30 V	1
			2
	0 V	GND	3
			4

### Signal assignment of an RJ45 to M12 cable

M12 to RJ45 direct

Signal	M12 pin number	RJ45 pin number
TxD+	1	1
TxD-	3	2
RxD+	2	3
RxD-	4	6

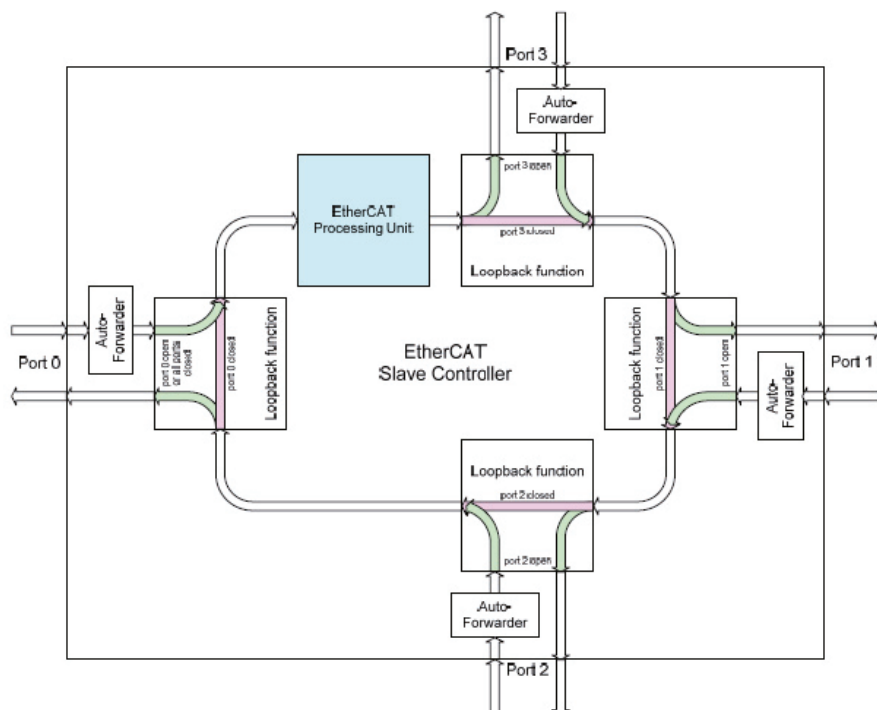
M12 to RJ45 crossover

Signal	M12 pin number	RJ45 pin number
TxD+	1	3
TxD-	3	6
RxD+	2	1
RxD-	4	2

## 4.1.4 Network Topology

The EtherCAT topology always forms a logical ring. However, different topologies are physically possible.





NOTICE	Star topology
	<p>If you choose a star topology (only one port of the encoder is used), imperatively connect the encoder via port IN. This is a decisive prerequisite for the proper operation of an EtherCAT device</p> <p>Port IN corresponds to port 0 of the ET1100, which represents the EtherCAT slave controller of the encoder. Port OUT of the encoder corresponds to port 1 of the ET1100.</p>







## 5 Commissioning and Operation

### 5.1 Function and Status LED

The encoder has four diagnosis LEDs.







Display	LED	Meaning
L/A IN		LINK/ACTIVITY IN is a LED of port IN, which lights up when the link is established, flashes during data exchange (activity) and is off in all other cases.
L/A OUT		LINK/ACTIVITY OUT is a LED of port OUT, which lights up when the link is established, flashes during data exchange (activity) and is off in all other cases.
RUN		The RUN LED shows the current state of the EtherCAT status machine. All applicable states are listed in the RUN LED table.
ERROR		The ERROR LED lights up in the event of an error. All applicable states are listed in the ERR LED table.

#### RUN LED

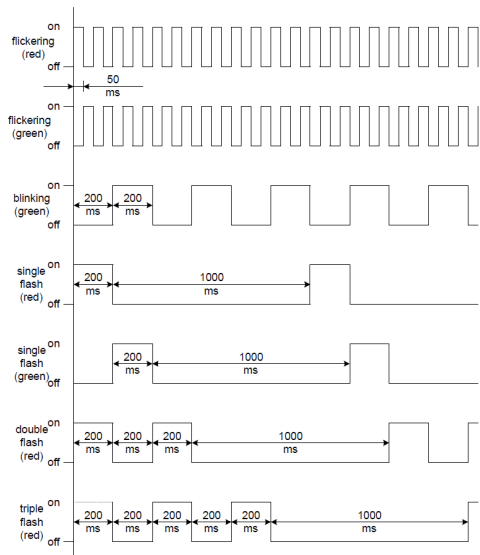
Display	LED	Meaning
Init State		No communication possible between the master and the drive. LED is off
Preoperational		In this condition, no process data traffic is possible. LED flashes quickly.
Safeoperational		The actual drive values are transmitted to the master. But no setpoint values can be sent to the drive. LED flashes slowly.
Operational		The complete process data traffic is active. Actual and setpoint values are transmitted. LED is constantly on.

Error messages / troubleshooting see next page.

**ERROR LED**

Display	LED	Meaning	Error cause	Addition
On		Error at the microcontroller of the application	Communication error or critical application error. In the event a bit is set in Object 0x1001 (errors register), also the ERR LED switches to constantly red	Position error, temperature limit value exceeded, startup error, watchdog of the process data interface between microcontroller and EtherCAT slave.
Double flash		Process data or EtherCAT watchdog timeout	An application watchdog timeout occurred	Sync manager watchdog timeout
Single flash		Local error	The slave changed autonomously the EtherCAT status because of a local error	Device changes an EtherCAT state from Operational to SafeOperationalError because of a synchronization error
Flash		Invalid configuration	General configuration error	Error preventing the master from performing any state change - invalid register values or invalid hardware configuration.
Flickering		Boot error	Boot errors are detected, even if the INIT state has been reached	Check sum error in the flash of the microcontroller.
Off		No error		

The exact time behavior of the LED states is described in the [official document](#) "Indicator Specification" of the CiA.



## 5.2 Quick Start Guide

### 5.2.1 Configuration

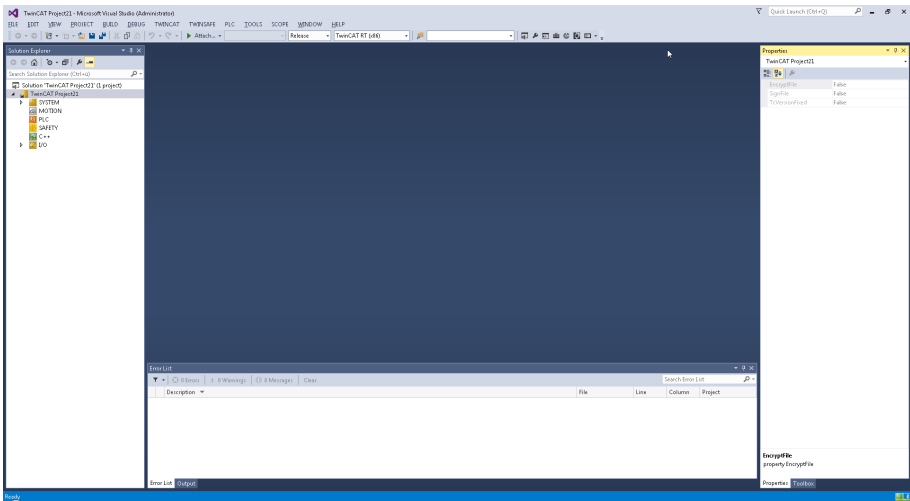
#### 5.2.1.1 Configuring the TwinCAT Project

- ✓ Install the XML file
  - a) Select the TwinCAT installation directory
  - b) Save the XML file in the following path: C:\TwinCAT\3.1\Config\Io\EtherCAT
  - c) Start TwinCAT3

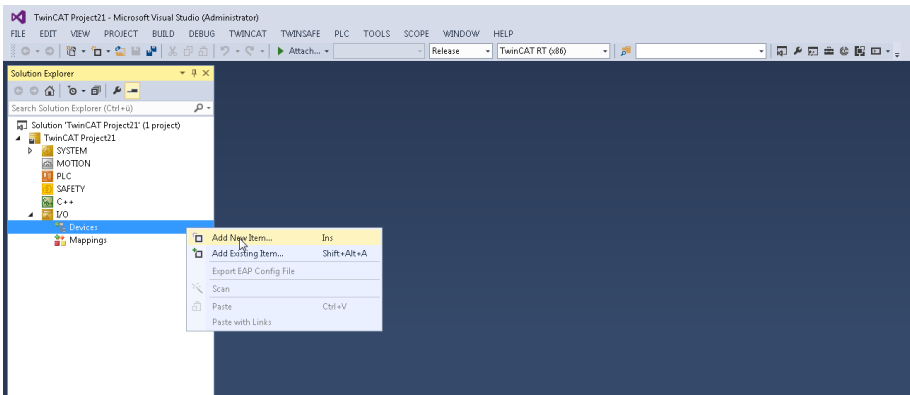
NOTICE	First start-up
	The first start-up requires more time, as the system manager analyzes all XML files in the installation directory. This can be followed on the progress bar in the left lower corner of the system manager window.

To allow the first use of the encoder, it must be created together with an EtherCAT master.

