

Documentation for

## EP3356-0022

1-channel precise load cell analysis (resistor bridge), 24 bit

Version: 1.1.0  
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**BECKHOFF**



# Table of contents

|  |           |
|--|-----------|
| <b>1 Foreword</b> .....                                    | <b>5</b>  |
| 1.1 Notes on the documentation.....                        | 5         |
| 1.2 Safety instructions .....                              | 6         |
| 1.3 Documentation issue status .....                       | 7         |
| <b>2 Product overview</b> .....                            | <b>8</b>  |
| 2.1 EP3356-0022 - Introduction.....                        | 8         |
| 2.2 EP3356-0022 - Technical data .....                     | 9         |
| 2.3 Basic principles of strain gauge technology .....      | 10        |
| <b>3 Basics of communication</b> .....                     | <b>17</b> |
| 3.1 EtherCAT basics.....                                   | 17        |
| 3.2 Watchdog setting.....                                  | 17        |
| 3.3 EtherCAT State Machine.....                            | 20        |
| 3.4 CoE interface.....                                     | 22        |
| 3.5 Distributed Clock .....                                | 26        |
| <b>4 Mounting and Cabling</b> .....                        | <b>27</b> |
| 4.1 Mounting.....  | 27        |
| 4.1.1 Dimensions .....                                     | 27        |
| 4.1.2 Fixing .....   | 28        |
| 4.1.3 Nut torque for connectors .....                      | 29        |
| 4.1.4 Additional checks.....                               | 30        |
| 4.2 EtherCAT.....  | 31        |
| 4.2.1 EtherCAT connection.....                             | 31        |
| 4.2.2 EtherCAT - Fieldbus LEDs .....                       | 32        |
| 4.3 Power supply .....                                     | 34        |
| 4.3.1 Power Connection .....                               | 34        |
| 4.3.2 Status LEDs for power supply .....                   | 37        |
| 4.3.3 Power cable conductor losses M8.....                 | 38        |
| 4.3.4 Conductor losses 7/8".....                           | 39        |
| 4.4 Cabling .....  | 40        |
| 4.5 UL Requirements.....                                   | 42        |
| 4.6 ATEX notes .....                                       | 43        |
| 4.6.1 ATEX - Special conditions .....                      | 43        |
| 4.6.2 BG2000-0000 - EtherCAT Box protection enclosure..... | 44        |
| 4.6.3 ATEX Documentation .....                             | 45        |
| <b>5 EP3356-0022 - Signal connection</b> .....             | <b>46</b> |
| 5.1 Analog voltage inputs M12 and meaning of the LEDs..... | 46        |
| <b>6 Commissioning/Configuration</b> .....                 | <b>48</b> |
| 6.1 TwinCAT configuration setup, manual.....               | 48        |
| 6.2 Configuration setup: TwinCAT - online scan .....       | 51        |
| 6.3 EtherCAT slave process data settings (PDO) .....       | 58        |
| 6.4 Configuration via TwinCAT .....                        | 59        |
| 6.5 Basic function principles .....                        | 67        |
| 6.6 Application notes .....                                | 77        |

|          |  |            |
|----------|--|------------|
| 6.7      | Calibration and adjustment .....                                 | 80         |
| 6.8      | Notices on analog specifications .....                           | 84         |
| 6.9      | Voltage measurement .....  | 89         |
| 6.10     | Distributed Clocks mode (EL3356-0010 and EP3356-0022 only) ..... | 91         |
| 6.11     | Process data .....   | 92         |
| 6.12     | Object description and parameterization .....                    | 100        |
| 6.13     | Example program .....  | 113        |
| 6.14     | Restoring the delivery state .....                               | 118        |
| <b>7</b> | <b>Appendix .....</b>  | <b>119</b> |
| 7.1      | General operating conditions .....                               | 119        |
| 7.2      | EtherCAT Box- / EtherCAT P Box - Accessories .....               | 120        |
| 7.3      | Support and Service .....  | 121        |

# 1 Foreword

## 1.1 Notes on the documentation

### Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

### Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

### Trademarks

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### Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with corresponding applications or registrations in various other countries.

The TwinCAT Technology is covered, including but not limited to the following patent applications and patents: EP0851348, US6167425 with corresponding applications or registrations in various other countries.

The logo for EtherCAT, featuring the word "EtherCAT" in a bold, black, sans-serif font. A red arrow points from the top of the "A" towards the right, ending above the "T". A registered trademark symbol (®) is located to the right of the "T".

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## 1.2 Safety instructions

### Safety regulations

Please note the following safety instructions and explanations!  
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

### Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

### Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

### Description of instructions

In this documentation the following instructions are used.  
These instructions must be read carefully and followed without fail!

#### **DANGER**

##### **Serious risk of injury!**

Failure to follow this safety instruction directly endangers the life and health of persons.

#### **WARNING**

##### **Risk of injury!**

Failure to follow this safety instruction endangers the life and health of persons.

#### **CAUTION**

##### **Personal injuries!**

Failure to follow this safety instruction can lead to injuries to persons.

#### **NOTE**

##### **Damage to environment/equipment or data loss**

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.



#### **Tip or pointer**

This symbol indicates information that contributes to better understanding.

## 1.3 Documentation issue status

| Version | Changes  |
|---------|--|
| 1.1.0   | <ul style="list-style-type: none"> <li>• Update Safety instructions</li> <li>• Update chapter <i>Mounting and Cabling</i></li> </ul> |
| 1.0.4   | <ul style="list-style-type: none"> <li>• Technical Data updated</li> <li>• EP3356-0022 – Signal connection updated</li> </ul>        |
| 1.0.3   | <ul style="list-style-type: none"> <li>• Basic function principles updated</li> </ul>  |
| 1.0.2   | <ul style="list-style-type: none"> <li>• Nut torque for connectors updated</li> </ul>  |
| 1.0.1   | <ul style="list-style-type: none"> <li>• Parallel connection of strain gauges updated</li> </ul>                                     |
| 1.0.0   | <ul style="list-style-type: none"> <li>• first publication</li> </ul>  |
| 0.5     | <ul style="list-style-type: none"> <li>• first preliminary version</li> </ul>  |

### Firm and hardware version

The documentation refers to the firm and hardware status that was valid at the time it was prepared.

The properties of the modules are subject to continuous development and improvement. Modules having earlier production statuses cannot have the same properties as modules with the latest status. Existing properties, however, are always retained and are not changed, so that these modules can always be replaced by new ones.

The firmware and hardware version (delivery state) can be found in the batch number (D number) printed at the side of the EtherCAT Box.

### Syntax of the batch number (D number)

D: WW YY FF HH

WW - week of production (calendar week)

YY - year of production

FF - firmware version

HH - hardware version

Example with D No. 29 10 02 01:

29 - week of production 29

10 - year of production 2010

02 - firmware version 02

01 - hardware version 01

## 2 Product overview

### 2.1 EP3356-0022 - Introduction

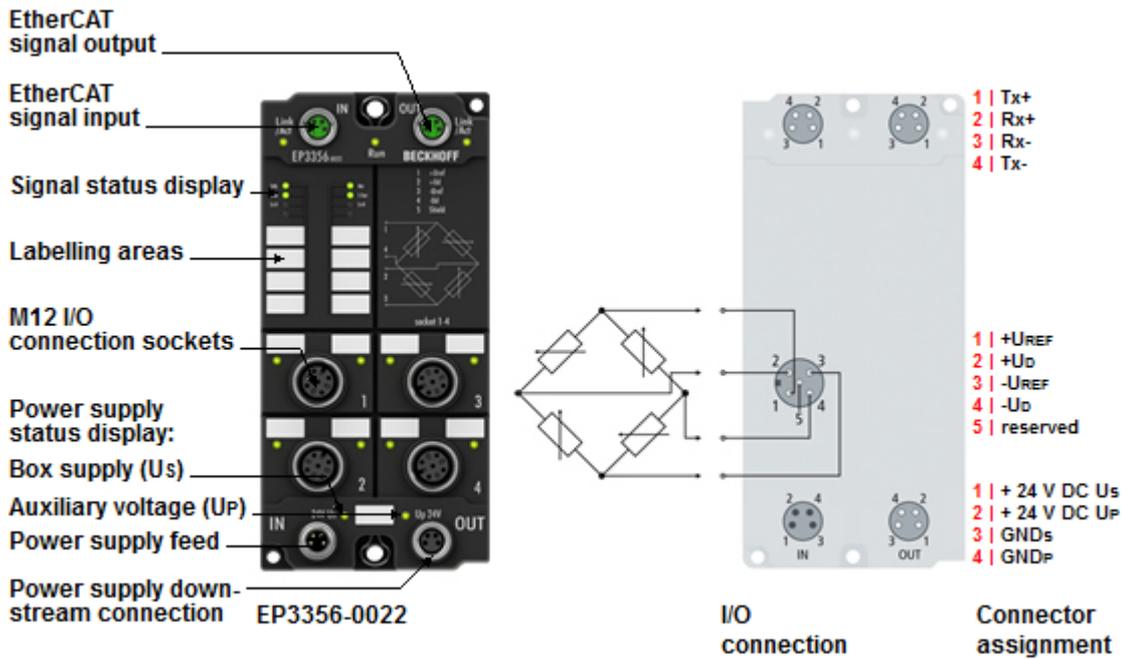


Fig. 1: EP3356-0022

#### 1-channel precise load cell analysis (resistor bridge), 24 bit

The EP3356 EtherCAT Box enables direct connection of a resistor bridge or load cell in a 4-wire connection technology. The ratio between the bridge voltage  $U_D$  and the supply voltage  $U_{ref}$  is determined simultaneously in the input circuit and the final load value is calculated as a process value on the basis of the settings in the EP3356. With automatic self-calibration (can be deactivated), dynamic filters and distributed clock support, the EP3356 with measuring cycles of 100  $\mu$ s can be used for fast and precise monitoring of torque or vibration sensors.

[Installation \[► 27\]](#)

[Configuration \[► 48\]](#)

## 2.2 EP3356-0022 - Technical data

| Technical data   | EP3356-0022   |
|--|---|
| Number of inputs   | 2, for 1 resistor bridge in full bridge technology  |
| Signal connection sockets [► 46]                                 | M12   |
| Resolution   | 24 Bit, 32 bit presentation   |
| Conversion time  | 0.1 ms...250 ms, configurable, max. 10,000 samples/s  |
| Nominal voltage  | 24 V <sub>DC</sub> (-15 %/+20 %)  |
| Distributed Clocks   | yes   |
| selectable modes   | yes (2)   |
| Measuring error  | <±0.01 % for the calculated load value in relation to the final load value with a 12 V feed and 24 mV bridge voltage (hence nominal strain gauge characteristic value of 2 mV/V), self-calibration active, 50 Hz filter active.<br>Attention: Due to external influences such as <u>temperature drifts</u> [► 10] and HF-disturbances may possibly occur a not insignificant error! |
| Measuring range U <sub>D</sub>                                   | max. -27 mV...+27 mV typ. (see <u>note</u> [► 89] concerning voltage measuring recommended: -25 mV...+25 mV rated voltage   |
| Measuring range U <sub>ref</sub>                                 | max. -13.8 V...+13.8 V typ. (see <u>note</u> [► 89] concerning voltage measuring recommended: -12 V...+12 V rated voltage   |
| Supported nominal sensitivity                                    | all, resolution of parameter: 0.01 µV/V<br>Recommended: 0.5 mV/V...4 mV/V   |
| Min. strain gauge resistor                                       | parallel operation of strain gauges only with suitable strain gauges recommended  |
| Input filter limit frequency (hardware)                          | 10 kHz low pass (-3 dB)   |
| Filter (software)  | Present 50 Hz,<br>Configurable: 50/60 Hz FIR notch filter, IIR low pass 4-fold averager   |
| Internal resistance  | >200 kΩ (U <sub>ref</sub> ), > 1 MΩ (U <sub>d</sub> )   |
| Special features   | self-calibration, quadruple averager, dynamic filters, fast data sampling, parallel connection  |
| Sensor supply  | U <sub>ref</sub> = 10 V (supplied by the EP3356)  |
| Current consumption from U <sub>s</sub> (without sensor current) | 120 mA  |
| Power supply connection  | feed: 1 x M8 male socket, 4-pin<br>downstream connection: 1 x M8 female socket, 4-pin   |
| Permissible ambient temperature during operation                 | -25°C...+60°C<br>0°C ... +55°C (according to cULus, see UL Requirements)  |
| Permissible ambient temperature during storage                   | -40°C...+85°C   |
| Vibration / shock resistance                                     | conforms to EN 60068-2-6 / EN 60068-2-27  |
| EMC immunity/emission  | conforms to EN 61000-6-2 / EN 61000-6-4   |
| Dimensions   | 126 mm x 60 mm x 40 mm  |
| Weight   | approx.. 450 g  |
| Installation position  | variable  |
| Protection class   | IP65, IP66, IP67 (according to EN 60529)  |
| Approvals  | CE, UL  |

## 2.3 Basic principles of strain gauge technology

Basic information on the technological field of "strain gauges/load cells" as metrological instruments is to be given below. The information is of general nature; it is up to the user to check the extent to which it applies to his application.

- Strain gauges serve either to directly measure the static (0 to a few Hz) or dynamic (up to several KHz) elongations, compressions or torsions of a body by being directly fixed to it, or to measure various forces or movements as part of a sensor (e.g. load cells/force transducers, displacement sensor, vibration sensors).
- In the case of the optical strain gauge (e.g. Bragg grating), an application of force causes a proportional change in the optical characteristics of a fiber used as a sensor. Light with a certain wavelength is fed into the sensor. Depending upon the deformation of the grating, which is laser-cut into the sensor, due to the mechanical load, part of the light is reflected and evaluated using a suitable measuring transducer (interrogator).

The commonest principle in the industrial environment is the electrical strain gauge. There are many common terms for this type of sensor: load cell, weighbridge, etc.

### Structure of electrical strain gauges

A strain gauge consists of a carrier material (e.g. stretchable plastic film) with an applied metal film from which a lattice of electrically conductive resistive material is worked in very different geometrical forms, depending on the requirements.

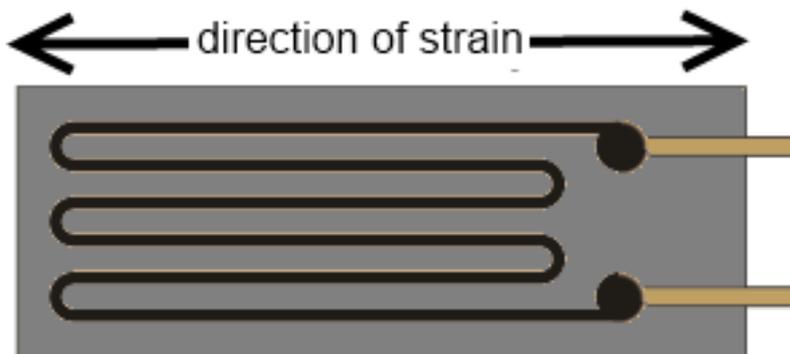


Fig. 2: Strain gauge

This utilizes a behavior whereby, for example in the case of strain, the length of a metallic resistance network increases and its diameter decreases, as a result of which its electrical resistance increases proportionally.

$$\Delta R/R = k \cdot \epsilon$$

$\epsilon = \Delta l/l$  thereby corresponds to the elongation; the strain sensitivity is called the k-factor. This also gives rise to the typical track layout inside the strain gauge: the resistor track or course is laid in a meandering pattern in order to expose the longest possible length to the strain.

### Example

The elongation  $\epsilon = 0.1\%$  of a strain gauge with k-factor 2 causes an increase in the resistance of 0.2%. Typical resistive materials are constantan ( $k \sim 2$ ) or platinum tungsten (92PT, 8W with  $k \sim 4$ ). In the case of semiconductor strain gauges a silicon structure is glued to a carrier material. The conductivity is changed primarily by deformation of the crystal lattice (piezo-resistive effect); k-factors of up to 200 can be achieved.

### Measurement of signals

The change in resistance of an individual strain gauge can be determined in principle by resistance measurement (current/voltage measurement) using a 2/3/4-conductor measurement technique

Usually 1/2/4 strain gauges are arranged in a Wheatstone bridge (-> quarter/half/full bridge); the nominal resistance/impedance  $R_0$  of all strain gauges (and the auxiliary resistors used if necessary) is usually equivalent to  $R_1=R_2=R_3=R_4=R_0$ . Typical values in the non-loaded state are  $R_0 = 120 \Omega, 350 \Omega, 700 \Omega$  and  $1 \text{ k}\Omega$ .

The full bridge possesses the best characteristics such as linearity in the feeding of current/voltage, four times the sensitivity of the quarter-bridge as well as systematic compensation of disturbing influences such as temperature drift and creeping. In order to achieve high sensitivity, the 4 individual strain gauges are arranged on the carrier in such a way that 2 are elongated and 2 are compressed in each case.

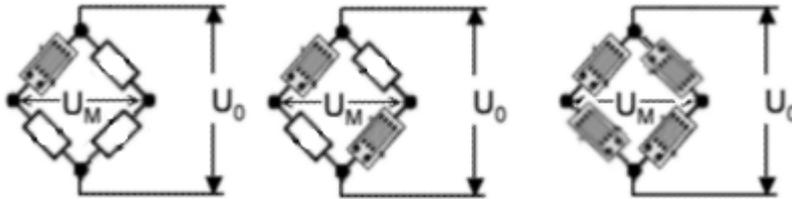


Fig. 3: quarter, half and full bridge

The measuring bridges can be operated with constant current, constant voltage, or also with AC voltage using the carrier frequency method.

**● Measuring procedure**  
**i**

The Beckhoff EL/KL335x Terminals and the EP3356 Box support only the constant excitation

• **Full bridge strain gauge at constant voltage (ratiometric measurement)**

Since the relative resistance change  $\Delta R$  is low in relation to the nominal resistance  $R_0$ , a simplified equation is given for the strain gauge in the Wheatstone bridge arrangement:

$$U_D/U_V = 1/4 * (\Delta R_1 - \Delta R_2 + \Delta R_3 - \Delta R_4)/R_0$$

$\Delta R$  usually has a positive sign in the case of elongation and a minus sign in the case of compression.

A suitable measuring instrument measures the bridge supply voltage  $U_V$  (or  $U_{Supply}$ ) and the resulting bridge voltage  $U_D$  (or  $U_{Bridge}$ ), and forms the quotients from both voltages, i.e. the ratio. After further calculation and scaling the measured value is output, e.g. in kg. Due to the division of  $U_D$  and  $U_V$  the measurement is in principle independent of changes in the supply voltage.

If the voltages  $U_V$  and  $U_D$  are measured simultaneously, i.e. at the same moment, and placed in relation to each other, then this is referred to as a ratiometric measurement.

The advantage of this is that (with simultaneous measurement!) brief changes in the supply voltage (e.g. EMC effects) or a generally inaccurate or unstable supply voltage likewise have no effect on the measurement.

A change in  $U_V$  by e.g. 1 % creates the same percentage change in  $U_D$  according to the above equation. Due to the simultaneous measurement of  $U_D$  and  $U_V$  the error cancels itself out completely during the division.

**4-conductor vs. 6-conductor connection**

If supplied with a constant voltage of 5 to 12 V a not insignificant current flows of e.g.  $12 \text{ V}/350 \Omega = 34.3 \text{ mA}$ . This leads not only to dissipated heat, wherein the specification of the strain gauge employed must not be exceeded, but possibly also to measuring errors in the case of inadequate wiring due to line losses not being taken into account or compensated.

In principle a full bridge can be operated with a 4-conductor connection (2 conductors for the supply  $U_V$  and 2 for the measurement of the bridge voltage  $U_D$ ).

If, for example, a 25 m copper cable (feed + return = 50 m) with a cross section  $q$  of  $0.25 \text{ mm}^2$  is used, this results in a line resistance of

$$RL = l / (\kappa * q) = 50 \text{ m} / (58 \text{ S}\cdot\text{m}/\text{mm}^2 * 0.25 \text{ mm}^2) = 3.5 \Omega$$

If this value remains constant, then the error resulting from it can be calibrated out. However, assuming a realistic temperature change of, for example, 30° the line resistance  $R_L$  changes by

$$\Delta R_L = 30^\circ \cdot 3.9 \cdot 10^{-4} \cdot 3.5 \Omega = 0.41 \Omega$$

In relation to a 350  $\Omega$  measuring bridge this means a measuring error of > 0.1 %.

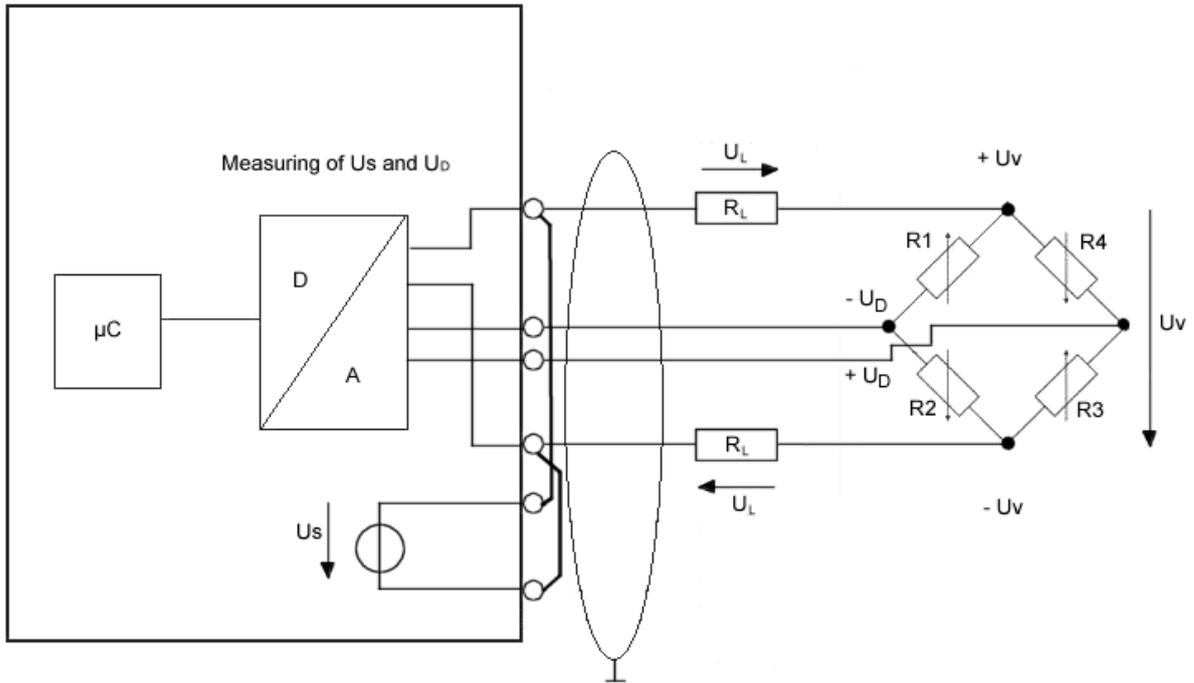


Fig. 4: 4-conductor connection

This can be remedied by a 6-conductor connection, in particular for precision applications (only possible with EL3356).

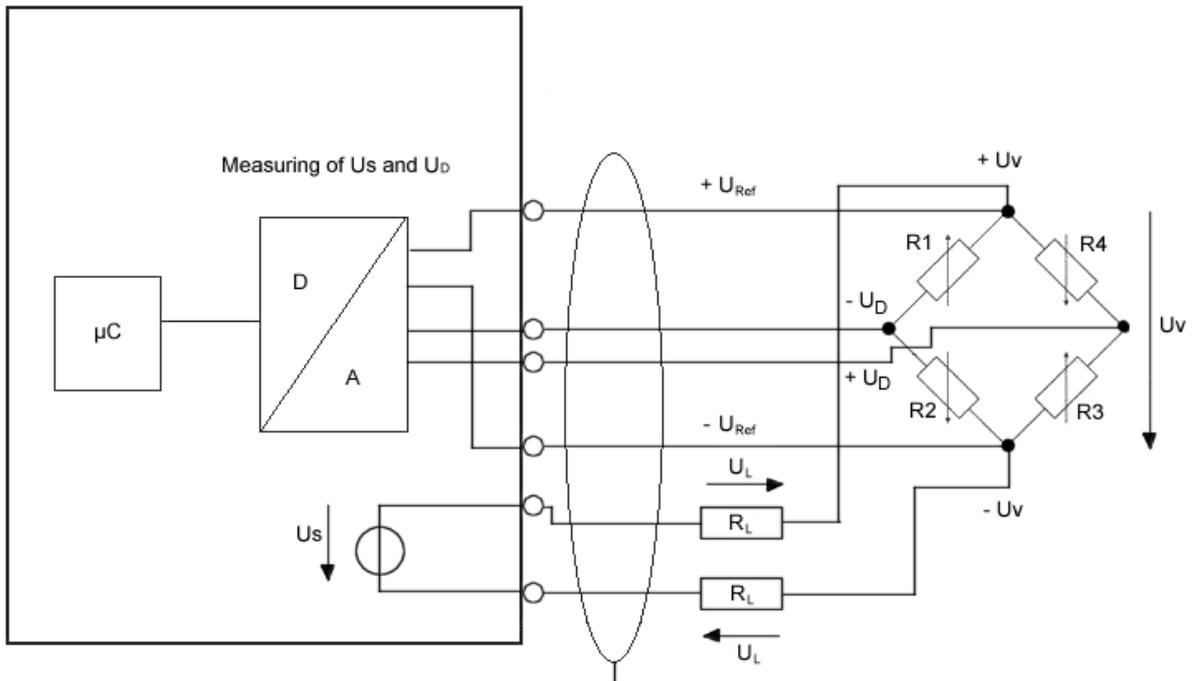


Fig. 5: 6-conductor connection

The supply voltage  $U_V$  is thereby fed to the strain gauge (= current carrying conductor). The incoming supply voltage  $U_{ref}$  is only measured with high impedance directly at the measuring bridge in exactly the same way as the bridge voltage  $U_D$  with two currentless return conductors in each case. The conductor-related errors are hence omitted.

Since these are very small voltage levels of the order of mV and  $\mu$ V, all conductors should be shielded. The shield must be connected to pin 5 of the M12 connector.

---

**● EP3356-0022: No 6-conductor connection necessary**

**i** The connection of a strain gauge over 4-conductor with the EP3356-0022 is sufficient because due to the shorter cable lengths no measurement errors occur.

---

### Structure of a load cell with a strain gauge

One application of the strain gauge is the construction of load cells.

This involves gluing strain gauges (full bridges as a rule) to an elastic mechanical carrier, e.g. a double-bending beam spring element, and additionally covered to protect against environmental influences.

The individual strain gauges are aligned for maximum output signals according to the load direction (2 strain gauges in the elongation direction and 2 in the compression direction).



Fig. 6: Example of a load cell

### The most important characteristic data of a load cell

**● Characteristic data**

**i** Please enquire to the sensor manufacturer regarding the exact characteristic data!

---

#### Nominal load $E_{max}$

Maximum permissible load for normal operation, e.g. 10 kg

Nominal characteristic value mV/V

The nominal characteristic value 2 mV/V means that, with a supply of  $U_s=10\text{ V}$  and at the full load  $E_{\max}$  of the load cell, the maximum output voltage  $U_D = 10\text{ V} * 2\text{ mV/V} * E = 20\text{ mV}$ . The nominal characteristic value is always a nominal value – a manufacturer's test report is included with good load cells stating the characteristic value determined for the individual load cell, e.g. 2.0782 mV/V.

### Minimum calibration value $V_{\min}$

This indicates the smallest mass that can be measured without the maximum permissible error of the load cell being exceeded [RevT].

This value is represented either by the equation  $V_{\min} = E_{\max} / n$  (where  $n$  is an integer, e.g. 10000), or in % of  $E_{\max}$  (e.g. 0.01).

This means that a load cell with  $E_{\max} = 10\text{ kg}$  has a maximum resolution of

$$V_{\min} = 10\text{ kg} / 10000 = 1\text{ g} \text{ or } V_{\min} = 10\text{ kg} * 0.01\% = 1\text{ g}.$$

### Accuracy class according to OIML R60

The accuracy class is indicated by a letter (A, B, C or D) and an additional number, which encodes the scale interval  $d$  with a maximum number  $n_{\max}$  (\*1000); e.g. C4 means Class C with maximally 4000d scale intervals.

The classes specify a maximum and minimum limit for scale intervals  $d$ :

- A: 50,000 – unlimited
- B: 5000 – 100,000
- C: 500 – 10,000
- D: 500 – 1000

The scale interval  $n_{\max} = 4000d$  states that, with a load cell with a resolution of  $V_{\min} = 1\text{ g}$ , a calibratable set of scales can be built that has a maximum measuring range of  $4000d * V_{\min} = 4\text{ kg}$ . Since  $V_{\min}$  is thereby a minimum specification, an 8 kg set of scales could be built – if the application allows – with the same load cell, wherein the calibratable resolution would then fall to  $8\text{ kg}/4000d = 2\text{ g}$ . From another point of view the scale interval  $n_{\max}$  is a maximum specification; hence, the above load cell could be used to build a set of scales with a measuring range of 4 kg, but a resolution of only 2000 divisions = 2 g, if this is adequate for the respective application. Also the classes differ in certain error limits related to non-repeatability/creep/TC

### Accuracy class according to PTB

The European accuracy classes are defined in an almost identical way (source: PTB).

| Class                    | Calibration values            | Minimum load | Max/e         |               |
|--------------------------|-------------------------------|--------------|---------------|---------------|
|                          |                               |              | Minimum value | Maximum value |
| I<br>Fine scales         | $0.001\text{ g} \leq e$       | 100 e        | 50000         |               |
| II<br>Precision scales   | $g \leq e \leq 0.05\text{ g}$ | 20 e         | 100           | 100000        |
|                          | $g \leq e$                    | 50 e         | 5000          | 100000        |
| III<br>Commercial scales | $g \leq e \leq 2\text{ g}$    | 20 e         | 100           | 10000         |
|                          | $g \leq e$                    | 20 e         | 500           | 10000         |
| IV<br>Coarse scales      | $5\text{ g} \leq e$           | 10 e         | 100           | 1000          |

### Minimum application range or minimum measuring range in % of rated load

This is the minimum measuring range/measuring range interval, which a calibratable load cell/set of scales must cover.

Example: above load cell  $E_{\max} = 10\text{ kg}$ ; minimum application range e.g. 40 %  $E_{\max}$

The used measuring range of the load cell must be at least 4 kg. The minimum application range can lie in any range between  $E_{min}$  and  $E_{max}$ , e.g. between 2 kg and 6 kg if a tare mass of 2 kg already exists for structural reasons. A relationship between  $n_{max}$  and  $V_{min}$  is thereby likewise apparent:  $4000 * 1\text{ g} = 4\text{ kg}$ .

There are further important characteristic values, which are for the most part self-explanatory and need not be discussed further here, such as nominal characteristic value tolerance, input/output resistance, recommended supply voltage, nominal temperature range etc.

**Parallel connection of strain gauges**

It is usual to distribute a load mechanically to several strain gauge load cells at the same time. Hence, for example, the 3-point bearing of a silo container on 3 load cells can be realized. Taking into account wind loads and loading dynamics, the total loading of the silo including the dead weight of the container can thus be measured. The mechanically parallel-connected load cells are usually also electrically connected in parallel and connect at two arbitrarily M12 sockets of EP3356-0022 (see figure below). To this end the following must be observed:

- the load cells must be matched to each other and approved by the manufacturer for this mode of operation
- the impedance of the load cells must be such that the current feed capability of the transducer electronics (max. 350 mA) is not overloaded.

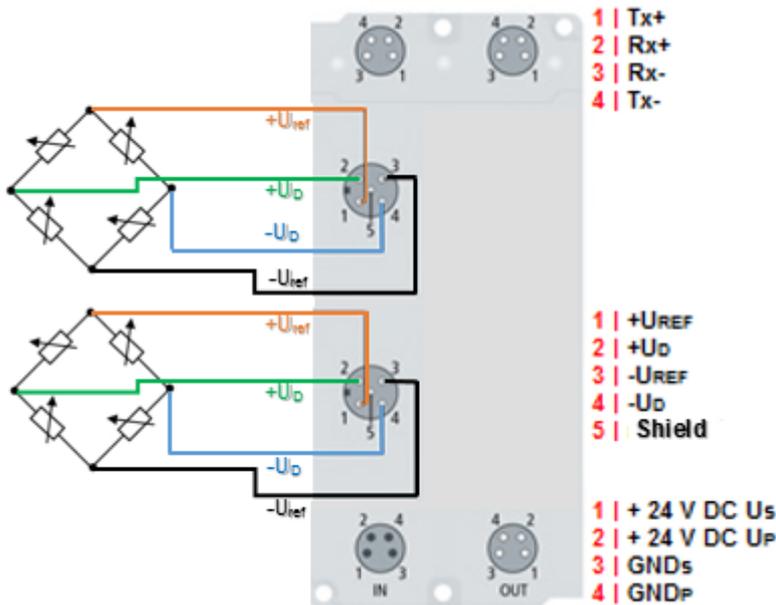


Fig. 7: Parallel connection of strain gauges

**Sources of error/disturbance variables**

**Inherent electrical noise of the load cell**

Electrical conductors exhibit so-called thermal noise (thermal/Johnson noise), which is caused by irregular temperature-dependent movements of the electrons in the conductor material. The resolution of the bridge signal is already limited by this physical effect. The rms value  $e_n$  of the noise can be calculated by  $e_n = \sqrt{4kTRB}$

In the case of a load cell with  $R_0 = 350\ \Omega$  at an ambient temperature  $T = 20\ ^\circ\text{C}$  ( $= 293\ \text{K}$ ) and a bandwidth of the measuring transducer of 50 Hz (and Boltzmann constant  $k = 1.38 * 10^{-23}\ \text{J/K}$ ), the rms  $e_n = 16.8\ \text{nV}$ . The peak-peak noise  $e_{pp}$  is thus approx.  $e_{pp} \sim 4 * e_n = 67.3\ \text{nV}$ .

