R67058.0002 - 3


# Manual

Encoders with EtherCAT interface

EtherCAT.
Conformance tested

# Table of Contents

# 1 Document

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

**Legal notices**

# 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:**<br>This symbol, together with the signal word **DANGER**, warns against immediately imminent threat to life and health of persons.<br>The non-compliance with this safety instruction will lead to death or severe adverse health effects. |
| ⚠ WARNING | **Classification:**<br>This symbol, together with the signal word **WARNING**, warns against a potential danger to life and health of persons.<br>The non-compliance with this safety instruction may lead to death or severe adverse health effects. |
| ⚠ CAUTION | **Classification:**<br>This symbol, together with the signal word **CAUTION**, warns against a potential danger for the health of persons.<br>The non-compliance with this safety instruction may lead to slight or minor adverse health effects. |
| ***ATTENTION*** | **Classification:**<br>The non-compliance with the **ATTENTION** note may lead to material damage. |
| ***NOTICE*** | **Classification:**<br>Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation. |

# 3 Product Description

## 3.1 Technical Data

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

| | |
|---|---|
| ***ATTENTION*** | **Destruction of the device**<br><br>Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again. |
| ***NOTICE*** | **General safety instructions**<br><br>Make sure that the whole plant remains switched off during the electrical installation.<br><br>• Make sure that the operating voltage is switched on or off simultaneously for the device and the downstream device. |
| ***NOTICE*** | **Traction relief**<br><br>Always mount all cables with traction relief. |
| ***ATTENTION*** | **Wear of the memory module**<br><br>Avoid too frequent writing of the EEPROM. It is used e.g. when setting a preset value. The memory module is designed for approximately 500,000 write cycles. If the maximum number of write cycles is exceeded, single memory areas may be damaged and errors may occur. |

### 4.1.2 Information for EMC-Compliant Installation

**Requirements for cables**

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

| | | |
|---|---|---|
| EMC acc. to EN 61326-1 | Criterion A<br>The device operates trouble-free, user data transmission proceeds without disturbance, internally stored data and configurations remain preserved | Criterion B<br>During a failure, a disturbed transmission of the user data is allowed, internally stored data and configurations remain preserved |
| Interference immunity | Is achieved with a shielded line | Is not achieved with a shielded line |
| | Class A Industrial environment<br>The device has a radiation according to Class A | Class B Living area<br>The device has a radiation according to Class B |
| Radiation | Is not achieved with a shielded line | Is achieved with a shielded line |

**Shielding and equipotential bonding**

- Apply the cable shield on a large contact area - ideally 360°. Use e. g. a shield terminal to this purpose.
- Pay attention to proper cable shield fastening.
- Preferably connect the shield on both sides with low impedance to the protective earth (PE), e.g.on the device and/or on the evaluation unit. 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 be connected to the shield on one side only, it must be made sure 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.


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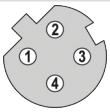
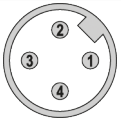
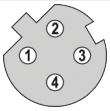
| Interface | Type of connection | Connector | | | | | Pin arrangement |
|---|---|---|---|---|---|---|---|
| | | **3x M12 connector, 4-pole** | | | | | |
| | | | Bus Port IN | | | |  |
| B | 2 | Signal | TxD+ | RxD+ | TxD- | RxD- | |
| | | Pin | 1 | 2 | 3 | 4 | |
| | | | Voltage supply | | | |  |
| | | Signal | + V | - | 0 V | - | |
| | | Pin | 1 | 2 | 3 | 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** |
|---|---|
| | 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 pre-requisite for the proper operation of an EtherCAT device<br>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. |

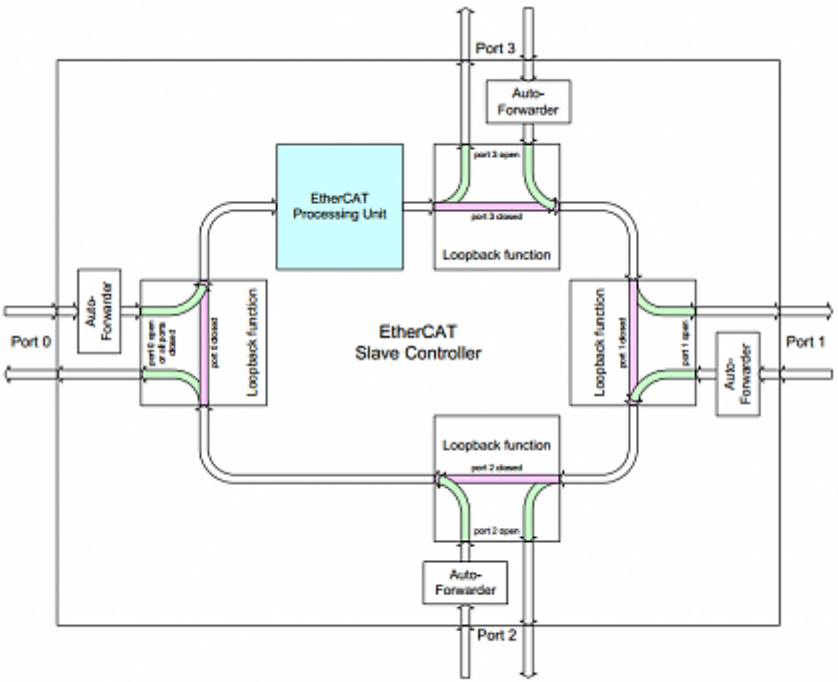



**Figure 5: Frame Processing**

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# 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**

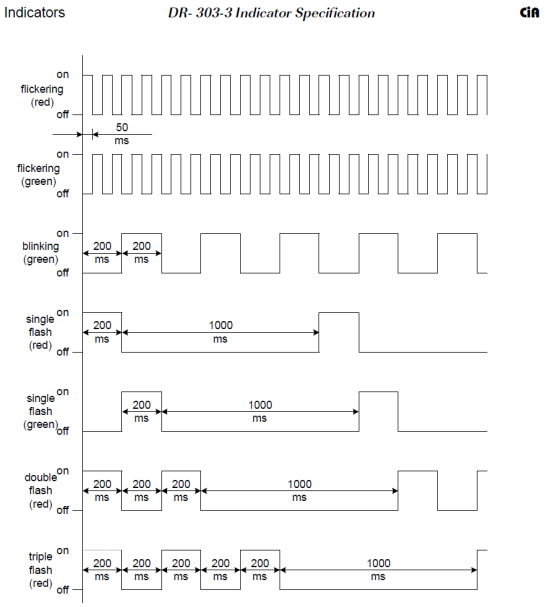
| Display | LED | Meaning |
|---|---|---|
| Init State |  | No communication possible between the master and the drive.<br>LED is off |
| Preoperational |  | In this condition, no process data traffic is possible. LED flashes quickly. |
| Safeoperational |  | The actual drive values are transmitted to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