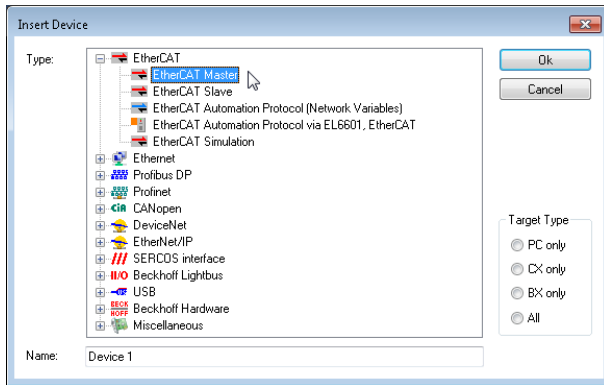
The graphic front end of the TwinCAT system is represented below:



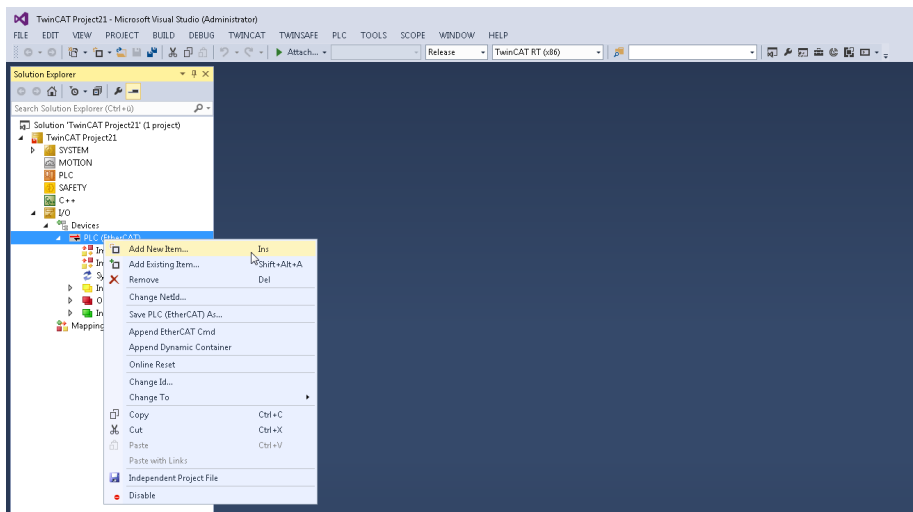
d) Click with the right mouse key on line <Devices> and select <Add New Item...> in the dialog that opens.



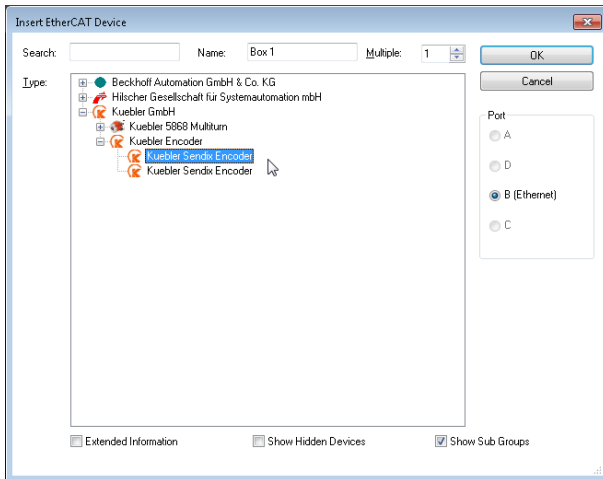
e) In the dialog that opens, select menu <EtherCAT>, sub menu <EtherCAT> and confirm with OK.



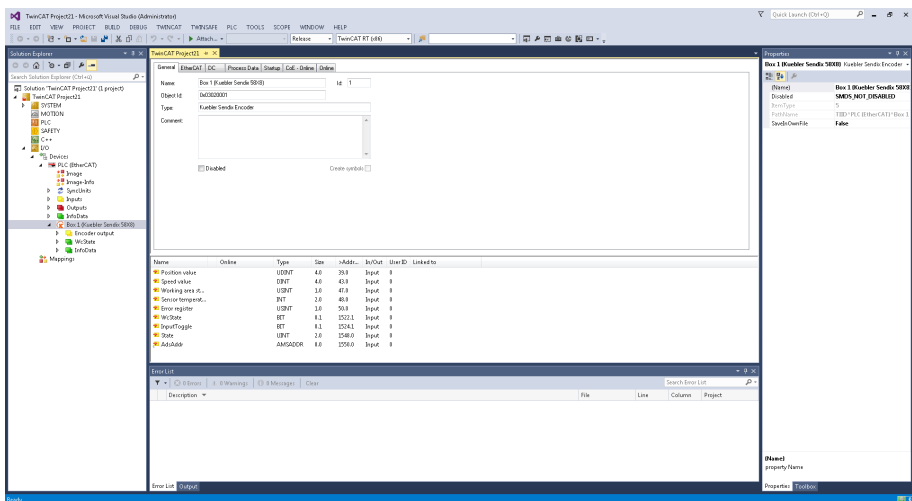
f) Click with the right mouse key on the new displayed menu item >PLC (EtherCAT)> and select sub menu >Add New Item...>.



g) In the dialog that opens, select the Sendix encoder as shown below.



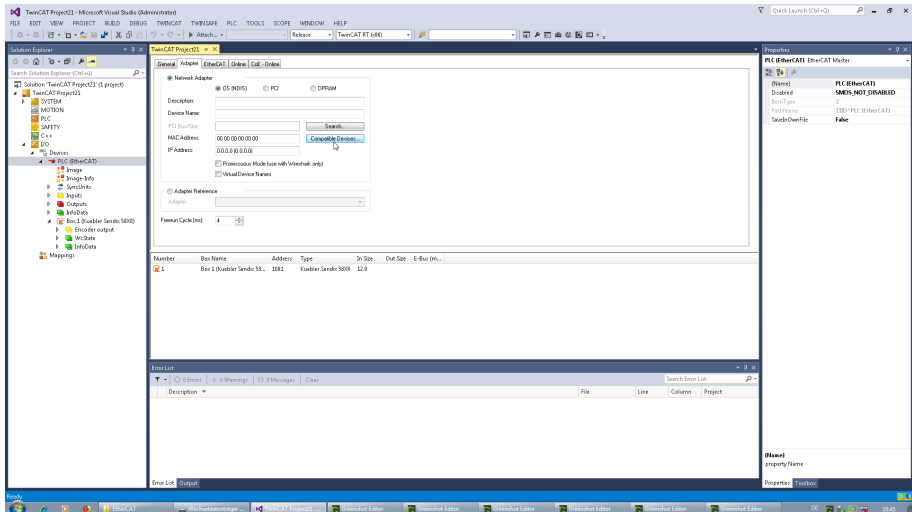
h) Then, the system manager window should appear as shown below:



⇒ The EtherCAT master and the encoder are now created.

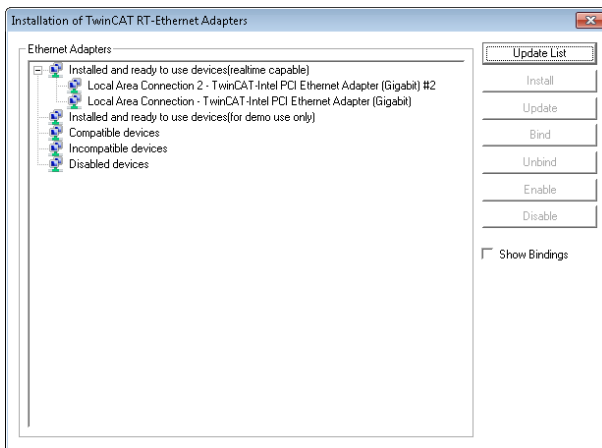
### 5.2.1.2 Configuring the Network Card

a) As shown in the figure, mark menu <PLC (EtherCAT)> and select in the right area tab <Adpater>.

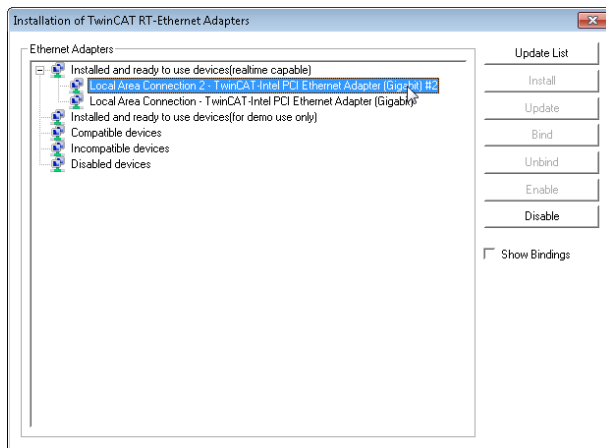


b) Click on button <Compatible devices...>, which opens the following window. The first line displays the installed adapters ready for TwinCAT operation (<Installed and ready to use devices>). No ready to use adapter is available yet in this example.

- ⇒ The second line, with its subitems, shows all TwinCAT compatible adapters of the PC, among which one or more can be selected for the installation of the TwinCAT real time extension.
- ⇒ The third line shows all incompatible adapters. These adapters are not suitable for use with TwinCAT. The fourth line shows all adapters that already have been used successfully under TwinCAT, but have been deactivated.



c) Mark at least one adapter from the category of the compatible adapters and click on button <Install>. The adapters are displayed as subitems of the installed and ready to use adapters.