**Example:**

In relation to the maximum output voltage  $U_{out-max}$  of a bridge with 2 mV/V and  $U_s = 5\ \text{V}$ , this corresponds to  $U_{out-max} = 5\ \text{V} * 2\ \text{mV/V} = 10\ \text{mV}$ . (For the nominal load) this results in a maximum resolution of  $10\ \text{mV}/67.3\ \text{nV} = 148588$  digits. Converted into bit resolution:  $\ln(148588)/\ln(2) = 17$  bits. Interpretation: a higher digital measuring resolution than 17 bits is thus inappropriate for such an analog signal in the first

step. If a higher measuring resolution is used, then additional measures may need to be taken in the evaluation chain in order to obtain the higher information content from the signal, e.g. hardware low-pass filter or software algorithms.

This resolution applies alone to the measuring bridge without any further interferences. The resolution of the measuring signal can be increased by reducing the bandwidth of the measuring unit.

If the strain gauge is glued to a carrier (load cell) and wired up, both external electrical disturbances (e.g. thermovoltage at connection points) and mechanical vibrations in the vicinity (machines, drives, transformers (mechanical and audible 50 Hz vibration due to magnetostriction etc.)) can additionally impair the result of measurement.

### Creep

Under a constant load, spring materials can further deform in the load direction. This process is reversible, but it generates a slowly changing measured value during the static measurement. In an ideal case the error can be compensated by constructive measures (geometry, adhesives).

### Hysteresis

If even elongation and compression of the load cell take place, then the output voltage does not follow exactly the same curve, since the deformation of the strain gauge and the carrier may be different due to the adhesive and its layer thickness.

### Temperature drift (inherent heating, ambient temperature)

Relatively large currents can flow in strain gauge applications, e.g.  $I = U_s/R_0 = 10 \text{ V} / 350 \Omega = 26 \text{ mA}$ . The power dissipation at the sensor is thus  $P_v = U \cdot I = 10 \text{ V} \cdot 26 \text{ mA} = 260 \text{ mW}$ . Depending on application/carrier material (= cooling) and ambient temperature, a not insignificant error can arise that is termed apparent elongation. The sensor manufacturers integrate suitable compensation elements in their strain gauges.

### Inadequate circuit technology

As already shown, a full bridge may be able (due to the system) to fully compensate non-linearity, creep and temperature drift. Wiring-related measuring errors are avoided by the 6-conductor connection.

### References

Some organizations are listed below that provide the specifications or documents for the technological field of weighing technology:

- OIML (ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE) [www.oiml.org/en](http://www.oiml.org/en)
- PTB - Physikalisch-Technischen Bundesanstalt [www.ptb.de/cms/](http://www.ptb.de/cms/)
- [www.eichamt.de](http://www.eichamt.de)
- WELMEC - European cooperation in legal metrology [www.welmec.org](http://www.welmec.org)
- DAkkS – Deutsche Akkreditierungsstelle [www.dakks.de](http://www.dakks.de)
- Fachgemeinschaft Waagen (AWA) im Verband Deutscher Maschinen- und Anlagenbau VDMA [www.vdma.org](http://www.vdma.org)

## 3 Basics of communication

### 3.1 EtherCAT basics

Basic information on the EtherCAT fieldbus can be found in the [EtherCAT system documentation](#).

### 3.2 Watchdog setting

#### General information on watchdog settings

The ELxxxx Terminals and EPxxxx Box Modules are equipped with a safety device (watchdog) that switches the outputs to a safe state after a time that can be preset, for example in the case of interrupted process data traffic, or to OFF, for example depending on device and setting.

The EtherCAT Slave Controller (ESC) has two watchdogs:

- SM watchdog (default: 100 ms)
- PDI watchdog (default: 100 ms)

#### SM Watchdog (SyncManagerWatchdog)

The SyncManager watchdog is reset after each successful EtherCAT process data communication with the terminal/box. If no EtherCAT process data communication takes place with the terminal/box for longer than the set and activated SM watchdog time, e.g. in the event of a line interruption, the watchdog is triggered and the outputs are set to FALSE. The OP status of the terminal/box is unaffected by this. The watchdog is only reset after a successful EtherCAT process data access. Set the monitoring time as specified below.

The SyncManager watchdog monitors correct and timely process data communication with the ESC from the EtherCAT side.

#### PDI watchdog (process data watchdog)

If no PDI communication with the EtherCAT slave controller (ESC) takes place for longer than the set and activated PDI watchdog time, this watchdog is triggered.

PDI (Process Data Interface) is the internal interface between the ESC and local processors in the EtherCAT slave, for example. The PDI watchdog can be used to monitor this communication for failure.

The PDI watchdog monitors correct and timely process data communication with the ESC but from the application side.

The SM and PDI watchdogs should be set separately for each slave in the TwinCAT System Manager:

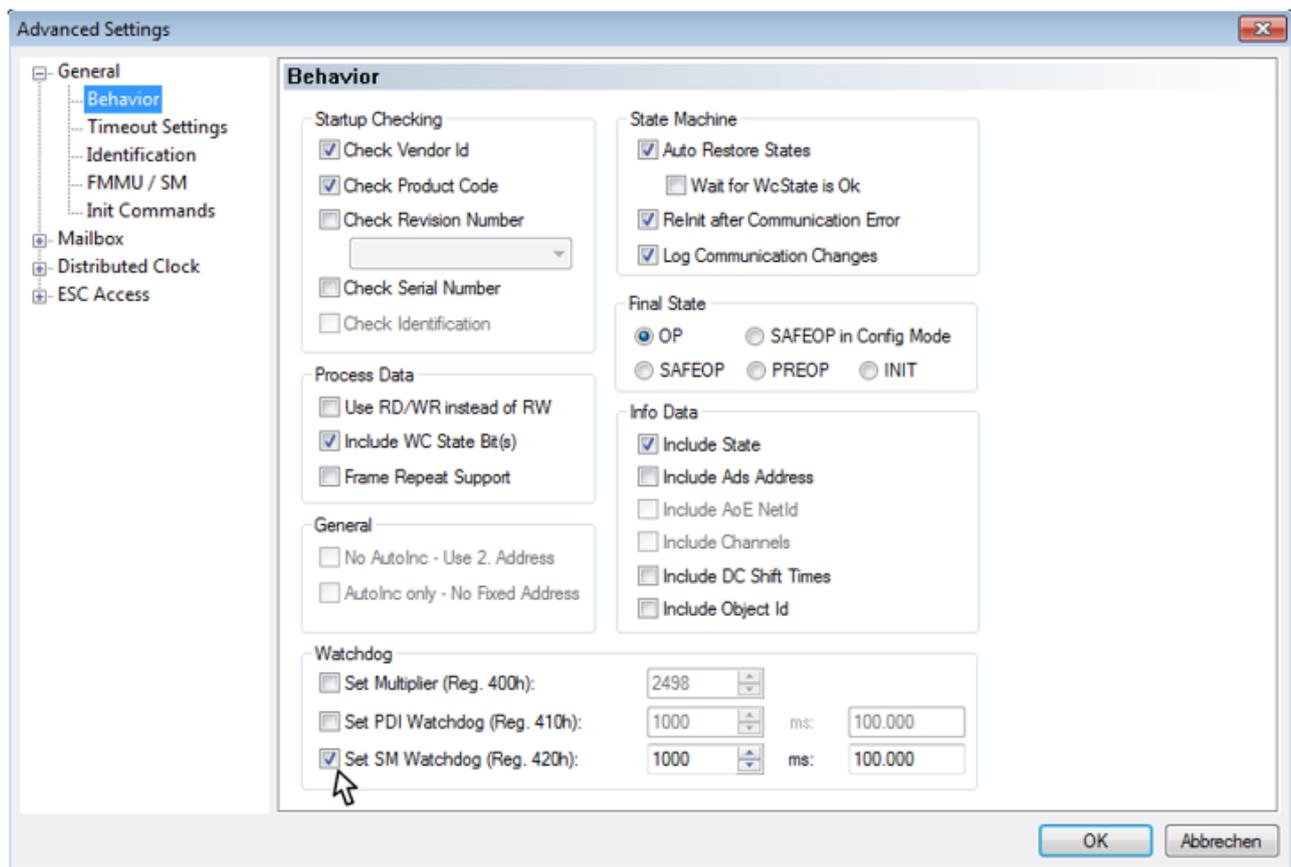


Fig. 8: EtherCAT tab --> Advanced settings --> Behavior --> Watchdog

#### Comments:

- The multiplier applies to both watchdogs.
- Each watchdog has its own timer setting, which together with the multiplier results in a time.
- Important: The multiplier/timer setting is loaded into the slave on start-up, if the corresponding checkbox is ticked. If the checkbox is not ticked, no download takes place, and the ESC setting remains unchanged.

#### Multiplier

Both watchdogs receive their pulses from the local terminal/box clock, divided by the watchdog multiplier.

$1/25 \text{ MHz} * (\text{watchdog multiplier} + 2) = 100 \text{ } \mu\text{s}$  (for default setting of 2498 for the multiplier)

The standard setting of 1000 for the SM watchdog corresponds to a release time of 100 ms.

The value in multiplier + 2 corresponds to the number of basic 40 ns ticks representing a watchdog tick.

The multiplier can be modified in order to adjust the watchdog time over a larger range.

#### Example "Set SM watchdog"

This checkbox enables manual setting of the watchdog times. If the outputs are set and the EtherCAT communication is interrupted, the SM watchdog is triggered after the set time and the outputs are deleted. This setting can be used for adapting a terminal to a slower EtherCAT master or long cycle times. The default SM watchdog setting is 100 ms. The setting range is from 0 to 65535. Together with a multiplier in a range from 1 to 65535, this covers a watchdog period of 0 to ~170 seconds.

#### Calculation

Multiplier = 2498 → watchdog base time =  $1 / 25 \text{ MHz} * (2498 + 2) = 0.0001 \text{ seconds} = 100 \text{ } \mu\text{s}$

SM watchdog = 10000 →  $10000 * 100 \text{ } \mu\text{s} = 1 \text{ second watchdog monitoring time}$

**⚠ CAUTION****Caution! Unintended behavior of the system is possible!**

The function for switching off of the SM watchdog via SM watchdog = 0 is only implemented in terminals from version -0016. In previous versions this operating mode should not be used.

**⚠ CAUTION****Caution! Damage to the equipment and unintended behavior of the system is possible!**

If the SM watchdog is activated and a value of 0 is entered the watchdog switches off completely. This is watchdog deactivation! Outputs are then *NOT* set to a safe state, in the event of an interruption in communication!

**● Outputs in SAFEOP**

**i** Watchdog monitoring is activated by default. It sets the outputs in the module to a safe state (e.g. OFF), depending on the *SAFEOP* and *OP* settings, and depending on the device and its settings. If this is prevented due to deactivation of watchdog monitoring in the module, outputs can be switched or remain set in device state *SAFEOP*.

### 3.3 EtherCAT State Machine

The state of the EtherCAT slave is controlled via the EtherCAT State Machine (ESM). Depending upon the state, different functions are accessible or executable in the EtherCAT slave. Specific commands must be sent by the EtherCAT master to the device in each state, particularly during the bootup of the slave.

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational and
- Operational
- Boot

The regular state of each EtherCAT slave after bootup is the OP state.

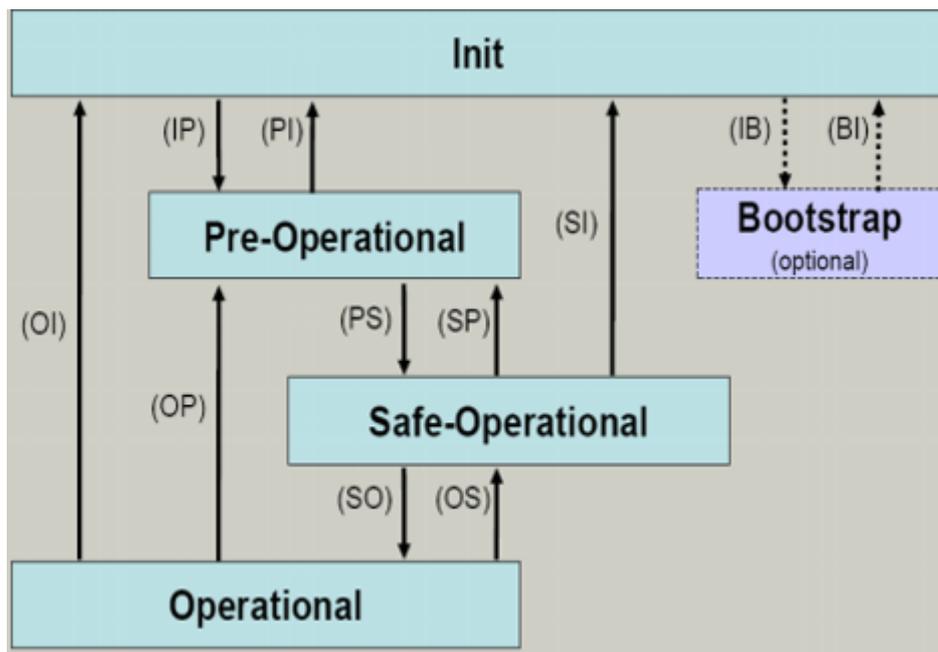


Fig. 9: EtherCAT State Machine

#### Init

After switch-on the EtherCAT slave in the *Init* state. No mailbox or process data communication is possible. The EtherCAT master initializes sync manager channels 0 and 1 for mailbox communication.

#### Pre-Operational (Pre-Op)

During the transition between *Init* and *Pre-Op* the EtherCAT slave checks whether the mailbox was initialized correctly.

In *Pre-Op* state mailbox communication is possible, but not process data communication. The EtherCAT master initializes the sync manager channels for process data (from sync manager channel 2), the FMMU channels and, if the slave supports configurable mapping, PDO mapping or the sync manager PDO assignment. In this state the settings for the process data transfer and perhaps terminal-specific parameters that may differ from the default settings are also transferred.

#### Safe-Operational (Safe-Op)

During transition between *Pre-Op* and *Safe-Op* the EtherCAT slave checks whether the sync manager channels for process data communication and, if required, the distributed clocks settings are correct. Before it acknowledges the change of state, the EtherCAT slave copies current input data into the associated DP-RAM areas of the EtherCAT slave controller (ECSC).

Mailbox and process data communication is possible in the *Safe-Op* state, but the slave keeps its outputs in the safe state. However, the input data are cyclically updated.

### **Operational (Op)**

Before the EtherCAT master switches the EtherCAT slave from *Safe-Op* to *Op* it must transfer valid output data.

In the *Op* state the slave copies the output data of the masters to its outputs. Process data and mailbox communication is possible.

### **Boot**

In the *Boot* state the slave firmware can be updated. The *Boot* state can only be reached via the *Init* state.

In the *Boot* state mailbox communication via the *file access over EtherCAT* (FoE) protocol is possible, but no other mailbox communication and no process data communication.

## 3.4 CoE interface

### General description

The CoE interface (CANopen over EtherCAT) is used for parameter management of EtherCAT devices. EtherCAT slaves or the EtherCAT master manage fixed (read only) or variable parameters which they require for operation, diagnostics or commissioning.

CoE parameters are arranged in a table hierarchy. In principle, the user has read access via the fieldbus. The EtherCAT master (TwinCAT System Manager) can access the local CoE lists of the slaves via EtherCAT in read or write mode, depending on the properties.

Different CoE parameter types are possible, including string (text), integer numbers, Boolean values or larger byte fields. They can be used to describe a wide range of features. Examples of such parameters include manufacturer ID, serial number, process data settings, device name, calibration values for analog measurement or passwords.

Organization takes place on 2 levels by means of hexadecimal numbering: the (main) index is named first, then the subindex. The value ranges are:

- Index 0 to 65535
- Subindex: 0...255

A parameter localized in this way is normally written as 0x8010:07, with preceding "0x" to identify the hexadecimal numerical range and a colon between index and subindex.

The relevant ranges for EtherCAT fieldbus users are:

- 0x1000: This is where fixed identity information for the device is stored, including name, manufacturer, serial number etc., plus information about the current and available process data configurations.
- 0x8000: This is where the operational and functional parameters for all channels are stored, such as filter settings or output frequency.

Other important ranges are:

- 0x4000: In some EtherCAT devices the channel parameters are stored here (as an alternative to the 0x8000 range).
- 0x6000: Input PDOs ("input" from the perspective of the EtherCAT master)
- 0x7000: Output PDOs ("output" from the perspective of the EtherCAT master)

---

### ● Availability



Not every EtherCAT device must have a CoE list. Simple I/O modules without dedicated processor usually have no variable parameters and therefore no CoE list.

---

If a device has a CoE list, it is shown in the TwinCAT System Manager as a separate tab with a listing of the elements:

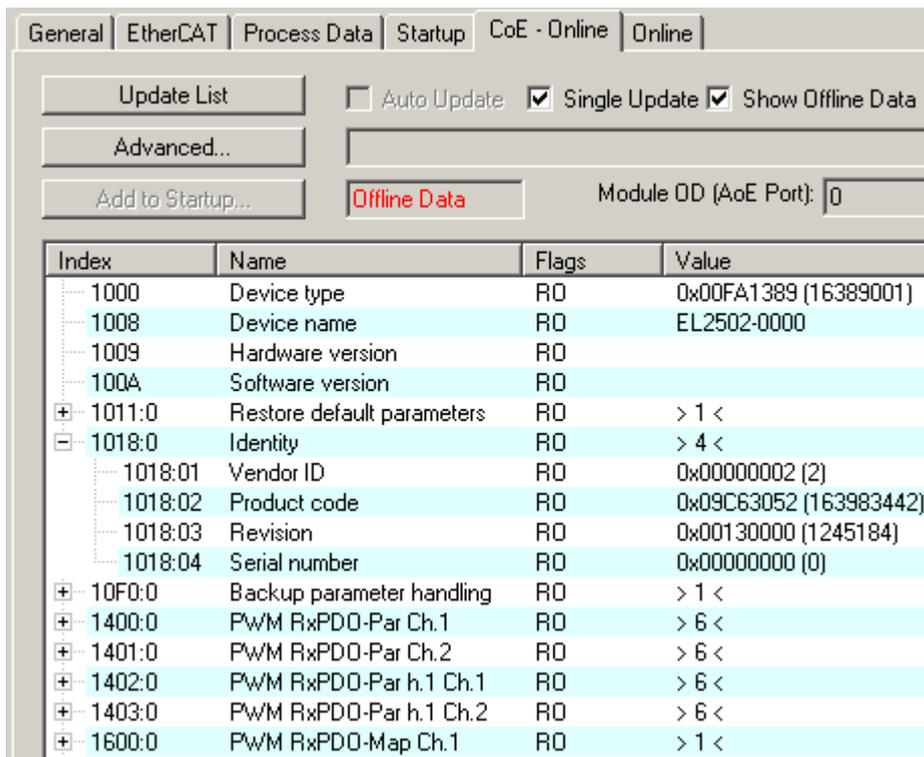


Fig. 10: CoE-Online tab

The CoE objects from 0x1000 to 0x1600, which are available in the example device "EL2502", can be seen in the above figure; the subindices from 0x1018 are expanded.

**Data management**

Some parameters, particularly the setting parameters of the slave, are configurable and writeable. This can be done in write or read mode

- via the System Manager (figure above) by clicking. This is useful for commissioning of the system/slaves. Click on the row of the index to be parameterized and enter a value in the *SetValue* dialog.
- from the control system/PLC via ADS, e.g. through function blocks from the TcEtherCAT.lib library This is recommended for modifications while the system is running or if no System Manager or operating staff are available.

**i Data management**

If CoE parameters on the slave are changed online, this is saved fail-safe in the device (EEPROM) in Beckhoff devices. This means that the changed CoE parameters are still retained after a restart. The situation may be different with other manufacturers.

**Startup list**

**i Startup list**

Changes in the local CoE list of the terminal are lost **if the terminal is replaced**. If a terminal is replaced with a new Beckhoff terminal, it will have the factory settings. It is therefore advisable to link all changes in the CoE list of an EtherCAT slave with the **Startup list** of the slave, which is processed whenever the EtherCAT fieldbus is started. In this way a replacement EtherCAT slave can automatically be parameterized with the specifications of the user.

If EtherCAT slaves are used which are unable to store local CoE values permanently, the Startup list must be used.

**Recommended approach for manual modification of CoE parameters**

- Make the required change in the System Manager. The values are stored locally in the EtherCAT slave

- If the value is to be stored permanently, enter it in the Startup list. The order of the Startup entries is usually irrelevant.

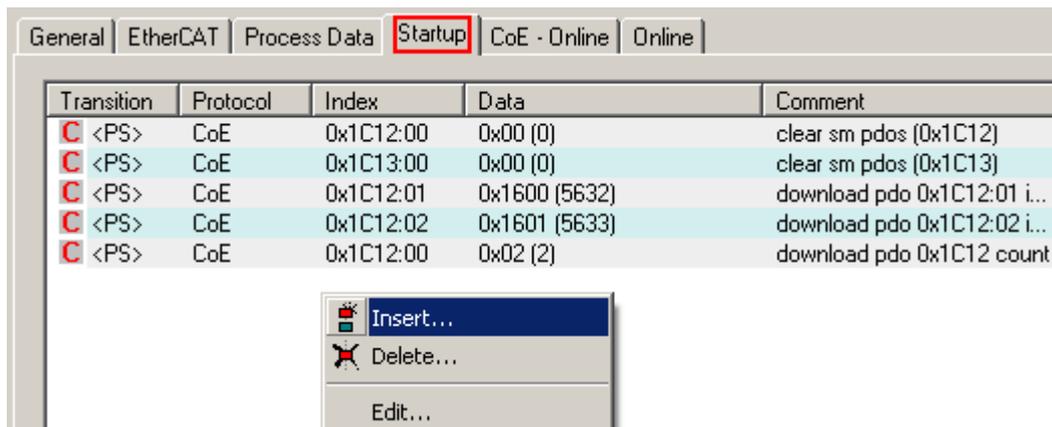


Fig. 11: Startup list in the TwinCAT System Manager

The Startup list may already contain values that were configured by the System Manager based on the ESI specifications. Additional application-specific entries can be created.

### Online/offline directory

While working with the TwinCAT System Manager, a distinction has to be made whether the EtherCAT device is "available", i.e. switched on and linked via EtherCAT and therefore **online**, or whether a configuration is created **offline** without connected slaves.

In both cases a CoE directory is visible according to the figure "CoE-Online tab", but the connectivity is displayed as offline/online.

- If the slave is offline
  - the offline list from the ESI file is displayed. In this case modifications are not meaningful or possible.
  - the configured status is shown under Identity
  - no firmware or hardware version is displayed, since these are features of the physical device.
  - Offline is shown in red

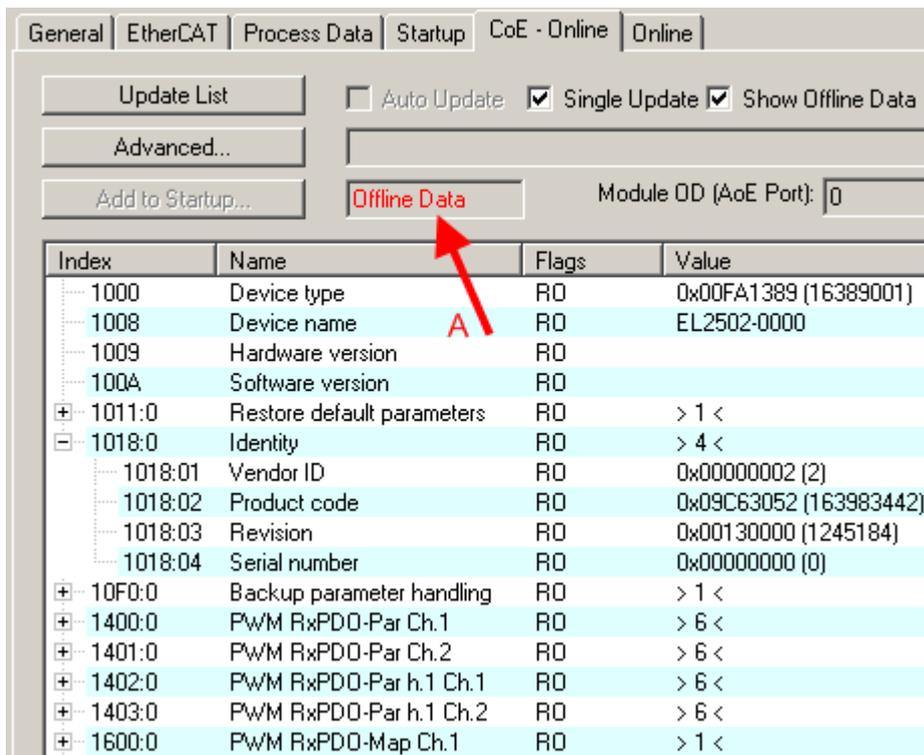


Fig. 12: Offline list

- If the slave is online
  - the actual current slave directory is read. This may take several seconds, depending on the size and cycle time.
  - the actual identity is displayed
  - the firmware and hardware version of the equipment according to the electronic information is displayed.
  - Online is shown in green

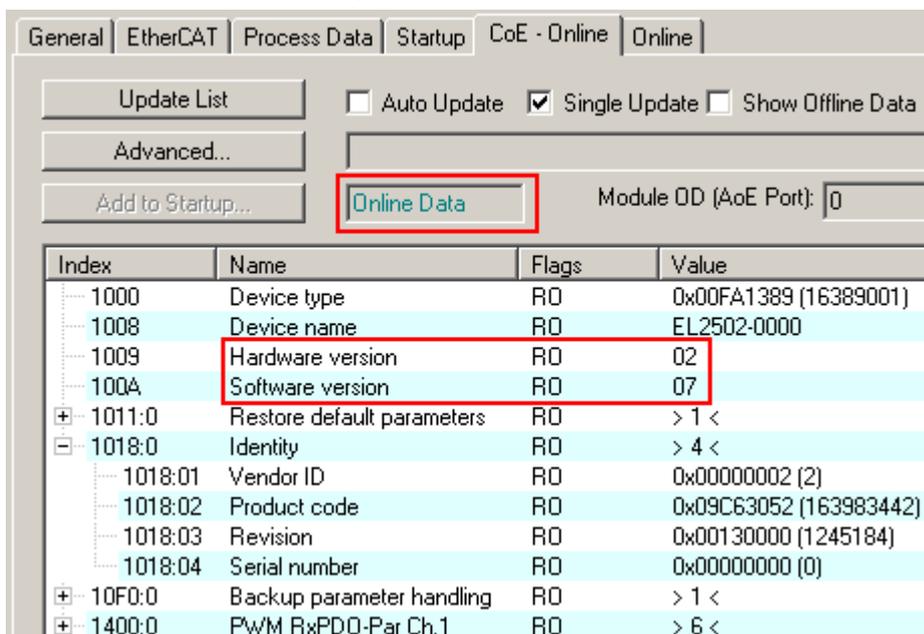


Fig. 13: Online list

### Channel-based order

The CoE directory is located in EtherCAT devices that usually encompass several functionally equivalent channels. e.g. a 4-channel 0 – 10 V analog input terminal also has 4 logical channels and thus 4 identical sets of parameter data for the channels. In order to avoid having to list each channel in the documentation, the placeholder "n" tends to be used for the individual channel numbers.

In the CoE system 16 indices, each with 255 subindices, are generally sufficient for representing all channel parameters. The channel-based order is therefore arranged in  $16_{\text{dec}}/10_{\text{hex}}$  steps. The parameter range 0x8000 exemplifies this:

- Channel 0: parameter range 0x8000:00 ... 0x800F:255
- Channel 1: parameter range 0x8010:00 ... 0x801F:255
- Channel 2: parameter range 0x8020:00 ... 0x802F:255
- ...

This is generally written as 0x80n0. Detailed information on the CoE interface can be found in the [EtherCAT system documentation](#) on the Beckhoff website.

## 3.5 Distributed Clock

The distributed clock represents a local clock in the EtherCAT slave controller (ESC) with the following characteristics:

- Unit 1 ns
- Zero point 1.1.2000 00:00
- Size 64 bit (sufficient for the next 584 years; however, some EtherCAT slaves only offer 32-bit support, i.e. the variable overflows after approx. 4.2 seconds)
- The EtherCAT master automatically synchronizes the local clock with the master clock in the EtherCAT bus with a precision of < 100 ns

For detailed information please refer to the [EtherCAT system description](#).

## 4 Mounting and Cabling

### 4.1 Mounting

#### 4.1.1 Dimensions

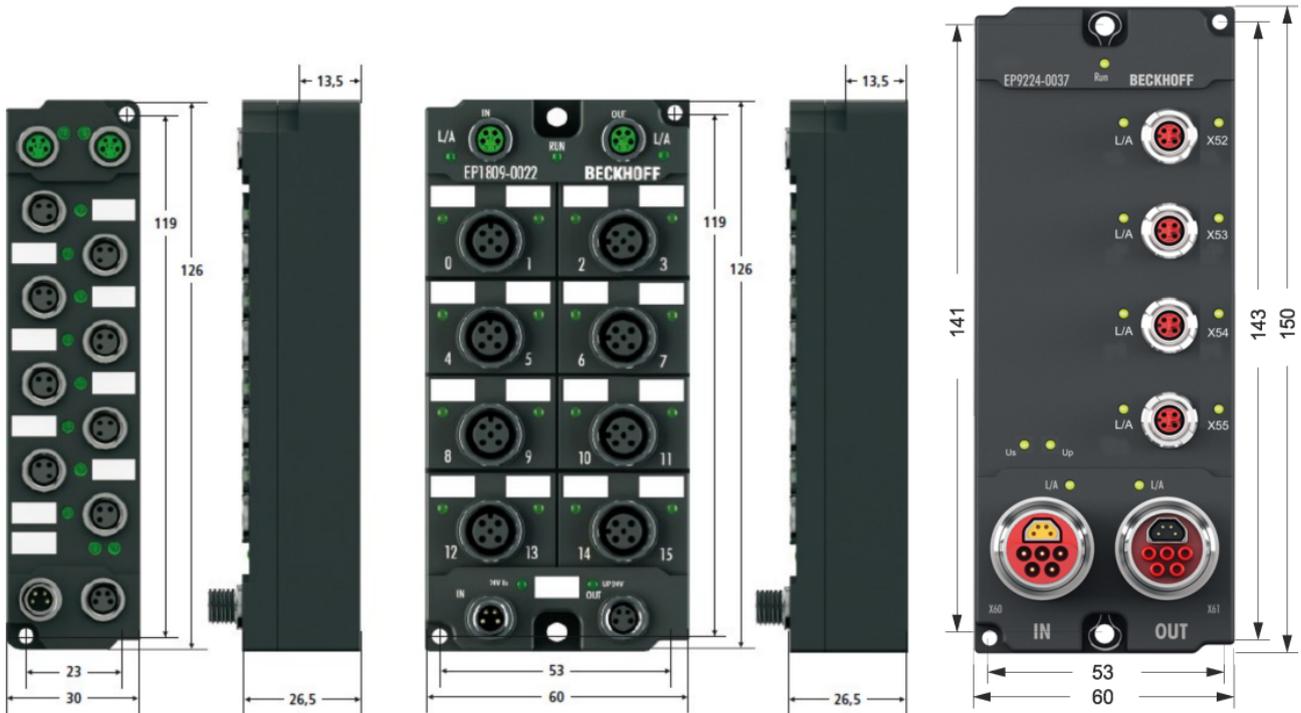


Fig. 14: Dimensions of the EtherCAT Box Modules

All dimensions are given in millimeters.

#### Housing properties

| EtherCAT Box           | lean body  | wide bodies  |
|------------------------|--|--|
| Housing material       | PA6 (polyamide)  |  |
| Casting compound       | Polyurethane   |  |
| Mounting               | two fastening holes Ø 3 mm for M3  | two fastening holes Ø 3 mm for M3<br>two fastening holes Ø 4.5 mm for M4 |
| Metal parts            | Brass, nickel-plated   |  |
| Contacts               | CuZn, gold-plated  |  |
| Power feed through     | max. 4 A (M8)<br>max. 16 A (7/8")<br>max. 15.5 A (B17 5G 1.5 mm <sup>2</sup> ) |  |
| Installation position  | variable   |  |
| Protection class       | IP65, IP66, IP67 (conforms to EN 60529) when screwed together                  |  |
| Dimensions (H x W x D) | app. 126 x 30 x 26.5 mm  | app. 126 x 60 x 26.5 mm<br>app. 150 x 60 x 26.5 mm (without 7/8", B17)   |

## 4.1.2 Fixing

### **Note or pointer**

**i** While mounting the modules, protect all connectors, especially the IP-Link, against contamination! Only with connected cables or plugs the protection class IP67 is guaranteed! Unused connectors have to be protected with the right plugs! See for plug sets in the catalogue.

Modules with narrow housing are mounted with two M3 bolts.

Modules with wide housing are mounted with two M3 bolts to the fixing holes located at the corners or mounted with two M4 bolts to the fixing holes located centrally.

The bolts must be longer than 15 mm. The fixing holes of the modules are not threaded.

When assembling, remember that the fieldbus connectors increases the overall height. See chapter accessories.

### **Mounting Rail ZS5300-0001**

The mounting rail ZS5300-0001 (500 mm x 129 mm) allows the time saving assembly of modules.

The rail is made of stainless steel, 1.5 mm thick, with already pre-made M3 threads for the modules. The rail has got 5.3 mm slots to mount it via M5 screws to the machine.