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# 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

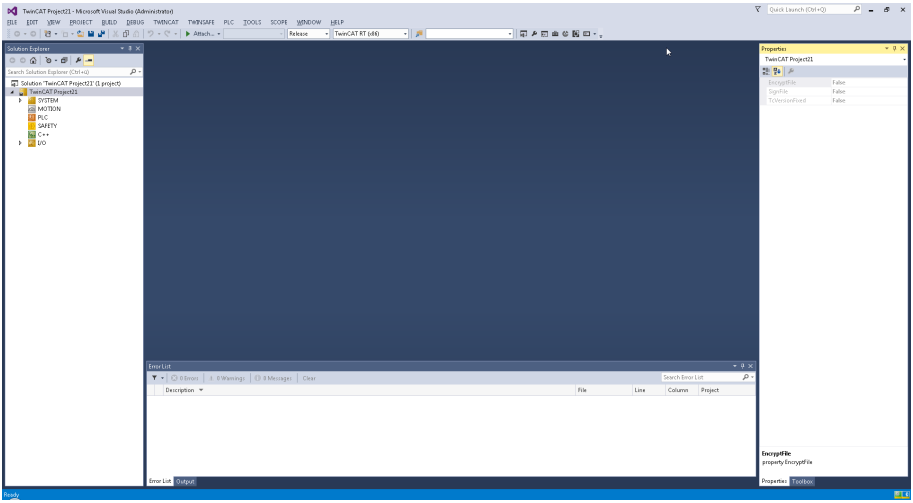
b) Save the XML file in the following path: C:\TwinCAT\3.1\Config\Io\EtherCAT

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:



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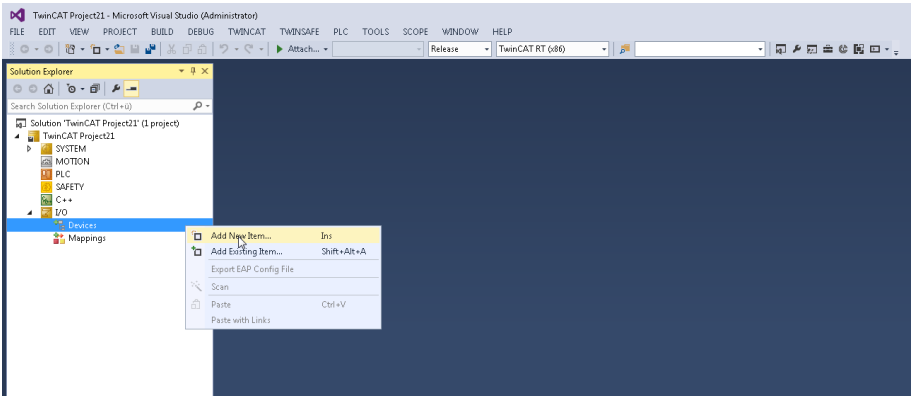
d) Click with the right mouse key on line <Devices> and select <Add New Item...> in the dialog that opens.

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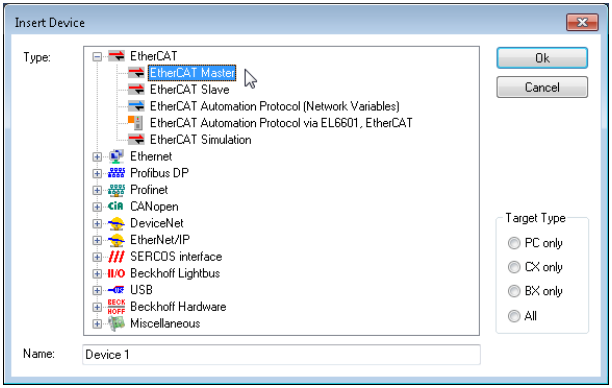
e) In the dialog that opens, select menu <EtherCAT>, sub menu <EtherCAT> and confirm with OK.

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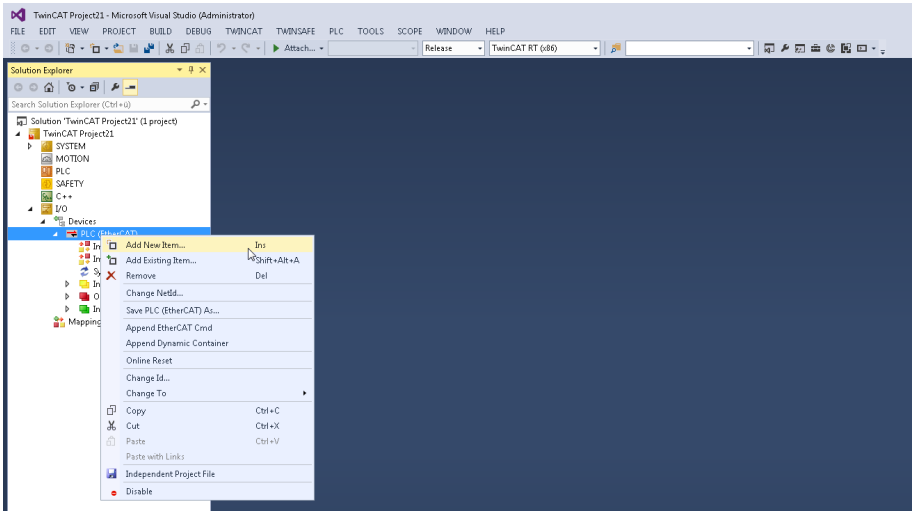
f) Click with the right mouse key on the new displayed menu item >PLC (EtherCAT)> and select sub menu >Add New Item...>.

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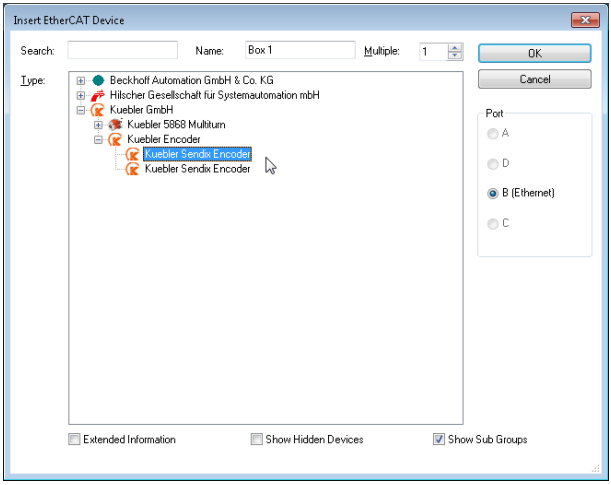
g) In the dialog that opens, select the Kübler Sendix encoder as shown below.