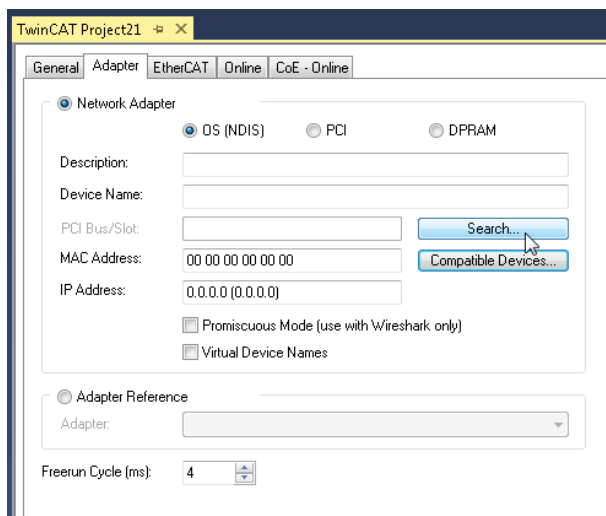
If, due to an update of the TwinCAT software, you already have a deactivated adapter, mark it and click on <Enable>. Also this adapter will then be displayed under the category of the installed and ready to use adapters.

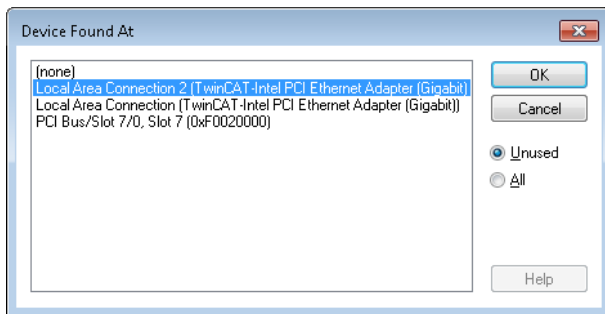
#### NOTICE

#### Compatible network cards.

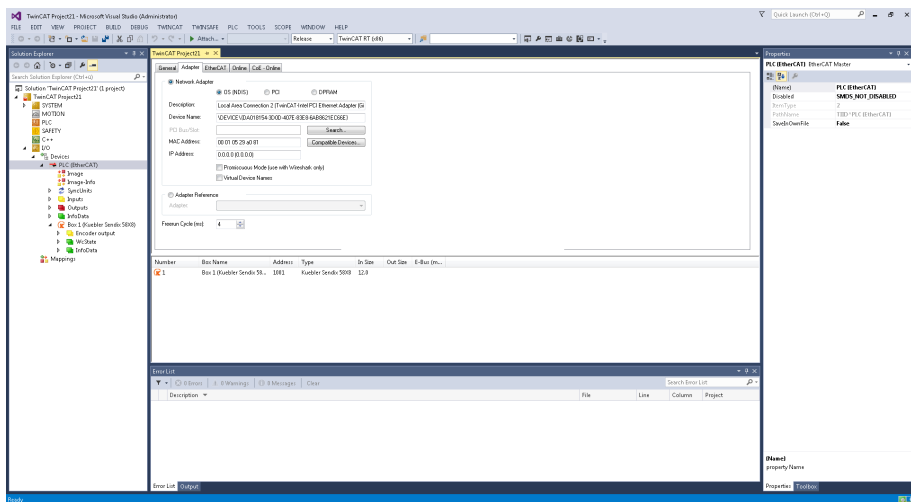
If not a single entry is displayed in the dialog, even though the installation of a network card was completed successfully, this network card is not suitable for use with TwinCAT.

- d) Close the window and click on button <Search...>. A selection window opens, allowing you selecting an adapter for the future TwinCAT communication with the encoder. In this specific example, the <PCICard> adapter has been selected.



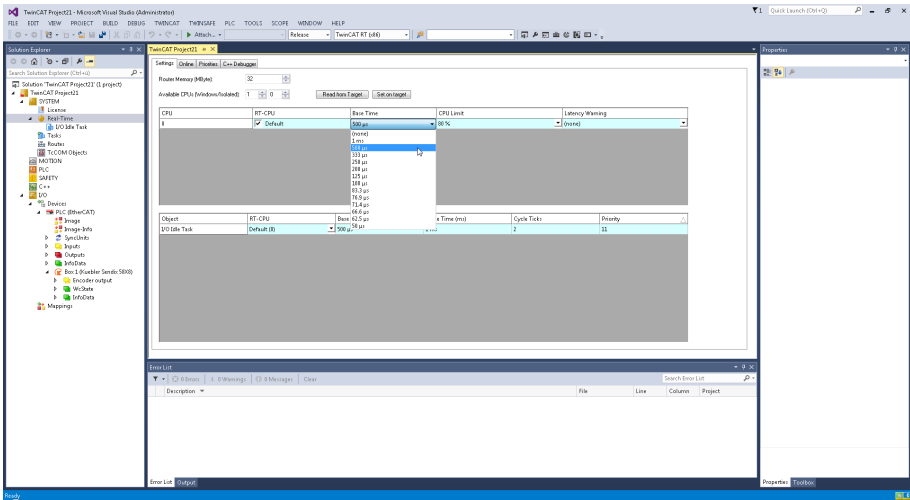


Finally, the <Adapter> tab corresponds to this figure.

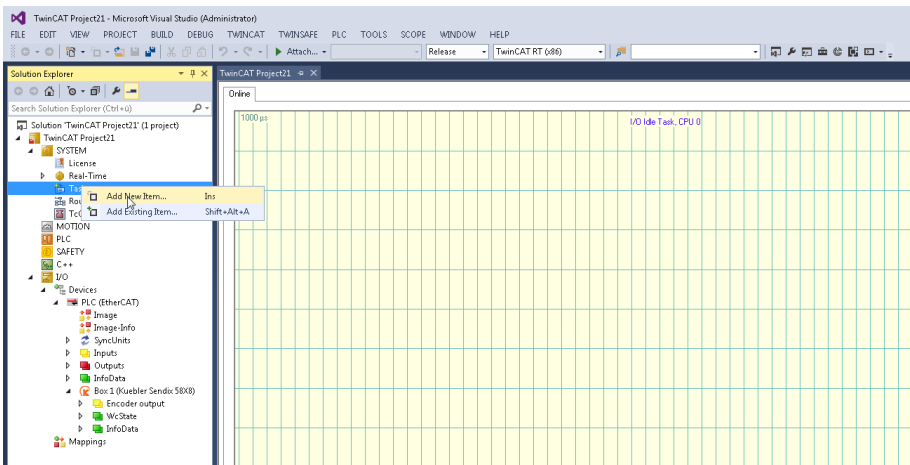


### 5.2.1.3 Configuring the DC Operation Mode

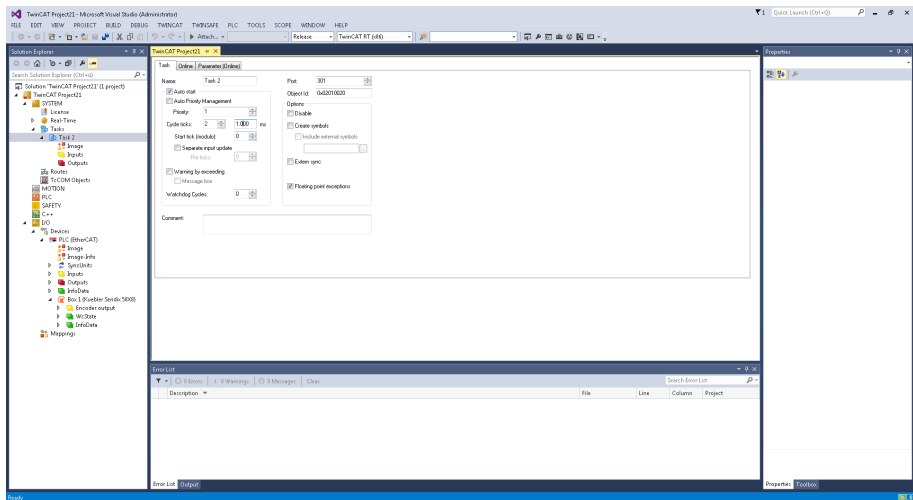
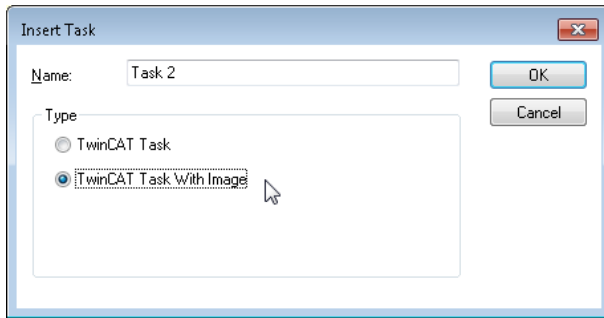
- In the system configuration, select sub menu <Real-time settings> as shown below and set the <Base time> to 500µs.



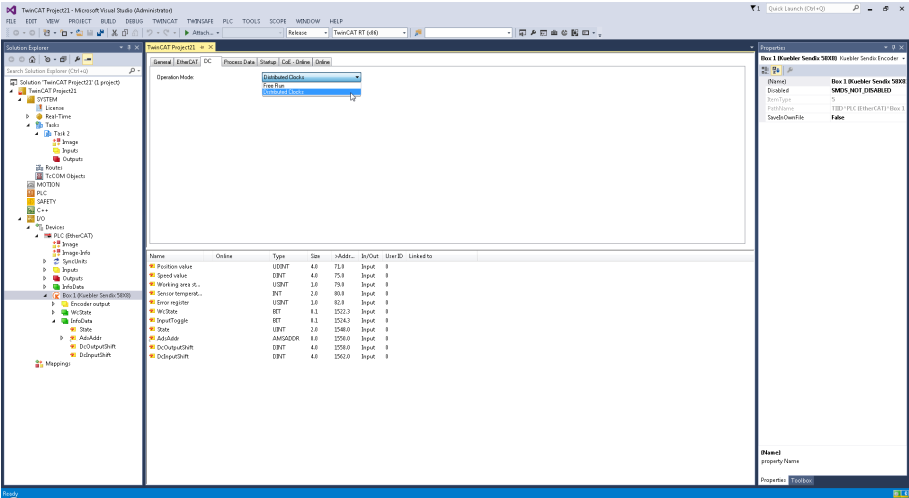
b) As shown in the figure, mark menu <Additional tasks> with the right mouse key and select sub menu item <Insert Task>. Click on OK in the dialog that then opens.



c) In the dialog window of Task 2, select all settings as shown in the figure.