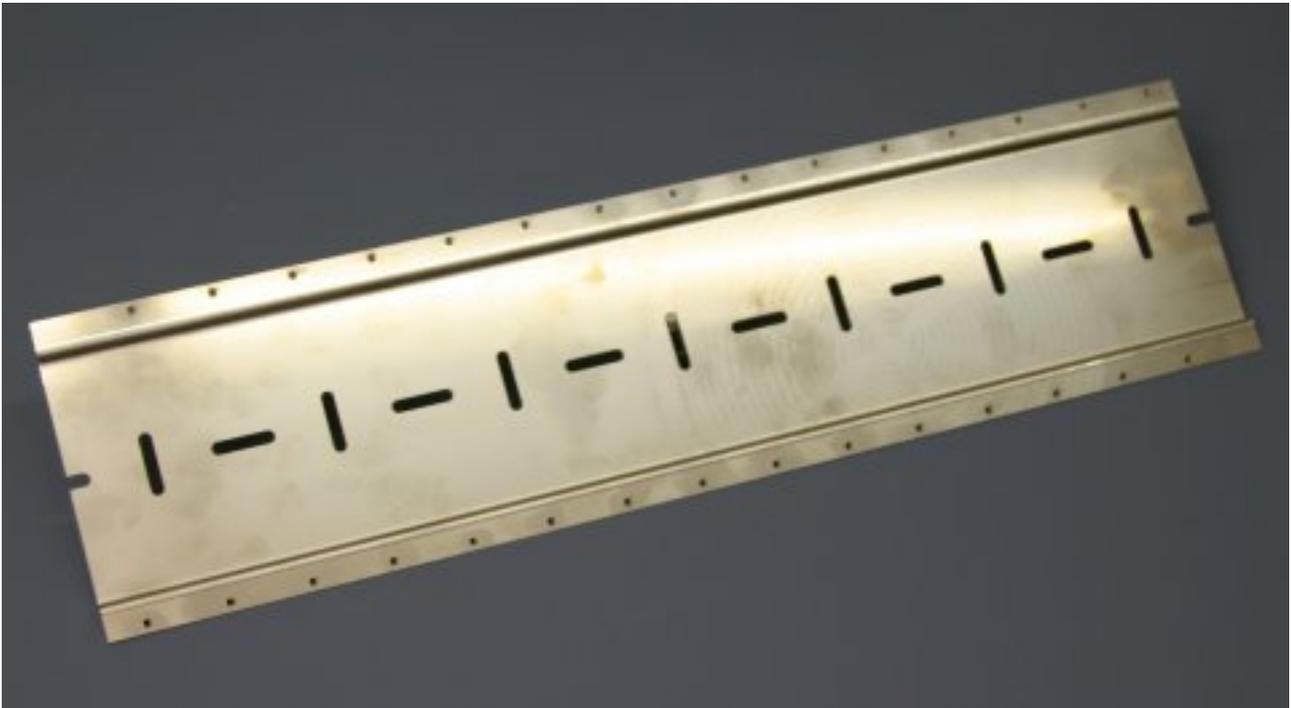


Fig. 15: Mounting Rail ZS5300-000

The mounting rail is 500 mm long, that way 15 narrow modules can be mounted with a distance of 2 mm between two modules. The rail can be cut to length for the application.

### **Mounting Rail ZS5300-0011**

The mounting rail ZS5300-0011 (500 mm x 129 mm) has in addition to the M3 threads also pre-made M4 threads to fix 60 mm wide modules via their middle holes.

Up to 14 narrow or 7 wide modules may be mixed mounted.

### 4.1.3 Nut torque for connectors

#### M8 connectors

It is recommended to pull the M8 connectors tight with a nut torque of **0.4 Nm**. When using the torque control screwdriver ZB8800 is also a max. torque of **0.5 Nm** permissible.

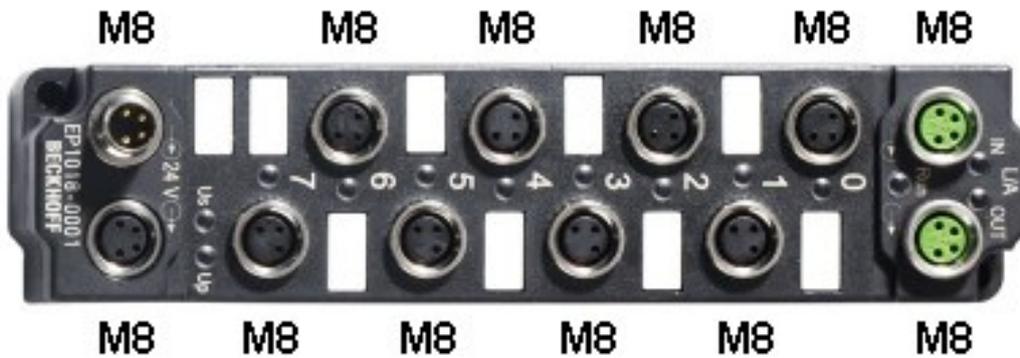


Fig. 16: EtherCAT Box with M8 connectors

#### M12 connectors

It is recommended to pull the M12 connectors tight with a nut torque of **0.6 Nm**.

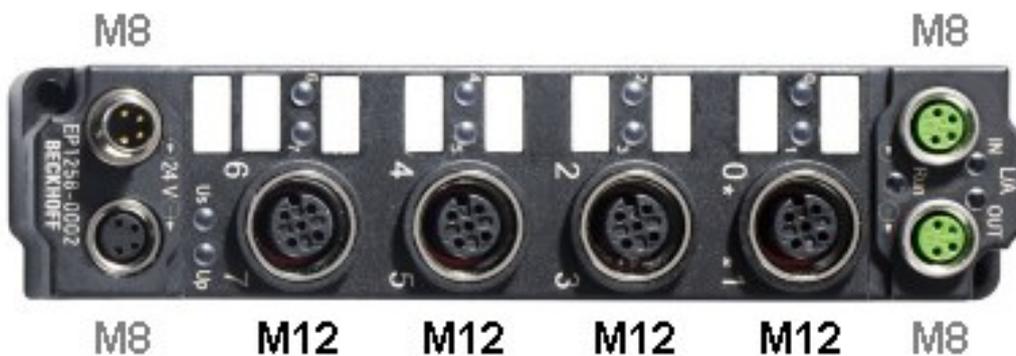


Fig. 17: EtherCAT Box with M8 and M12 connectors

**7/8" plug connectors**

We recommend fastening the 7/8" plug connectors with a torque of **1.5 Nm**.

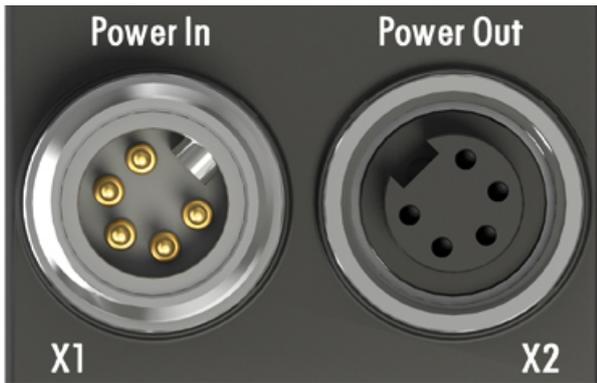


Fig. 18: 7/8" plug connectors

**Torque socket wrenches**



Fig. 19: ZB8801 torque socket wrench



**Ensure the right torque**

Use the torque socket wrenches available by Beckhoff to pull the connectors tight ([ZB8800](#), [ZB8801-0000](#))!

**4.1.4 Additional checks**

The boxes have undergone the following additional tests:

| Verification | Explanation   |
|--------------|---|
| Vibration    | 10 frequency runs in 3 axes                               |
|              | 5 Hz < f < 60 Hz displacement 0.35 mm, constant amplitude |
|              | 60.1 Hz < f < 500 Hz acceleration 5 g, constant amplitude |
| Shocks       | 1000 shocks in each direction, in 3 axes                  |
|              | 35 g, 11 ms   |

## 4.2 EtherCAT

### 4.2.1 EtherCAT connection

For the incoming and ongoing EtherCAT connection,

- the EtherCAT Box (EPxxxx) has two M8 sockets, marked in **green**
- the Coupler Box (FBB-x110) has two M12 sockets

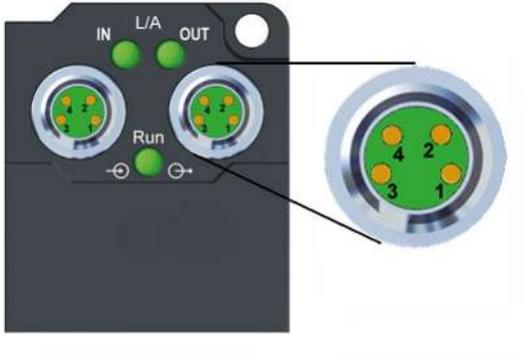


Fig. 20: EtherCAT Box: M8, 30 mm housing



Fig. 21: EtherCAT Box: M860 mm housing (example: EP9214)



Fig. 22: Coupler Box: M12

#### Assignment

There are various different standards for the assignment and colors of connectors and cables for Ethernet/ EtherCAT.

| Ethernet/EtherCAT |                | Plug connector |       |                   | Cable   |   | Standard     |
|-------------------|----------------|----------------|-------|-------------------|---|---|--------------|
| Signal            | Description    | M8             | M12   | RJ45 <sup>1</sup> | ZB9010, ZB9020, ZB9030, ZB9032, ZK1090-6292, ZK1090-3xxx-xxxx | ZB9031 and old versions of ZB9030, ZB9032, ZK1090-3xxx-xxxx | TIA-568B     |
| Tx +              | Transmit Data+ | Pin 1          | Pin 1 | Pin 1             | yellow <sup>2</sup>   | orange/white <sup>3</sup>                                   | white/orange |
| Tx -              | Transmit Data- | Pin 4          | Pin 3 | Pin 2             | orange <sup>2</sup>   | orange <sup>3</sup>   | orange       |
| Rx +              | Receive Data+  | Pin 2          | Pin 2 | Pin 3             | white <sup>2</sup>  | blue/white <sup>3</sup>                                     | white/green  |
| Rx -              | Receive Data-  | Pin 3          | Pin 4 | Pin 6             | blue <sup>2</sup>   | blue <sup>3</sup>   | green        |
| Shield            | Shield         | Housing        |       | Shroud            | Screen  | Screen  | Screen       |

<sup>1</sup>) colored markings according to EN 61918 in the four-pin RJ45 connector ZS1090-0003

<sup>2</sup>) wire colors according to EN 61918

<sup>3</sup>) wire colors

**i Assimilation of color coding for cable ZB9030, ZB9032 and ZK1090-3xxxx-xxxx (with M8 connectors)**

For unification the prevalent cables ZB9030, ZB9032 and ZK1090-3xxx-xxxx this means the pre assembled cables with M8 connectors were changed to the colors of EN61918 (yellow, orange, white, blue). So different color coding exists. But the electrical properties are absolutely identical.

**EtherCAT connector**

The following connectors can be supplied for use in Beckhoff EtherCAT systems.

| Name        | Connector         | Comment   |
|-------------|-------------------|---|
| ZS1090-0003 | RJ45              | four-pole, IP20, field-configurable                                 |
| ZS1090-0004 | M12, male         | four-pin, IP67, for field assembly                                  |
| ZS1090-0005 | RJ45              | eight-pole, IP20, field-configurable, suitable for gigabit Ethernet |
| ZS1090-0006 | M8 plug connector | four-pole, IP67, field-configurable, for cable type ZB903x          |
| ZS1090-0007 | M8 socket         | four-pole, IP67, field-configurable, for cable type ZB903x          |
| ZS1090-1006 | M8 plug connector | four-pole, IP67, field-configurable up to OD = 6.5 mm               |
| ZS1090-1007 | M8 socket         | four-pole, IP67, field-configurable up to OD = 6.5 mm               |

**4.2.2 EtherCAT - Fieldbus LEDs**



Fig. 23: EtherCAT-LEDs

**LED display**

| LED     | Display         | Meaning   |
|---------|-----------------|---|
| IN L/A  | off             | no connection to the preceding EtherCAT module        |
|         | Lit             | LINK: connection to the preceding EtherCAT module     |
|         | flashing        | ACT: Communication with the preceding EtherCAT module |
| OUT L/A | off             | no connection to the following EtherCAT module        |
|         | Lit             | LINK: connection to the following EtherCAT module     |
|         | flashing        | ACT: Communication with the following EtherCAT module |
| Run     | off             | Status of the EtherCAT module is Init                 |
|         | flashes quickly | Status of the EtherCAT module is pre-operational      |
|         | flashes slowly  | Status of the EtherCAT module is safe-operational     |
|         | Lit             | Status of the EtherCAT module is operational          |

**i EtherCAT statuses**

The various statuses in which an EtherCAT module may be found are described in the Basic System Documentation for EtherCAT, which is available for download from our website ([www.beckhoff.com](http://www.beckhoff.com)) under Downloads.

## 4.3 Power supply

### 4.3.1 Power Connection

The feeding and forwarding of supply voltages is done via two M8 connectors at the bottom end of the modules:

- IN: left M8 connector for feeding the supply voltages
- OUT: right M8 connector for forwarding the supply voltages

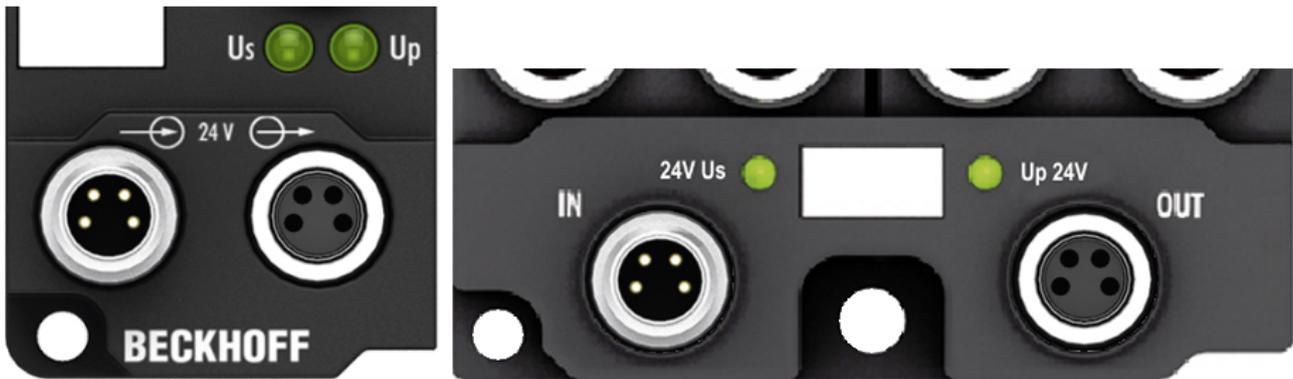


Fig. 24: EtherCAT Box, Connectors for power supply

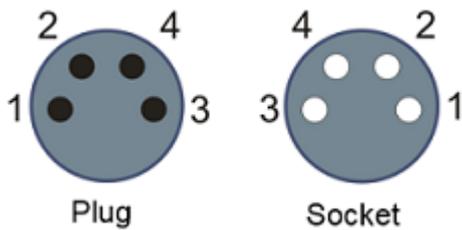


Fig. 25: Pin assignment M8, Power In and Power Out

Table 1: PIN assignment

| Pin | Voltage                                       |  |
|-----|---|--|
| 1   | Control voltage $U_s$ , +24 V <sub>DC</sub>   |  |
| 2   | Auxiliary voltage $U_p$ , +24 V <sub>DC</sub> |  |
| 3   | GNDs*   | *) may be connected internally to each other depending on the module: see specific module descriptions |
| 4   | GNDp*   |  |

The pins M8 connectors carry a maximum current of 4 A.

Two LEDs display the status of the supply voltages.

#### NOTE

#### **Don't confuse the power connectors with the EtherCAT connectors!**

Never connect the power cables (M8, 24 V<sub>DC</sub>) with the green marked EtherCAT sockets of the EtherCAT Box Modules! This can damage the modules!

#### **Control voltage $U_s$ : 24 V<sub>DC</sub>**

Power is supplied to the fieldbus, the processor logic, the inputs and the sensors from the 24 V<sub>DC</sub> control voltage  $U_s$ . The control voltage is electrically isolated from the fieldbus circuitry.

**Auxiliary voltage Up 24 V<sub>DC</sub>**

The Auxiliary voltage Up supplies the digital outputs; it can be brought in separately. If the load voltage is switched off, the fieldbus functions and the power supply and functionality of the inputs are retained.

**Redirection of the supply voltages**

The IN and OUT power connections are bridged in the module (not IP204x-Bxxx and IE204x). The supply voltages Us and Up can thus easily be transferred from EtherCAT Box to EtherCAT Box.

**NOTE****Pay attention to the maximum permissible current!**

Pay attention also for the redirection of the supply voltages Us and Up, the maximum permissible current for M8 connectors of 4 A must not be exceeded!

**Supply via EP92x4-0023 PowerBox modules**

If the machine requires higher current or if the EtherCAT Box Modules are installed far away from the control cabinet with included power supply, the usage of four channel power distribution modules EP9214 or EP9224 (with integrated data logging, see [www.beckhoff.com/EP9224](http://www.beckhoff.com/EP9224)) is recommended.

With these modules intelligent power distribution concepts with up to 2 x 16 A and a maximum of 2.5 mm<sup>2</sup> cable cross-section can be realized.

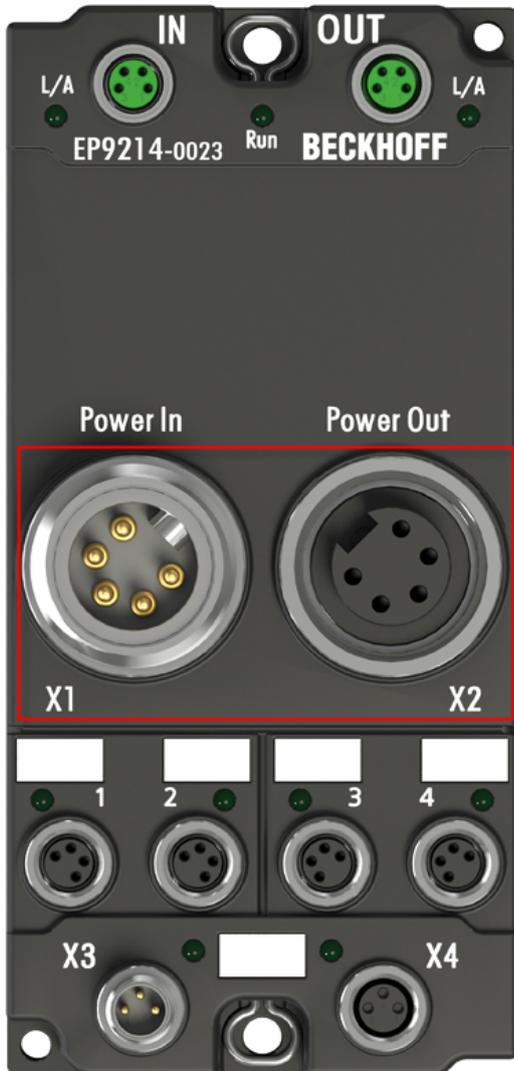


Fig. 26: EP92x4-0023, Connectors for Power In and Power Out

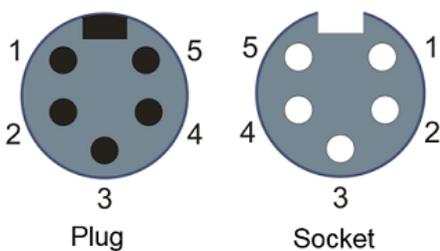


Fig. 27: Pin assignment 7/8", Power In and Power Out

**Electrical isolation**

**Digital modules**

In the digital input/output modules, the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are connected to each other!

Check this at the documentation of each used EtherCAT Box.

**Analog modules**

In the analog input/output modules the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are separated from each other in order to ensure electrical isolation of the analog signals from the control voltage.

In some of the analog modules the sensors or actuators are supplied by Up - this means, for instance, that in the case of 0...10 V inputs, any reference voltage (0...30 V) may be connected to Up; this is then available to the sensors (e.g. smoothed 10 V for measuring potentiometers).

Details of the power supply may be taken from the specific module descriptions.

| <b>NOTE</b>  |  |
|--|--|
| <b>Electrical isolation may be cancelled!</b>  |  |
| If digital and analog fieldbus boxes are connected directly via four-core power leads, the analog signals in the fieldbus boxes may be no longer electrically isolated from the control voltage! |  |

**4.3.2 Status LEDs for power supply**



Fig. 28: Status LEDs for power supply

**LED display**

| LED                    | Display           | Meaning  |
|------------------------|-------------------|--|
| Us (Control voltage)   | off               | The power supply voltage Us is not present   |
|                        | green illuminated | The power supply voltage Us is present   |
|                        | red illuminated   | Because of overload (current > 0.5 A) the sensor supply generated from power supply voltage Us was switched off for all sensors fed from this. |
| Up (Auxiliary voltage) | off               | The power supply voltage Up is not present   |
|                        | green illuminated | The power supply voltage Up is present   |

### 4.3.3 Power cable conductor losses M8

The ZK2020-xxxx-yyyy power cables should not exceed the total length of 15 m at 4 A (with continuation). When planning the cabling, note that at 24 V nominal voltage, the functionality of the module can no longer be assured if the voltage drop reaches 6 V. Variations in the output voltage from the power supply unit must also be taken into account.

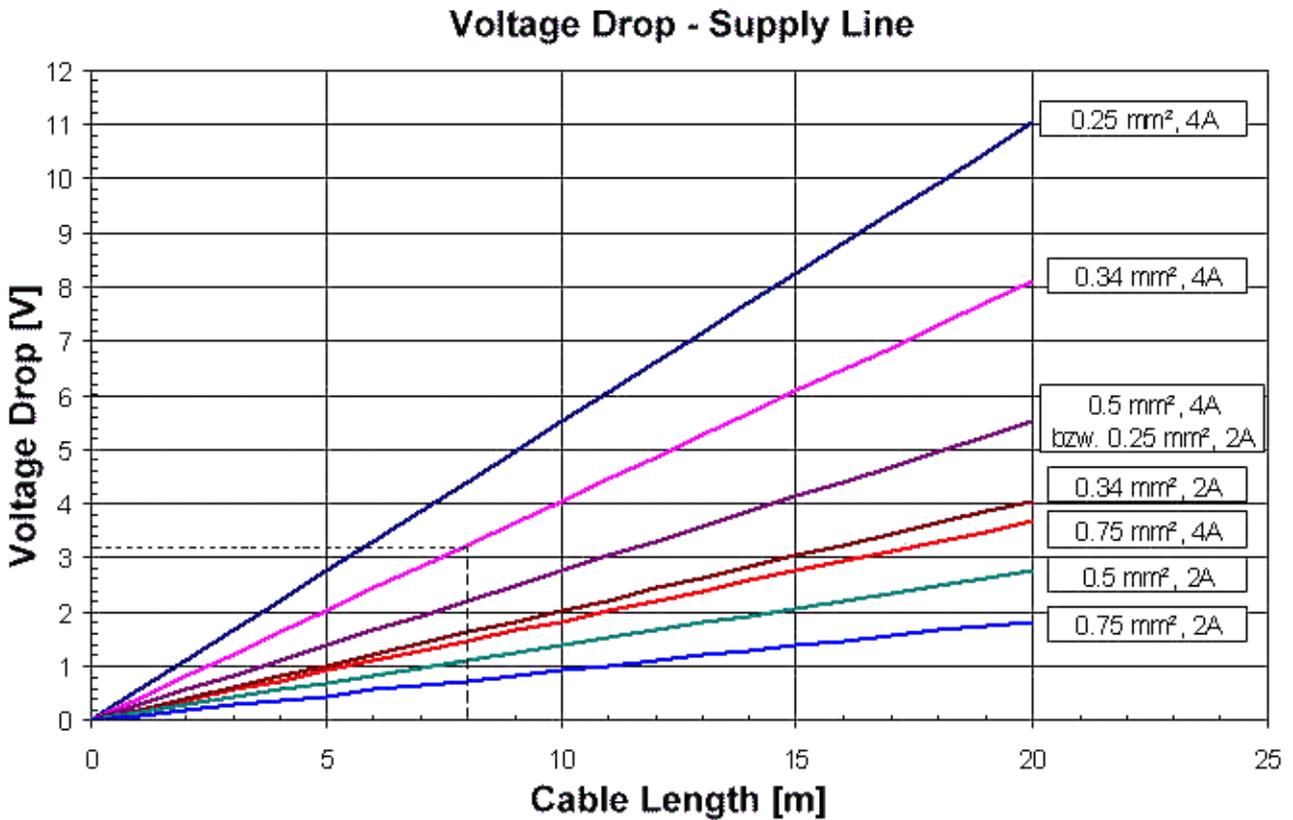


Fig. 29: Power cable conductor losses

#### Example

8 m power cable with 0.34 mm<sup>2</sup> cross-section has a voltage drop of 3.2 V at 4 A.

#### **i** EP92x4 Power Distribution Modules

With EP9214 and EP9224 Power Distribution Modules intelligent concepts for voltage supply are available. Further information may be found under [www.beckhoff.com/EP9224](http://www.beckhoff.com/EP9224).

### 4.3.4 Conductor losses 7/8"

In the case of the power cables ZK2030-xxxx-yyy, a total length of 15 m should not be exceeded at 16 A. When wiring, note that with a rated voltage of 24 V the function of the modules can no longer be guaranteed from a voltage drop of 6 V. Variations in the output voltage from the power supply unit must also be taken into account.

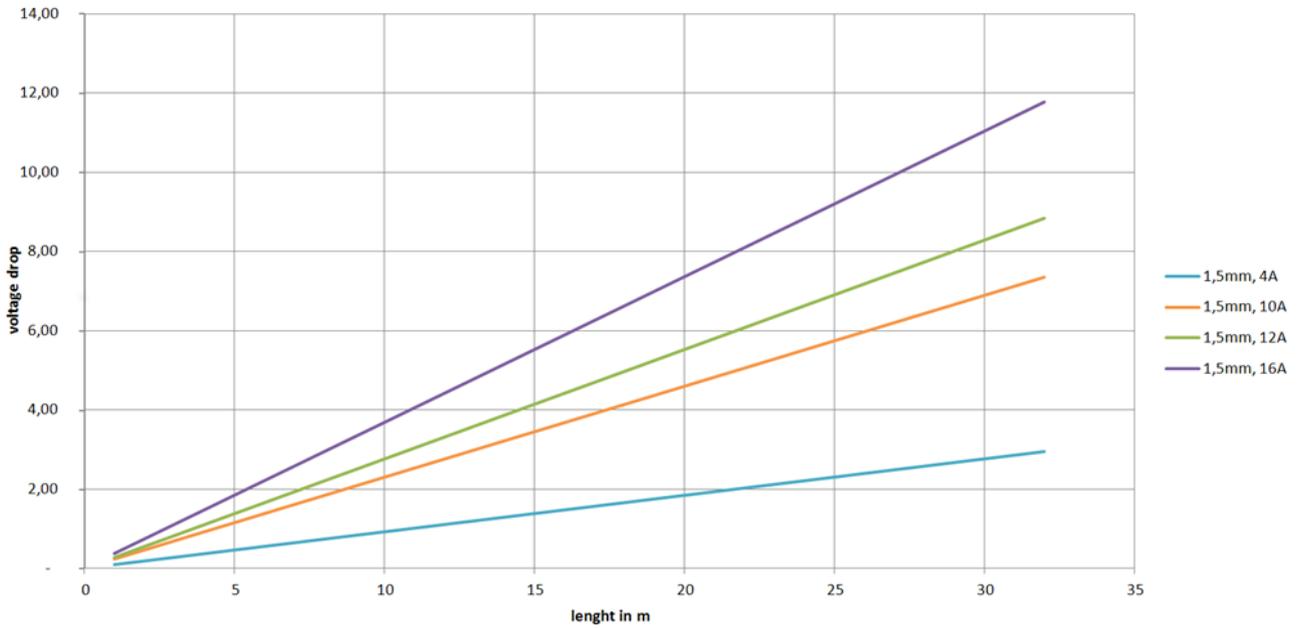


Fig. 30: ZK2030-xxxx-yyy - Conductor losses

Alternatively, larger cable cross-section can be used, e.g. 2.5 mm<sup>2</sup>.

## 4.4 Cabling

A list of EtherCAT cables, power cables, sensor cables, Ethernet/EtherCAT connectors and field-configurable connectors can be found under the following link: [https://beckhoff.de/english/fieldbus\\_box/ethercat\\_box\\_accessories\\_overview.htm?id=25525466903389](https://beckhoff.de/english/fieldbus_box/ethercat_box_accessories_overview.htm?id=25525466903389)

The corresponding data sheets can be found under the following link:

[https://beckhoff.de/english/ethercat-box/ethercat\\_box\\_cables.htm?id=690338951657421](https://beckhoff.de/english/ethercat-box/ethercat_box_cables.htm?id=690338951657421)

### EtherCAT cables



Fig. 31: ZK1090-3131-0xxx

For connecting EtherCAT devices, only use shielded Ethernet cables with a minimum specification of **category 5 (CAT5) according to EN 50173 or ISO/IEC 11801**.

#### ● Wiring recommendations

**i** Detailed recommendations for EtherCAT cabling can be found in the documentation "Design recommendations for EtherCAT/Ethernet infrastructure", which is available for download from [www.beckhoff.de](http://www.beckhoff.de).

EtherCAT uses four cable wires for signal transmission.

Due to automatic cable detection (auto-crossing) symmetric (1:1) or cross-over cables can be used between EtherCAT devices from Beckhoff.

**Power cable**

Fig. 32: ZK2020-3132-0xxx

**Sensor cables**

Fig. 33: Selection of Beckhoff sensor cables

## 4.5 UL Requirements

The installation of the EtherCAT Box Modules certified by UL has to meet the following requirements.

### Supply voltage

#### ⚠ CAUTION

##### CAUTION!

This UL requirements are valid for all supply voltages of all marked EtherCAT Box Modules!  
For the compliance of the UL requirements the EtherCAT Box Modules should only be supplied

- by a 24 V<sub>DC</sub> supply voltage, supplied by an isolating source and protected by means of a fuse (in accordance with UL248), rated maximum 4 Amp, or
- by a 24 V<sub>DC</sub> power source, that has to satisfy *NEC class 2*.  
A *NEC class 2* power supply shall not be connected in series or parallel with another (class 2) power source!

#### ⚠ CAUTION

##### CAUTION!

To meet the UL requirements, the EtherCAT Box Modules must not be connected to unlimited power sources!

### Networks

#### ⚠ CAUTION

##### CAUTION!

To meet the UL requirements, EtherCAT Box Modules must not be connected to telecommunication networks!

### Ambient temperature range

#### ⚠ CAUTION

##### CAUTION!

To meet the UL requirements, EtherCAT Box Modules has to be operated only at an ambient temperature range of 0 to 55°C!

### Marking for UL

All EtherCAT Box Modules certified by UL (Underwriters Laboratories) are marked with the following label.



Fig. 34: UL label

## 4.6 ATEX notes

### 4.6.1 ATEX - Special conditions

#### ⚠ WARNING

**Observe the special conditions for the intended use of EtherCAT Box modules in potentially explosive areas – directive 94/9/EU.**

- The certified components are to be installed in the BG2000-0000 protection enclosure [► 44] that guarantees a protection against mechanical hazards!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of 0 - 55°C for the use of EtherCAT Box modules in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

#### Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0: 2006
- EN 60079-15: 2005

#### Marking

The EtherCAT Box modules certified for potentially explosive areas bear the following marking:



II 3 G Ex nA II T4 DEKRA 11ATEX0080 X Ta: 0 - 55°C

or



II 3 G Ex nA nC IIC T4 DEKRA 11ATEX0080 X Ta: 0 - 55°C

#### Batch number (D number)

The EtherCAT Box modules bear a batch number (D number) that is structured as follows:

D: WW YY FF HH

WW - week of production (calendar week)

YY - year of production

FF - firmware version

HH - hardware version

Beispiel mit Ser. Nr.: 29 10 02 01:

29 - week of production 29

10 - year of production 2010

02 - firmware version 02

01 - hardware version 01

## 4.6.2 BG2000-0000 - EtherCAT Box protection enclosure

### ⚠ WARNING

#### Risk of electric shock and damage of device!

Bring the EtherCAT system into a safe, powered down state before starting installation, disassembly or wiring of the modules!

### ATEX

The BG2000-0000 protection enclosure has to be mounted over a single EtherCAT Box to fulfill the special conditions according to ATEX [▶ 43].

### Installation

Put the cables for EtherCAT, power supply and sensors/actuators through the hole of the BG2000-0000 protection enclosure.

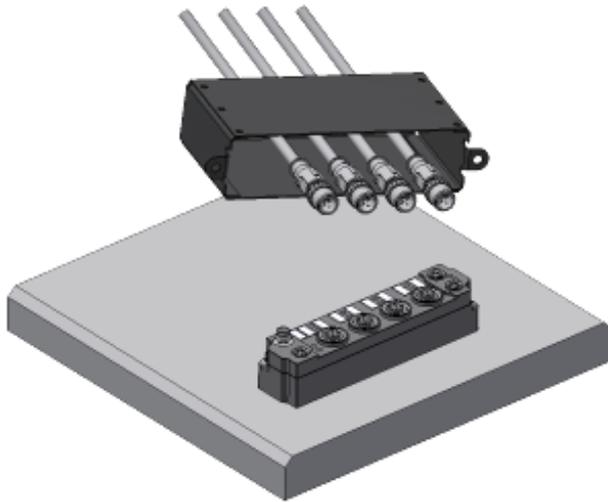


Fig. 35: BG2000-0000, putting the cables

Fix the wires for EtherCAT, power supply and sensors/actuators to the EtherCAT Box.