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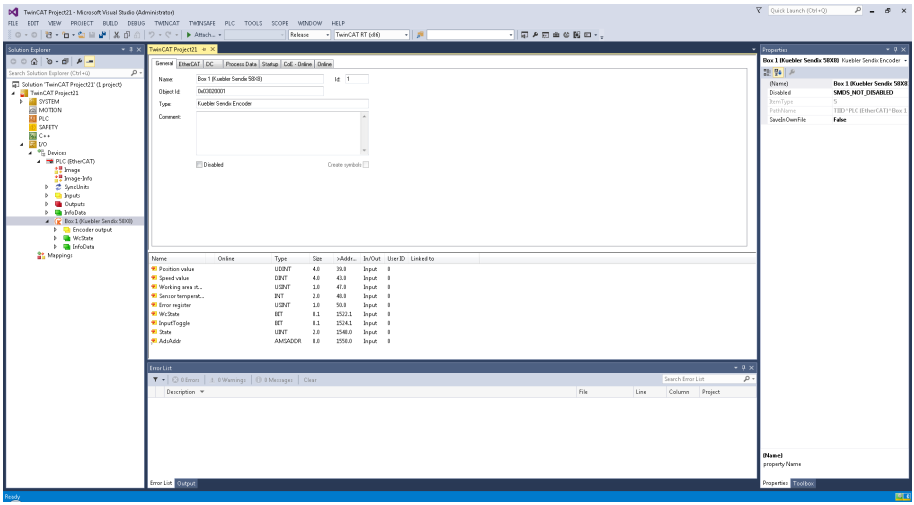
h) Then, the system manager window should appear as shown below:



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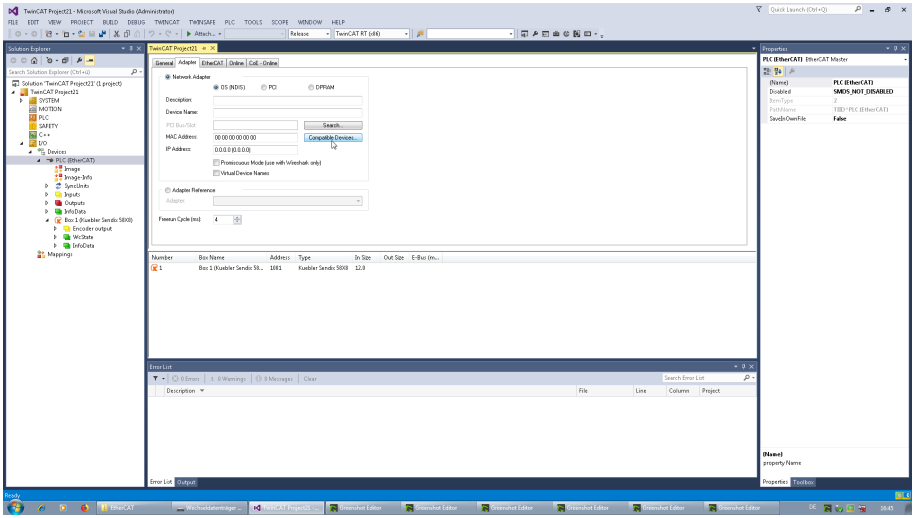
⇨ The EtherCAT master and the encoder are now created.

### 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 <Adapter>.



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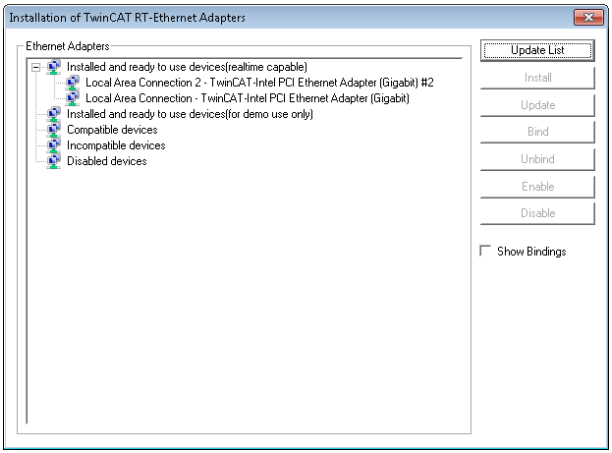
b) Click on button <Compatible devices...>, which opens the following window. The first line displays the installed adapters ready for TwinCAT operation (<Installed and ready to use devices>). No ready to use adapter is available yet in this example.

⇨ 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.

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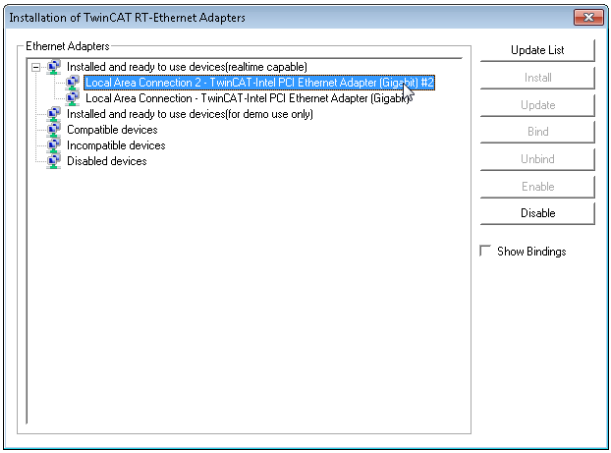
c) Mark at least one adapter from the category of the compatible adapters and click on button <Install>. The adapters are displayed as subitems of the installed and ready to use adapters.

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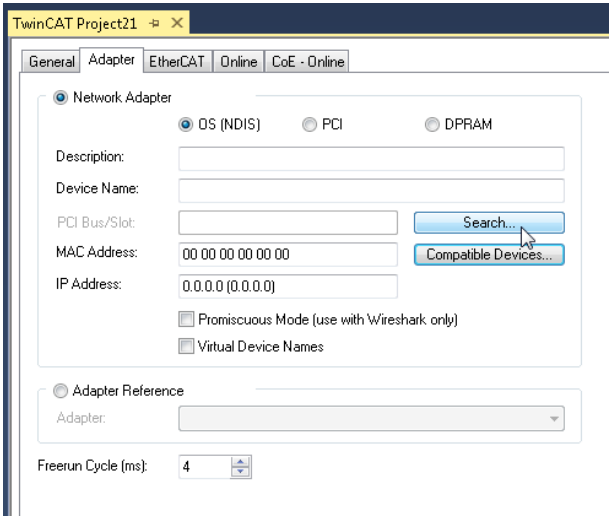
If, due to an update of the TwiCAT software, you already have a deactivated adapter, mark it and click on <Enable>. Also this adapter will then be displayed under the category of the installed and ready to use adapters.

| ***NOTICE*** | **Compatible network cards.**<br><br>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.