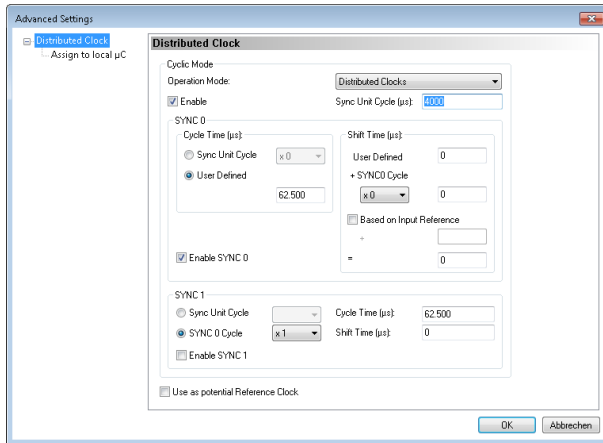
d) Mark menu item <Box 1 (Sendix 58X8)> and select tab <DC>. Select the operation mode Distributed Clocks:



e) Click on button <Advanced settings...> and make sure the settings correspond to the figure. In particular SYNC 0 Cycle Time should be at least 62,500 µs.

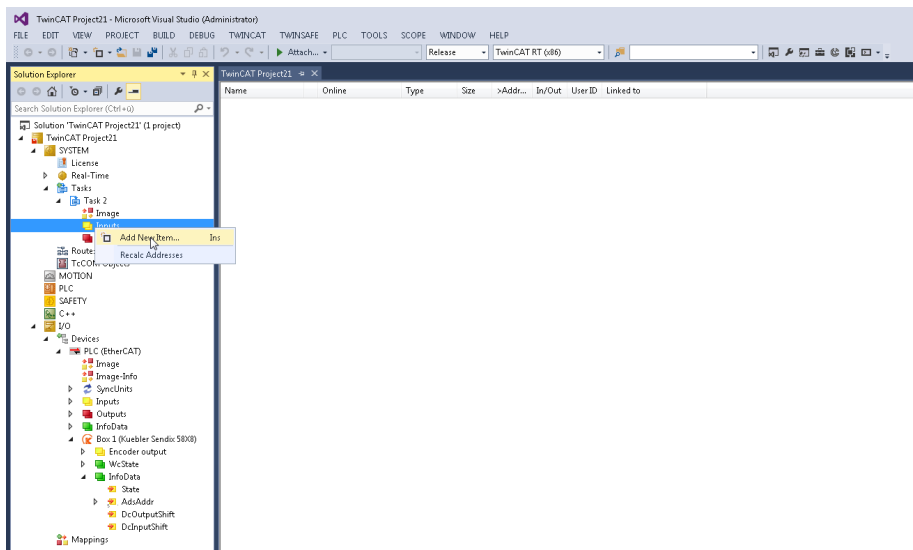
NOTICE	DC cycle time
	<p>The cycle time of 62.5 µs may only be used if no other process data than the position is to be transmitted. In other words, with the 62.5 µs cycle time, only Object 0x6004 or 0x2004 may be mapped, but not both. The transmission time, and thus the duration of the DC cycle, depends on the number of mapped bytes. If the DC cycle time is too short, communication will break down. Therefore, imperatively comply with Annex DC cycle times DC cycle times [ 47].</p>

As shown in the figure, the system manager is in configuration mode, as shown by <Config Mode> in the blue field in the right bottom corner.

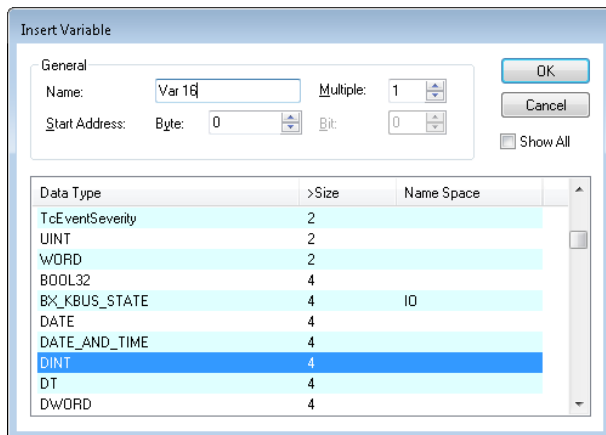


### 5.2.1.4 Process Data Representation

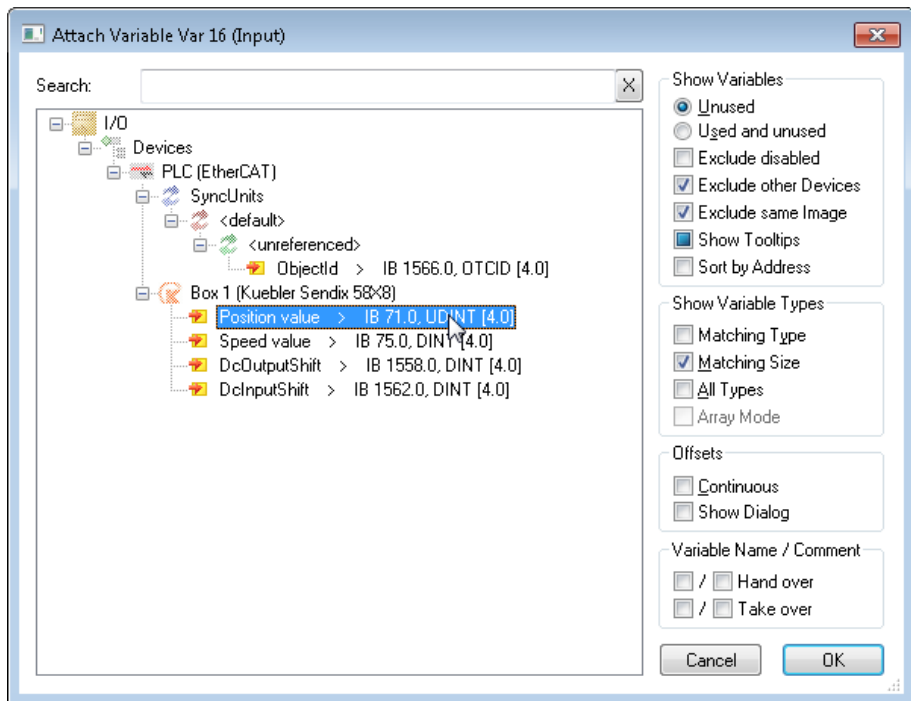
- a) As shown in the figure, mark <Inputs> with the right mouse key and select the sub menu item <Add New Item...>.



- b) In the displayed dialog, see following figure, select a variable of the DINT 4 type. The encoder position value will be represented in this variable. Click on <OK>.



c) Mark variable <Var 34> and click on button <Attach with...>. Select the encoder position value <Position value> and click on button <OK>.

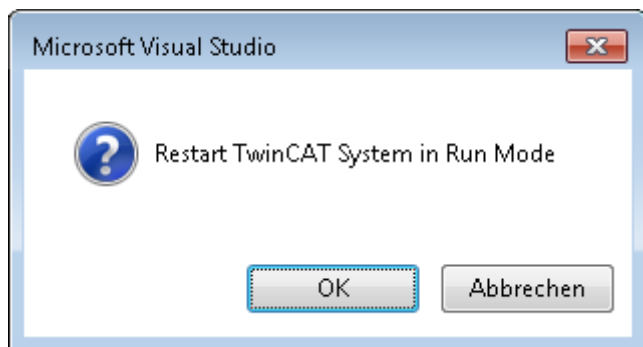
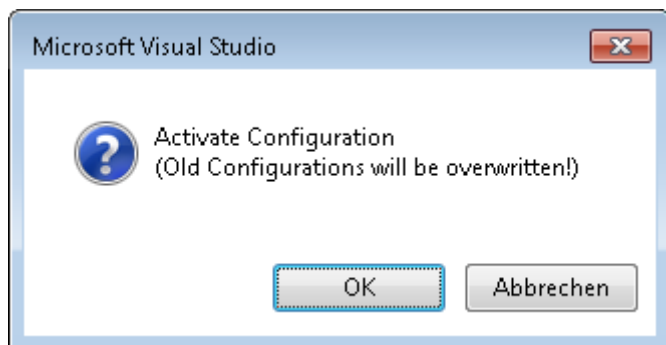


### 5.2.1.5 Configuring the Encoder

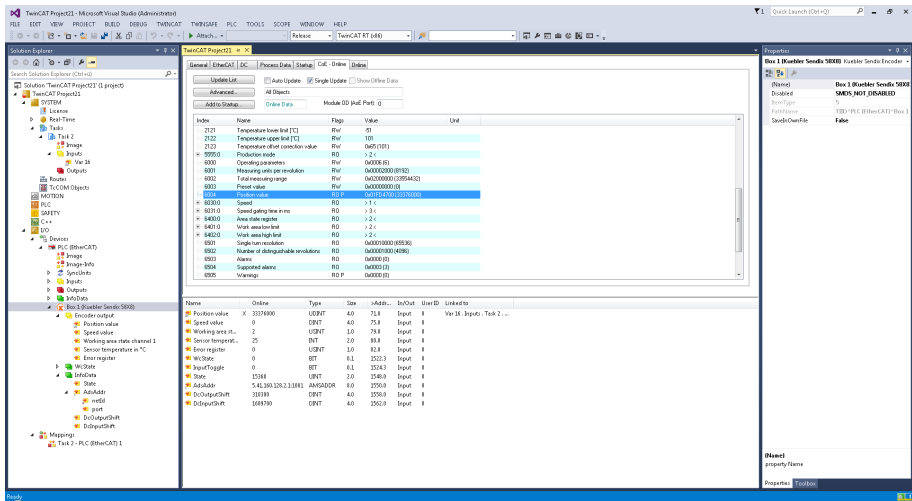
The following figure 39 shows an example of the SDOs and PDOs supported by the encoder. The objects are based on the CiA CANopen – Encoders Profile in version 3.2.10 of February 18, 2011 and will be explained below.