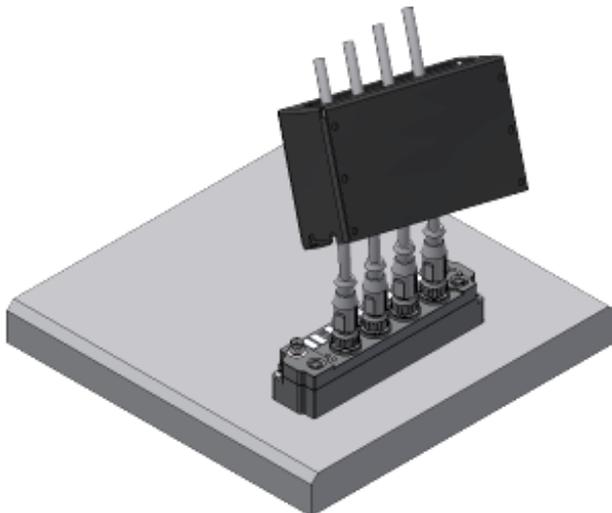


Fig. 36: BG2000-0000, fixing the cables

Mount the BG2000-0000 protection enclosure over the EtherCAT Box.

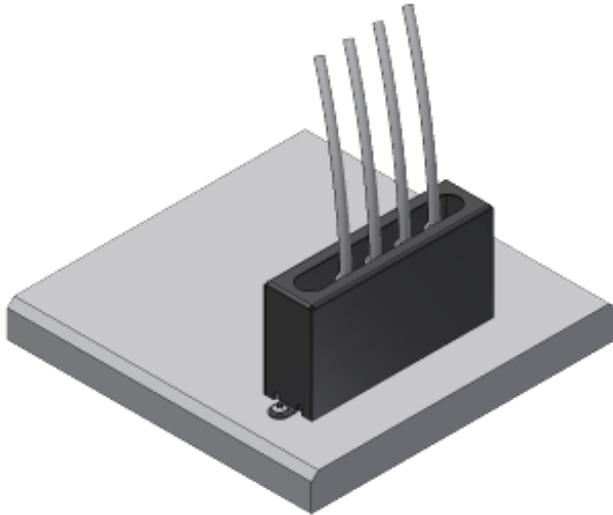


Fig. 37: BG2000-0000, mounting the protection enclosure

### 4.6.3 ATEX Documentation



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#### Notes about operation of EtherCAT Box Modules (EPxxxx-xxxx) in potentially explosive areas (ATEX)

Pay also attention to the continuative documentation Notes about operation of EtherCAT Box Modules (EPxxxx-xxxx) in potentially explosive areas (ATEX) that is available in the download area of the Beckhoff homepage <http://www.beckhoff.com>!

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## 5 EP3356-0022 - Signal connection

### 5.1 Analog voltage inputs M12 and meaning of the LEDs

#### 1-channel precise load cell analysis

The analog input enables direct connection of a resistor bridge or load cell in a 4-wire connection technology.

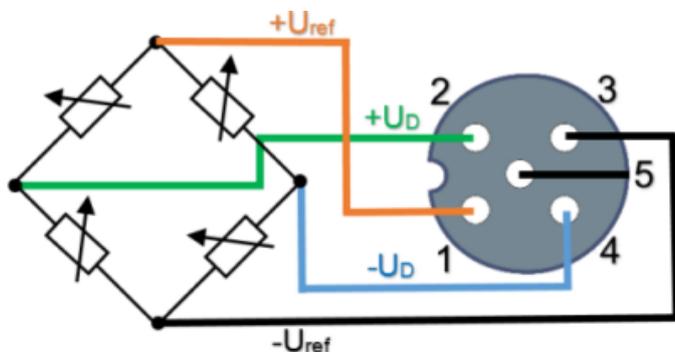


Fig. 38: Analog voltage input M12, resistor bridge

The shield must be connected to pin 5 of the M12 connector.

You can find an example for the parallel connection of strain gauges [here](#) [► 15].

The voltage  $U_{ref}$  is 10 V and is supplied by the EP3356-0022.



#### Do not earth the cable screen of the sensor on the sensor side

If a shielded sensor cable is used, it should be not grounded on the sensor side. Otherwise it may come in certain system configurations to error of measurement.

Meanings of the LEDs



Fig. 39: LEDs EP3356-0022

| LED          | Color | Meaning   |   |
|--------------|-------|---|---|
| RUN          | green | This LED indicates the terminals/boxes operating state: |   |
|              |       | off   | State of the EtherCAT State Machine [▶ 60]: <b>INT</b> = Initialization of the terminal/box   |
|              |       | blinking  | State of the EtherCAT State Machine: <b>PREOP</b> = Setting for mailbox communication and variant standard settings   |
|              |       | single flash  | State of the EtherCAT State Machine: <b>SAFEOP</b> = Channel checking of the Sync Manager [▶ 60] and the Distributed Clocks: Outputs stay in safe operation mode.   |
|              |       | on  | State of the EtherCAT State Machine: <b>OP</b> = Normal operation mode, mailbox- and process data communication possible  |
|              |       | flickering  | State of the EtherCAT State Machine: <b>BOOTSTRAP</b> = mode for firmware updates of the terminal/box   |
| Measure      | green | on  | Measuring active (valid process data)   |
|              |       | off   | <ul style="list-style-type: none"> <li>• Calibration active (if LED self calibration is lit) or</li> <li>• Testing active (if LED self test is lit)</li> <li>• filters are initialized</li> </ul>   |
| Steady state | green | on  | The measuring value is steady   |
|              |       | off   | The measuring value is not steady   |
| Self Calibr. | green | on  | <ul style="list-style-type: none"> <li>• Calibration active</li> <li>• Process data are not valid</li> </ul>  |
| Self Test    | green | on  | <ul style="list-style-type: none"> <li>• Self test active</li> <li>• Process data are not valid</li> </ul>  |
| Error Dif    | red   | on  | <ul style="list-style-type: none"> <li>• Channel 1 (strain gauge differential signal) is out of valid value range</li> <li>• Internal reference voltage of channel 1 is not present</li> </ul>  |
| Error Ref    | red   | on  | <ul style="list-style-type: none"> <li>• Channel 2 (strain gauge differential signal) is out of valid value range</li> <li>• Internal reference voltage of channel 2 is not present</li> <li>• Reference voltage too low (between -1 V and +1 V)</li> </ul> |

## 6 Commissioning/Configuration

### 6.1 TwinCAT configuration setup, manual

This part of the documentation describes the manual configuration of an EtherCAT Box in TwinCAT.

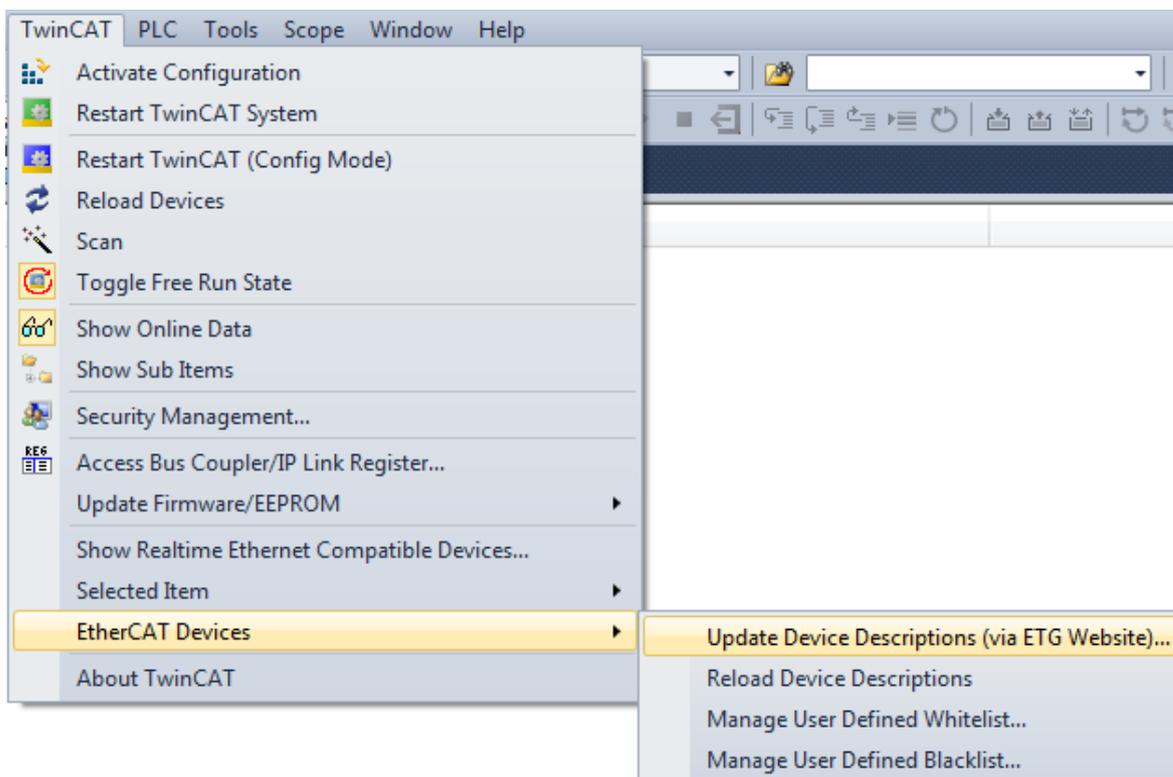
#### Distinction between Online and Offline

The distinction between online and offline refers to the existence of the actual I/O environment (drives, terminals). If the configuration is to be prepared in advance of the system configuration as a programming system, e.g. on a laptop, this is only possible in "Offline configuration" mode. In this case all components have to be entered manually in the configuration, e.g. based on the electrical design (as described below under TwinCAT configuration setup, manual). If the designed control system is already connected to the EtherCAT system and all components are energized and the infrastructure is ready for operation, the TwinCAT configuration can simply be generated through "scanning" from the runtime system. This is referred to as online configuration. In any case, during each startup the EtherCAT master checks whether the devices it finds match the configuration. This test can be parameterized in the advanced device settings.

To ensure that the latest features/settings of the master can be used, always download the latest ESI file. Please note the following information.

#### **i** Installation of the latest ESI-XML device description

The TwinCAT System Manager needs the device description files for the devices to be used in order to generate the configuration in online or offline mode. The device descriptions are contained in the so-called ESI files (EtherCAT Slave Information) in XML format. These files can be requested from the respective manufacturer and are made available for download. The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website (<https://www.beckhoff.de/english/download/elconfg.htm?id=1983920606140>). The ESI files should be stored in the TwinCAT installation directory (default: C:\TwinCAT\IO\EtherCAT). The files are read (once) when a new System Manager window is opened. A TwinCAT installation includes the Beckhoff ESI files that were current at the time when the TwinCAT build was created. From TwinCAT 2.11 and in TwinCAT 3 the ESI directory can be updated from the System Manager, if the programming PC is connected to the internet (TwinCAT → EtherCAT Devices → Update Device Description...)



**Adding a module manually**

- The EtherCAT system must be in a safe, de-energized state before you connect the EtherCAT modules to the EtherCAT network.
- Switch on the operating voltage, open the TwinCAT System Manager [▶ 59] (Config mode)
- Adding a new I/O device. In the following dialog select the device: *EtherCAT (Direct Mode)*, and confirm with OK.

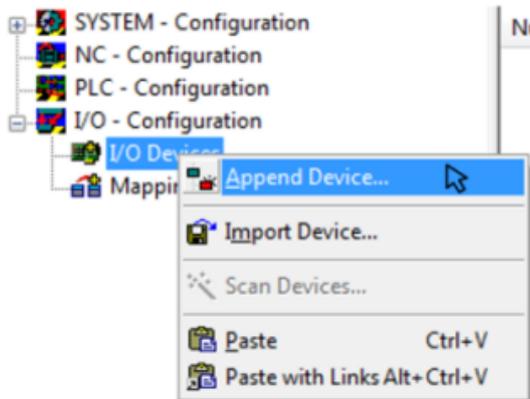


Fig. 40: Appending a new I/O device (I/O Devices-> right-click -> Append Device...)

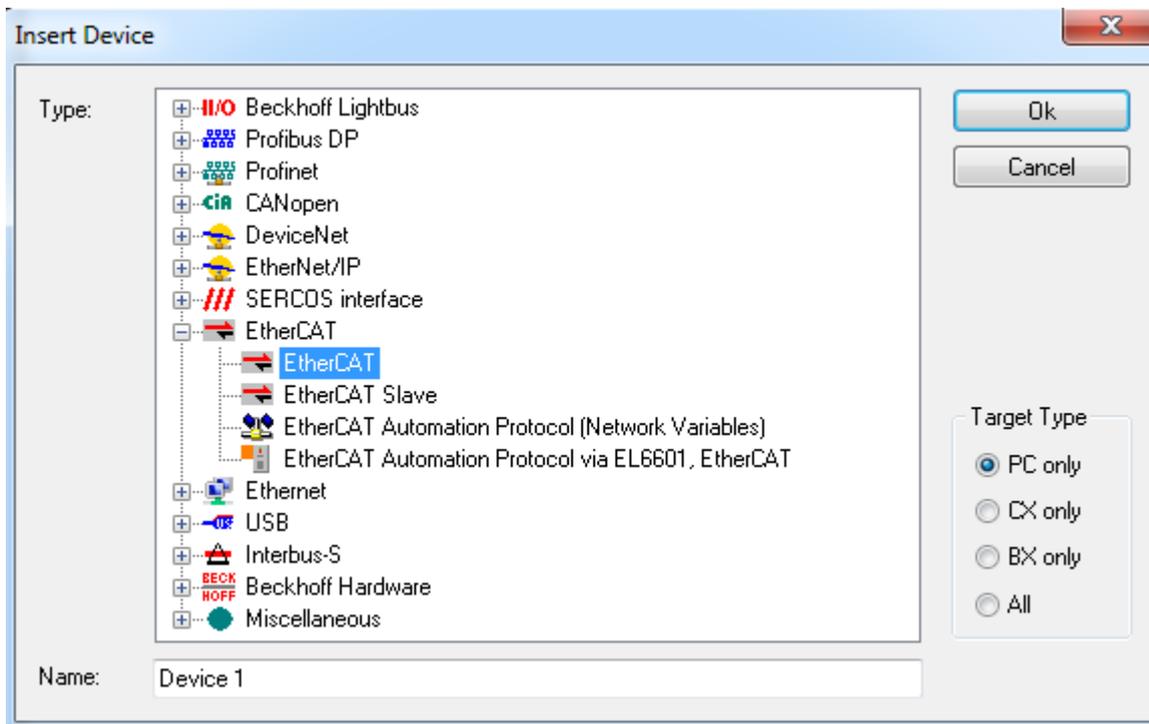


Fig. 41: Selecting the device (EtherCAT)

- Adding a new Box.

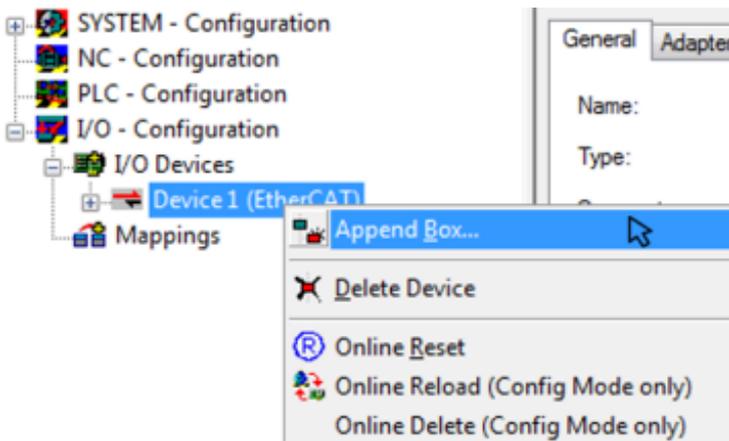


Fig. 42: Appending a new box (Device -> right-click -> Append Box... )

- In the dialog that is displayed select the required Box (e.g. EP6224-2022) and confirm with OK.

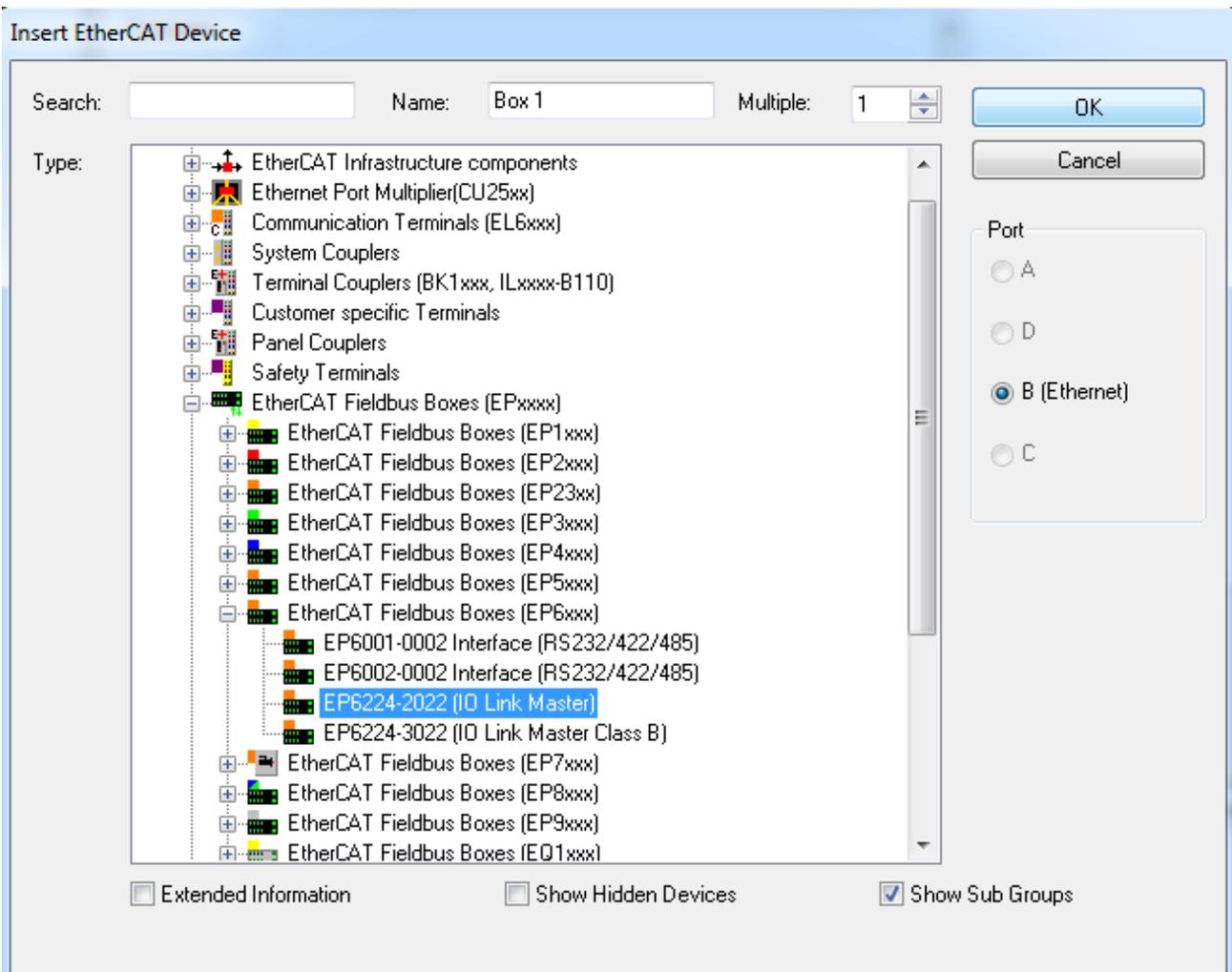


Fig. 43: Selecting a Box (e.g. EP6224-2022)

## 6.2 Configuration setup: TwinCAT - online scan

This part of the documentation describes the configuration of a physically existing EtherCAT Box in TwinCAT.

### Online configuration setup „Scanning“ (TwinCAT 3.x)

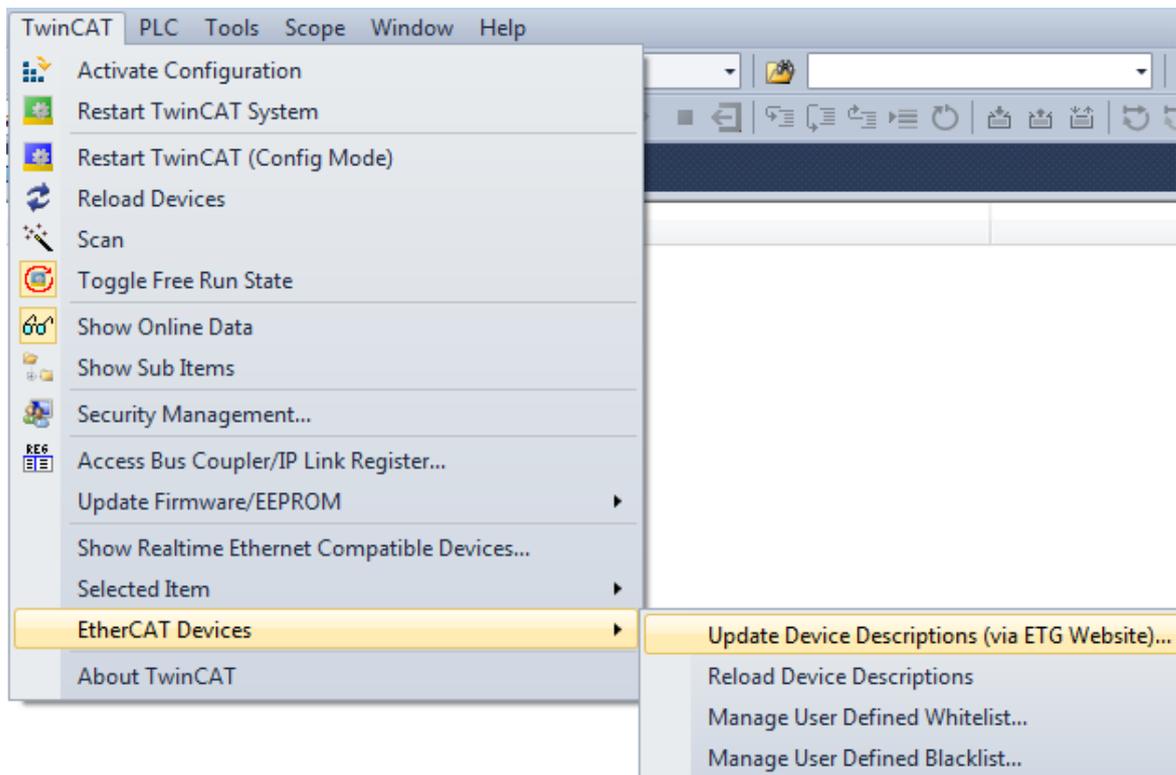
#### Distinction between Online and Offline

The distinction between online and offline refers to the existence of the actual I/O environment (drives, terminals). If the configuration is to be prepared in advance of the system configuration as a programming system, e.g. on a laptop, this is only possible in “Offline configuration” mode. In this case all components have to be entered manually in the configuration, e.g. based on the electrical design (as described under TwinCAT configuration setup, manual). If the designed control system is already connected to the EtherCAT system and all components are energized and the infrastructure is ready for operation, the TwinCAT configuration can simply be generated through “scanning” from the runtime system. This is referred to as online configuration. In any case, during each startup the EtherCAT Box checks whether the devices it finds match the configuration.

To ensure that the latest features/settings of the EtherCAT Box can be used, always download the latest ESI file. Please note the following information.

#### **i** Installation of the latest ESI-XML device description

The TwinCAT System Manager needs the device description files for the devices to be used in order to generate the configuration in online or offline mode. The device descriptions are contained in the so-called ESI files (EtherCAT Slave Information) in XML format. These files can be requested from the respective manufacturer and are made available for download. The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website (<https://www.beckhoff.de/english/download/elconfig.htm?id=1983920606140>). The ESI files should be stored in the TwinCAT installation directory (default: C:\TwinCAT\IO\EtherCAT). The files are read (once) when a new System Manager window is opened. A TwinCAT installation includes the Beckhoff ESI files that were current at the time when the TwinCAT build was created. From TwinCAT 2.11 and in TwinCAT 3 the ESI directory can be updated from the System Manager, if the programming PC is connected to the internet (TwinCAT → EtherCAT Devices → Update Device Description)



The following conditions must be met before a configuration can be set up

- The actual EtherCAT and IO-Link hardware (devices, couplers, drives) must be present and installed.
- The devices/modules must be connected via an EtherCAT cables or an IO-Link cable in the same way as they are intended to be used later.
- The devices/modules must be connected to the power supply and ready for communication.
- TwinCAT must be in CONFIG mode on the target system.

The online scan process consists of:

- Detecting the EtherCAT device (Ethernet port at the IPC)
- Detecting the connected EtherCAT devices: This step can be performed independent of the previous step.
- Troubleshooting

The scan with existing configuration can also be carried out for comparison.

### Detecting/scanning of the EtherCAT device

The online device search can be used if the TwinCAT system is in Config mode (blue TwinCAT icon or blue indication in the System Manager).

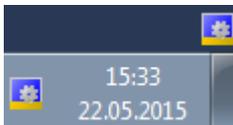


Fig. 44: TwinCAT Config mode display

#### ● Online scanning in Config mode

**i**

The online search is not available in RUN mode (production operation).

Note the differentiation between TwinCAT programming system and TwinCAT target system. The TwinCAT icon next to the Windows clock always shows the TwinCAT mode of the local IPC. The System Manager window shows the TwinCAT state of the target system.



Right-clicking on "I/O Devices" in the configuration tree opens the search dialog.

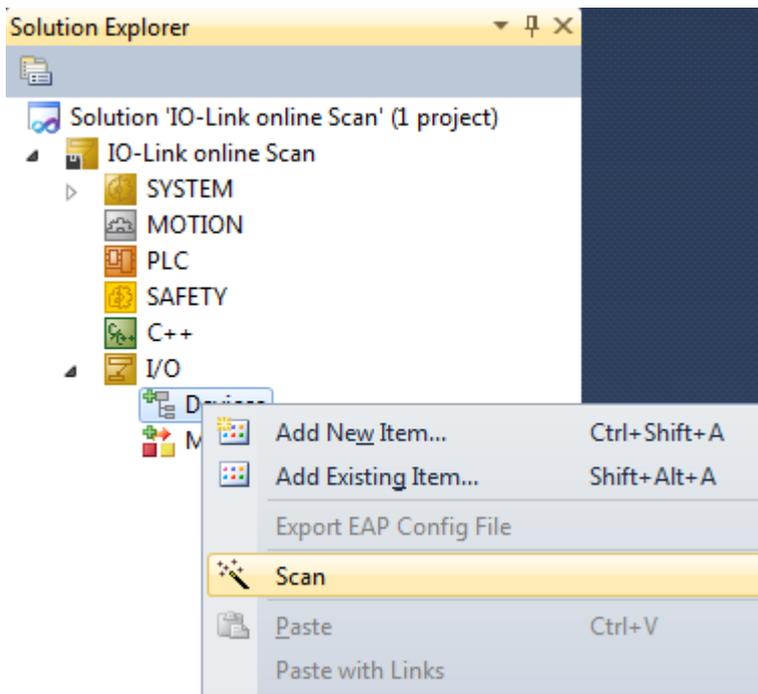


Fig. 45: Scan Devices

This scan mode not only tries to find EtherCAT devices (or Ethernet ports that can be used as such), but also NOVRAM, fieldbus cards, SMB etc. Not all devices can be found automatically.

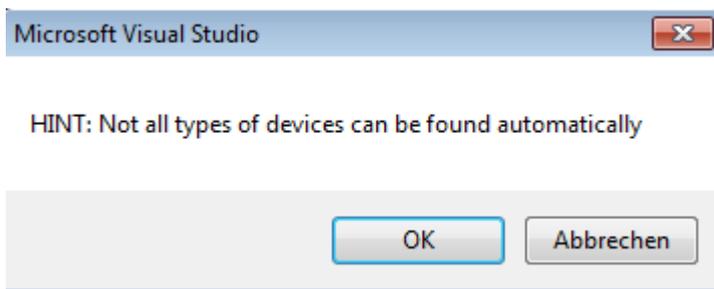


Fig. 46: Note for automatic device scan

Ethernet ports with installed TwinCAT real-time driver are shown as “RT Ethernet” devices. An EtherCAT frame is sent to these ports for testing purposes. If the scan agent detects from the response that an EtherCAT device is connected, the port is immediately shown as an “EtherCAT Device”.

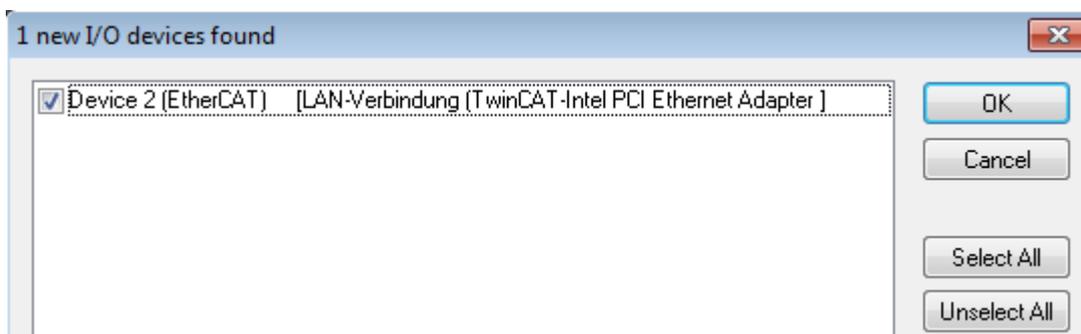


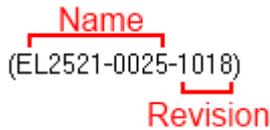
Fig. 47: detected Ethernet devices

After confirmation with “OK” a device scan is suggested for all selected devices (see the illustration below).

**Detecting/Scanning the EtherCAT devices**

**Online scan functionality**

**i** During a scan the master queries the identity information of the EtherCAT device from the device EEPROM. The name and revision are used for determining the type. The respective devices are located in the stored ESI data and integrated in the configuration tree in the default state defined there.



If an EtherCAT device was created in the configuration (manually or through a scan), the I/O field can be scanned for devices/slaves.

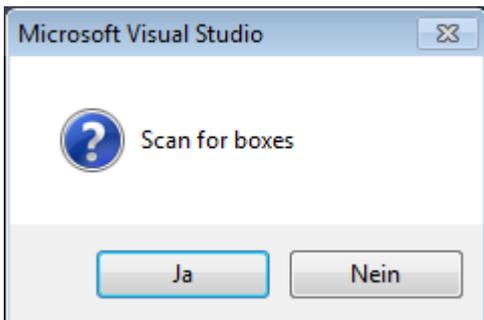


Fig. 48: scan query after automatic creation of an EtherCAT device

The configuration was established and switched directly to the online state (operational). The EtherCAT system should be in a cyclic operational state, as shown in the following illustration.

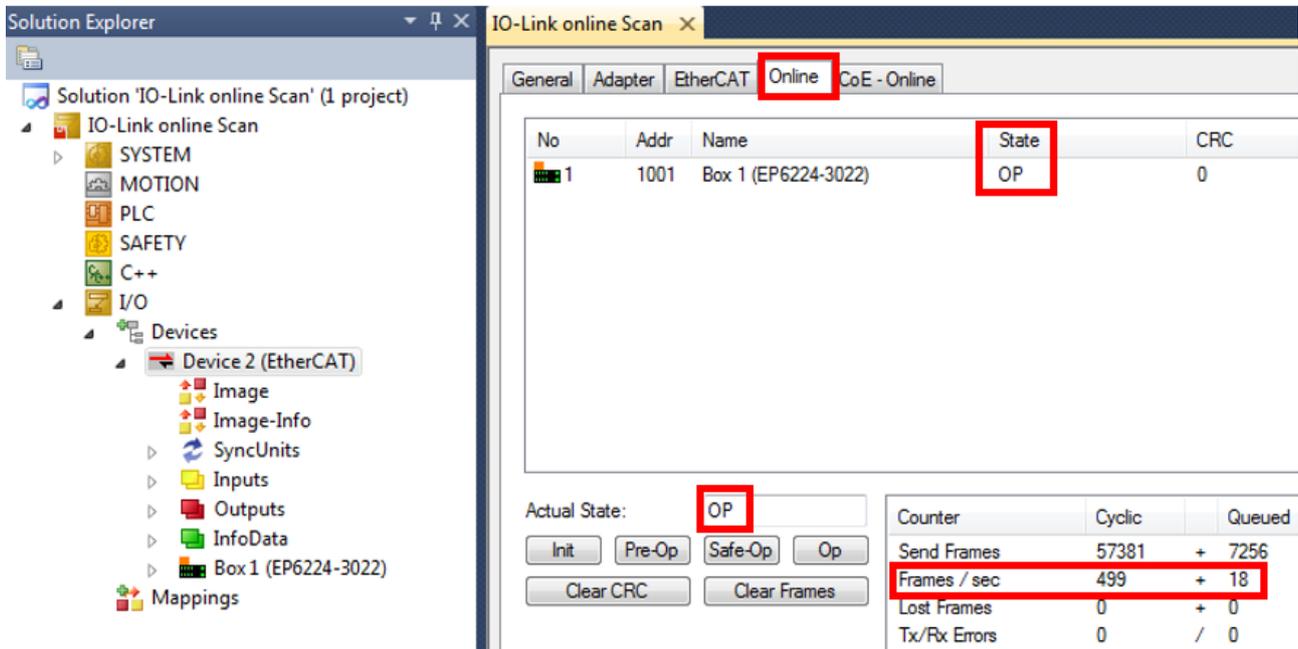


Fig. 49: online display example

Please note:

- All Boxes should be in OP state
- “frames/sec” should match the cycle time taking into account the sent number of frames
- no excessive “LostFrames” or CRC errors should occur

The configuration is now complete. It can be modified as described under manual procedure.

The connected EtherCAT Box (EP6224-3022) is displayed in the TwinCAT tree, as shown in the following illustration.