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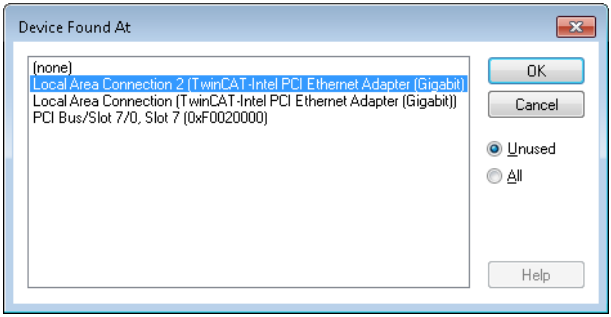


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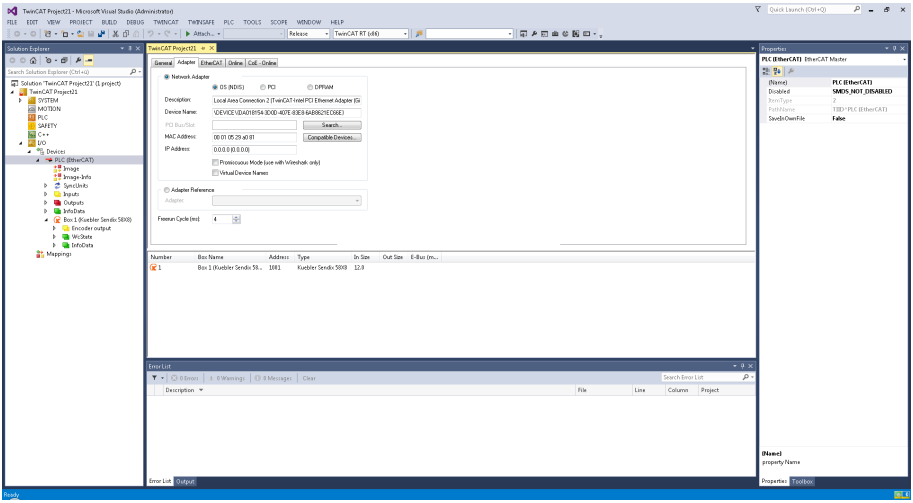
Finally, the <Adapter> tab corresponds to this figure.



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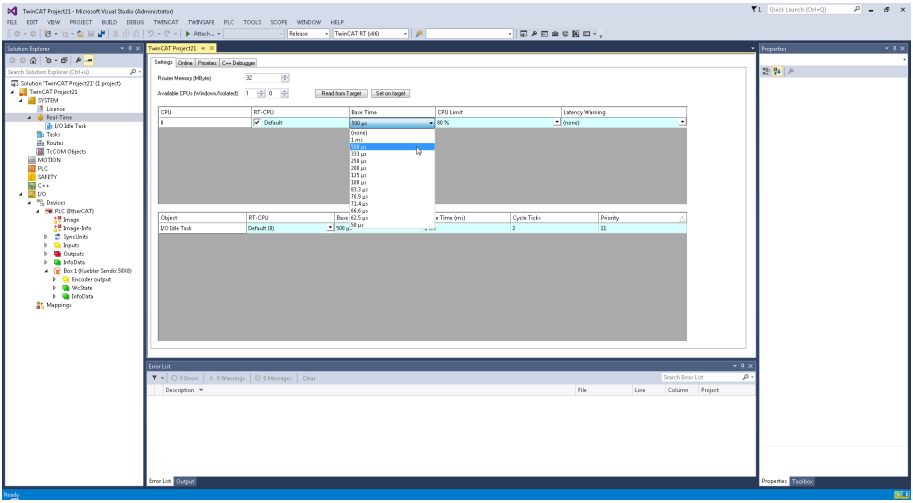
### 5.2.1.3 Configuring the DC Operation Mode

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



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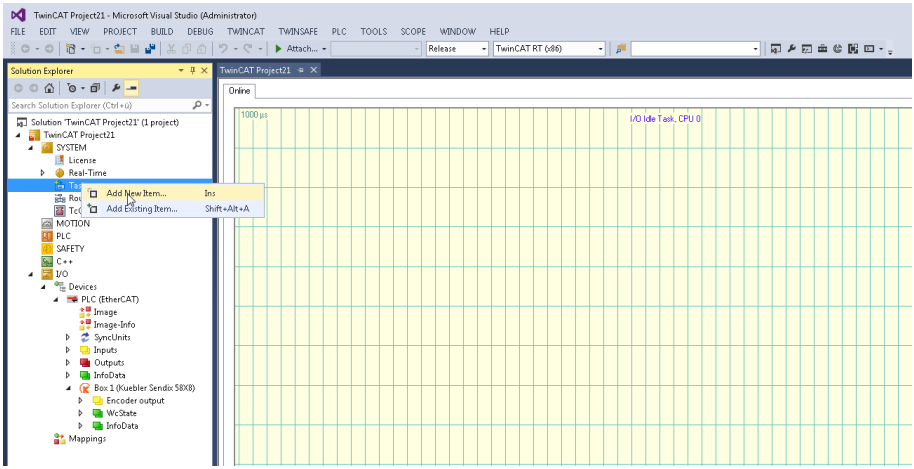
b) As shown in the figure, mark menu <Additional tasks> with the right mouse key and select sub menu item <Insert Task>. Click on OK in the dialog that then opens.

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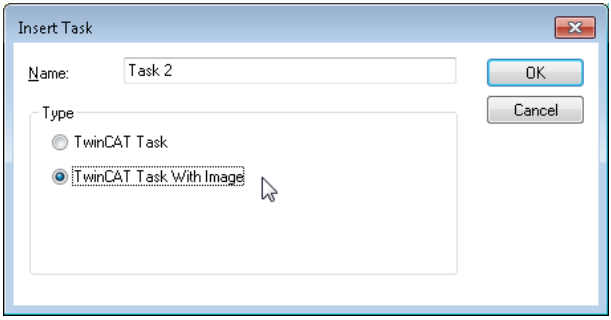
c) In the dialog window of Task 2, select all settings as shown in the figure.