### 5.2.2 Commissioning

- a) Connect the encoder and the PC through the network card that has been configured for TwinCAT.
  - ⇒ The red LED lights only briefly when the encoder firmware starts. Then the yellow LED of the port used to connect the encoder to TwinCAT / to the control switches to constantly on.
- b) Activate the DC mode of TwinCAT through menu "Actions", sub menu "Activate Configuration...".
- c) Confirm the two following dialogs with OK.



If all conditions for <Operational Mode> are met, TwinCAT switches to the real-time display and shows the position value. The current values can be found in the lower half of the screen.



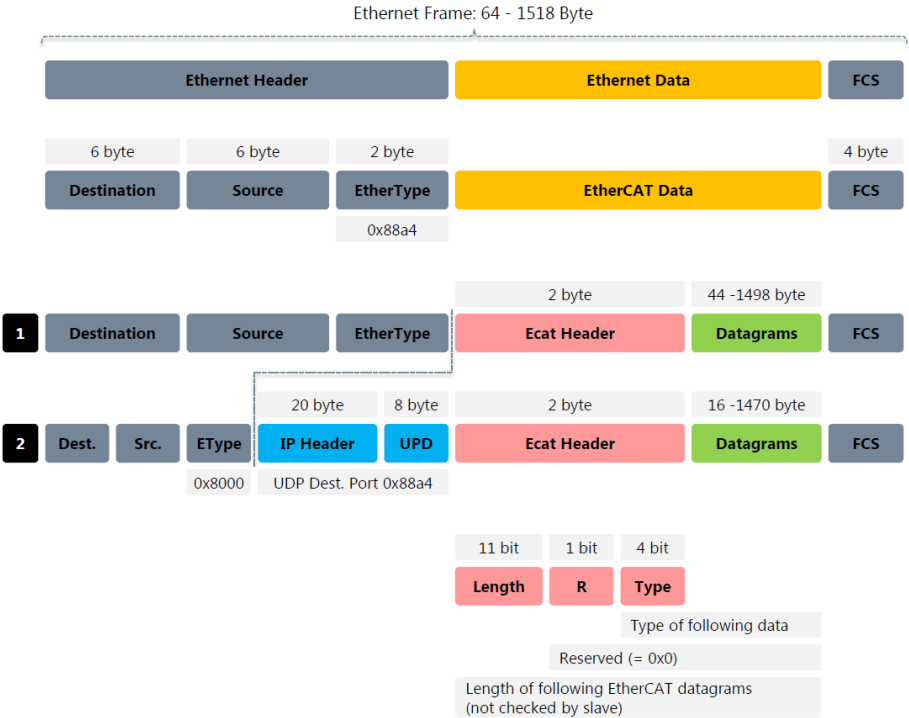
The yellow LED of the corresponding port now flashes quickly cyclically. The green RUN LED is constantly on.

### 5.3 Protocol Features

### 5.3.1 Data Transmission

EtherCAT transmits data on the basis of a standard IEEE 802.3 Ethernet frame. The specific IEEE EtherType is: 88A4h. Alternatively, it is also possible to use UDP.

The structure of the EtherCAT frame is shown in the following figure.



## 5.4 CANopen Object Dictionary

EtherCAT can provide the same communication mechanisms as the ones known from CANopen: Object dictionary, PDO (process data objects) and SDO (service data objects). Even the network management is comparable. So EtherCAT can be implemented with minimum work on devices equipped until now with CANopen. Large sections of the CANopen firmware can be re-used. Objects can be optionally extended to take into account the larger bandwidth of EtherCAT.

The object dictionary describes the whole range of functions (parameters) of a CANopen device and is organized in the form of a table. The object dictionary not only contains the standardized data types and objects of the CANopen communication profile and the device profiles, but also, if applicable, manufacturer-specific objects and data types.

The description of the object directory entries is structured as follows:

Index (hex)	Sub index (hex)	Object	Name	Type	Attr.	M/O
-------------	-----------------	--------	------	------	-------	-----

### Index

16-bit address of the entry

### Sub index

8-bit pointer to a subentry

- Is only used with complex data structures (e. g. record, array).
- If there is no subentry: Sub index=0.

**Object**

- NULL entry without data
- DOMAIN larger variable volume of data, e. g. program code
- DEFTYPE data types definition, e. g. boolean, float, unsigned16
- DEFSTRUCT definition of a record entry, e. g. PDO mapping structure
- VAR single data value, e. g. boolean, float, unsigned16, string
- ARRAY field with similar data, e. g. unsigned16 data
- RECORD field with arbitrarily mixed data types

**Name**

Short description of the function

**Type**

Data type, e. g. boolean, float, unsigned16, integer

**Attribute**

Specifies the access rights for the object:

- rw read and write access
- ro only read access
- const only read access, value = constant

**M/O**

- M Mandatory: The object must be implemented in the device.
- O Optional: The object must not be implemented in the device.

## 5.5 Description of the Objects

### 5.5.1 Communication Objects

Index	Object symbol	Attribute	Name	M/O	Type
1000h	VAR	CONST	Device Type	M	Unsigned32
1001h	VAR	RO	Error Register	M	Unsigned8
1008h	VAR	CONST	Manufacturer Device Name	O	Visible string
1009h	VAR	CONST	Manufacturer Hardware Version	O	Visible string
100Ah	VAR	CONST	Manufacturer Software Version	O	Visible string
1010h	ARRAY	RW	Store parameters (Device Profile)	O	Unsigned32
1011h	VAR	RW	Restore parameters (Device Profile)	O	Unsigned32
1018h	RECORD	RO	Identity Object	M	PDOComPar
1029h	ARRAY	RW	Error Behavior	O	Unsigned8
1100h	VAR	RO	EtherCAT Address	M	
1A00h	ARRAY	RW	TxPDO 1 Normal PDO mapping	C	Unsigned64
1C00h	RECORD	RO	Sync manager type	M	Sync_Par
1C12h		RW	RxPDO assign	M	
1C13h		RW	TxPDO assign	M	
1C33h		RO	SM input parameter	M	

### 5.5.2 Manufacturer-Specific Objects

Index	Attribute	Name
2000h	RO	System time at position reading
2004h	RO	Raw position value
2120h	RO	Temperature value [°C]
2121h	RW	Temperature lower limit [°C]
2122h	RW	Temperature upper limit [°C]
2123h	RW	Temperature offset correction value

### 5.5.3 Device-Specific Objects

Index	Object symbol	Attribute	Name	M/O	Type
6000h	VAR	RW	Operating parameters	M	unsigned16
6001h	VAR	RW	Measuring Units per Revolution (MUR)	M	unsigned32
6002h	VAR	RW	Total Measuring Range (TMR)	M	unsigned32
6003h	VAR	RW	Preset value	M	unsigned32
6004h	VAR	RO	Position value	M	unsigned32
6030h	Array	RO	Speed Value	M	unsigned16
6031h	RECORD	RO	Speed gating time in ms	M	unsigned16
6400h	ARRAY	RO	Area state register	O	unsigned8
6401h	ARRAY	RW	Working Area Low Limit	O	unsigned32
6402h	ARRAY	RW	Working Area High Limit	O	unsigned32
6501h	VAR	RO	Singleturn resolution	M	unsigned32
6502h	VAR	RO	Number of distinguishable revolutions	M	unsigned16
6503h	VAR	RO	Alarms	M	unsigned16
6504h	VAR	RO	Supported alarms	M	unsigned16
6505h	VAR	RO	Warnings	M	unsigned16
6506h	VAR	RO	Supported warnings	M	unsigned16
6507h	VAR	RO	Profile and SW version	M	unsigned32
6509h	VAR	RO	Offset value (calculated)	M	unsigned32
650Bh	VAR	RO	Serial Number	M	unsigned32

### 5.5.4 Objects not mentioned

All objects not mentioned are used for additional information and can be found in the respective CANopen profile.

### 5.5.5 Object 1000h - Device type

Display for the Sendix-series of encoders.