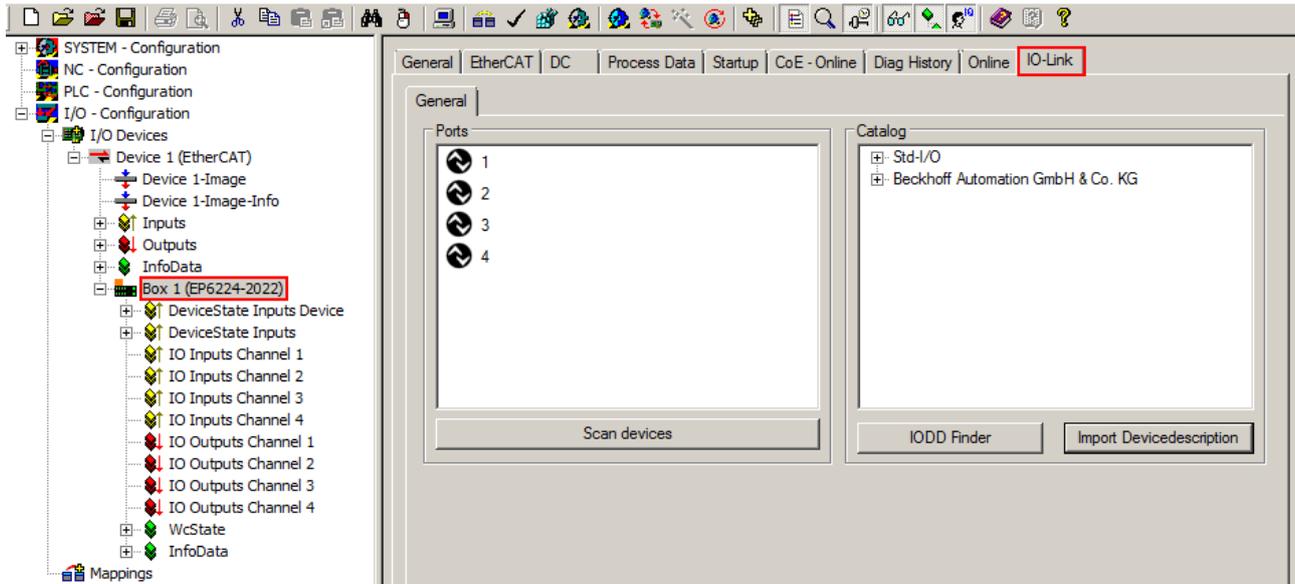


Fig. 50: Master display after “Scan for boxes”

**Troubleshooting**

Various effects may occur during scanning.

- An **unknown device** is detected, i.e. an EtherCAT device for which no ESI XML description is available.  
In this case the System Manager offers to read any ESI that may be stored in the device.
- **Device are not detected properly**  
Possible reasons include
  - faulty data links, resulting in data loss during the scan
  - the device has an invalid device description
 The connections and devices should be checked in a targeted manner, e.g. via the emergency scan. Then re-run the scan.

**Scan over existing Configuration**

If a scan is initiated for an existing configuration, the actual I/O environment may match the configuration exactly or it may differ. This enables the configuration to be compared.

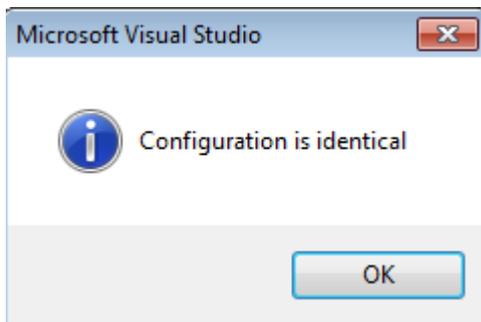


Fig. 51: Identical configuration

If differences are detected, they are shown in the correction dialog, so that the user can modify the configuration as required.

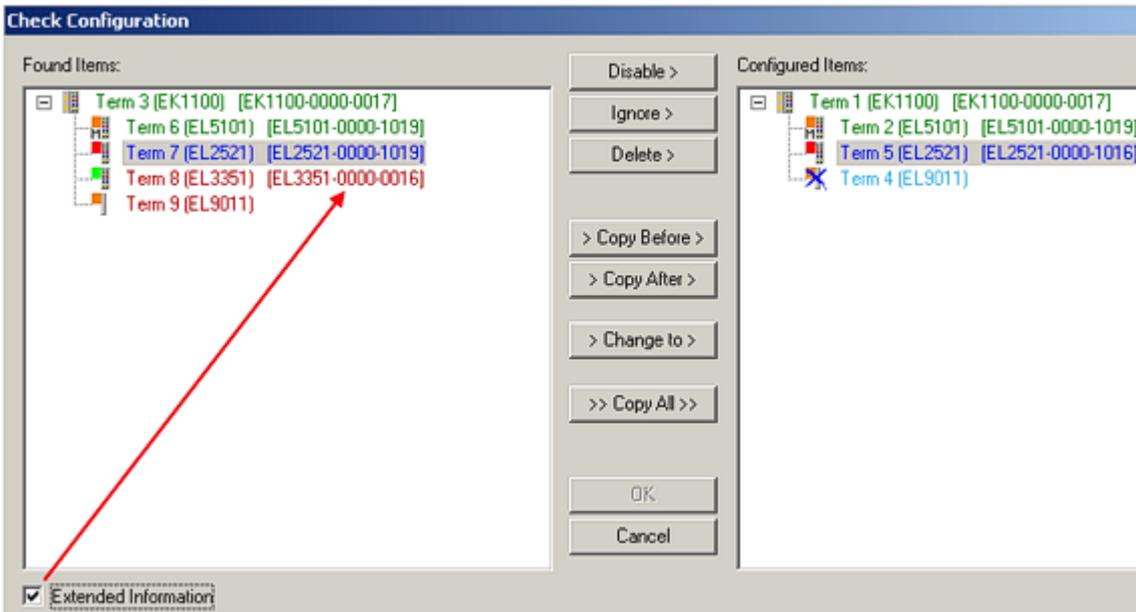


Fig. 52: Example correction dialog

It is recommended to check the „Extended Information“ box, in order to show differences in the revision.

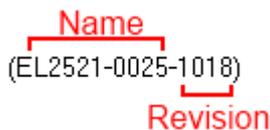
| Color      | Explanation   |
|------------|---|
| green      | This EtherCAT device matches the entry on the other side. Both type and revision match.   |
| blue       | This EtherCAT device is present on the other side, but in a different revision.<br>If the found revision is higher than the configured revision, the slave may be used provided compatibility issues are taken into account.<br><br>If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found devices may not support all functions that the master expects based on the higher revision number. |
| light blue | This EtherCAT device is ignored ("Ignore" button)   |
| red        | This EtherCAT device is not present on the other side.  |

**i Device selection based on revision, compatibility**

The ESI description also defines the process image, the communication type between master and device and the device functions, if applicable. The physical device (firmware, if available) has to support the communication queries/settings of the master. This is backward compatible, i.e. newer devices (higher revision) should be supported if the EtherCAT master addresses them as an older revision. The following compatibility rule of thumb is to be assumed for Beckhoff EtherCAT Terminals/Boxes:

**Device revision in the system >= device revision in the configuration**

This also enables subsequent replacement of devices without changing the configuration (different specifications are possible for drives). Example: If an EL2521-0025-**1018** is specified in the configuration, an EL2521-0025-**1019** or higher (-**1020**, -**1021**) can be used in practice.



If current ESI descriptions are available in the TwinCAT system, the last revision offered in the selection dialog matches the Beckhoff state of production. It is recommended to use the last device revision when creating a new configuration, if current Beckhoff devices are used in the real application. Older revisions should only be used if older devices from stock are to be used in the application.

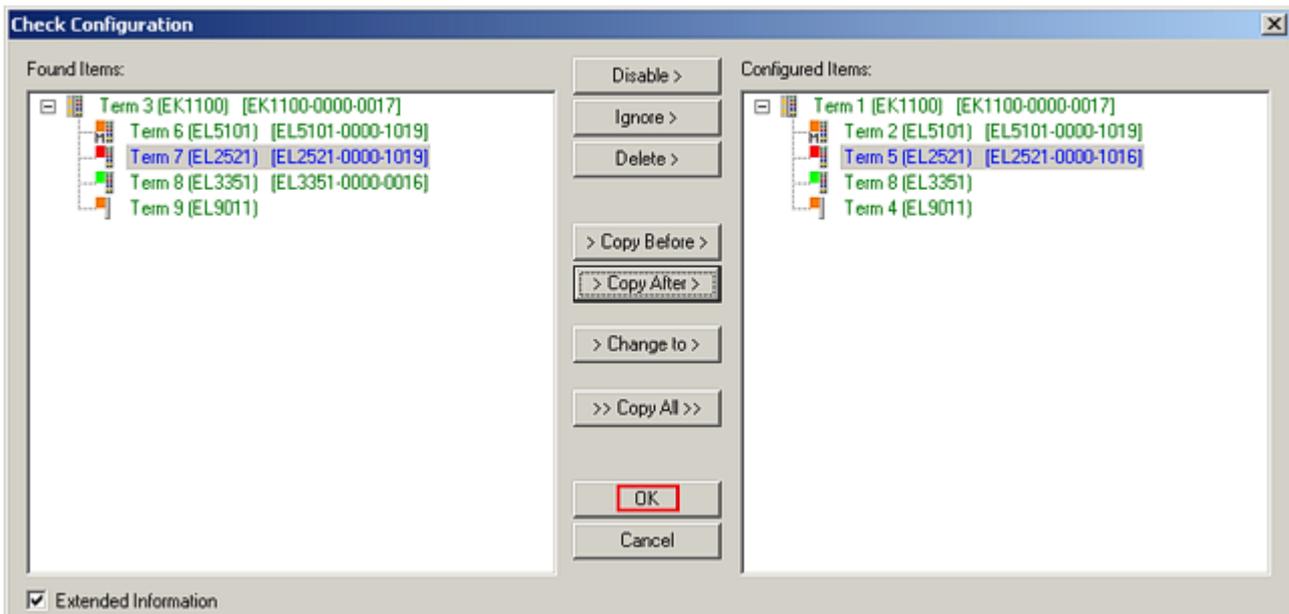


Fig. 53: Example correction dialog with modifications

Once all modifications have been saved or accepted, click “OK” to transfer them to the real \*.tsm configuration.

## 6.3 EtherCAT slave process data settings (PDO)

The process data transferred by an EtherCAT slave during each cycle (Process Data Objects, PDOs) are user data which the application expects to be updated cyclically or which are sent to the slave. To this end the EtherCAT master (Beckhoff TwinCAT) parameterizes each EtherCAT slave during the start-up phase to define which process data (size in bits/bytes, source location, transmission type) it wants to transfer to or from this slave. Incorrect configuration can prevent successful start-up of the slave.

For Beckhoff EtherCAT EL/ES/EP slaves the following applies in general:

- The input/output process data supported by the device are defined by the manufacturer in the ESI/XML description. The TwinCAT EtherCAT Master uses the ESI description to configure the slave correctly.
- The process data can be modified in the system manager. See the device documentation. Examples of modifications include: Mask out a channel, displaying additional cyclic information, 16-bit display instead of 8-bit data size, etc.
- In so-called “intelligent” EtherCAT devices the process data information is also stored in the CoE directory. Any changes in the CoE directory that lead to different PDO settings prevent successful startup of the slave. It is not advisable to deviate from the designated process data, because the device firmware (if available) is adapted to these PDO combinations.

If the device documentation envisages modification of process data, proceed as follows (see illustration below).

- A: Select the device to configure
- B: In the “Process Data” tab select Input or Output under SyncManager (C)
- D: The PDOs can be selected or deselected
- H: The new process data are visible as linkable variables in the system manager. The new process data are active once the configuration has been activated and TwinCAT has been restarted (or the EtherCAT master has been restarted)
- E: If a slave supports this, Input and Output PDO can be modified simultaneously by selecting a so-called PDO record (“predefined PDO settings”).

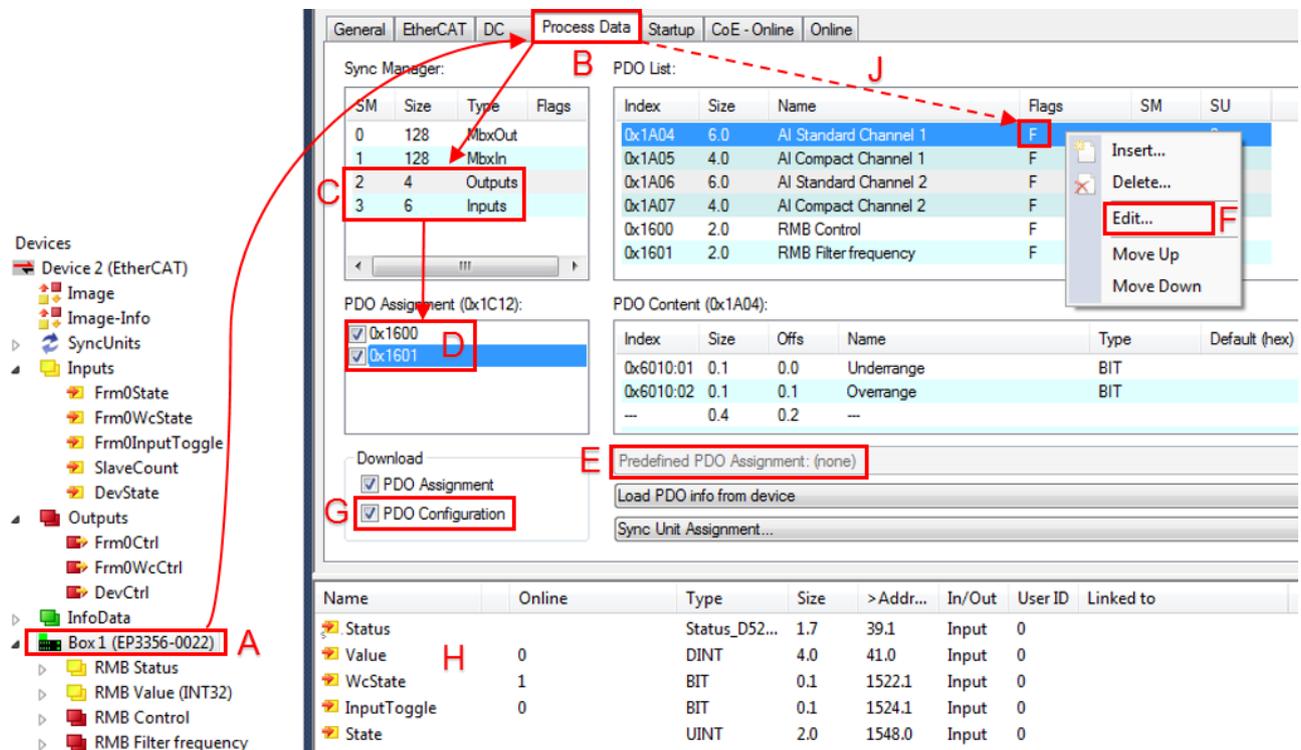


Fig. 54: Configuring the process data

**i Manual modification of the process data**

According to the ESI description, a PDO can be identified as "fixed" with a flag "F" in the PDO overview (see previous illustration, J). The configuration of such PDOs cannot be changed, even if TwinCAT offers the associated dialog ("Edit"). In particular, CoE content cannot be displayed as cyclic process data. This generally also applies in cases where a device supports download of the PDO configuration, "G". In case of incorrect configuration the EtherCAT slave usually refuses to start and change to OP state. The System Manager displays an "invalid SM cfg" logger message:

```
`Box 1 (EP3356)` (0022): state change aborted (requested ,SAFEOP`, back to ,PREOP`), `Box1 (EP3356)` (0022): `PREOP to SAFEOP`failed! Error: `check device state for SAFEOP`, AL Status `0x0012`read and 0x0004` expected. AL status code `0x001e – invalid SM IN cfg` This error message „invalid SM IN cfg“ or „invalid SM OUT cfg“ provides an indication of the reason for the failed start.
```

## 6.4 Configuration via TwinCAT

In the left-hand window of the TwinCAT System Manager, click on the branch of the EtherCAT Box you wish to configure (EP2816-0008 in this example).

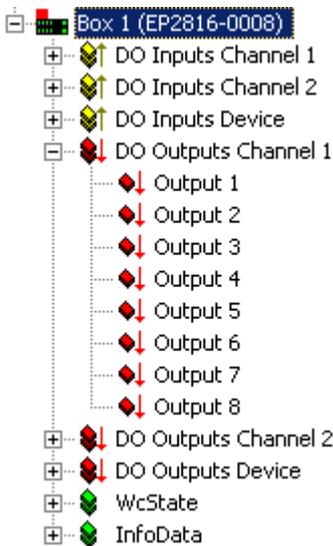


Fig. 55: Branch of the EtherCAT box to be configured

In the right-hand window of the TwinCAT System manager, various tabs are now available for configuring the EtherCAT Box.

**General tab**

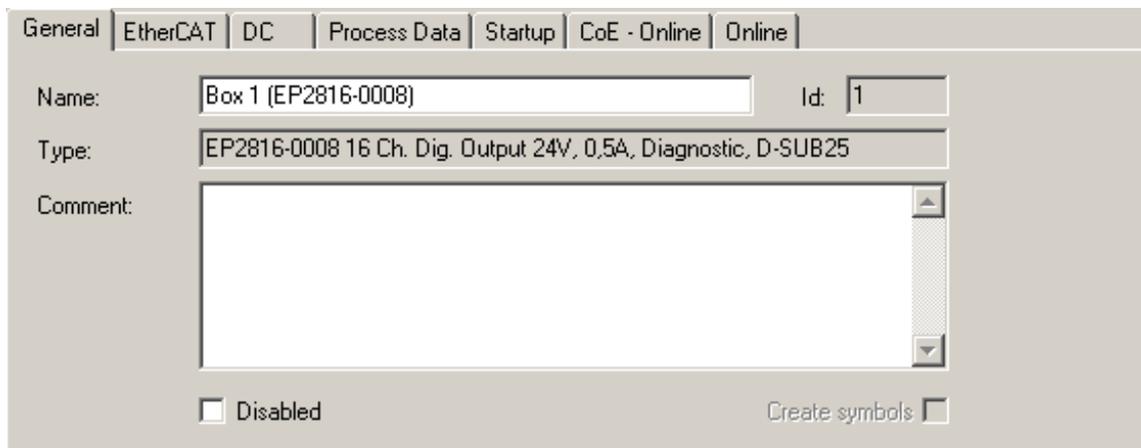


Fig. 56: General tab

|                       |  |
|-----------------------|--|
| <b>Name</b>           | Name of the EtherCAT device  |
| <b>Id</b>             | Number of the EtherCAT device  |
| <b>Type</b>           | EtherCAT device type   |
| <b>Comment</b>        | Here you can add a comment (e.g. regarding the system).                                |
| <b>Disabled</b>       | Here you can deactivate the EtherCAT device.   |
| <b>Create symbols</b> | Access to this EtherCAT slave via ADS is only available if this checkbox is activated. |

### EtherCAT tab

Fig. 57: EtherCAT tab

|                          |   |
|--------------------------|---|
| <b>Type</b>              | EtherCAT device type  |
| <b>Product/Revision</b>  | Product and revision number of the EtherCAT device  |
| <b>Auto Inc Addr.</b>    | Auto increment address of the EtherCAT device. The auto increment address can be used for addressing each EtherCAT device in the communication ring through its physical position. Auto increment addressing is used during the start-up phase when the EtherCAT master allocates addresses to the EtherCAT devices. With auto increment addressing the first EtherCAT slave in the ring has the address 0000 <sub>hex</sub> . For each further slave the address is decremented by 1 (FFFF <sub>hex</sub> , FFFE <sub>hex</sub> etc.). |
| <b>EtherCAT Addr.</b>    | Fixed address of an EtherCAT slave. This address is allocated by the EtherCAT master during the start-up phase. Tick the checkbox to the left of the input field in order to modify the default value.  |
| <b>Previous Port</b>     | Name and port of the EtherCAT device to which this device is connected. If it is possible to connect this device with another one without changing the order of the EtherCAT devices in the communication ring, then this combobox is activated and the EtherCAT device to which this device is to be connected can be selected.  |
| <b>Advanced Settings</b> | This button opens the dialogs for advanced settings.  |

The link at the bottom of the tab points to the product page for this EtherCAT device on the web.

### Process Data tab

Indicates the configuration of the process data. The input and output data of the EtherCAT slave are represented as CANopen process data objects (PDO). The user can select a PDO via PDO assignment and modify the content of the individual PDO via this dialog, if the EtherCAT slave supports this function.

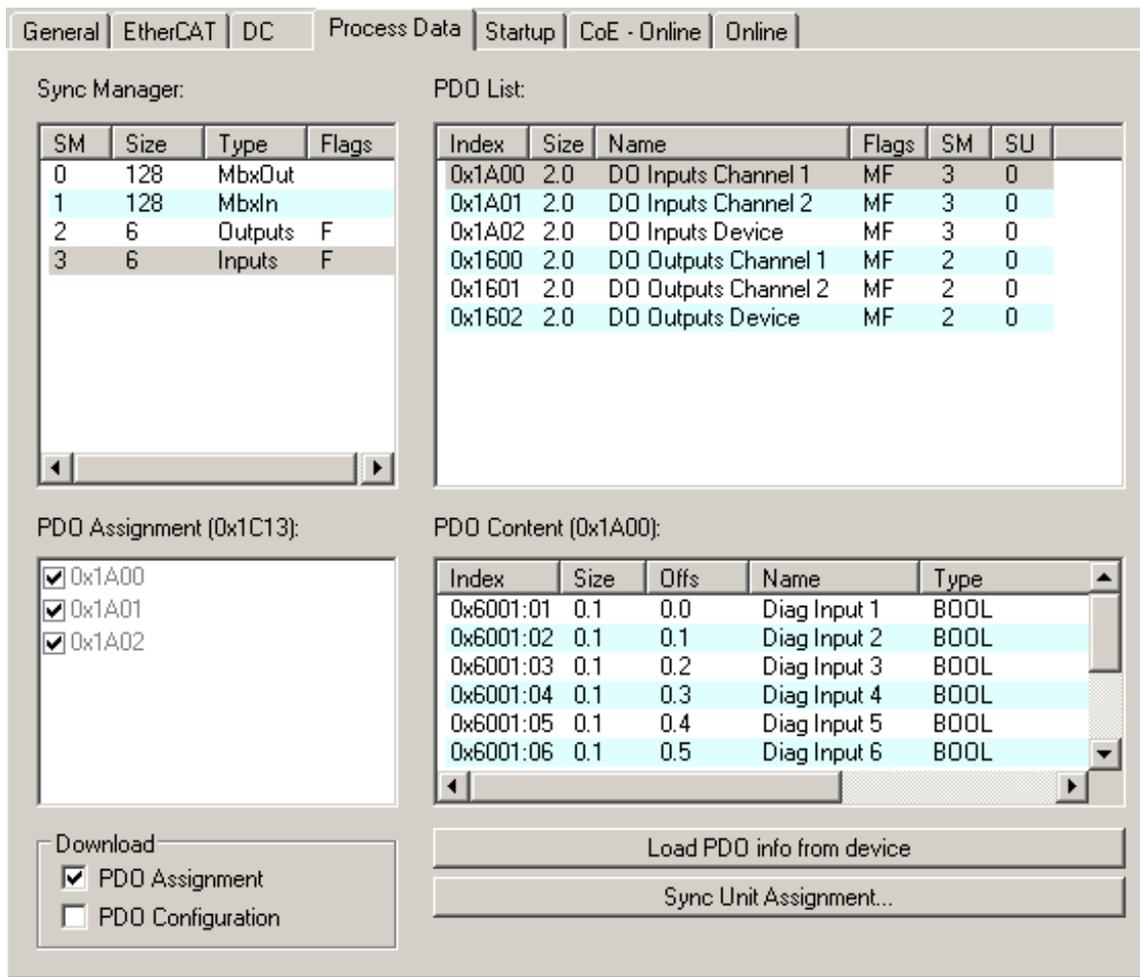


Fig. 58: Process Data tab

**Sync Manager**

Lists the configuration of the Sync Manager (SM).

If the EtherCAT device has a mailbox, SM0 is used for the mailbox output (MbxOut) and SM1 for the mailbox input (MbxIn).

SM2 is used for the output process data (outputs) and SM3 (inputs) for the input process data.

If an input is selected, the corresponding PDO assignment is displayed in the *PDO Assignment* list below.

**PDO Assignment**

PDO assignment of the selected Sync Manager. All PDOs defined for this Sync Manager type are listed here:

- If the output Sync Manager (outputs) is selected in the Sync Manager list, all RxPDOs are displayed.
- If the input Sync Manager (inputs) is selected in the Sync Manager list, all TxPDOs are displayed.

The selected entries are the PDOs involved in the process data transfer. In the tree diagram of the System Manager these PDOs are displayed as variables of the EtherCAT device. The name of the variable is identical to the *Name* parameter of the PDO, as displayed in the PDO list. If an entry in the PDO assignment list is deactivated (not selected and greyed out), this indicates that the input is excluded from the PDO assignment. In order to be able do select a greyed out PDO, the currently selected PDO has to be deselected first.

## **i** Activation of PDO assignment

- the EtherCAT slave has to run through the PS status transition cycle (from pre-operational to safe-operational) once (see [Online tab \[▶ 65\]](#)),
- and the System Manager has to reload the EtherCAT slaves (  button)

## PDO list

List of all PDOs supported by this EtherCAT device. The content of the selected PDOs is displayed in the *PDO Content* list. The PDO configuration can be modified by double-clicking on an entry.

| Column | Description   |
|--------|---|
| Index  | PDO index.  |
| Size   | Size of the PDO in bytes.   |
| Name   | Name of the PDO.<br>If this PDO is assigned to a Sync Manager, it appears as a variable of the slave with this parameter as the name.                                 |
| Flags  | F Fixed content: The content of this PDO is fixed and cannot be changed by the System Manager.  |
|        | M Mandatory PDO. This PDO is mandatory and must therefore be assigned to a Sync Manager! Consequently, this PDO cannot be deleted from the <i>PDO Assignment</i> list |
| SM     | Sync Manager to which this PDO is assigned. If this entry is empty, this PDO does not take part in the process data traffic.  |
| SU     | Sync unit to which this PDO is assigned.  |

## PDO Content

Indicates the content of the PDO. If flag F (fixed content) of the PDO is not set the content can be modified.

## Download

If the device is intelligent and has a mailbox, the configuration of the PDO and the PDO assignments can be downloaded to the device. This is an optional feature that is not supported by all EtherCAT slaves.

## PDO Assignment

If this check box is selected, the PDO assignment that is configured in the PDO Assignment list is downloaded to the device on startup. The required commands to be sent to the device can be viewed in the [Startup \[▶ 62\]](#) tab.

## PDO Configuration

If this check box is selected, the configuration of the respective PDOs (as shown in the PDO list and the PDO Content display) is downloaded to the EtherCAT slave.

## Startup tab

The *Startup* tab is displayed if the EtherCAT slave has a mailbox and supports the *CANopen over EtherCAT* (CoE) or *Servo drive over EtherCAT* protocol. This tab indicates which download requests are sent to the mailbox during startup. It is also possible to add new mailbox requests to the list display. The download requests are sent to the slave in the same order as they are shown in the list.

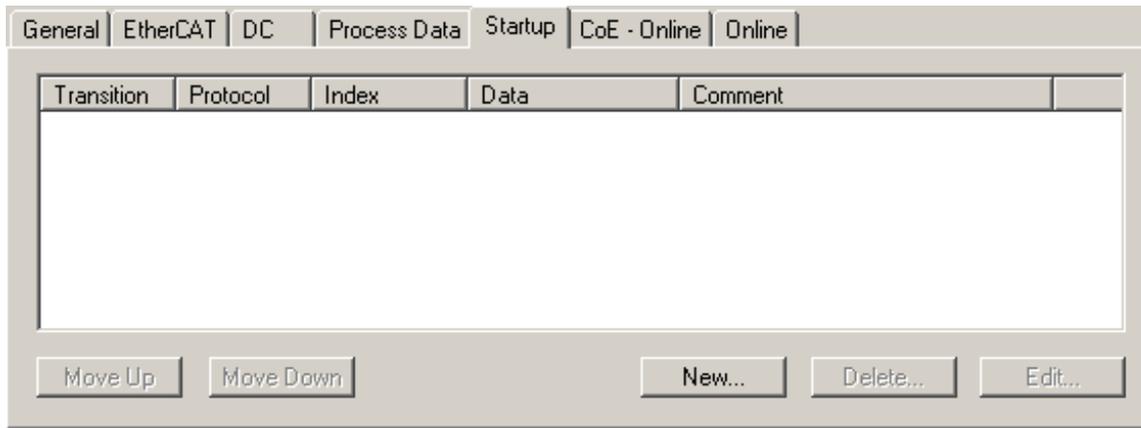


Fig. 59: Startup tab

| Column     | Description  |
|------------|--|
| Transition | Transition to which the request is sent. This can either be <ul style="list-style-type: none"> <li>the transition from pre-operational to safe-operational (PS), or</li> <li>the transition from safe-operational to operational (SO).</li> </ul> If the transition is enclosed in "<>" (e.g. <PS>), the mailbox request is fixed and cannot be modified or deleted by the user. |
| Protocol   | Type of mailbox protocol   |
| Index      | Index of the object  |
| Data       | Date on which this object is to be downloaded.   |
| Comment    | Description of the request to be sent to the mailbox   |

- Move Up** This button moves the selected request up by one position in the list.
- Move Down** This button moves the selected request down by one position in the list.
- New** This button adds a new mailbox download request to be sent during startup.
- Delete** This button deletes the selected entry.
- Edit** This button edits an existing request.

**CoE - Online tab**

The additional *CoE - Online* tab is displayed if the EtherCAT slave supports the *CANopen over EtherCAT* (CoE) protocol. This dialog lists the content of the object directory of the slave (SDO upload) and enables the user to modify the content of an object from this list. Details for the objects of the individual EtherCAT devices can be found in the device-specific object descriptions.

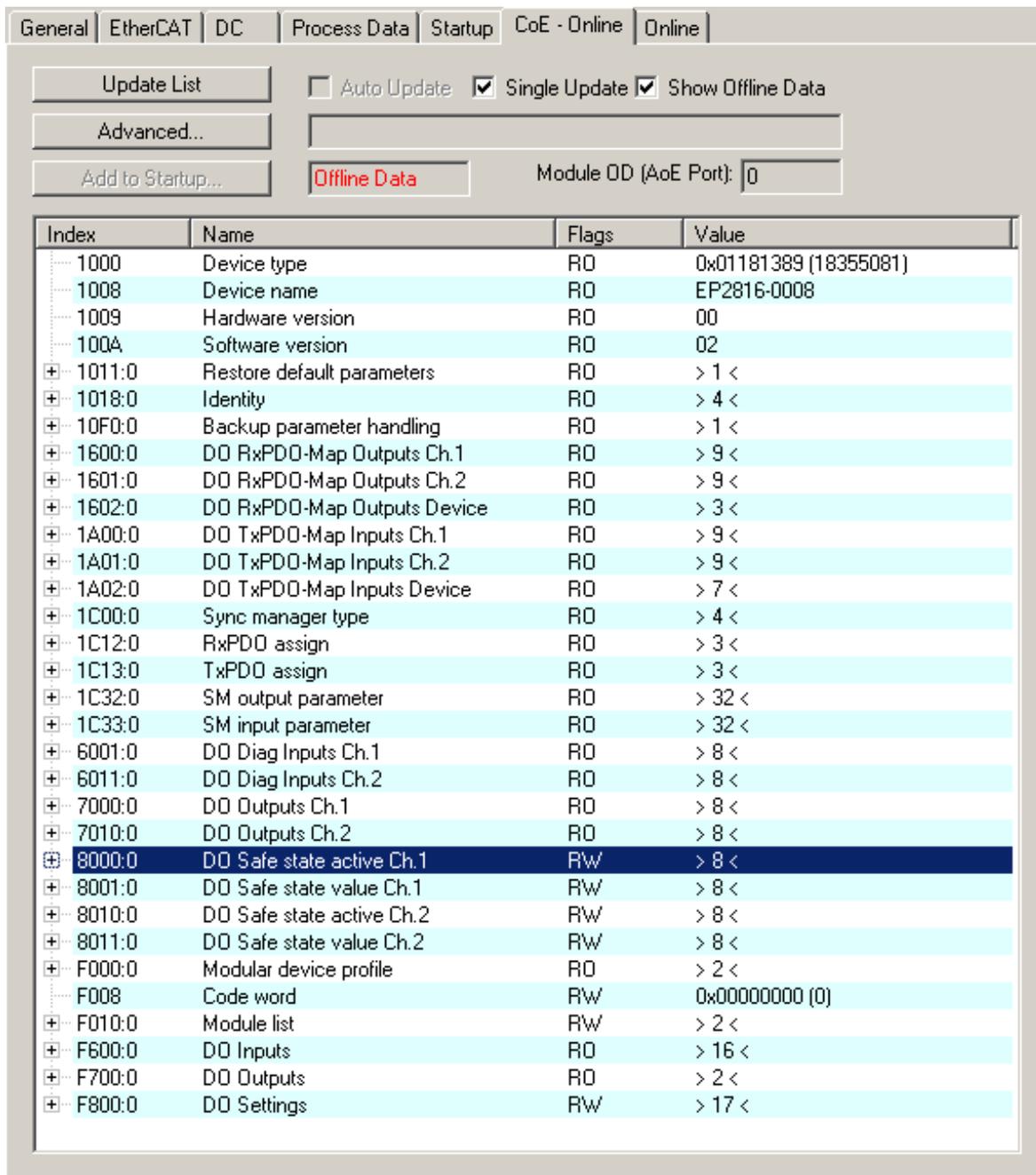


Fig. 60: CoE - Online tab

**Object list display**

| Column | Description   |
|--------|---|
| Index  | Index and subindex of the object  |
| Name   | Name of the object  |
| Flags  | RW The object can be read, and data can be written to the object (read/write)   |
|        | RO The object can be read, but no data can be written to the object (read only) |
|        | P An additional P identifies the object as a process data object.               |
| Value  | Value of the object   |

- Update List** The *Update list* button updates all objects in the displayed list
- Auto Update** If this check box is selected, the content of the objects is updated automatically.
- Advanced** The *Advanced* button opens the *Advanced Settings* dialog. Here you can specify which objects are displayed in the list.