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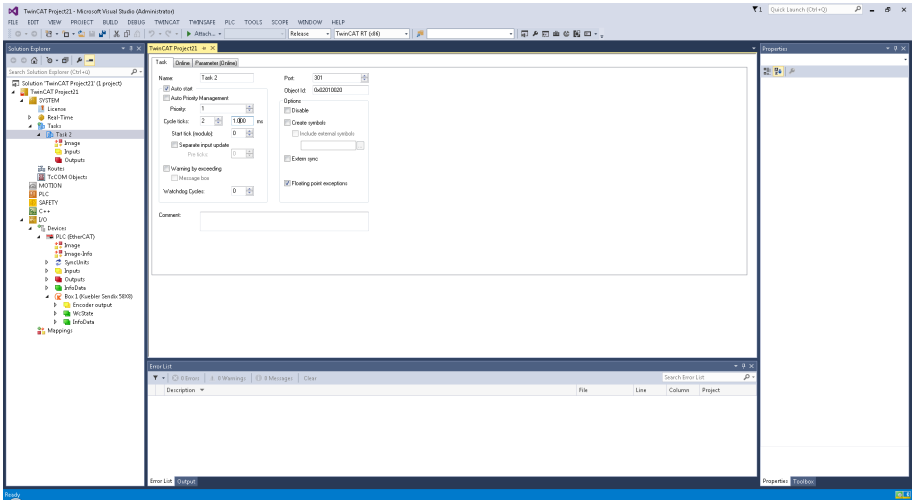
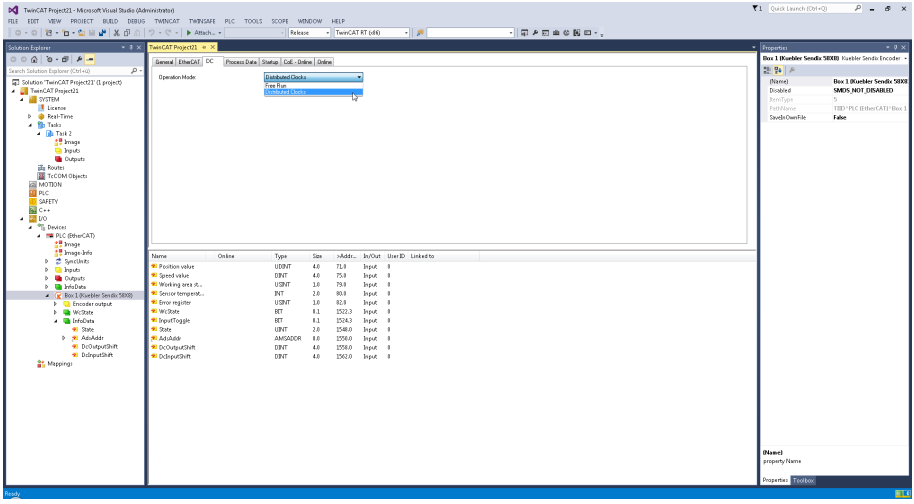


d) Mark menu item <Box 1 (Kübler Sendix 58X8)> and select tab <DC>. Select the operation mode Distributed Clocks:



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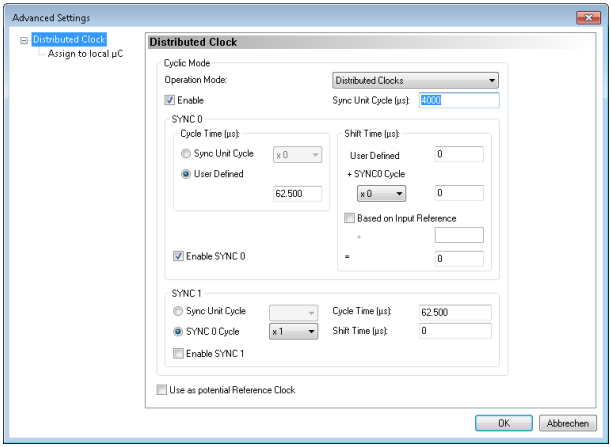
e) Click on button <Advanced settings...> and make sure the settings correspond to the figure. In particular SYNC 0 Cycle Time should be at least 62,500 µs.

| NOTICE | DC cycle time |
|---|---|
| | 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 [▶ 48]. |

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.

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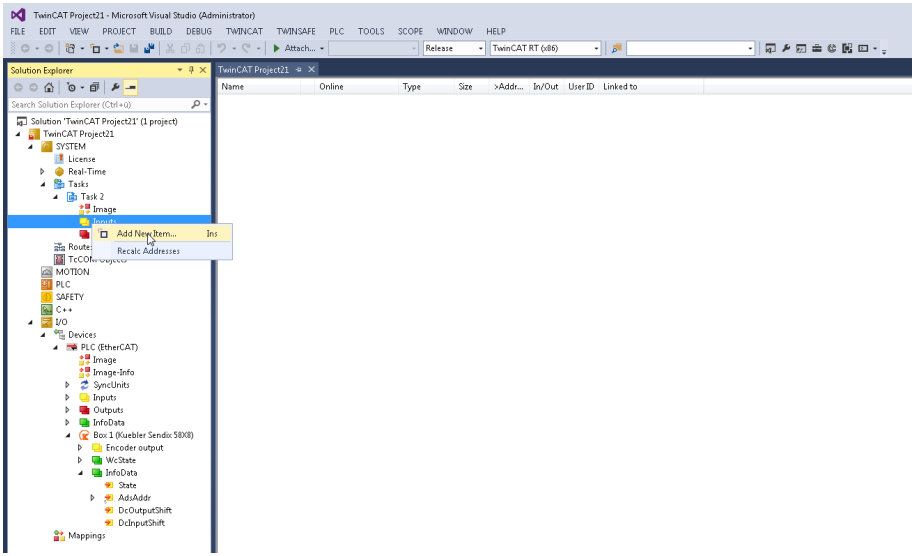
### 5.2.1.4 Process Data Representation

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

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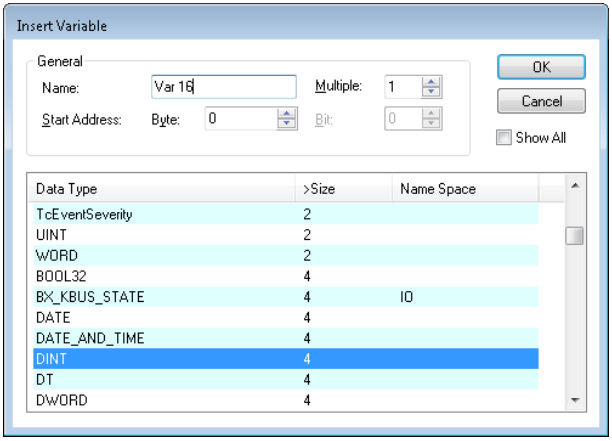
b) In the displayed dialog, see following figure, select a variable of the DINT 4 type. The encoder position value will be represented in this variable. Click on <OK>.