- 0x00010196 for singleturn encoders
- 0x00020196 for multiturn encoders

### 5.5.6 Object 1001h - Error register

<b>NOTICE</b>	<b>Temperature error</b>
	<p>From the time point of view, reading the temperature is an operation that should not be neglected. Therefore, in DC mode, the temperature is only read out continuously from the ASIC when it is part of the process data. In other words, when object 0x2120 is mapped. If DC mode is activated, but object 0x2120 is not mapped, object 0x2120 will show the correct temperature value immediately after switching on, but this value will not be updated in the Operational status. In this case, no possibly occurred temperature error will be displayed in object 1001.</p> <p>In the case of FreeRun mode, the temperature is always updated with every bus cycle.</p>

Object 1001h is the error register of the encoder. If an error occurs, it will be displayed, in the event of temperature overshoot or undershoot, directly by this register in bit 3. In this case, bit 0 (generic error) is always set too. The total error code is thus, in the event of inadmissible temperature overshoot / undershoot, 0x09.

In addition, an EMERGENCY message is issued with code 0x4200.

In case of a position error or a "Commissioning diagnostic" error, first bit 0 "generic error" and bit 5 "device profile specific error" are set in this register. Whether position errors or "Commissioning diagnostic" errors have occurred can be found in object 0x6503. Refer to the description of object 0x6503.

### 5.5.7 Object 1008h - Device name

Displays the device name. In the case of an encoder, the value "Kuebler Sendix Encoder" is displayed.

### 5.5.8 Object 1009h - Hardware version

Returns the hardware version.

### 5.5.9 Object 100Ah - Software version

Represents the constant value "Va.b.", with a and b representing respectively the numerical values of the major and minor firmware version.

### 5.5.10 Object 1010h – Store parameters

Command "save" under subindex 1h (save all parameters) saves the parameters in the non-volatile memory (EEPROM).

All communication objects, application objects and manufacturer-specific objects are saved under this subitem. This operation requires about 14 ms.

In order to prevent accidental saving, the command is only carried out when the code word string SAVE is entered in this subindex.

A read access to subindex 1h provides information about the memory functionality

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
<b>Request</b>	23	10	10	01	73	61	76	65
<b>Response</b>	60	10	10	01	00	00	00	00

Byte 4: 0x73 (ASCII code for S)

Byte 5: 0x61 (ASCII code for A)

Byte 6: 0x76 (ASCII code for V)

Byte 7: 0x65 (ASCII code for E)

### 5.5.11 Object 1011h - Load factory settings

The default values can be restored with a specific command. In order to prevent accidental loading of the standard values, the command is only carried out when the code word string LOAD is entered in this subindex.

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
<b>Request</b>	23	11	10	01	6C	6F	61	64
<b>Response</b>	60	11	10	01	00	00	00	00

Byte 4: 0x6C (ASCII code for L)

Byte 5: 0x6F (ASCII code for O)

Byte 6: 0x61 (ASCII code for A)

Byte 7: 0x64 (ASCII code for D)

### 5.5.12 Object 1018h - Identity object

The identity object contains information about the manufacturer and the device:

Sub Index	Designation	Contents
0h	Supported Subindices	4
1h	Vendor ID	Vendor-ID (000000013h)
2h	Product Code	z. B. 0x58682001 CANopen Sensor
3h	Revision Number	Software revision number (e. g. 102) Subindex 4h: "read" only
4h	Serial Number	8-digit serial number of the device

### 5.5.13 Object 1029h - Error Behavior

In case of a serious error, the device should switch automatically to Pre-Operational mode. This object allows setting how the device has to behave in case of an error.

The following error classes are covered:

#### 1029h, Subindex 1 Communication error

- Bus off status of the CAN interface

### 1029h, Subindex 2 Device Profile Specific

- Sensor error and controller error
- Temperature error

### 1029h, Subindex 3 Manufacturer Specific

- internal error

Byte 0

 $2^7 \dots 2^0$ 

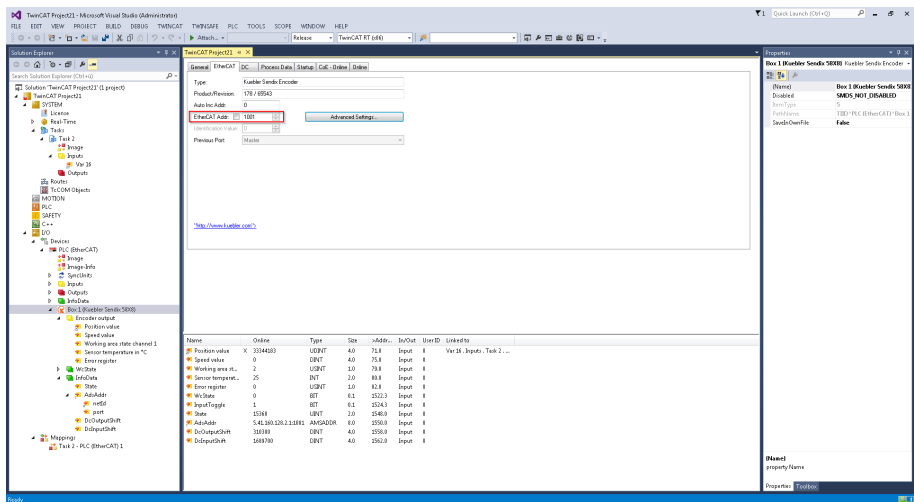
The value of the object classes is set up as follows:

Value range 8 bits

- 0 Pre-Operational mode (only if the Operational mode was active previously)
- 1 no mode change
- 2 Stopped mode
- 3 ... 127 reserved

#### 5.5.14 Object 1100h - EtherCAT address

Object 1100 returns the EtherCAT address of the encoder. In the specific case of TwinCAT, this is the address set in the dialog below.



### 5.5.15 Object 1C00h - Sync manager type

Object 1C00h returns the assignment of the type to the respective sync manager. The assignment of the sync manager to the type is selected as follows:

Sync-Manager 0: 1 Mailbox receive (master to slave)

Sync-Manager 1: 2 Mailbox send (slave to master)

Sync-Manager 2: 0 Deactivated, as the encoder has no output process data

Sync-Manager 3: 4 Input process data (slave to master)

### 5.5.16 Object 1A00h - TxPDO1 mapping

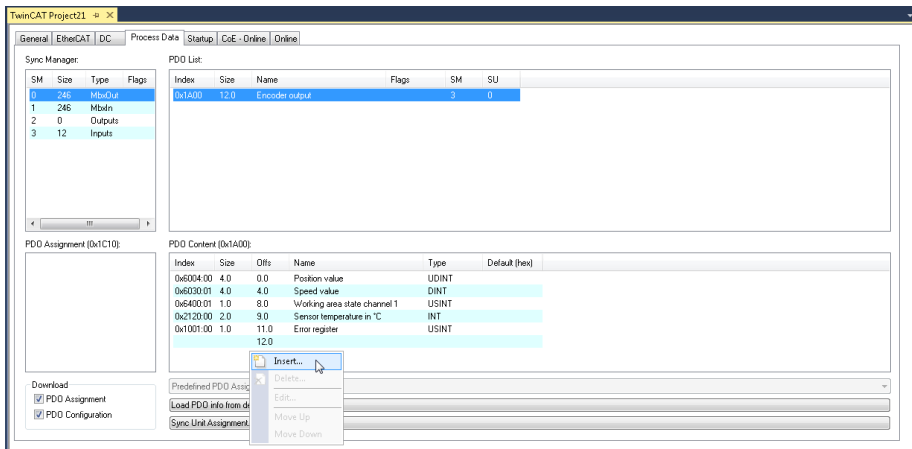
The mapping object for PDO 1 is defined in the object dictionary index 1A00h. It consists of one entry and it can be modified by the user (variable mapping).

This object allows selecting the data to be transmitted as process data at runtime. These can for example be entered in register "Process data" of the TwinCAT manager as shown in figure 44.

Click with the right mouse key on the last entry of the list and select menu item <Insert>.

The dialog for selecting individual objects opens.

The objects can be placed in any order.



#### NOTICE

#### DC cycle time

For DC mode, comply with annex "DC cycle times". The DC cycle time to be set increases with every additional process data byte.

Irrespective of whether the encoder is operated in DC or in FreeRun mode, a maximum of seven objects can be inserted for mapping.

**Edit Pdo Entry**

Name:

Index (hex):

Sub Index:

Data Type:

Bit Length:

OK Cancel

From Dictionary:

- 0x1001 - Error register
- 0x2000 - System time at position reading
- 0x2004 - Raw position value
- 0x2120 - Sensor temperature value [°C]
- 0x6004 - Position value
- 0x6030:01 - Speed value
- 0x6400:01 - Work area state channel 1
- 0x6400:02 - Work area state channel 2
- 0x6505 - Warnings

### 5.5.17 Object 1C12h - RxPDO assignment

Since the encoder has no output process data, there is no assignment to an RxPDO object.

### 5.5.18 Object 1C13h - TxPDO assignment

The assignment of the encoder process data takes place through object 0x1A00.

### 5.5.19 Object 1C33h - SM 3 input parameter

Object 1C33h has only read-only subindexes.

The data is purely for information purposes.

- In DC mode, the type of synchronization can be read in subindex 1, e. g. 2 means "DC SYNC0 synchronized with AL event".
- The cycle time can be checked through subindex 2.
- Subindex 5 allows (in addition) reading the minimum cycle time.

### 5.5.20 Object 2000h - System time at position reading

This object represents the system time at the moment when the position is generated in the encoder.

### 5.5.21 Object 2004h - Raw position value

This object allows evaluating the raw data position. The raw data depends only on the physical resolution of the encoder and is independent of the scaling operations.

### 5.5.22 Object 2120h - Sensor temperature value

The encoder includes an ASIC made of a temperature sensor. It allows displaying the internal temperature of the encoder sensor. Object 0x2120 displays the temperature in °C.