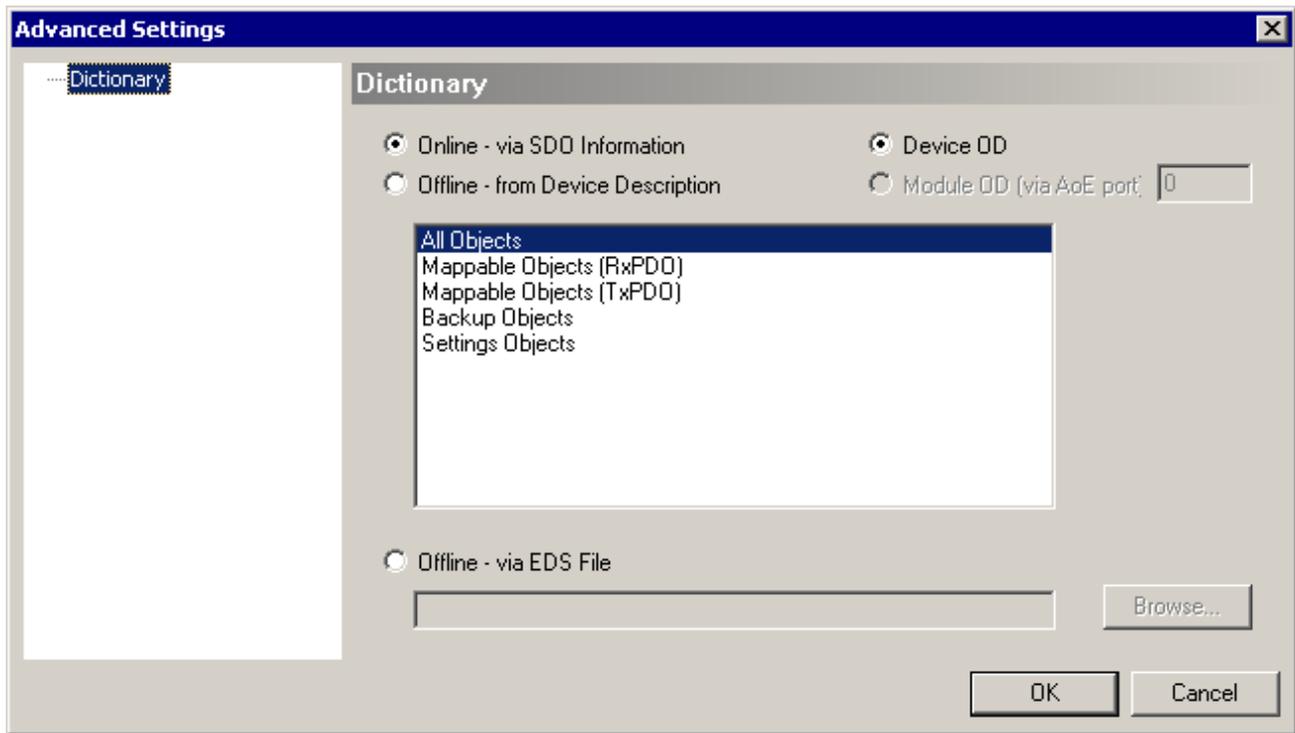


Fig. 61: Advanced settings

**Online - via SDO information**

If this option button is selected, the list of the objects included in the object directory of the slave is uploaded from the slave via SDO information. The list below can be used to specify which object types are to be uploaded.

**Offline - via EDS file**

If this option button is selected, the list of the objects included in the object directory is read from an EDS file provided by the user.

**Online tab**

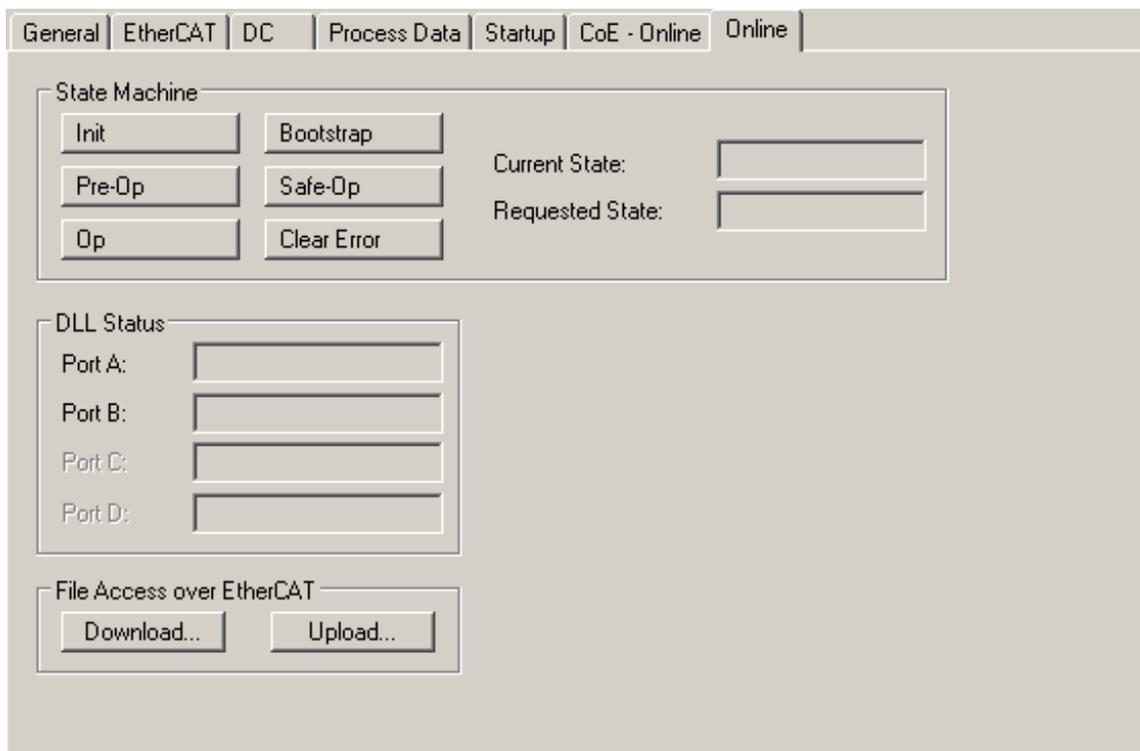


Fig. 62: Online tab

**State Machine**

|                        |   |
|------------------------|---|
| <b>Init</b>            | This button attempts to set the EtherCAT device to the <i>Init</i> state.   |
| <b>Pre-Op</b>          | This button attempts to set the EtherCAT device to the <i>pre-operational</i> state.  |
| <b>Op</b>              | This button attempts to set the EtherCAT device to the <i>operational</i> state.  |
| <b>Bootstrap</b>       | This button attempts to set the EtherCAT device to the <i>Bootstrap</i> state.  |
| <b>Safe-Op</b>         | This button attempts to set the EtherCAT device to the <i>safe-operational</i> state.   |
| <b>Clear Error</b>     | This button attempts to delete the fault display. If an EtherCAT slave fails during change of state it sets an error flag.<br><br>Example: An EtherCAT slave is in PREOP state (pre-operational). The master now requests the SAFEOP state (safe-operational). If the slave fails during change of state it sets the error flag. The current state is now displayed as ERR PREOP. When the <i>Clear Error</i> button is pressed the error flag is cleared, and the current state is displayed as PREOP again. |
| <b>Current State</b>   | Indicates the current state of the EtherCAT device.   |
| <b>Requested State</b> | Indicates the state requested for the EtherCAT device.  |

**DLL Status**

Indicates the DLL status (data link layer status) of the individual ports of the EtherCAT slave. The DLL status can have four different states:

| Status              | Description   |
|---------------------|---|
| No Carrier / Open   | No carrier signal is available at the port, but the port is open.   |
| No Carrier / Closed | No carrier signal is available at the port, and the port is closed. |
| Carrier / Open      | A carrier signal is available at the port, and the port is open.    |
| Carrier / Closed    | A carrier signal is available at the port, but the port is closed.  |

**File Access over EtherCAT**

|                 |  |
|-----------------|--|
| <b>Download</b> | With this button a file can be written to the EtherCAT device. |
| <b>Upload</b>   | With this button a file can be read from the EtherCAT device.  |

## 6.5 Basic function principles

### ● EL/EP3356 and special versions

**i** Unless stated otherwise, the designation „EL/EP3356“always refers also to special versions such as the EL3356-0010 and EP3356-0022.

The measuring functions of the EL/EP3356 can be described as follows:

- The EL3356 Analog Input Terminal and the EP3356-0022 Analog Input Box are used to acquire the supply voltage to a load cell as a reference voltage, and the differential voltage that is proportional to the force acting on the cell.
- It is compulsory to connect a full bridge. If there is only a quarter or half bridge available, you have to add external auxiliary bridges. In this case you have to modify the nominal characteristic value.
- The reference and differential voltages are measured simultaneously
- Since the two voltages are measured at the same time, there is basically no need for a high-precision reference voltage with respect to the level. On changing the reference voltage, the differential voltage across the full bridge changes by the same degree. Therefore a stabilized reference voltage should be used that is subject to only low fluctuations (e.g. the EL95xx supply terminal)
- The change of the quotient of the differential and reference voltages corresponds to the relative force acting on the load cell.
- The quotient is converted into a weight and is output as process data.
- The data processing is subject to the following filtering procedures:
  - the analog converter (ADC) integrates over 76 samples
  - calculation of mean values in the averager (if activated)
  - software filter IIR/FIR (if activated)
- The EL/EP3356 has an automatic compensation/self-calibration function. Default state: self-calibration activated, execution every 3 minutes
  - errors in the analog input stages (temperature drift, long-term drift etc.) are checked by regular automatic calibration, and compensated to bring the measurement within the permitted tolerance range.
  - the automatic function can be deactivated or activated in a controlled manner
- The EL/EP3356 can also be used as a 2-channel analog input terminal/box for voltage measurement [► 89].
- The EL3356-0010/EP3356-0022 has a timestamp function that can be activated through Distributed Clocks. The filter functionality is not available in Distributed Clocks mode.

### General notes

- The measuring ranges of both channels (supply voltage and bridge voltage) should always be used as widely as possible in order to achieve a high measuring accuracy. We recommended a supply voltage of 12 V in connection with a load cell that has such a sensitivity (e.g. 2 mV/V) that the largest possible bridge voltage – ideally  $\pm 25$  mV – is generated. Please consider the max. input voltage (see technical data).

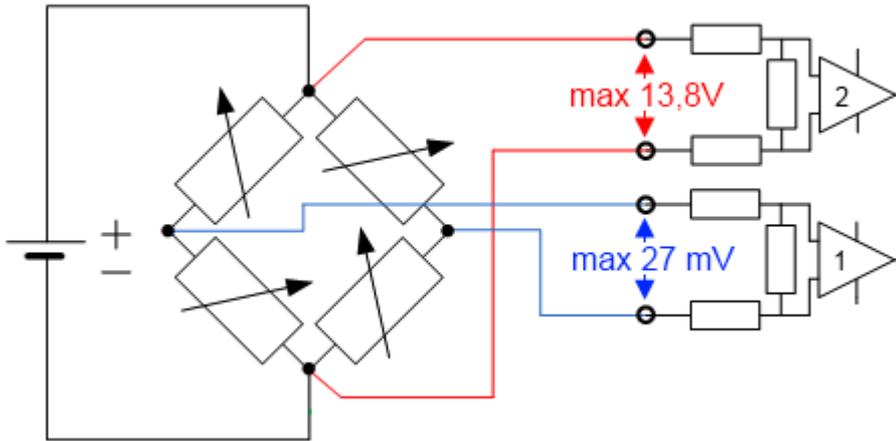


Fig. 63: Max. input voltages

- Parallel operation of load cells is possible with the EL/EP3356. Please note:
  - the EL3356 does not provide a supply! Hence, the power supply employed must be sufficiently large, since the total bridge resistance of all strain gauges connected together is considerably reduced due to the parallel connection.
  - Load cells approved and calibrated by the load cell manufacturer for parallel operation should be used. The nominal characteristic values [mV/V], zero offset [mV/V] and impedance [ $\Omega$ , ohm] are then usually adjusted accordingly.
  - a 6-wire connection is expressly recommended with the EL3356

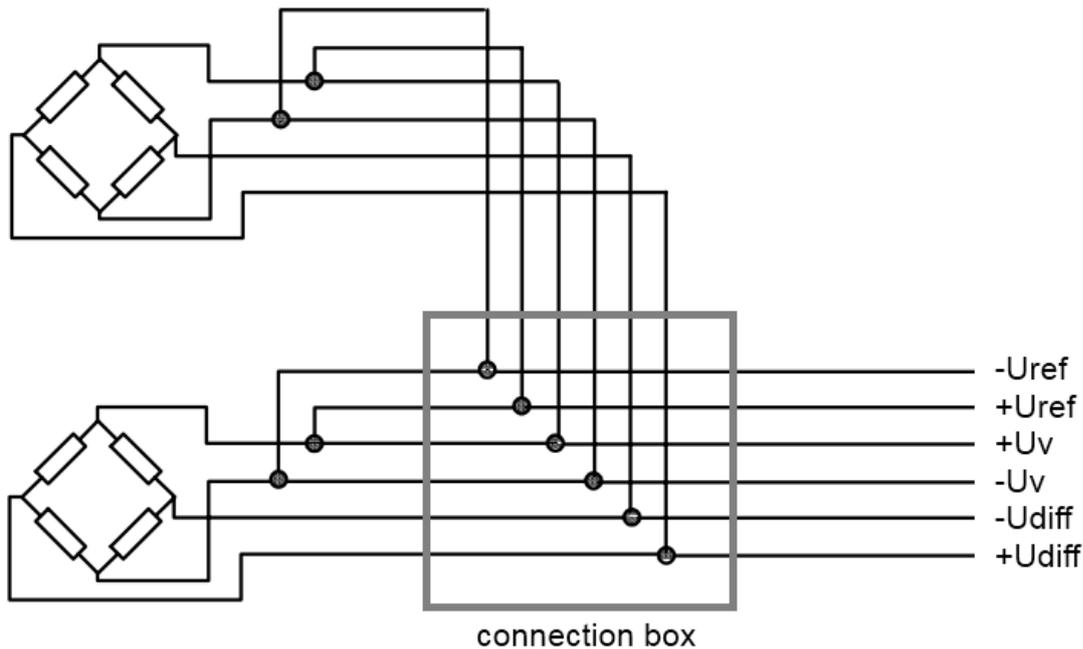


Fig. 64: Parallel connection with EL3356

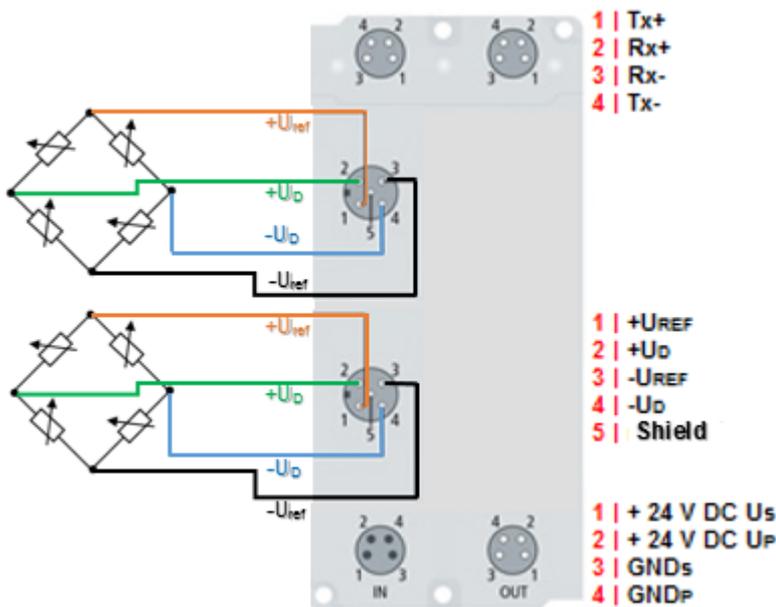


Fig. 65: Parallel connection with EP3356

- Load cell signals have a low amplitude and are occasionally very sensitive to electromagnetic interference. Considering the typical system characteristics and taking into account the technical possibilities, purposeful state-of-the-art EMC protective measures are to be taken. The shield of the sensor cable can be connected to the EL3356 at the terminal points 4/8. In the case of high electromagnetic interference levels, it may be helpful to additionally connect the cable screen before the terminal using suitable screening material.
- the minimum permissible assigned EtherCAT cycle time for the EL/EP3356 is 100  $\mu$ s.
- If the EL3356-0010/EP3356-0022 is to be used in Distributed Clocks mode:
  - DC must be activated
  - the [Process data](#) [► 92] [Timestamp](#) must be activated. The filter functionality is not available then.

Signal flow diagram

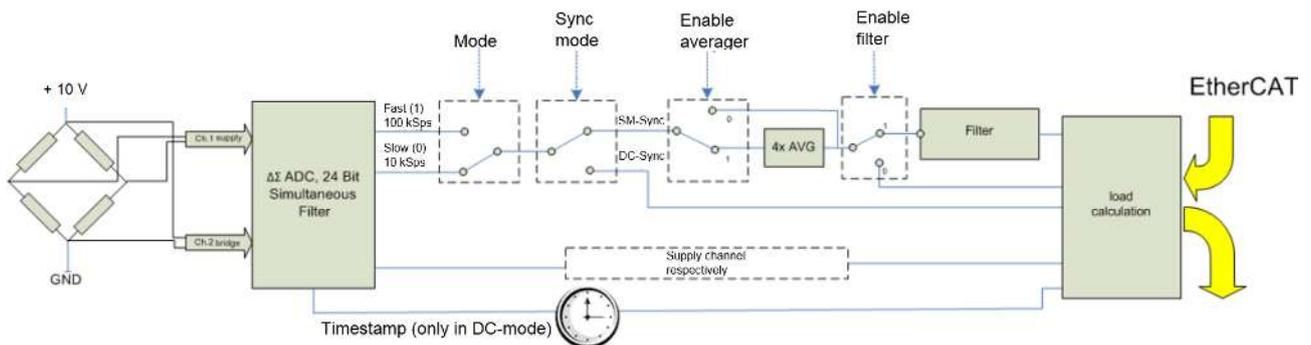


Fig. 66: Block diagram of EP3356-0022

The EL/EP3356 processes the data in the following order:

- Hardware low-pass 10 KHz
- 2-channel simultaneous sampling at 10.5/105.5 kSps with 64-fold oversampling by delta-sigma ( $\Delta\Sigma$ ) converter and internal pre-filtration
- 4-fold averager (can be deactivated)
- Software filter (can be deactivated)
- Calculating the weight

## **i** Measurement principle of delta-sigma ( $\Delta\Sigma$ ) converter

The measurement principle employed in the EL/EP3356, with real sampling in MHz range, shifts aliasing effects into a very high frequency range, so that normally no such effects are to be expected in the KHz range.

### Averager

In order to make use of the high data rates of the Analog-to-Digital converter (ADC) even with slow cycle times, a mean value filter is connected after the ADC. This determines the sliding mean value of the last 4 measured values. This function can be deactivated for each mode via the CoE object "Mode X enable averager".

### Software filter

The EL/EP3356 is equipped with a digital software filter which, depending on its settings, can adopt the characteristics of a Finite Impulse Response filter (FIR filter), or an Infinite Impulse Response filter (IIR filter). The filter is activated by default as 50 Hz-FIR.

In the respective measuring mode the filter can be activated (0x8000:01, 0x8000:02) [► 104] and parameterized (0x8000:11, 0x8000:12) [► 104] (the EL3356-0000 supports only mode 0).

### FIR 50/60 Hz

- The filter performs a notch filter function and determines the conversion time of the terminal/box. The higher the filter frequency, the faster the conversion time. A 50 Hz and a 60 Hz filter are available. Notch filter means that the filter has zeros (notches) in the frequency response at the filter frequency and multiples thereof, i.e. it attenuates the amplitude at these frequencies. The FIR filter operates as a non-recursive filter.

### PDO filter

- The filter behaves like the 50/60 Hz FIR filter described above. However, the filter frequency can be adjusted here in 0.1 Hz steps by means of an output data object. The filter frequency range extends from 0.1 Hz to 200 Hz and can be reparameterised during operation. To do this the PDO 0x1601 ("RMB filter frequency") must be displayed in the process data and the entry "PDO filter frequency" must be selected in the object 0x8000:11. This function allows the EL/EP3356 to suppress interference of a known frequency in the measuring signal. A typical application, for example, is a silo that is filled and weighed by a driven screw conveyor. The rotary speed of the screw conveyor is known and can be adopted into the object as a frequency. Thus mechanical oscillations can be removed from the measuring signal.

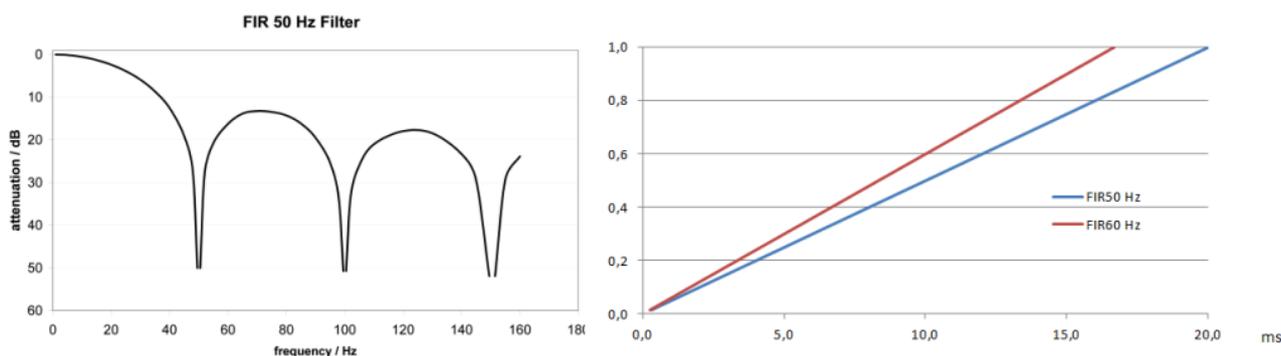


Fig. 67: Notch characteristic/amplitude curve and step response of the FIR filter

### IIR-Filter 1 to 8

- The filter with IIR characteristics is a discrete time, linear, time invariant filter that can be set to eight levels (level 1 = weak recursive filter, up to level 8 = strong recursive filter). The IIR can be understood to be a moving average value calculation after a low-pass filter.

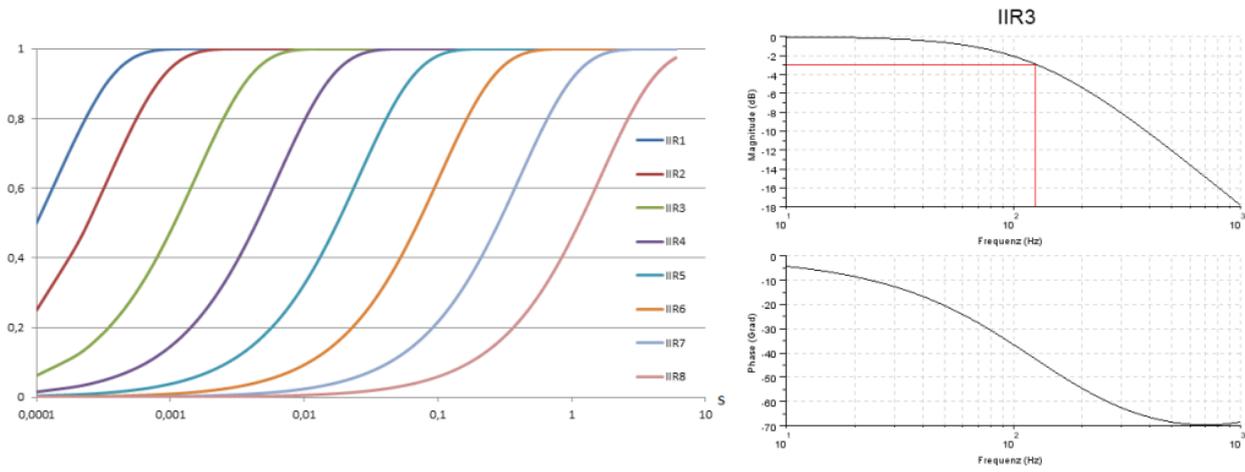


Fig. 68: Step response and Bode diagram of the IIR filter

## Overview of conversion times

| Filter Settings    | Value                | PDO update time EL3356                     | PDO update time EP3356-0022/EL3356-0010 | Filter property   | Limit frequency (-3 dB) [Hz] (typ.) | Comment                       | Rise time 10-90 % [s] (typ.) |
|--------------------|----------------------|--|---|---|-------------------------------------|-------------------------------|------------------------------|
| Filter deactivated | -                    | min. 10 ms                                 | Cycle-synchronous, min. 100 µs          | -   | -                                   | -                             | -                            |
| 0                  | FIR 50 Hz            | min. 10 ms                                 | 312.5 µs                                | 50 Hz notch filter  | 22 Hz                               | Typ. conversion time 312.5 µs | 0.013                        |
| 1                  | FIR 60 Hz            | min. 10 ms                                 | 260.4 µs                                | 60 Hz notch filter  | 25 Hz                               | Typ. conversion time 260.4 µs | 0.016                        |
| 2                  | IIR1                 | Cyclesynchronous (up to min. 10 ms update) | Cycle-synchronous (up to min. 100 µs)   | Low-pass  | 2000 Hz                             | $a_0=1/2^1 = 0.5$             | 0.0003                       |
| 3                  | IIR2                 |  |   | Low-pass  | 500 Hz                              | $a_0=1/2^2 = 0.25$            | 0.0008                       |
| 4                  | IIR3                 |  |   | Low-pass  | 125 Hz                              | $a_0=1/2^4 = 62.5e-3$         | 0.0035                       |
| 5                  | IIR4                 |  |   | Low-pass  | 30 Hz                               | $a_0=1/2^6 = 15.6e-3$         | 0.014                        |
| 6                  | IIR5                 |  |   | Low-pass  | 8 Hz                                | $a_0=1/2^8 = 3.91e-3$         | 0.056                        |
| 7                  | IIR6                 |  |   | Low-pass  | 2 Hz                                | $a_0=1/2^{10} = 977e-6$       | 0.225                        |
| 8                  | IIR7                 |  |   | Low-pass  | 0.5 Hz                              | $a_0=1/2^{12} = 244e-6$       | 0.9                          |
| 9                  | IIR8                 |  |   | Low-pass  | 0.1 Hz                              | $a_0=1/2^{14} = 61.0e-6$      | 3.6                          |
| 10                 | Dynamic IIR          |  |   | The filter changes dynamically between the filters IIR1 to IIR8 |                                     |                               |                              |
| 11                 | PDO Filter frequency | min. 10 ms                                 | 1/PDO Value[Hz]*64                      | Notch filter with adjustable frequency                          | ca. 0,443 * PDO Value [Hz]          | -                             | -                            |

### ● Filter and cycle time

**i** If the FIR filters (50 Hz or 60 Hz) are switched on, the process data are updated maximally with the specified conversion time (see table). The IIR filter works cycle-synchronously. Hence, a new measured value is available in each PLC cycle.

At which point the filters can be adjusted is described in the chapter "Object description and parameterization" for example under index 0x8000:12.

### ● IIR filter

**i** Differential equation:  $Y_n = X_n * a_0 + Y_{n-1} * b_1$  with  $a_0 + b_1 = 1$   
 $a_0 =$  (see table),  $b_1 = 1 - a_0$

### Dynamic IIR Filter

The dynamic IIR filter automatically switches through the 8 different IIR filters depending on the weight change. The idea:

- The target state is always the IIR8-Filter, i.e. the greatest possible damping and hence a very calm measured value.
- In the input variable changes rapidly the filter is opened, i.e. switched to the next lower filter (if still possible). This gives the signal edge more weight and the measured value curve can follow the load quickly.
- If the measured value changes very little the filter is closed, i.e. switched to the next higher filter (if still possible). Hence the static state is mapped with a high accuracy.
- The evaluation as to whether a downward change of filter is required or whether an upward change is possible takes place continuously at fixed time intervals.

Parameterization takes place via the CoE entries 0x8000:13 and 0x8000:14 [► 104]. Evaluation takes place according to 2 parameters:

- The "Dynamic filter change time" object (0x8000:13) [▶ 104] is used to set the time interval at which the existing signal is re-evaluated.
- Object 0x8000:14 [▶ 104] is used to specify the maximum deviation that is permissible during this time without filter switching occurring.

**Example:**

The dynamic filter is to be adjusted in such a manner that a maximum slope of 0.5 digits per 100 ms (5 digits per second) is possible without the filter being opened. This results in a "calm" measured value. In the case of a faster change, however, it should be possible to immediately follow the load.

- Dynamic filter change time (0x8000:13) [▶ 104] = 10 (equivalent to 100 ms)
- Object 0x8000:14 [▶ 104] is used to specify the maximum deviation that is permissible during this time without filter switching occurring.

The measured value curve is shown below for a slower (left) and faster (right) change.

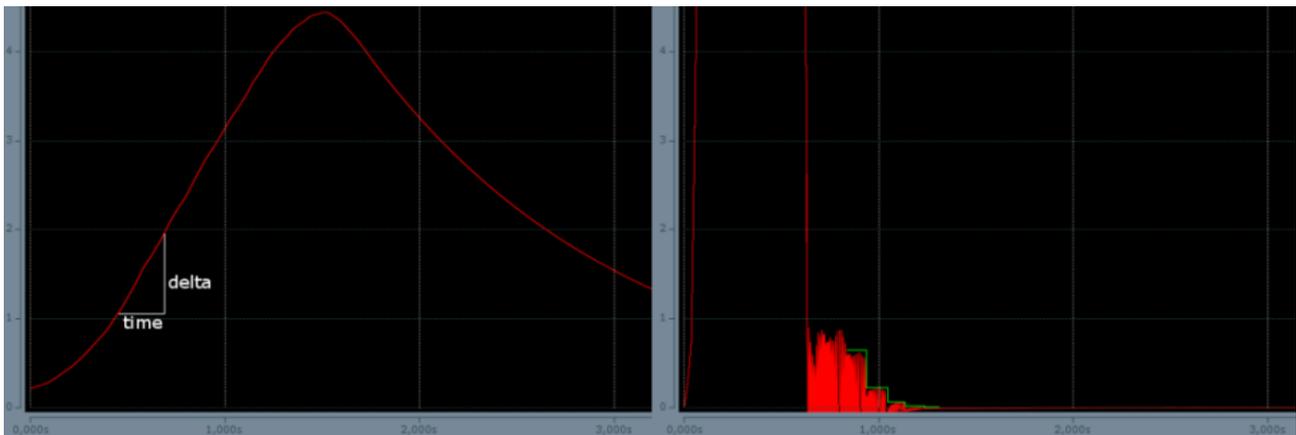


Fig. 69: Effect of dynamic IIR filters

- Left: The scales are slowly loaded. The change in the weight (delta/time) remains below the mark of 0.5 digits per 100 ms. The filter therefore remains unchanged at the strongest level (IIR8), resulting in a low-fluctuation measured value.
- Right: The scales are suddenly loaded. The change in the weight immediately exceeds the limit value of 0.5 digits per 100 ms. The filter is opened every 100 ms by one level (IIR8 --> IIR7 --> IIR6 etc.) and the display value immediately follows the jump. After the removal of the weight the signal quickly falls again. If the change in the weight is less than 0.5 digit per 100 ms, the filter is set one level stronger every 100 ms until IIR8 is reached. The green line is intended to clarify the decreasing "noise level"

**Calculating the weight**

Each measurement of the analog inputs is followed by the calculation of the resulting weight or the resulting force, which is made up of the ratio of the measuring signal to the reference signal and of several calibrations.

$Y_R = (U_{Diff} / U_{ref}) \times A_i$  (1.0) Calculation of the raw value in mV/V

$Y_L = ( (Y_R - C_{ZB}) / (C_n - C_{ZB}) ) * E_{max}$  (1.1) Calculation of the weight

$Y_S = Y_L * A_s$  (1.2) Scaling factor (e.g. factor 1000 for rescaling from kg to g)

$Y_G = Y_S * (G / 9.80665)$  (1.3) Influence of acceleration of gravity

$Y_{AUS} = Y_G \times \text{Gain} - \text{Tara}$  (1.4) Gain and Tare

## Legend

| Name              | Designation  | CoE Index       |
|-------------------|--|-----------------|
| $U_{\text{Diff}}$ | Bridge voltage/differential voltage of the sensor element, after averager and filter   |                 |
| $U_{\text{ref}}$  | Bridge supply voltage/reference signal of the sensor element, after averager and filter  |                 |
| $A_i$             | Internal gain, not changeable. This factor accounts for the unit standardisation from mV to V and the different full-scale deflections of the input channels |                 |
| $C_n$             | Nominal characteristic value of the sensor element (unit mV/V, e.g. nominally 2 mV/V or 2.0234 mV/V according to calibration protocol)                       | 8000:23 [▶ 104] |
| $C_{\text{ZB}}$   | Zero balance of the sensor element (unit mV/V, e.g. -0.0142 according to calibration protocol)   | 8000:25 [▶ 104] |
| $E_{\text{max}}$  | Nominal load of the sensor element   | 8000:24 [▶ 104] |
| $A_s$             | Scaling factor (e.g. factor 1000 for rescaling from kg to g)   | 8000:27 [▶ 104] |
| G                 | Acceleration of gravity in m/s <sup>2</sup> (default: 9.80665 ms/s <sup>2</sup> )  | 8000:26 [▶ 104] |
| Gain              |  | 8000:21 [▶ 104] |
| Tare              |  | 8000:22 [▶ 104] |

## Conversion mode

The so-called conversion mode determines the speed and latency of the analog measurement in the EL/EP3356. The characteristics:

| Mode | Meaning   | typ. latency | EL3356 | EL3356-0010 and EP3356-0022 | typ. current consumption  |
|------|---|--------------|--------|-----------------------------|---|
| 0    | <i>High precision</i><br>Analog conversion at 10.5 kSps (samples per second) Slow conversion and thus high accuracy   | 7,2 ms       | x      | x                           | 70 %<br>(see <a href="#">Technical data [▶ 9]</a> regarding nominal value)  |
| 1    | <i>High speed / low latency</i> Analog conversion at 105.5 kSps (samples per second) Fast conversion with low latency | 0,72 ms      | -      | x                           | 100 %<br>(see <a href="#">Technical data [▶ 9]</a> regarding nominal value) |

Due to the conversion principle of the EL/EP3356, the analog voltage is only available as a digital value after a defined time. This is shown in figure below.