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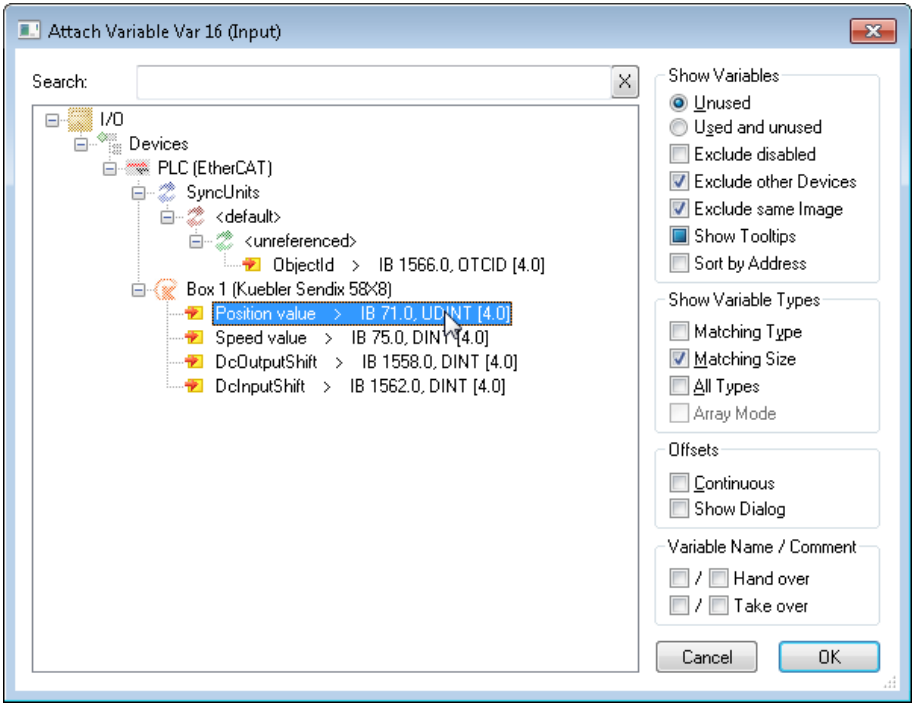
c) Mark variable <Var 34> and click on button <Attach with...>. Select the encoder position value <Position value> and click on button <OK>.

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#### 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.

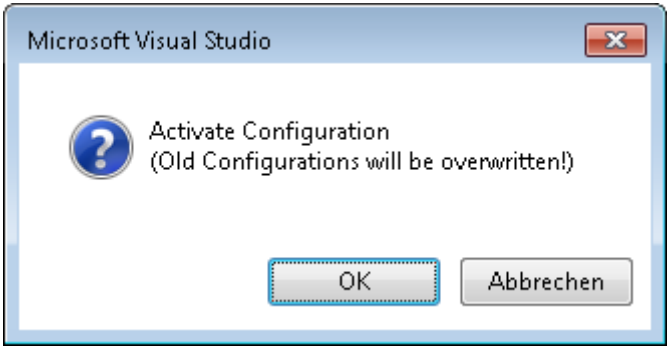
## 5.2.2 Commissioning

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.

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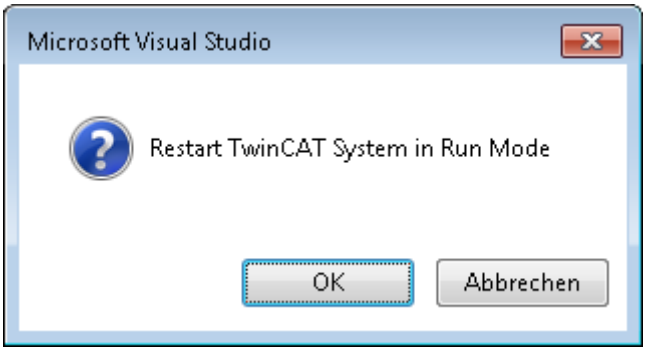


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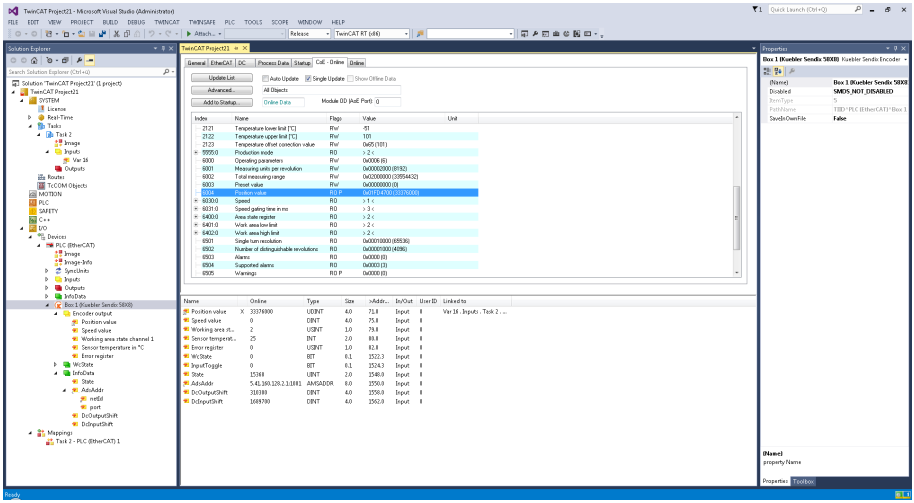
If all conditions for <Operational Mode> are met, TwinCAT switches to the real-time display and shows the position value. The current values can be found in the lower half of the screen.



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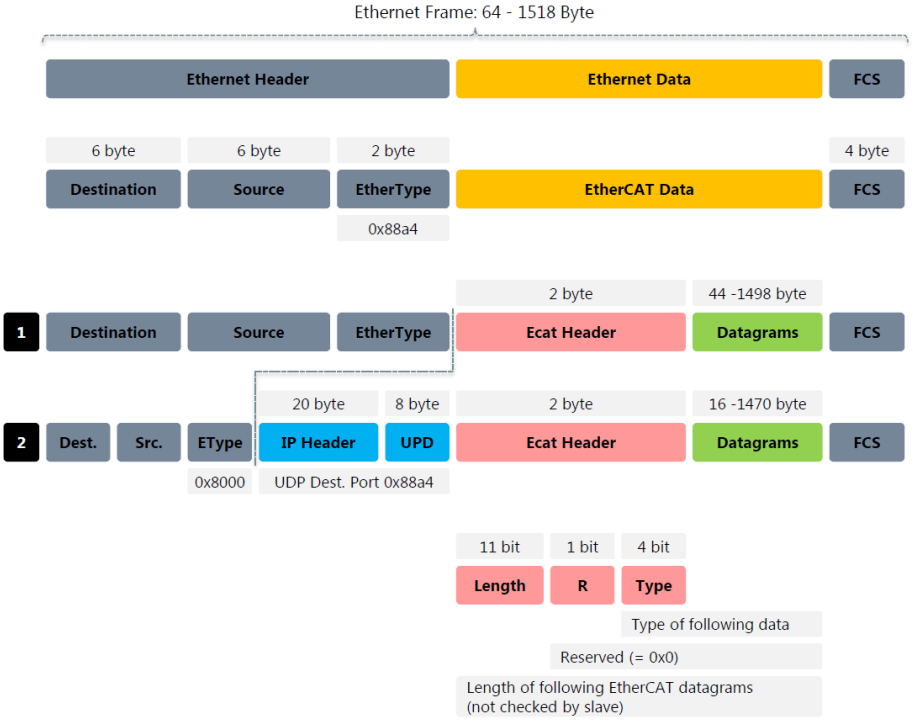
The yellow LED of the corresponding port now flashes quickly cyclically. The green RUN LED is constantly on.