### 5.5.23 Object 2121h - Temperature lower limit

The encoder includes an ASIC made of a temperature sensor. It allows displaying the internal temperature of the encoder sensor.

This object allows setting the lower temperature limit, below which an alarm is triggered, which is notified through object 1001h (error register) and a corresponding emergency message.

The value is given in °C. The value entered here can range from -45°C ... +90°C.

<b>NOTICE</b>	<b>Bus cycle time interruption</b>
	This value is set with the ASIC interface that also allows reading the position. Therefore, in DC mode, bus cycle time is interrupted for 250 ms. Therefore, this value should ideally be set in PreOperational mode.

### 5.5.24 Object 2122h - Temperature upper limit

The encoder includes an ASIC made of a temperature sensor. It allows displaying the internal temperature of the encoder sensor. This object allows setting the upper temperature limit, above which an alarm is triggered, which is notified through object 1001h (error register) and a corresponding emergency message. The value entered here can range from -45°C ... +90°C.

<b>NOTICE</b>	<b>Bus cycle time interruption</b>
	This value is set with the ASIC interface that also allows reading the position. Therefore, in DC mode, bus cycle time is interrupted for 250 ms. Therefore, this value should ideally be set in PreOperational mode.

### 5.5.25 Object 2123h - Temperature offset correction value

This object allows adjusting the temperature sensor so that the value 64 (decimal) is displayed through object 2120h for 0°C.

<b>NOTICE</b>	<b>Bus cycle time interruption</b>
	This value is set with the ASIC interface that also allows reading the position. Therefore, in DC mode, bus cycle time is interrupted for 250 ms. Therefore, this value should ideally be set in PreOperational mode.

### 5.5.26 Object 6000h - Operating parameters

<b>NOTICE</b>	<b>Bus cycle time interruption</b>
	This value is set with the ASIC interface that also allows reading the position. Therefore, in DC mode, bus cycle time is interrupted for 250 ms.

#### Code sequence

0 = increasing for clockwise rotation (cw)

1 = increasing for counter-clockwise rotation (ccw)

#### Commissioning diagnostic control

0 = disabled

1 = enabled

#### Scaling

0 = disabled

1 = enabled (consider object 6001, 6002)

#### Speed Format

Bit = 0	Bit = 1	Speed unit
0	0	Rounds per minute (default)
0	1	Steps per 10 ms
1	0	Steps per 100 ms
1	1	Steps per second

#### Non binary ratio

0 = Binary Ratio of TMR to MUR

1 = Non Binary Ratio of TMR to MUR

Bit	Function	Bit = 0	Bit = 1
0	Code sequence	CW	CCW
1	Commissioning Diagnostic Control	Disabled	Enabled
2	Switch scaling on	Disabled	Enabled
3 ... 12	Reserved		
13	Speed Unit	see above	see above
14	Speed Unit	see above	see above
15	NBR	Binary	Non-binary

### 5.5.27 Object 6001h - Measuring units per revolution (MUR)

This parameter sets the desired resolution per revolution. The encoder calculates internally the corresponding scaling factor. The calculated scaling factor MURF (by which the physical position value is multiplied) is calculated according to the following formula:

$MURF = \text{Measuring steps per revolution (6001h)} / \text{phys. resolution singleturn (6501h)}$

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Values range: 1....maximum physical resolution (16384) 214 bits

Only valid if scaling (6000h bit2) is activated.

### 5.5.28 Object 6002h - Total number of measuring units (TMR)

This parameter sets the total number of measuring steps for singleturn and multiturn. The maximum physical resolution is multiplied by a factor. The factor is always  $< 1$ .

After the scaled total position of the measuring steps, the encoder resets back to zero.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Values range: 1....maximum physical resolution (4294967296)  $2^{32}$  bits

When changing TMR/MUR, the system also checks the TMR/MUR ratio.

If TMR is set to a value that leads to a wrong ratio, an error message is returned and the new value is rejected. The old value remains active in the encoder. Only valid if scaling (6000h bit2) is activated.

### 5.5.29 Object 6003h - Preset value

The position value of the encoder is set to the preset value input. This allows e.g. aligning the zero position of the encoder with the zero position of the machine.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Values range: 0.... maximum physical resolution (4294967295)  $(2^{32})^{-1}$  bits

When inputting the preset value, the system checks automatically whether the point lies within the active scaling or within the total measuring range. Otherwise it rejects the input.

### 5.5.30 Object 6004h - Position value unscaled or scaled

The encoder returns the current position value (possibly multiplied by the scaling factor).

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Values range: 0....maximum physical resolution (4294967296) (32) bits

The TMR/MUR ratio is active when scaling is active, otherwise the 32-bit raw position of the encoder is output.

Output of the current position =  $((GP\_U / STA\_U) * MUR) \% TMR$  (modulo division)

### 5.5.31 Object 6030h - Speed value

The encoder returns the current calculated speed (possibly with scaling factor) as a signed 32-bit value. Speed depends on the settings of object 6031h. These values influence the calculation and the result.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Values range: 0 ... +/- maximum speed 15000 RPM (signed value)

In case of values > 12000 RPM, a warning message is emitted and the warning bit "Overspeed bit 0" is set in object Warnings 6505h. Parameters that also influence this object are mentioned in object 6031h.

### 5.5.32 Object 6031h - Speed gating time

According to reference [1], this object defines the time interval to be used for speed calculation.

#### Subindex 0

Defines the maximum supported subindex, which always has the value three in this case.

#### Subindex 1 (Time value T)

Defines the base time for the gating time. The actual gating time value results from the combination of subindexes 1, 2 and 3.

**Subindex 2 (Multiplier value M)**

The value of subindex 1 is multiplied by the value of this subindex.

**Subindex 3 (Divider value D)**

The value of subindex 1 is divided by the value of this subindex.

Therefore, gating time G results from:  $G = T * M / D$

<b>NOTICE</b>	<b>Maximum gating time</b>
	<p>The maximum permissible gating time is 2 seconds.</p> <p>If the SDO download value exceeds this value, the encoder reacts with a SDO download abort message: "Value of parameter too high". This takes place regardless of which of the subindexes eventually caused the overshoot.</p>

**5.5.33 Object 6400h - Work area status register**

Subindexes 1 and 2 define two values that allow evaluating the current encoder position with respect to predefined work area values. See also the reference.

Both work areas are set with objects 0x6401 and 0x6402.

**5.5.34 Object 6401h - Work area low limit**

Defines the lower limit value of both areas for the representation by object 6400h.

**5.5.35 Object 6402h - Work area high limit**

Defines the upper limit value of both areas for the representation by object 6400h.

**5.5.36 Object 6501h - Singleturn resolution**

This object provides the singleturn resolution of an encoder. For the encoder, this is generally the value 65536, which corresponds to 16 bits.

**5.5.37 Object 6502h - Number of distinguishable revolutions**

In the case of a multiturn encoder, this is the multiturn resolution.

The encoder has a 12-bit multiturn unit and thus a value of 4096. If there is no multiturn unit, this object has the value 1.

**5.5.38 Object 6503h - Alarms**

This object gives information about the occurrence of the following errors at the encoder.

- Position error: "pe"
- Commissioning diagnostic error: "cde"

Data content:

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

### 5.5.39 Object 6504h - Supported alarms

This object indicates which error cases are signaled externally, thus in object 0x6503. These are position errors and commissioning diagnostics.

### 5.5.40 Object 6505h - Warnings

This object signals the following encoder warnings.

- Light control reserve reached: "lcr"
- Speed range exceeded: "sr"  
This bit is set for 9000 RPM.

Data content:

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

### 5.5.41 Object 6506h - Supported warnings

This object indicates which warnings are signaled externally, thus in object 0x6505. There are two warnings:

- Transmission current outside of the allowable range.
- Speed exceeded outside of the allowable range.

### 5.5.42 Object 6507h - Profile and software version

Like object 0x1A00, the software version is represented in the two upper nibbles. If the software version is V4.5, the value of this object is 0x04050302, the two lower nibbles 0x0302 representing the CANopen profile version, thus 3.2.

### 5.5.43 Object 6509h - Offset value

The offset value is updated at the time of switching on and later every time the preset value (object 0x6003) is activated.

## 6 Maintenance

The device is maintenance-free. In harsh environments, we recommend regular inspections for firm seating and possible damages at the device. Repair work may only be carried out by the manufacturer, see Contact [► 52].

### **Prior to the work**

1. Switch off the power supply and secure it against switching on again.
2. Then disconnect the power supply lines physically.
3. Remove operating and auxiliary materials and remaining processing materials from the encoder.

# 7 Annex

## 7.1 TMT / MUR ratio

The singleturn and multiturn units of the encoder work independently of each other. Depending on the disc resolution or on the interpolator, the bits in charge of the resolution can always be increased or reduced bit by bit only. This also applies to the multiturn gear. This fact has an influence on the MUR and TMR values that can be selected.

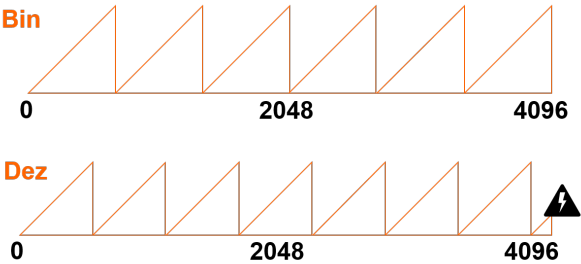
The TMR value must be chosen so that the value itself or its multiple corresponds to the total measuring range and is a binary multiple of MUR.