A step signal 0->1 is applied to the input. The measured value is reached and readable within the defined accuracy after 7.2 ms or 0.72 ms, depending on the conversion mode 0/1. At this time the timestamp is also acquired in Distributed Clocks mode. In real operation a step signal is not normally connected, but rather a higher frequency but constant signal. The EL3356 then maps the input signal with the corresponding latency for further processing, for which reason faster querying of the sampling unit at shorter intervals than the latency (EL3356-0010 allows up to 100 µs) makes sense for true-to-detail mapping of the analog input signal.

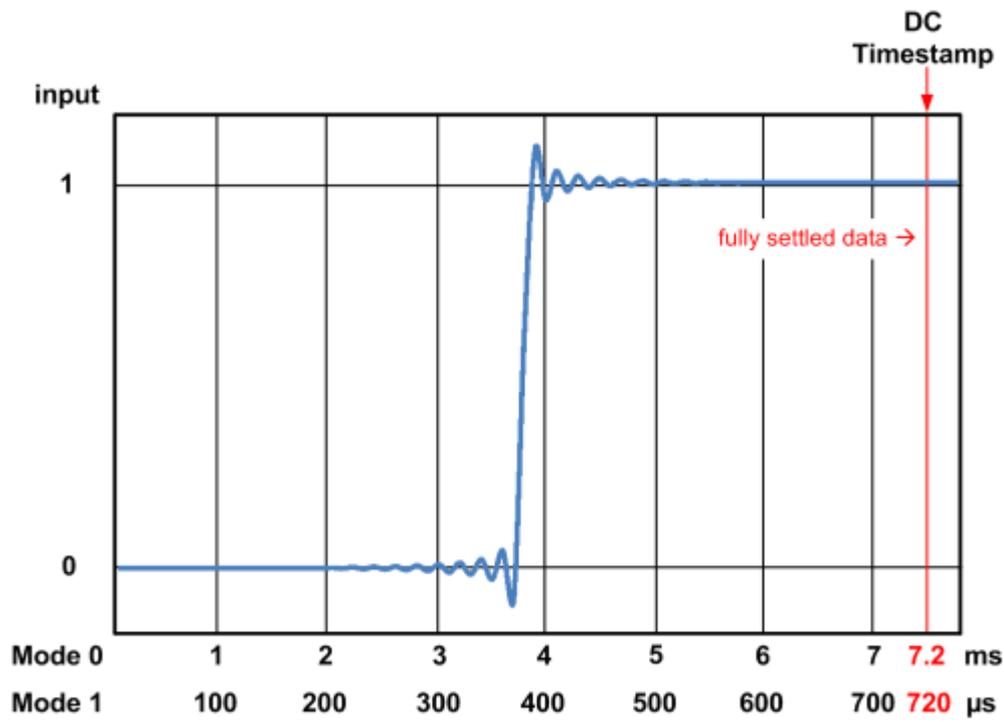


Fig. 70: Latency of the Analog-to-Digital converter

It is not possible to change the specified latency.

Beyond that the following are individually adjustable in each mode via CoE

- activation of the averager
- activation of the filter
- type of filter

|         |                               |    |               |
|---------|-------------------------------|----|---------------|
| 8000:0  | RMB Settings                  | RW | > 50 <        |
| 8000:01 | Mode0 enable filter           | RW | TRUE          |
| 8000:02 | Mode1 enable filter           | RW | TRUE          |
| 8000:03 | Mode0 enable averager         | RW | TRUE          |
| 8000:04 | Mode1 enable averager         | RW | TRUE          |
| 8000:05 | Symmetric reference potential | RW | TRUE          |
| 8000:11 | Mode0 filter settings         | RW | FIR 50 Hz (0) |
| 8000:12 | Mode1 filter settings         | RW | FIR 50 Hz (0) |

Fig. 71: Setting parameters in CoE belonging to the individual modes

The EL3356 has only mode 0, the EI3356-0010 has modes 0 & 1.

**Mode change (EL3356-0010 only)**

In particular for dynamic weighing procedures it may make sense to considerably change the measuring characteristic during the weighing procedure. For example, if a bulk material is filled by the sack within 5 seconds, a very open filter should initially be used so that the measured value quickly follows the fill level. During this phase it is of no importance that the measured value is very inaccurate and subject to high fluctuations. If the sack is >90 % full, filling must be slowed down and the loading must be followed with higher accuracy; the filter must be closed. Therefore the two conversion modes can be switched via the process data bit "Sample mode" in the EL3356-0010 and in the EP3356-0022 in relation to the processing of the analog values.

The mode change takes about 30 ms, during which time the measured values are invalid and indicate this by the status byte.

- ◆ Ctrl
- ◆ Start calibration
- ◆ Disable calibration
- ◆ Input freeze
- ◆ **Sample mode**
- ◆ Tara

Fig. 72: Sample mode switching

## 6.6 Application notes

### Symmetric reference potential

The EL/EP3356 measures the two voltages  $U_{\text{supply}}$  and  $U_{\text{bridge}}$  independently of each other and without electrical reference to a supply voltage. The measuring accuracy can be increased still further if an internal coupling is employed to prevent the internal measuring circuits from drifting apart. To this end the EL/EP3356 has an internal switch that is closed in the default state and establishes a potential reference between the internal electronics and the bridge point.

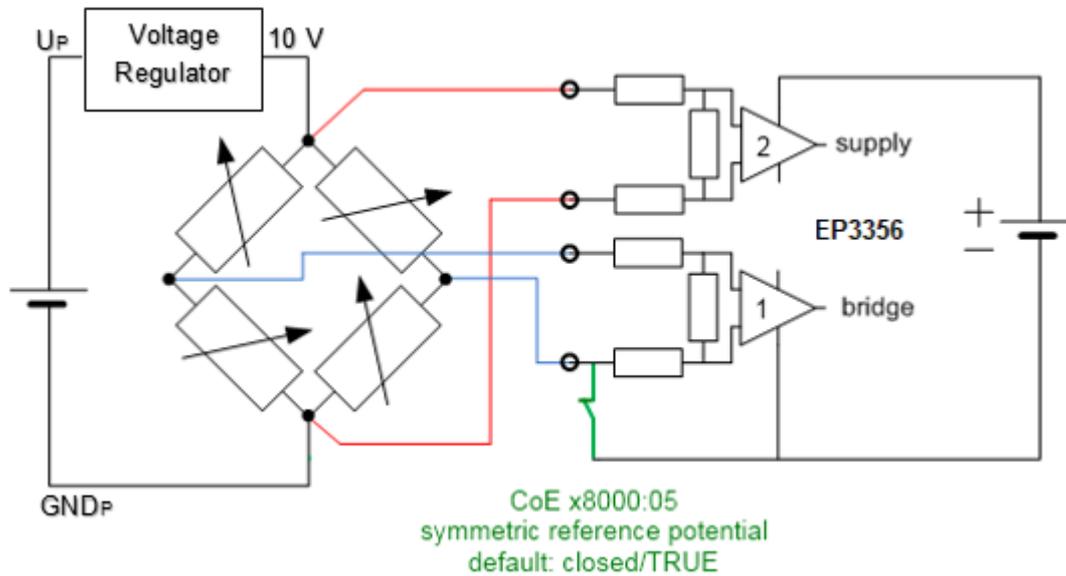


Fig. 73: Internal switch for increasing the measuring accuracy

If several strain gauges are supplied by the same power supply and equalising currents flow that falsify the measurement, the switch can be opened via CoE [0x8000:05](#) [► 104]. Alternatively, electrically isolated strain gauge supplies are to be installed.

### Open-circuit recognition

The EL/EP3356 has no express open-circuit recognition facility. If one of the bridge wires is broken, however, the voltage measured there generally moves towards the final value, thus displaying an error in the status word. Over/underrange of the supply voltage is likewise indicated.

### Input freeze

If the terminal/box is placed in the freeze state by *InputFreeze* in the control word, no further analog measured values are relayed to the internal filter. This function is usable, for example, if a filling surge is expected from the application that would unnecessarily overdrive the filters due to the force load. This would result in a certain amount of time elapsing until the filter had settled again. The user himself must determine a sensible *InputFreeze* time for his filling procedure.

For clarification: temporal control of the *InputFreeze* and the decision regarding its use must be realised by the user in the PLC, they are not components of the EL/EP3356.

In the following example (recorded with Scope2) impulses on a 15 kg load cell are recorded; the filter is wide open at IIR1 so that steep edges occur in the signal.

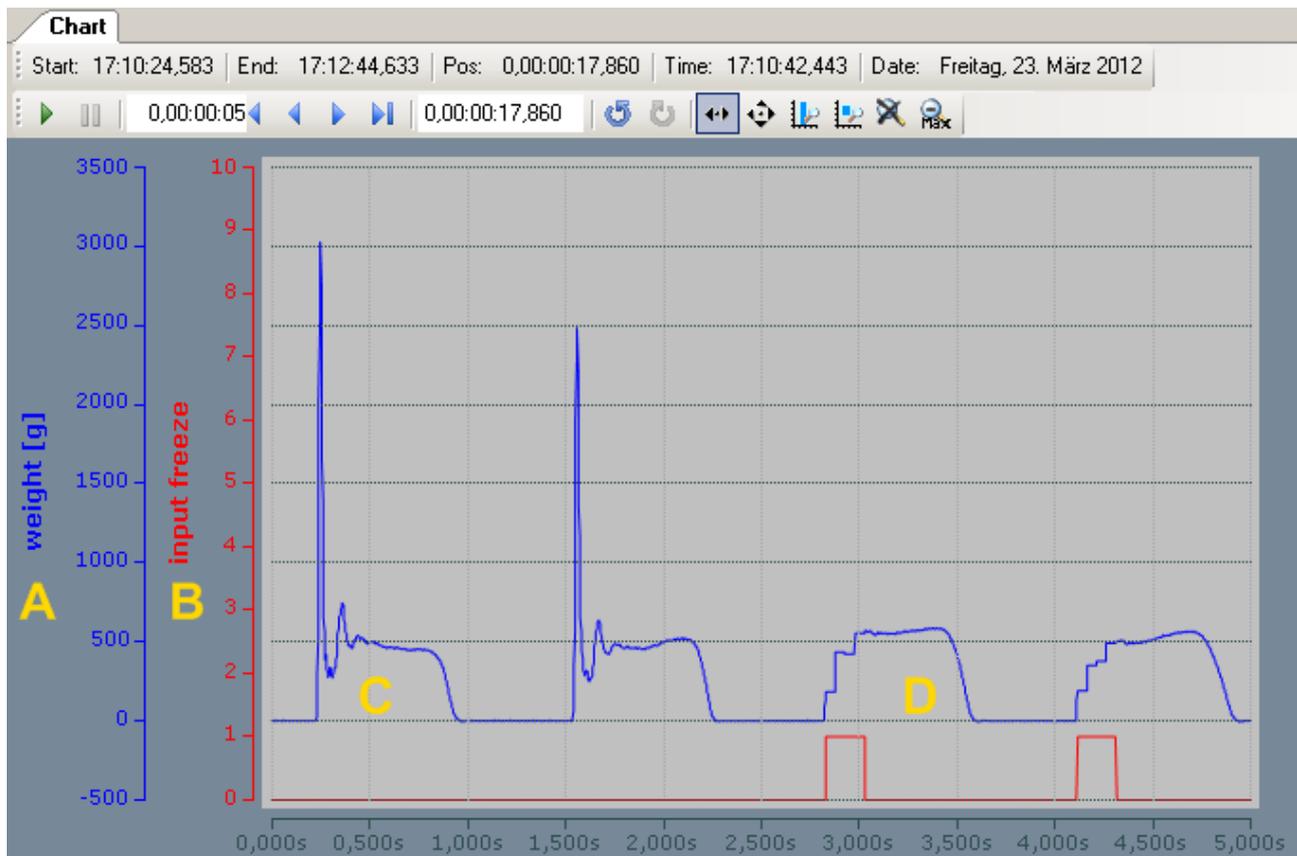


Fig. 74: Impulses on a load cell with and without InputFreeze

Explanation: The weight (A) is shown in blue; the state of the InputFreeze variable, which can be controlled by the PLC program and can be TRUE/FALSE, is shown in red (B). The first two impulses (C) lead to large peak deflections in the signal. After that the following is activated in the PLC program (see [example program](#) [► 113]):

- if the measured value for the last cycle (cycle time 100 µs) has changed by more than 10 g (indicating a sudden load), *blInputFreeze* is set to TRUE for 50 ms by a TOF block on the EL/EP3356

The effect can be seen in (D): The peak load is no longer acknowledged by the EL/EP3356. If it is optimally adapted to the expected force impulse, the EL/EP3356 can measure the current load value without overshoot.

### Gravity adaption

The calculation of the weight depends on the gravitation/the Earth's gravitational force/acceleration due to gravity at the place of installation of the scales. In general, acceleration due to the gravitational pull of the earth at the place of installation is not equal to the defined standard value of  $g = 9.80665 \text{ m/s}^2$ . For example, 4 zones of acceleration due to gravity are defined in Germany, in which a local acceleration due to gravity of  $9.807 \text{ m/s}^2$  to  $9.813 \text{ m/s}^2$  is to be assumed. Hence, within Germany alone there is a clear dispersion of the order of parts per thousand for acceleration due to gravity, which has a direct effect on the measured weight in accordance with the equation  $FG = m \cdot g$ !

If

- load cells are used in the theoretical calibration with characteristic values according to the sensor certificate
- calibration weights are used whose weight at the place of installation of the scales is by nature different to that at the place of origin
- scales of the accuracy class I to III are to be realized
- scales that are generally independent of acceleration due to gravity are to be realized

then one should check whether the gravity correction needs to be adapted via object [0x8000:26](#) [► 104].

**Idling recognition**

Weighing is a dynamic procedure that can lead to large jumps in the bridge voltage and thus to the calculation of the value. Following a change in load, the measured value must first "settle" so that the process value is evaluable in the controller. The evaluation of the measured value and the decision over the degree of calmness can be done in the controller; however, the EL/EP3356 also offers this function, which is activated by default. The result is output in the status word.

- If the load value remains within a range of values y for longer than time x, then the *SteadyState* is activated in the *StatusWord*.
- *SteadyState* is set to FALSE as soon as this condition no longer applies.
- The parameters x and y can be specified in the CoE
- The evaluation is naturally considerably affected by the filter setting

In the following example (recorded with TwinCAT Scope2), a 15 kg load cell is suddenly unloaded and loaded with 547 g. *SteadyState* is subject to a window time from 100 ms and a tolerance of 8 g (15 kg nominal value, scaling 1000; see CoE).

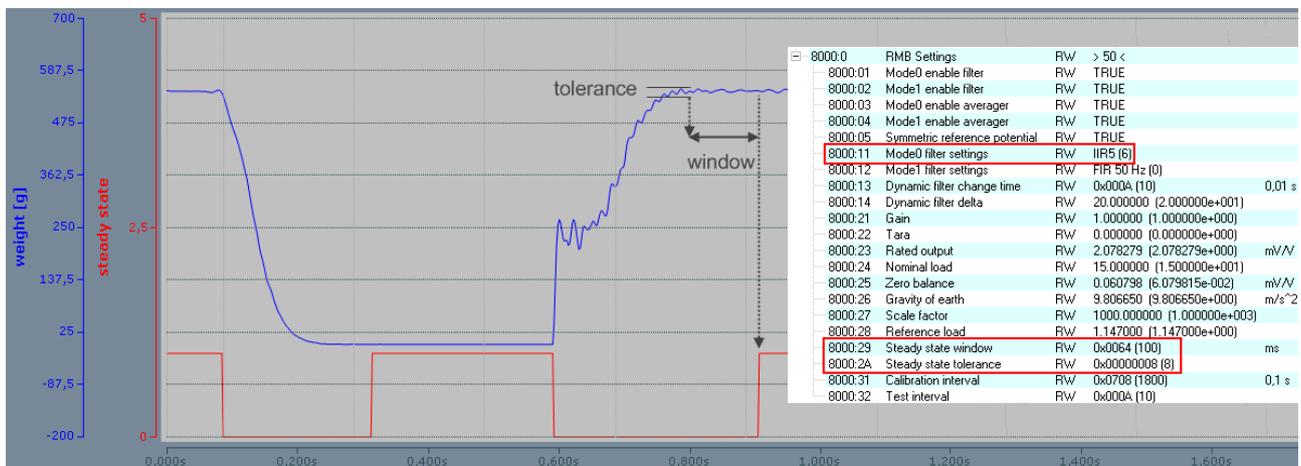


Fig. 75: Load cell loaded and unloaded

**Official calibration capability**

"Official calibration" is a special kind of calibration that is accomplished according to special regulations with the involvement of trained personnel using prescribed aids. The use of "officially calibrated" scales is mandatory in the Central European region, in particular for the filling of foodstuffs. This ensures the correctness of the weighed quantities in a particular way.

The Beckhoff EL/KL335x terminals and the EP3356 boxes cannot be officially calibrated as individual devices. However, they can be integrated as elements in applications that can then be equipped by the integrator with the required characteristics for official calibration capability using appropriate means.

## 6.7 Calibration and adjustment

The term "calibration" can be applied in 3 different ways to the EL/EP3356:

- Sensor calibration: once-only calibration of the employed sensor (strain gauge) during commissioning of the system
- Self-calibration: continuously repeated self-calibration of the terminal/box for the improvement of the measuring accuracy
- Tare: repeated gross/net compensation by taring

### ● EL/EP3356 and special versions



Unless stated otherwise, the designation „EL/EP3356“ always refers also to special versions such as the EL3356-0010 and the EP3356-0022.

### Sensor calibration

The EL/EP3356 is matched to the characteristic curve of the sensor element by means of the calibration. Two values are required for this procedure: the initial value without a load ("zero balance") and fully loaded ("rated output"). These values can be determined by a calibration protocol or by a calibration using calibration weights.

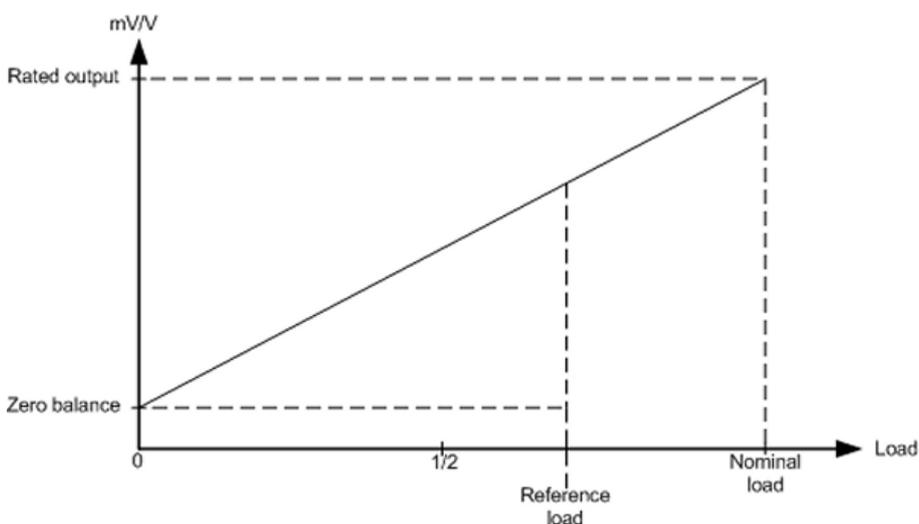


Fig. 76: Adaptation to the sensor curve

### Calibration by means of compensation in the system

In the "practical" calibration, measurement takes place first with the scales unloaded, then with a defined load on the scales. The EL/EP3356 automatically calculates the existing sensor characteristic values from the measured values.

Sequence:

1. Perform a CoE reset with object 0x1011:01, see [Restoring the delivery state \[► 118\]](#)
2. Set scale factor to 1000 (0x8000:27 [► 104]) (for declaration of weight in g)
3. Set gravity of earth (0x8000:26 [► 104]) if necessary (default: 9.806650)
4. Set gain to (0x8000:21 [► 104]) = 1
5. Set tare to 0 (0x8000:22 [► 104])
6. Set the filter (0x8000:11 [► 104]) to the strongest level: IIR8
7. Specify the nominal load of the sensor in 0x8000:24 [► 104] ("Nominal load")

- Zero balance: Do not load the scales. As soon as the measured value indicates a constant value for at least 10 seconds, execute the command "0x0101" (257dec) on CoE object 0xFB00:01 [▶ 102]. This command causes the current mV/V value (0x9000:11 [▶ 104]) to be entered in the "Zero balance" object. Check: CoE objects 0xFB00:02 [▶ 102] and 0xFB00:03 [▶ 102] must contain "0" after execution

| Object  | Access                 | Value          |
|---------|------------------------|----------------|
| 801E:0  | AI Internal data       | RO > 1 <       |
| 801F:0  | AI Vendor data         | RW > 2 <       |
| 8020:0  | AI Settings            | RW > 24 <      |
| 802E:0  | AI Internal data       | RO > 1 <       |
| 802F:0  | AI Vendor data         | RW > 2 <       |
| 9000:0  | RMB Info data          | RO > 17 <      |
| A000:0  | RMB Diag data          | RO > 24 <      |
| F000:0  | Modular device profile | RO > 2 <       |
| F008    | Code word              | RW 0x00000000  |
| F010:0  | Module list            | RW > 3 <       |
| FB00:0  | RMB Command            | RO > 3 <       |
| FB00:01 | Request                | RW 01 01       |
| FB00:02 | Status                 | RO 0x00 (0)    |
| FB00:03 | Response               | RO 00 00 00 00 |

- Load the scales with a reference load. This should be at least 20 % of the rated load. The larger the reference load, the better the sensor values can be calculated. In object 0x8000:28 [▶ 104] ("Reference load"), enter the load in the same unit as the rated load (0x8000:24 [▶ 104]). As soon as the measured value indicates a constant value for at least 10 seconds, execute the command "0x0102" (258dec) on CoE object 0xFB00:01 [▶ 102]. By means of this command the EL/EP3356 determines the output value for the nominal weight ("Rated output") Check: CoE objects 0xFB00:02 [▶ 102] and 0xFB00:03 [▶ 102] must contain "0" after execution.

| Object  | Access                 | Value             |
|---------|------------------------|-------------------|
| 8010:0  | AI Settings            | RW > 24 <         |
| 801E:0  | AI Internal data       | RO > 1 <          |
| 801F:0  | AI Vendor data         | RW > 2 <          |
| 8020:0  | AI Settings            | RW > 24 <         |
| 802E:0  | AI Internal data       | RO > 1 <          |
| 802F:0  | AI Vendor data         | RW > 2 <          |
| 9000:0  | RMB Info data          | RO > 17 <         |
| A000:0  | RMB Diag data          | RO > 24 <         |
| F000:0  | Modular device profile | RO > 2 <          |
| F008    | Code word              | RW 0x00000000 (0) |
| F010:0  | Module list            | RW > 3 <          |
| FB00:0  | RMB Command            | RO > 3 <          |
| FB00:01 | Request                | RW 01 01          |
| FB00:02 | Status                 | RO 0x00 (0)       |
| FB00:03 | Response               | RO 00 00 00 00    |

- Reset: execute the command "0x0000" (0dec) on CoE object 0xFB00:01 [▶ 102].
- Set the filter to a lower stage.

### Calibration according to the sensor calibration protocol (theoretical calibration)

The sensor characteristic values according to the manufacturer's certificate are communicated here directly to the EL/EP3356, so that it can calculate the load.

- Perform a CoE reset with object 0x1011:01, see [Restoring the delivery state \[▶ 118\]](#)
- Set scale factor to 1000 (0x8000:27 [▶ 104]) (for declaration of weight in g)
- Set gravity of earth (0x8000:26 [▶ 104]) if necessary (default: 9.806650)
- Set gain to (0x8000:21 [▶ 104]) = 1
- Set tare to 0 (0x8000:22 [▶ 104])
- Specify the nominal load of the sensor in 0x8000:24 [▶ 104] ("Nominal load")
- Adopt the "Rated output" (mV/V value 0x8000:23 [▶ 104]) from the calibration protocol
- Adopt the "Zero balance" (0x8000:25 [▶ 104]) from the calibration protocol

#### ● Calibration

**i** The calibration is of great importance for the accuracy of the system. In order to increase this, the filter should be set as strong as possible over the entire calibration phase. It may take several seconds before a static value is obtained.

## ● Local storage

**i** The values modified during the theoretical and practical calibration are stored in a local EEPROM. This can be written to up to 1 million times. In order to prolong the life of the EEPROM, therefore, the commands should not be executed cyclically.

## Self-calibration of the measuring amplifiers

The measuring amplifiers are periodically subjected to examination and self-calibration. Several analog switches are provided for this purpose, so that the various calibration signals can be connected. It is important for this process that the entire signal path, including all passive components, is examined at every phase of the calibration. Only the interference suppression elements (L/C combination) and the analog switches themselves cannot be examined. In addition, a self-test is carried out at longer intervals.

The self-calibration is carried out every 3 minutes in the default setting.

### Self-calibration

- The time interval is set in 100 ms steps with object `0x8000:31` [▶ `104`]; default: 3 min. Duration approx. 150 ms

### Self-test

- is additionally carried out together with every *n*th self-calibration. The multiple (*n*) is set with object `0x8000:32` [▶ `104`]; default: 10 additional duration approx. 70 ms.

By means of the self-calibration of the input stages at the two operating points (zero point and final value), the two measuring channels are calibrated to each other.

### Interface for controller

The self-calibration takes place automatically at the defined intervals. In order to prevent calibration during a time-critical measurement, the automatic calibration can be disabled via the "Disable calibration" bit in *ControlWord*, also permanently. If it should be additionally necessary to carry out a manual test, this is started by a rising edge of the "Start manual calibration" bit in the process image.

While the terminal is performing a self-calibration or a self-test, the "Calibration in progress" bit is set in the process image. Once started, a self-calibration/self-test cannot be aborted.

If the self-calibration has been disabled by "Disable calibration", it can nevertheless be started by the "Start calibration" process data bit.

## ● Self-calibration

**i** The self-calibration takes place for the first time directly after starting up the terminal/box. At this point the external reference voltage must already be applied. If the reference voltage is only applied later, the self-calibration must be manually initiated (process data bit: „Start calibration“). The self-calibration must be executed at least once after each start-up. The supply voltage must be applied during the self-calibration, since otherwise the necessary reference voltages cannot be generated. A lower measuring accuracy is to be expected if the self-calibration is disabled for a longer period or permanently.

After a change of the settings in the CoE (range `x80nn`), a self-calibration will be executed in each case (also for *DisabledCalibration* = TRUE), because the settings have an influence to the measuring procedure. CoE settings should be done as far as possible out of running measuring procedures.

## Taring

When taring, the scales are "zeroed" using an arbitrary applied load; i.e. an offset correction is performed. This is necessary for the gross/net compensation of goods that cannot be weighed without a container that has a mass of its own.

The EL/EP3356 supports 2 tarings; it is recommended to set a strong filter when taring.

## Temporary tare

- The correction value is NOT stored in the terminal/box and is lost in the event of a power failure. To this end the command "0x0001" is executed on CoE object [0xFB00:01 \[▶ 102\]](#) (binary dialog in the System Manager: "01 00"). This sets the tare object ([0x8000:22 \[▶ 104\]](#)) such that the display value is 0. Note: in the case of a device restart (INIT → OP) the tare is not deleted. In addition this tare can be executed via the control word:

- Ctrl
- Start calibration
- Disable calibration
- Input freeze
- Sample mode
- Tara**

**Permanent tare**

- The correction value is stored locally in the terminal's/boxes EEPROM and is not lost in the event of a power failure. To this end the command "0x0002" is executed on CoE object [0xFB00:01 \[▶ 102\]](#) (binary dialog in the System Manager: "02 00"). This sets the tare object ([0x8000:22 \[▶ 104\]](#)) such that the display value is 0.

**Local storage**

The values modified during the theoretical and practical calibration are stored in a local EEPROM. This can be written to up to 1 million time. In order to prolong the life of the EEPROM, therefore, the commands should not be executed cyclically.

**Commands**

The functions discussed above are carried out by means of commands in the standardized object [0xFB00 \[▶ 102\]](#).

| Index   | Name     | Comment   |
|---------|----------|---|
| FB00:01 | Request  | Entry of the command to be executed   |
| FB00:02 | Status   | Status of the command currently being executed<br>0: Command executed without error<br>255: Command is being executed |
| FB00:03 | Response | Optional response value of the command  |

The function blocks *FB\_EcCoESdoWrite* and *FB\_EcCoESdoRead* from the *TcEtherCAT.lib* (contained in the standard TwinCAT installation) can be used in order to execute the commands from the PLC.

**Commands of the EL/EP3356**

The following commands can be transferred to the terminal/box via the CoE entry [0xFB00:01 \[▶ 102\]](#).

| Command | Comment  |
|---------|--|
| 0x0101  | Execute zero balance   |
| 0x0102  | Execute calibration  |
| 0x0001  | Execute tare procedure (value is NOT saved in the terminal's/boxes EEPROM) |
| 0x0002  | Execute tare procedure (value is saved in the terminal's/boxes EEPROM)     |

## 6.8 Notices on analog specifications

Beckhoff I/O devices (terminals, boxes) with analog inputs are characterized by a number of technical characteristic data; refer to the technical data in the respective documents.

Some explanations are given below for the correct interpretation of these characteristic data.

### Full scale value

An I/O device with an analog input measures over a nominal measuring range that is limited by an upper and a lower limit (initial value and end value); these can usually be taken from the terminal/box designation. The range between the two limits is called the measuring span and corresponds to the equation (end value - initial value). Analogous to pointing devices this is the measuring scale (see IEC 61131) or also the dynamic range. For analog I/O devices from Beckhoff the rule is that the limit with the largest value is chosen as the full scale value of the respective product (also called the reference value) and is given a positive sign. This applies to both symmetrical and asymmetrical measuring spans.

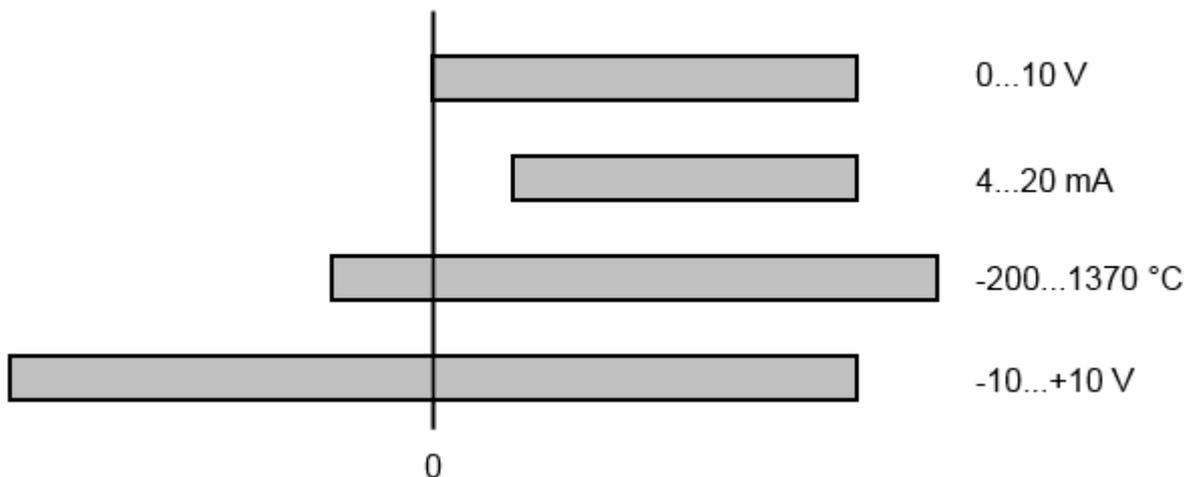


Fig. 77: Measuring range

For the above **examples** this means:

- Measuring range 0 to 10 V: asymmetric unipolar, full scale value = 10 V, measuring span = 10 V
- Measuring range 4 to 20 mA: asymmetric unipolar, full scale value = 20 mA, measuring span = 16 mA
- Measuring range -200 to 1370 °C: asymmetric bipolar, full scale value = 1370 °C, measuring span = 1570 °C
- Measuring range -10 to +10 V: symmetric bipolar, full scale value = 10 V, measuring span = 20 V

This applies equally for analog output terminals/boxes.

### ± Measuring error [% of the full scale value] (also: measurement error)

The relative measuring error is referenced to the full scale value and is calculated as the quotient of the largest numerical deviation from the true value ('measuring error') referenced to the full scale value.

$$\text{Messfehler} = \frac{|\text{max. Abweichung}|}{\text{MBE}}$$

The measuring error is generally valid for the entire permitted operating temperature range, also called the 'usage error limit' and contains random and systematic portions of the referred device (i.e. 'all' influences such as temperature, inherent noise, aging, etc.).

It always to be regarded as a positive/negative span with ±, even if it is specified without ± in some cases.

The maximum deviation can also be specified directly.

**Example:** Measuring range 0 to 10 V and measuring error  $< \pm 0.3\%$  full scale value  $\rightarrow$  maximum deviation  $\pm 30$  mV in the permissible operating temperature range.