## 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.

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## 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 reused. 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)
- 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

| | |
|---|---|
| VAR | Variable |
| ARRAY | Array of variables |
| RW | Read/Write |
| RO | Read only |
| Const | Constant |
| Name | Object name |
| M/O | Mandatory or optional |

### 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 0x1000 - Device type

Indicates the device type. Special numbers are assigned to every device type.

- 0x00010196 Singleturn encoder
- 0x00020196 Multiturn encoder
- 0x060001A1 Linear measuring system

### 5.5.6 Object 0x1001 - Error register

| *NOTICE* | **Temperature error** |
|---|---|
| | 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.<br>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.<br><br>In the case of FreeRun mode, the temperature is always updated with every bus cycle. |

Object 1001h is the error register of the device. 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 0x1008 - Device name

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

### 5.5.8 Object 0x1009 - Hardware version

Returns the hardware version.

### 5.5.9 Object 0x100A - 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 0x1010 – 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 |
|---|---|---|---|---|---|---|---|---|
| **Request** | 23 | 10 | 10 | 01 | 73 | 61 | 76 | 65 |
| **Response** | 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 0x1011 - Load factory settings

**Load the factory settings via object 0x1011 - "Restore default parameters"**

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 |
|---|---|---|---|---|---|---|---|---|
| Request | 23 | 11 | 10 | 01 | 6C | 6F | 61 | 64 |
| Response | 60 | 11 | 10 | 01 | 00 | 00 | 00 | 00 |

Byte 0: 6Ch (ASCII code for "l")

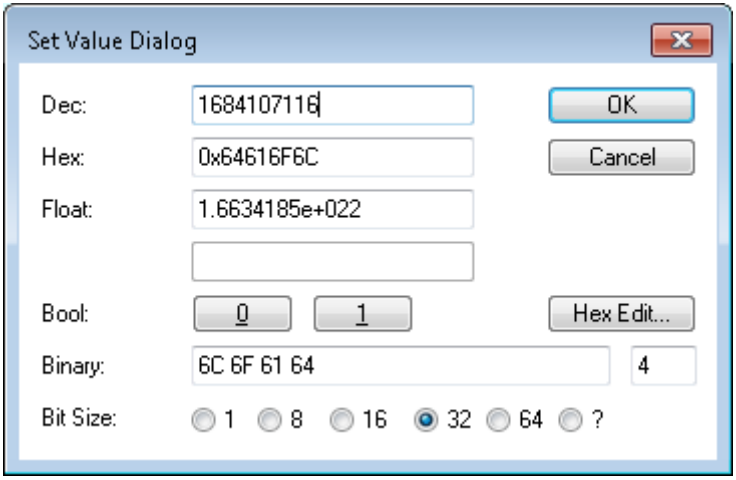
Byte 1: 6Fh (ASCII code for "o")

Byte 2: 61h (ASCII code for "a")

Byte 3: 64h (ASCII code for "d")

A double-click on the line "Restore all parameters" opens a dialog as shown in figure 42. After inputting the value 0x64616F6C, which is the Hex signature of the word "load" according to ISO 8859, all user parameters are replaced with the ones from the non-volatile memory.

The configuration must be activated to make the values become active under TwinCAT.

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The same applies to subindex 2 insofar as a double-click must be made on line "Restore factory default values", which then activates the so-called factory values. In this case, the user parameters receive the values determined at the time of manufacture of the encoder. In this case too, the values under TwinCAT only become active when the configuration is activated.

## 5.5.12 Object 0x1018 - Identity object

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

| Sub Index | Designation | Contents |
|---|---|---|
| 0x0 | Supported Subindices | 4 |
| 0x1 | Vendor ID | Vendor ID (0x13) Fritz Kübler GmbH |
| 0x2 | Product code | e. g. 0x58682001 CANopen Sensor |
| 0x3 | Revision Number | Software revision number (e. g. 102)<br>Subindex 4h: read only |
| 0x4 | Serial Number | 8-digit serial number of the device |

## 5.5.13 Object 0x1029 - 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
- Life guarding event occurred
- Heartbeat monitoring failed

**1029h, Subindex 2 Device profile specific**

- Sensor error and controller error
- Temperature error

**1029h, Subindex 3 Manufacturer specific**

- internal error

| Byte 0 |
| --- |
| $2^7 \ldots 2^0$ |

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)

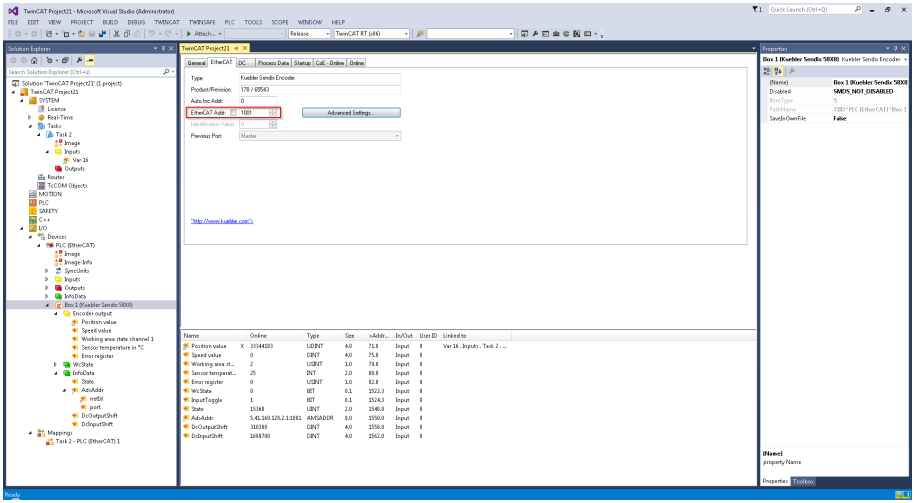
1 = no mode change

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.