The total measuring range is defined as the product of the singleturn resolution  $g_{ST}$  (e. g. 65536 corresponding to 16 bits) with the multiturn resolution  $g_{MT}$  (z. B. 4096 corresponding to 12 bits).

If TMR is a binary multiple of MUR, the position value will move as shown in the first figure below, without error at the end of the range, where an overflow from the maximum position to zero takes place.

NOTICE	Check of the binary division ratio
	<p>The check of the binary ratio between TMR and MUR can be enabled and disabled with the bit "nbr" in object 6000. The default value of this bit is zero, which means that the check is carried out. If this value of this bit one, the check is disabled during the SDO download. Any value can then be loaded for MUR and TMR.</p> <p>Before the bit "nbr" is disabled, the values for MUR (object 6001) and TMR (object 6002) should be set so that they fulfill the "binary" criterion. Otherwise, they will automatically be modified to default values.</p>

If TMR is not a binary multiple of MUR, an error will occur at the end of the area, as shown in the second figure.



Therefore, a binary multiple is defined as  $TMR=MUR/2k$  and in a specific case  $TMR=g_{ST}/2k$  with  $k=0, \pm 1, \pm 2, \dots$

If  $k$  is positive, TMR is a binary multiple of MUR.

If  $k = 0$ ,  $TMR = MUR$ .

If  $k$  is negative,  $MUR$  is a multiple of  $TMR$ .

Figuratively speaking: the "saw teeth" in the figures then already exist  $k$  times within one revolution.

The following framework conditions must thus be met for  $MUR$  and  $TMR$ :

- The  $MUR$  value will only be accepted during SDO download if it meets the following criterion:  
 $0 < MUR < g\_ST$
- In addition,  $MUR$  must be a multiple of 2:  
 $MUR = g\_ST/2n$   
 with  $0 < n < \infty$
- The  $TMR$  value of an encoder without multturn unit will only be accepted during SDO download if it meets the following criterion:  
 $0 < TMR < g\_ST$
- $TMR$  must be a multiple of 2:  $TMR = MUR/2k$  and in a specific case  
 $TMR = g\_ST/2k$   
 with  $k = 0, \pm 1, \pm 2, \dots$
- For an encoder with a multturn unit, the following condition must be met for the  $TMR$  value to be accepted during SDO download:  
 $0 < TMR < MUR \cdot g\_MT$ ,  
 in a specific case  $0 < TMR < g\_ST \cdot g\_MT$   
 $TMR$  must be a multiple of 2:  $TMR = MUR \cdot g\_MT/2k$   
 with  $k = 0, \pm 1, \pm 2, \dots$

## 7.2 DC cycle times

Number of transmitted bytes	Contents	Transmission time in $\mu s$
4	Object 0x6004 with scaled position	55 or 107 depending on whether a binary ratio or any ratio applies to $MUR$ and $TMR$ . See description bit $NBR$ in object 0x6000.
5	0x6004 and 0x1001	63
10	0x6004 (scaled position) 0x6505 (warnings) 0x2000 (system time)	76 or 128 depending on whether a binary ratio or any ratio applies to $MUR$ and $TMR$ . See description bit $NBR$ in object 0x6000.

## 7.3 Supported network controllers

Intel Fast Ethernet Controllers (Vendor ID: 0x8086)

Device ID	Description	Device ID	Description	Device ID	Description
0x1029	82559	0x103E	82801DB	0x1068	82562
0x1030	82559	0x1050	82801EB/ER	0x1069	Intel PRO/100
0x1031	82801CAM	0x1051	82801EB/ER	0x106A	Intel PRO/100
0x1032	82801CAM	0x1052	82801EB/ER	0x106B	Intel PRO/100

0x1033	82801CAM	0x1053	82801EB/ER	0x1094	Intel PRO/100
0x1034	82801CAM	0x1054	82801EB/ER	0x1209	8255xER/IT
0x1038	82801CAM	0x1055	82801EB/ER	0x1229	82557/8/9/0/1
0x1039	82801CAM	0x1056	82801EB/ER	0x1249	82559ER
0x103A	82801DB	0x1057	82801EB/ER	0x1259	82801E
0x103B	82801DB	0x1059	82551QM	0x245D	82801E
0x103C	82801DB	0x1064	82801EB/ER	0x27DC	Intel PRO/100
0x103D	82801DB	0x1067	Intel PRO/100		

Intel Gigabit Ethernet Controllers (Vendor ID: 0x8086)

Device ID	Description	Device ID	Description	Device ID	Description
0x1000	82542	0x1028	82545GM	0x1098	80003ES2LAN
0x1001	82543GC	0x1049	82566MM	0x1099	82546GB
0x1004	82543GC	0x104A	82566DM	0x109A	82573L
0x1008	82544EI	0x104B	82566DC	0x10A4	82571EB
0x1009	82544EI	0x104C	82562V	0x10A7	82575
0x100C	82544EI	0x104D	82566MC	0x10A9	82575
0x100D	82544GC	0x104E	82571EB	0x10B5	82546GB
0x100E	82540EM	0x104F	82571EB	0x10B9	82572EI
0x100F	82545EM	0x1060	82571EB	0x10BA	80003ES2LAN
0x1010	82546EB	0x1075	82547EI	0x10BB	80003ES2LAN
0x1011	82545EM	0x1076	82541GI	0x10BC	82571EB
0x1012	82546EB	0x1077	82547EI	0x10C4	82562GT
0x1013	82541EI	0x1078	82541ER	0x10C5	82562G
0x1014	82541ER	0x1079	82546EB	0x10C9	82576
0x1015	82540EM	0x107A	82546EB	0x10D3	82574L
0x1016	82540EP	0x107B	82546EB		
0x1017	82540EP	0x107C	82541GI		
0x1018	82541EI	0x107D	82572EI		
0x1019	82547EI	0x107E	82572EI		
0x101A	82547EI	0x107F	82572EI		
0x101D	82546EB	0x108A	82546GB		
0x101E	82540EP	0x108B	82573E		
0x1026	82545GM	0x108C	82573E		
0x1027	82545GM	0x1096	80003ES2LAN		

## 7.4 Decimal / Hexadecimal conversion table

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	0	51	33	102	66	153	99	204	CC
1	1	52	34	103	67	154	9A	205	CD
2	2	53	35	104	68	155	9B	206	CE
3	3	54	36	105	69	156	9C	207	CF
4	4	55	37	106	6A	157	9D	208	D0
5	5	56	38	107	6B	158	9E	209	D1
6	6	57	39	108	6C	159	9F	210	D2
7	7	58	3A	109	6D	160	A0	211	D3
8	8	59	3B	110	6E	161	A1	212	D4
9	9	60	3C	111	6F	162	A2	213	D5
10	0A	61	3D	112	70	163	A3	214	D6
11	0B	62	3E	113	71	164	A4	215	D7
12	0C	63	3F	114	72	165	A5	216	D8
13	0D	64	40	115	73	166	A6	217	D9
14	0E	65	41	116	74	167	A7	218	DA
15	0F	66	42	117	75	168	A8	219	DB
16	10	67	43	118	76	169	A9	220	DC
17	11	68	44	119	77	170	AA	221	DD
18	12	69	45	120	78	171	AB	222	DE
19	13	70	46	121	79	172	AC	223	DF
20	14	71	47	122	7A	173	AD	224	E0
21	15	72	48	123	7B	174	AE	225	E1
22	16	73	49	124	7C	175	AF	226	E2
23	17	74	4A	125	7D	176	B0	227	E3
24	18	75	4B	126	7E	177	B1	228	E4
25	19	76	4C	127	7F	178	B2	229	E5
26	1A	77	4D	128	80	179	B3	230	E6
27	1B	78	4E	129	81	180	B4	231	E7
28	1C	79	4F	130	82	181	B5	232	E8
29	1D	80	50	131	83	182	B6	233	E9
30	1E	81	51	132	84	183	B7	234	EA

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
31	1F	82	52	133	85	184	B8	235	EB
32	20	83	53	134	86	185	B9	236	EC
33	21	84	54	135	87	186	BA	237	ED
34	22	85	55	136	88	187	BB	238	EE
35	23	86	56	137	89	188	BC	239	EF
36	24	87	57	138	8A	189	BD	240	F0
37	25	88	58	139	8B	190	BE	241	F1
38	26	89	59	140	8C	191	BF	242	F2
39	27	90	5A	141	8D	192	C0	243	F3
40	28	91	5B	142	8E	193	C1	244	F4
41	29	92	5C	143	8F	194	C2	245	F5
42	2A	93	5D	144	90	195	C3	246	F6
43	2B	94	5E	145	91	196	C4	247	F7
44	2C	95	5F	146	92	197	C5	248	F8
45	2D	96	60	147	93	198	C6	249	F9
46	2E	97	61	148	94	199	C7	250	FA
47	2F	98	62	149	95	200	C8	251	FB
48	30	99	63	150	96	201	C9	252	FC
49	31	100	64	151	97	202	CA	253	FD
50	32	101	65	152	98	203	CB	254	FE
								255	FF



# Glossary

**CCW**

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counterclockwise, counting direction

**CW**

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clockwise, counting direction

**ERR**

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Error

**ETG brochure**

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ETG brochure 02.2018

**HEX**

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Hexadecimal

**LSB**

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Least Significant Bit

**MSB**

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Most Significant Bit

**MUR**

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Measuring Units per Revolution

**rpm**

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Rounds per Minute

**TwinCAT**

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TwinCAT (The Windows Control and Automation Technology) - Windows Automation suite for the real-time control of EtherCAT devices