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## 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

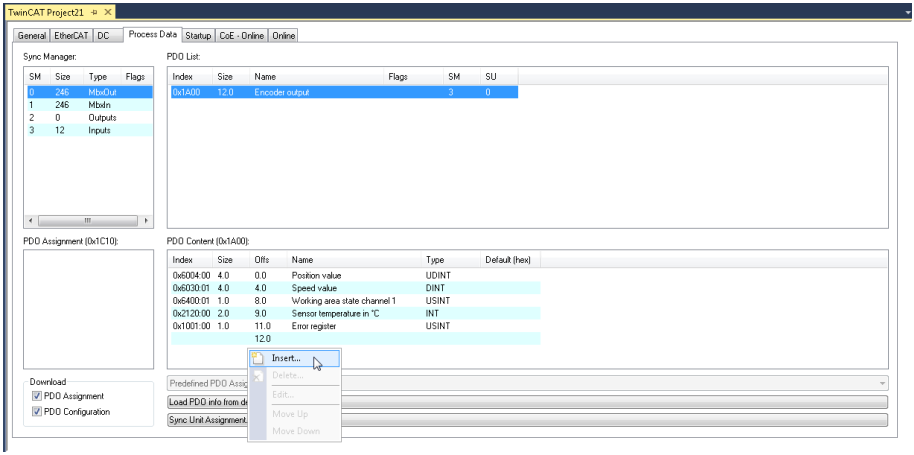
Sync-Manager 3: 4 Input process data (slave to master)

## 5.5.16 Object 1A00h - TxPDO1 mapping

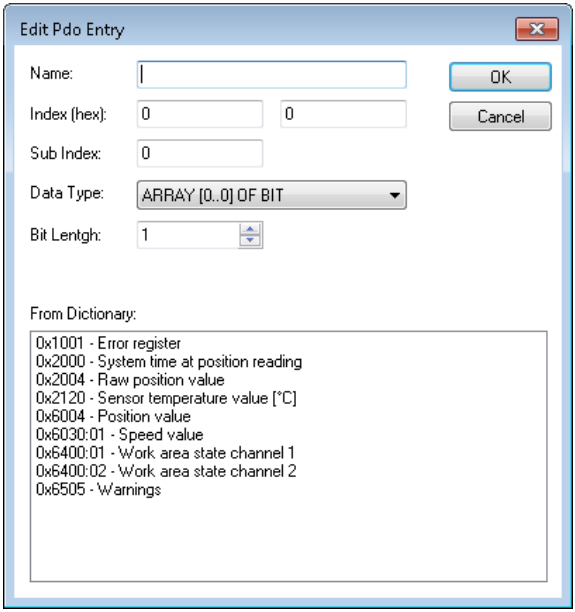
The mapping object for PDO 1 is defined in the object dictionary index 1A00h. It consists of one entry and it can be modified by the user (variable mapping).

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

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## 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.

| ***NOTICE*** | **Bus cycle time interruption**<br><br>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.

| ***NOTICE*** | **Bus cycle time interruption**<br><br>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.

| NOTICE | Bus cycle time interruption<br><br>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

| NOTICE | Bus cycle time interruption<br><br>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 0x6001 - 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 = Measuring steps per revolution (6001h) / phys. resolution singleturn (6501h)

Data content:

| Byte 0 | Byte 1 | Byte 2 | Byte 3 |
|---|---|---|---|
| $2^{7}…2^{0}$ | $2^{15}…2^{8}$ | $2^{23}…2^{16}$ | $2^{31}…2^{34}$ |

Values range: 1.... maximum physical resolution (16384) $2^{14}$ bits

Only valid if scaling (6000h) is activated.

## 5.5.28 Object 0x6002 - 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 |
|---|---|---|---|
| $2^{7}…2^{0}$ | $2^{15}…2^{8}$ | $2^{23}…2^{16}$ | $2^{31}…2^{34}$ |

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 0x6003 - 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 |
|---|---|---|---|
| $2^7 \ldots 2^0$ | $2^{15} \ldots 2^8$ | $2^{23} \ldots 2^{16}$ | $2^{31} \ldots 2^{24}$ |

Values range: 0.... maximum physical resolution (4294967295) $(232)^{-1}$ bits

When inputting the preset value, the systems 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 0x6004 - 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 |
|---|---|---|---|
| $2^7 \ldots 2^0$ | $2^{15} \ldots 2^8$ | $2^{23} \ldots 2^{16}$ | $2^{31} \ldots 2^{34}$ |

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 0x6030 - 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 |
|---|---|---|---|
| $2^7 \ldots 2^0$ | $2^{15} \ldots 2^8$ | $2^{23} \ldots 2^{16}$ | $2^{31} \ldots 2^{34}$ |

Values range: 0 ... +/- maximum speed 15,000 RPM (signed value)

In case of values > 12,000 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

| *NOTICE* | **Maximum gating time** |
|---|---|
| | The maximum permissible gating time is 2 seconds. |
| | 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. |

## 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 singleturm resolution of an encoder. For the Kübler 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 Kübler 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

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 chapter Contact [▷ 53].

**Prior to the work**

- Switch off the power supply and secure it against switching on again.
- Then disconnect the power supply lines physically.
- Remove operating and auxiliary materials and remaining processing materials from the measuring system.

# 7 Annex

## 7.1 TMT / MUR ratio

The singleturn and multiturn units of the encoder work independently of each other. Depending on the singleturn 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 section. 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.

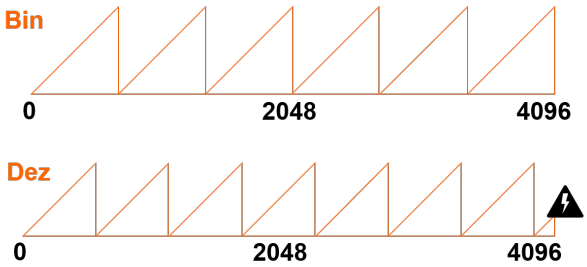
To get around this, i. e. to be able to ensure a decimal division ratio, the device has the so-called round-axis function (Endless Shaft Control). This function allows the device to calculate the actual position internally - also in the event of an overflow of the physical total measuring range (TMR).

The total measuring range is defined as the product of the singleturn resolution MUR (e. g. 65,536 corresponding to 16 bits) with the multiturn resolution NDR (e. g. 4,096 corresponding to 12 bits).

If TMR is a binary multiple of MUR, the position value will move as shown in the first illustration 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** |
|---|---|
| | 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.<br><br>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. |

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




*83423371*

Therefore, a binary multiple is defined as

TMR=MUR/2k and in a specific case TMR=MUR/2k

with k=0, ± 1, ± 2, …

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:

  $0 < MUR < MUR_{max}$
- In addition, MUR must be a multiple of 2:

  MUR = MUR/2n

  with 0 < n
- The TMR value of an encoder without multiturn unit will only be accepted during SDO download if it meets the following criterion:

  0 < MUR < TMR
- TMR must be a multiple of 2: TMR = MUR/2k and in a specific case

  TMR = MUR/2k

  with k = 0, ± 1, ± 2, …
- For an encoder with a multiturn unit, the following condition must be met for the TMR value to be accepted during SDO download:

  0 < TMR < MUR*NDR,

  in a specific case 0 < TMR < MUR*NDR

  TMR must be a multiple of 2: TMR = MUR*NDR/2k

  with k = 0, ± 1, ± 2, …

## 7.2 DC cycle times

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

counterclockwise, counting direction

**cw**

clockwise, counting direction

**ERR**

Error

**ETG brochure**

ETG brochure 02.2018

**HEX**

Hexadecimal

**LSB**

Least Significant Bit

**MSB**

Most Significant Bit

**MUR**

Measuring Units per Revolution

**rpm**

Rounds per Minute

**TwinCAT**

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