Notice: since this specification also includes the temperature drift, a significantly lower measuring error can usually be assumed in case of a constant ambient temperature and thermal stabilization of the device. This applies equally for analog output terminals/boxes.

**Single-ended/differential typification**

For analog inputs Beckhoff makes a basic distinction between two types: single-ended (SE) and differential (DIFF), referring to the difference in electrical connection with regard to the potential difference.

The diagram shows two-channel versions of an SE module and a DIFF module as examples for all multi-channel versions.

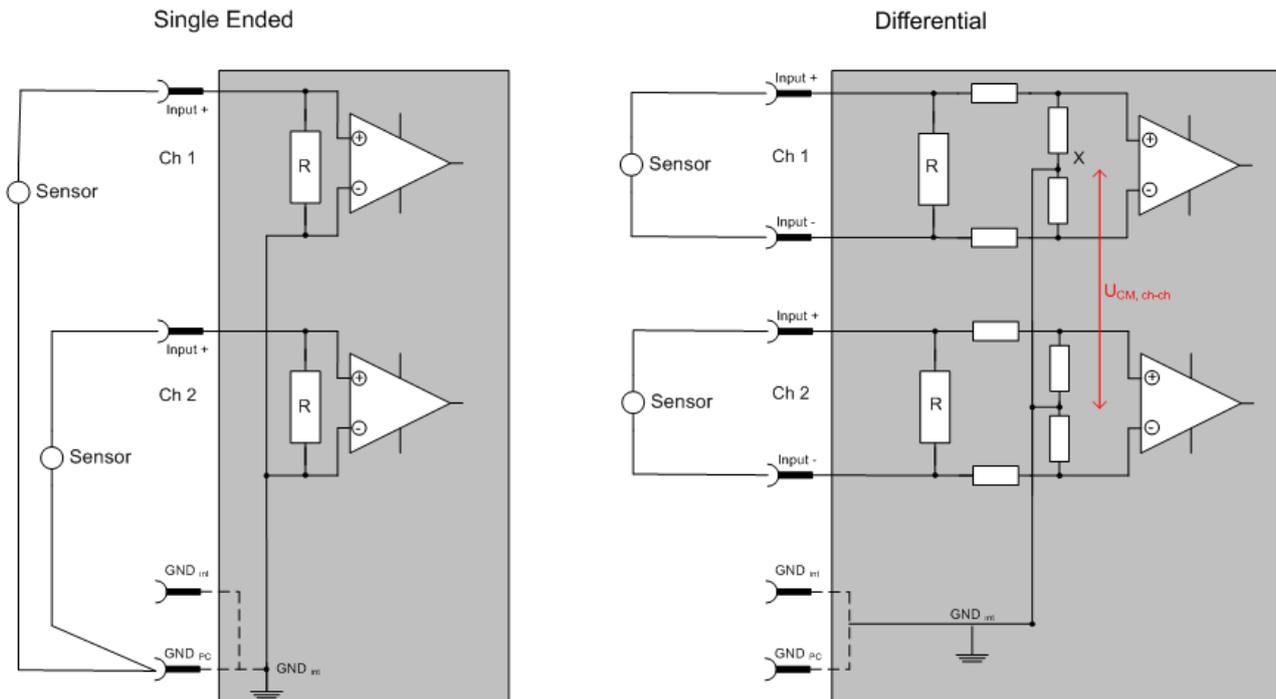


Fig. 78: Single-ended/differential typification

Notice: Dashed lines indicate that the respective connection may not necessarily be present in each SE or DIFF module.

The basic rule:

- Analog measurements always take the form of voltage measurements between two potential points. For voltage measurements a large R is used, in order to ensure a high impedance. For current measurements a small R is used as shunt. If the purpose is resistance measurement, corresponding considerations are applied.
  - Beckhoff generally refers to these two points as input+/signal potential and input-/reference potential.
  - For measurements between two potential points two potentials have to be supplied.
  - Regarding the terms "single-wire connection" or "three-wire connection", please note the following for pure analog measurements: three- or four-wire connections can be used for sensor supply, but are not involved in the actual analog measurement, which always takes place between two potentials/wires. In particular this also applies to SE, even though the term suggest that only one wire is required.
- The term "electrical isolation" should be clarified in advance. Beckhoff IO modules feature 1...8 or more analog channels; with regard to the channel connection a distinction is made in terms of:
  - how the channels WITHIN a module relate to each other, or
  - how the channels of SEVERAL modules relate to each other.

The property of electrical isolation indicates whether the channels are directly connected to each other.

- Beckhoff terminals/boxes always feature electrical isolation between the field/analog side and the bus/EtherCAT side. In other words, if two analog terminals/boxes are not connected via the power contacts, the modules are effectively electrically isolated.
- If channels within a module are electrically isolated, or if a single-channel module has no power contacts, the channels are effectively always differential. See also explanatory notes below. Differential channels are not necessarily electrically isolated.
- Analog measuring channels are subject to technical limits, both in terms of the recommended operating range (continuous operation) and the destruction limit. Please refer to the respective terminal documentation for further details.

Explanation

- **Differential**

- Differential measurement is the most flexible concept. The user can freely choose both connection points, input+/signal potential and input-/reference potential, within the framework of the technical specification.
- A differential channel can also be operated as SE, if the reference potential of several sensors is linked. This interconnection may take place via the system GND.
- Since a differential is configured symmetrically internally (see diagram), there will be a mid-potential (X) between the two supplied potentials that is the same as the internal ground/reference ground for this channel. If several DIFF channels are used in a module without electrical isolation, the technical property V<sub>CM</sub> (common-mode voltage) indicates the degree to which the mean voltage of the channels may differ.
- The internal reference ground may be accessible as connection point at the terminal/box, in order to stabilize a defined GND potential in the terminal/box. In this case it is particularly important to pay attention to the quality of this potential (noiselessness, voltage stability). At this GND point a wire may be connected to make sure that V<sub>CM,max</sub> is not exceeded in the differential sensor cable. If differential channels are not electrically isolated, usually only one V<sub>CM,max</sub> is permitted. If the channels are electrically isolated this limit should not apply, and the channels voltages may differ up to the specified separation limit.
- Differential measurement in combination with correct sensor wiring has the special advantage that any interference affecting the sensor cable (ideally the feed and return line are arranged side by side, so that interference signals have the same effect on both wires) has very little effect on the measurement, since the potential of both lines varies jointly (hence the term common mode). In simple terms: Common-mode interference has the same effect on both wires in terms of amplitude and phasing.
- Nevertheless, the suppression of common-mode interference within a channel or between channels is subject to technical limits, which are specified in the technical data.

- **Single Ended**

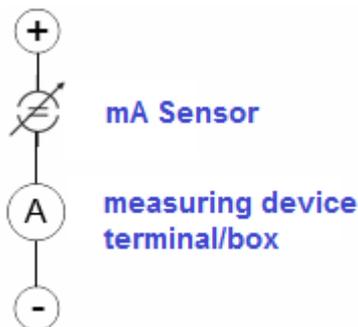
- If the analog circuit is designed as SE, the input/reference wire is internally fixed to a certain potential that cannot be changed. This potential must be accessible from outside on at least one point for connecting the reference potential, e.g. via the power contacts.
- In other words, in situations with several channels SE offers users the option to avoid returning at least one of the two sensor cables to the terminal/box (in contrast to DIFF). Instead, the reference wire can be consolidated at the sensors, e.g. in the system GND.
- A disadvantage of this approach is that the separate feed and return line can result in voltage/current variations, which a SE channel may no longer be able to handle. See common-mode interference. A V<sub>CM</sub> effect cannot occur, since the module channels are internally always 'hard-wired' through the input/reference potential.

### Typification of the 2/3/4-wire connection of current sensors

Current transducers/sensors/field devices (referred to in the following simply as 'sensor') with the industrial 0/4-20 mA interface typically have internal transformation electronics for the physical measured variable (temperature, current, etc.) at the current control output. These internal electronics must be supplied with energy (voltage, current). The type of cable for this supply thus separates the sensors into *self-supplied or externally supplied sensors*:

- **Self-supplied sensors**

- The sensor draws the energy for its own operation via the sensor/signal cable + and -. So that enough energy is always available for the sensor's own operation and open-circuit detection is possible, a lower limit of 4 mA has been specified for the 4-20 mA interface; i.e. the sensor allows a minimum current of 4 mA and a maximum current of 20 mA to pass.
- For a 2-wire connection; see IEC60381-1
- Such current transducers generally represent a current sink and thus like to sit between + and – as a 'variable load'. Refer also to the sensor manufacturer's information.



Therefore, they are to be connected according to the Beckhoff terminology as follows:

- preferably to '**single-ended**' inputs if the +Supply connections of the terminal/box are also to be used - connect to +Supply and Signal
- the sensor draws the energy/operating voltage for its own operation from 2 supply cables of its own. One or two further sensor cables are used for the signal transmission of the current loop:

#### Externally supplied sensors

- **3- and 4-wire connection see Fig. Connection of externally supplied sensors, cf. IEC60381-1**
- **the sensor draws the energy/operating voltage for its own operation from 2 supply cables of its own. One or two further sensor cables are used for the signal transmission of the current loop:**
  1. sensor cable: according to the Beckhoff terminology such sensors are to be connected to '**single-ended**' inputs in 3 cables with +/-Signal lines and if necessary FE/shield
  2. sensor cables: In the case of sensors with 4-wire connection according to +/-Signal/-Signal, you must check whether +Signal may be connected to +Supply or -Signal to -Supply.
    - Yes: then you can connect accordingly to a Beckhoff '**single-ended**' input.
    - the Beckhoff '**differential**' input for +Signal and -Signal is to be selected; +Supply and -Supply are to be connected via additional cables.

Notice: expert organizations such as NAMUR demand a usable measuring range <4 mA/>20 mA for error detection and adjustment, see also NAMUR NE043.

The Beckhoff device documentation must be consulted in order to see whether the respective device supports such an extended signal range.

In general the polarity/direction of current is to be observed due to the internal diode!

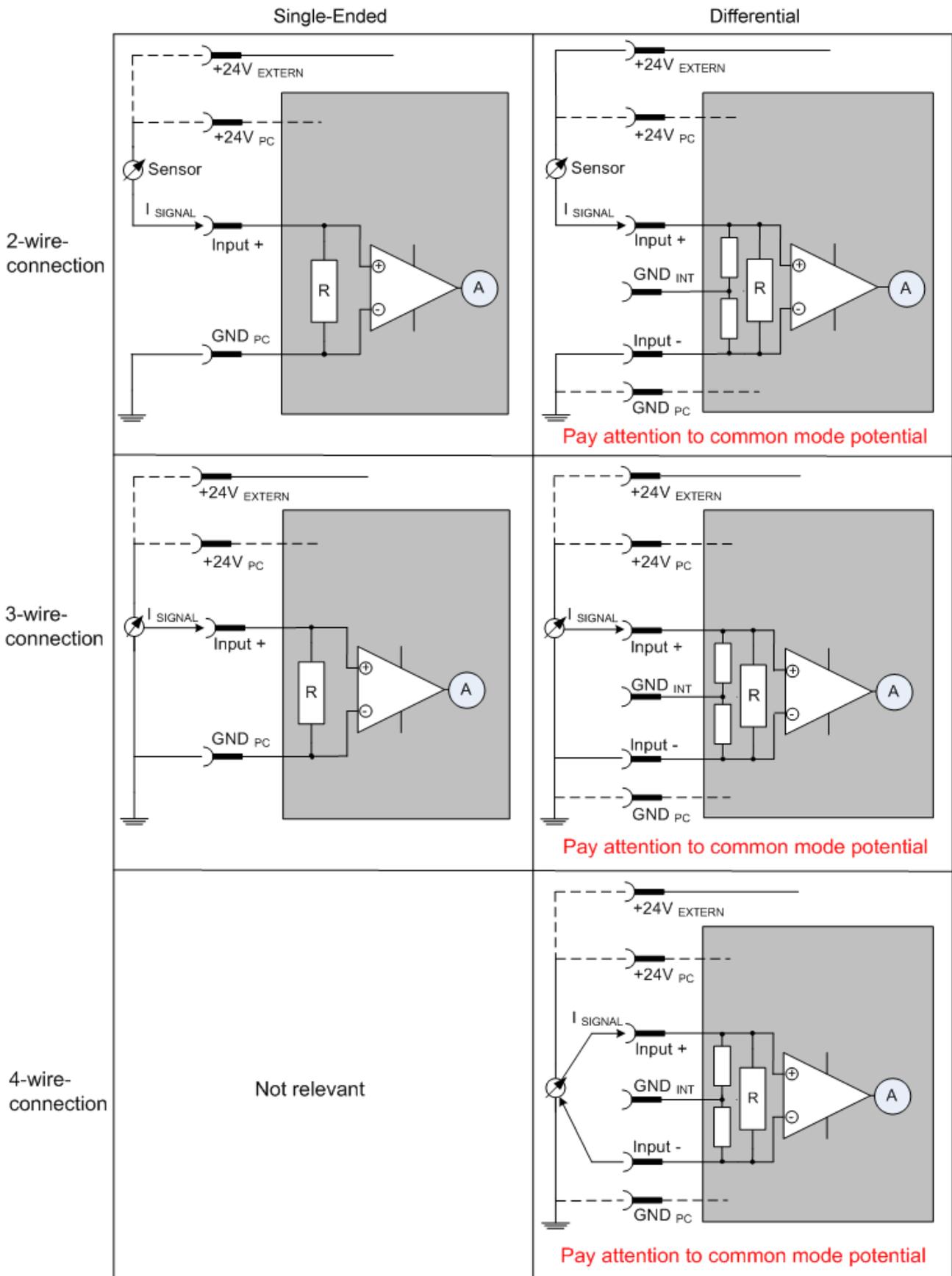


Fig. 79: 2/3/4-wire connection as single-ended or differential connection technology

## 6.9 Voltage measurement

### ● EL/EP3356 and special versions

**i** Unless stated otherwise, the designation „EL/EP3356“ always refers also to special versions such as the EL3356-0010 and EP3356-0022.

The EL/EP3356 principally offers a 2-channel voltage measurement on one terminal/box with 2 very different measuring ranges of  $\pm 25$  mV and  $\pm 12$  V nominal voltage. The load on the one connected strain gauge can be calculated from the two simultaneously measured voltages; the EL/EP3356 already performs this calculation in the terminal/box and thus represents a 1-channel terminal/box in the sense of load calculation.

The following applies to the individual channels:

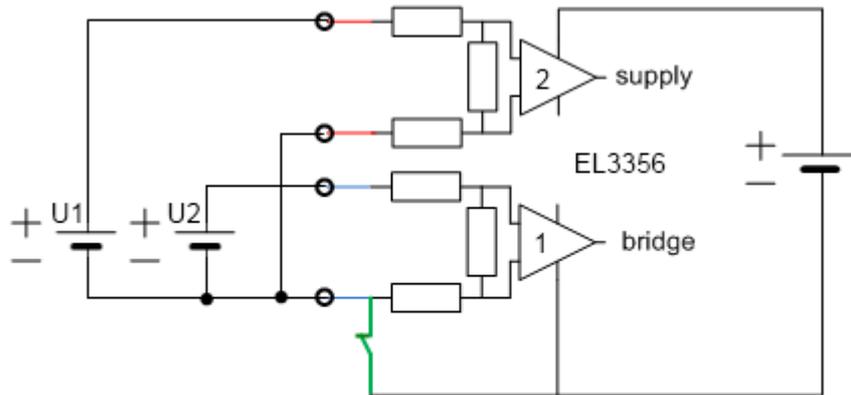
- Channel 1:
  - Typical measuring range approx.  $-13.5$  V to 0 to  $+13.5$  V (equivalent to process value  $0x80.00.00.00$  to 0 to  $0x7F.FF.FF.FF$ )
  - Nominal measuring range:  $-12$  V... 0 ...  $+12$  V
  - max. permissible voltage  $-U_D$  vs.  $+U_D$ :  $\pm 13.5$  V
  - Measuring error  $< \pm 0.1$  % of the full scale value, 50 Hz filter active
- Channel 2:
  - Typical measuring range approx.  $-27$  mV to 0 to  $+27$  mV (equivalent to process value  $0x80.00.00.00$  to 0 to  $0x7F.FF.FF.FF$ )
  - Nominal measuring range:  $-25$  mV... 0 ...  $+25$  mV
  - max. permissible voltage  $-U_{ref}$  vs.  $+U_{ref}$ :  $\pm 27$  mV
  - Measuring error  $< \pm 0.1$  % of the full scale value, 50 Hz filter active
- in strain gauge mode the connected strain gauge guarantees that no impermissibly high potential differences arise inside and outside the circuit.

In the standard setting the EL/EP3356 operates as a 1-channel strain gauge monitor with the process image [[▶ 92](#)]; the terminal/box can be switched to 2-channel voltage measurement by changing the process data. See the notes on the process image regarding this. If the EL/EP3356 is not used as a load measuring terminal/box, but rather as a 2-channel analog input measuring terminal/box, the following must be observed:

- The CoE settings are to be found for:
  - Channel 1: objects under  $0x8010:xx$  [[▶ 102](#)]
  - Channel 2: objects under  $0x8020:xx$  [[▶ 102](#)]
  - the strain gauge objects under  $x8000:xx$  have no function. Exception: the averager ( $0x8000:03$  [[▶ 104](#)]) can also be used in voltage measuring mode and applies to both channels simultaneously.
- Self-calibration is not possible and useful.
- The two analog channels are not calibrated by the manufacturer, since this is not required for the relative measurement in strain gauge mode. This means, for example, for channel 1 with a nominal measuring range of  $\pm 12$  V or a typical measuring range of  $\pm 13.5$  V, that the maximum measured value  $0x7F.FF.FF.FF$  can be output by one terminal/box for example as 13.4 V and by another as 13.6 V. If terminals/boxes output identical process values for identical applied voltages, meaning that they are exchangeable, each channel must be calibrated by the user by making settings for each channel in the CoE. The user calibration (CoE  $0x80n0:17$  [[▶ 102](#)] [offset],  $0x80n0:18$  [[▶ 102](#)] [gain]) or the user scaling (CoE  $0x80n0:11$  [[▶ 102](#)] [offset],  $0x80n0:12$  [[▶ 102](#)] [gain]) can be used for this.

## **i** Voltage measurement

In the voltage measuring mode the **EL3356** is to be connected to external GND with a single-ended connection. In addition the internal GND reference is to be closed by the CoE switch *SymmetricReferencePotential*. The EP3356 “supply” is not usable because the box internally generated 10 V.



CoE x8000:05  
symmetric reference potential  
default: closed/TRUE

## 6.10 Distributed Clocks mode (EL3356-0010 and EP3356-0022 only)

In the Distributed Clocks mode (DC mode), the precise timestamp is recorded for each measured value and transmitted to the controller as cyclic process data. To this end

- DC must be activated. To do this, select DC-Synchron (input based) on the "DC" tab
- The PDO x1A03 in the [Process data management \[► 92\]](#) is to be activated in the SyncManager 3 "Inputs"

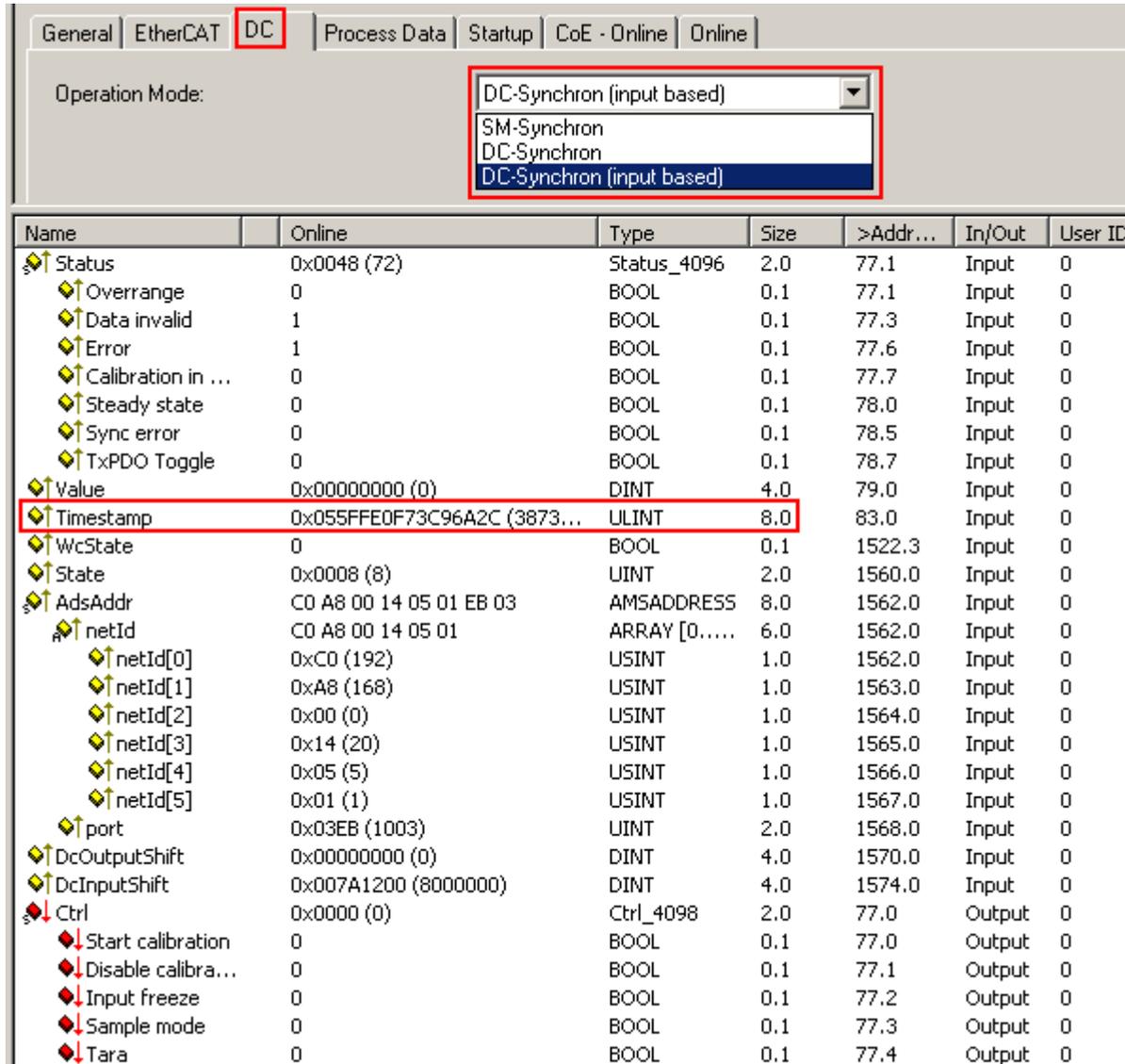


Fig. 80: Activation of DC and PDO timestamp in the TwinCAT System Manager

The EL3356-0010/EP3356-0022 operates free running with a cyclic, but not equidistant measurement; the time intervals between 2 measured values are therefore not constant. For this reason the 64-bit timestamp delivered with the process value must be evaluated by the user.

In order to suppress falsification of the measurement results by upstream filters, both the software filter and the averager are deactivated in this operating mode. The measurement/calculation and provision of the measured value in the process data therefore takes place at the conversion rate corresponding to the mode:

- EL3356: 10.5 kSps
- EL3356-0010/EP3356-0022: 10.5 or 105.5 kSps

The minimum permissible EtherCAT cycle time is 100 µs for the EL3356-0010/EP3356-0022 with and without DC mode.

## Time stamp

See Notes on [latency regarding \[► 67\]](#) the time when the actual timestamp is acquired.

## 6.11 Process data

This section describes the individual PDOs and their content. A PDO (Process Data Object) is a unit on cyclically transmitted process values. Such a unit can be an individual variable (e.g. the weight as a 32-bit value) or a group/structure of variables. The individual PDOs can be activated or deactivated separately in the TwinCAT System Manager. The "Process data" tab is used for this (visible only if the terminal/box is selected on the left). A change in the composition of the process data in the TwinCAT System Manager becomes effective only after restarting the EtherCAT system.

The EL/EP3356 can be used in 2 basic operating modes

- 1-channel strain gauge evaluation (strain gauge, balance beam, load cell): Here, both analog input voltages are measured internally, they are calculated locally according to the internal settings in the terminal/box and the resulting load value is output to the controller as a cyclic process value. The terminal/box is to be regarded as a 1-channel terminal/box. The load value can be output as an integer or as a float/real representation.
- 2-channel voltage measurement: Both analog input voltages are output directly as process values; no load calculation takes place. The value and status information can be output for each channel.

The basic operating mode of the EL3356 terminal / EP3356 box is determined by the selection of the process data (PDO).

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### ● EL/EP3356 and special versions

**i** EL/EP3356, EL3356-0010 and EP3356-0022 have the same process data except. EL3356: no mode switching in the *ControlWord*

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### Selection of process data

The process data of the EL/EP3356 are set up in the TwinCAT System Manager. The individual PDOs can be activated or deactivated separately. The "Process data" tab is used for this (visible only if the terminal/box is selected on the left).

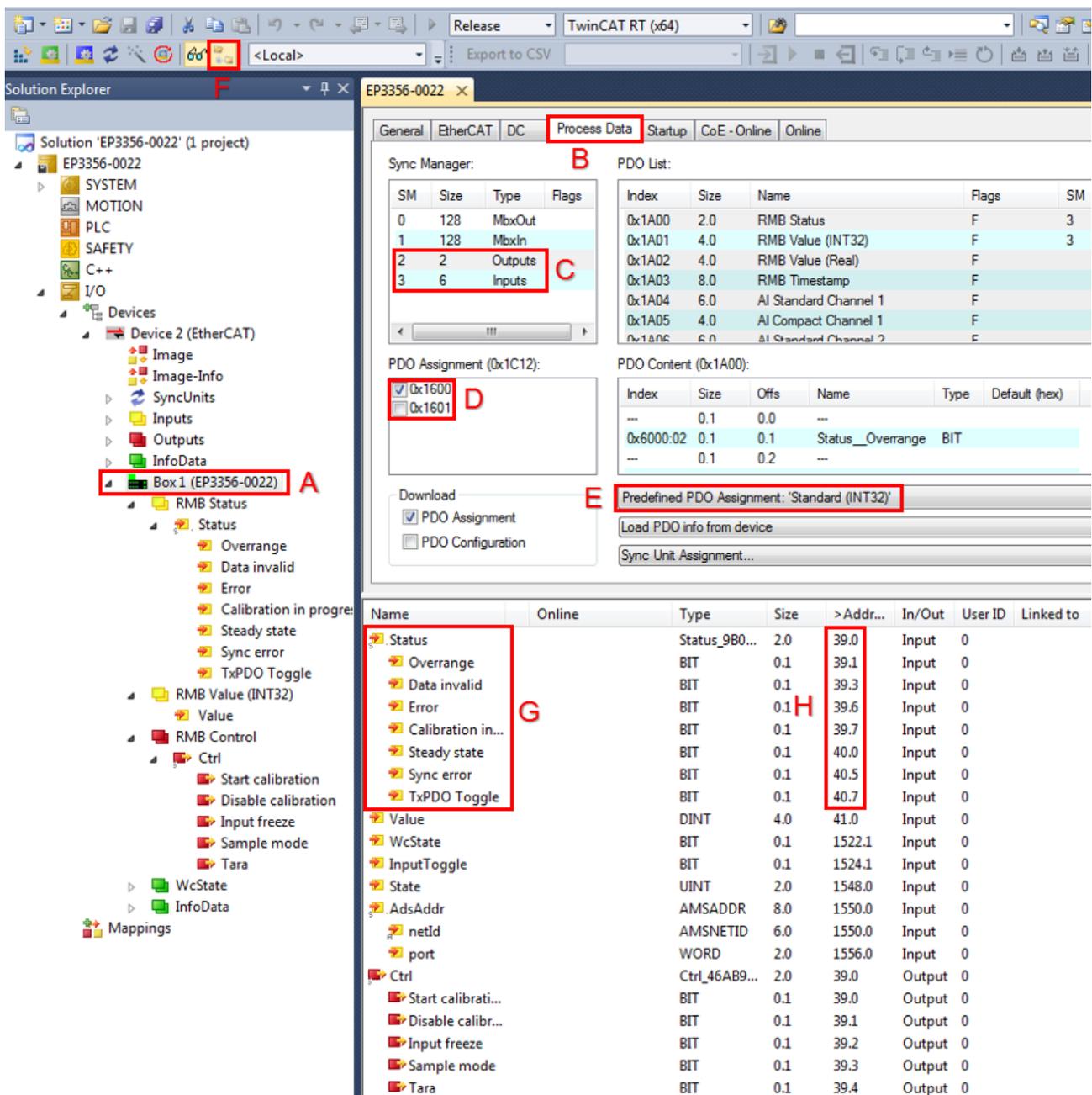


Fig. 81: EP3356 - process data selection in the TwinCAT System Manager

If the terminal/box is selected in the System Manager (A), the *Process data* tab (B) shows the PDO selection. The two SyncManagers of the inputs (SM3) and outputs (SM2) can be changed (C). If one of the two is clicked on, the PDO possible for this SyncManager appears underneath it (D). PDOs that are already activated have an activated checkbox in front of them; this is activated by clicking on it.

The process data which then belong to the device are listed underneath it (G). So that the individual bit meanings are visible, e.g. in the *Status* status word, and can be separately linked (G), ShowSubVariables must be activated in the System Manager (F). The bit position at which the subvariables are located in the status or control word (Ctrl) can be taken from the address overview (H) or the following information.

### Predefined PDO Assignment

In order to simplify the configuration, typical configuration combinations of process data are stored in the device description. The predefined configurations can be selected in the process data overview. Therefore the function is available only if the ESI/XML files are saved in the system ([downloadable from the Beckhoff website](#)).

The following combinations are possible (see also previous figure, E):

|   |
|---|
| Predefined PDO Assignment: 'Standard (INT32)'       |
| Predefined PDO Assignment: (none)                   |
| Predefined PDO Assignment: 'Standard (INT32)'       |
| Predefined PDO Assignment: 'Standard (REAL)'        |
| Predefined PDO Assignment: '2x AnalogIn (Standard)' |
| Predefined PDO Assignment: '2x AnalogIn (Compact)'  |

- *Standard (INT32): [Default setting] load calculation; 32-bit integer load value as final value according to the calculation specifications in the CoE, no further conversion necessary in the PLC*
- *Standard (REAL): Load calculation; 32-bit floating-point load value as final value according to the calculation specifications in the CoE, no further conversion necessary in the PLC*
- *2x AnalogIn (Standard): 2-channel voltage measurement, 32-bit integer voltage value with additional information (under-range, over-range, error, TxPdoToggle)*
- *2x AnalogIn (Compact): 2-channel voltage measurement, 32-bit integer voltage value only*

## Default process image

The default process image is standard (INT32).

| Name                      | Online                  | Type          | Size | >Addr... | In/Out | User ID |
|---------------------------|-------------------------|---------------|------|----------|--------|---------|
| ↕ Status                  | 0x8100 (33024)          | Status_4096   | 2.0  | 45.0     | Input  | 0       |
| ↕ Overrange               | 0                       | BOOL          | 0.1  | 45.1     | Input  | 0       |
| ↕ Data invalid            | 0                       | BOOL          | 0.1  | 45.3     | Input  | 0       |
| ↕ Error                   | 0                       | BOOL          | 0.1  | 45.6     | Input  | 0       |
| ↕ Calibration in progress | 0                       | BOOL          | 0.1  | 45.7     | Input  | 0       |
| ↕ Steady state            | 1                       | BOOL          | 0.1  | 46.0     | Input  | 0       |
| ↕ Sync error              | 0                       | BOOL          | 0.1  | 46.5     | Input  | 0       |
| ↕ TxPDO Toggle            | 1                       | BOOL          | 0.1  | 46.7     | Input  | 0       |
| ↕ Value                   | 0x00000097 (151)        | DINT          | 4.0  | 47.0     | Input  | 0       |
| ↕ WcState                 | 0                       | BOOL          | 0.1  | 152.1    | Input  | 0       |
| ↕ State                   | 0x0008 (8)              | UINT          | 2.0  | 156.0    | Input  | 0       |
| ↕ AdsAddr                 | C0 A8 00 14 05 01 EB 03 | AMSADDRESS    | 8.0  | 156.0    | Input  | 0       |
| ↕ netId                   | C0 A8 00 14 05 01       | ARRAY [0..... | 6.0  | 156.0    | Input  | 0       |
| ↕ netId[0]                | 0xC0 (192)              | USINT         | 1.0  | 156.0    | Input  | 0       |
| ↕ netId[1]                | 0xA8 (168)              | USINT         | 1.0  | 156.3.0  | Input  | 0       |
| ↕ netId[2]                | 0x00 (0)                | USINT         | 1.0  | 156.4.0  | Input  | 0       |
| ↕ netId[3]                | 0x14 (20)               | USINT         | 1.0  | 156.5.0  | Input  | 0       |
| ↕ netId[4]                | 0x05 (5)                | USINT         | 1.0  | 156.6.0  | Input  | 0       |
| ↕ netId[5]                | 0x01 (1)                | USINT         | 1.0  | 156.7.0  | Input  | 0       |
| ↕ port                    | 0x03EB (1003)           | UINT          | 2.0  | 156.8.0  | Input  | 0       |
| ↕ Ctrl                    | 0x0000 (0)              | Ctrl_4098     | 2.0  | 45.0     | Output | 0       |
| ↕ Start calibration       | 0                       | BOOL          | 0.1  | 45.0     | Output | 0       |
| ↕ Disable calibration     | 0                       | BOOL          | 0.1  | 45.1     | Output | 0       |
| ↕ Input freeze            | 0                       | BOOL          | 0.1  | 45.2     | Output | 0       |
| ↕ Sample mode             | 0                       | BOOL          | 0.1  | 45.3     | Output | 0       |
| ↕ Tara                    | 0                       | BOOL          | 0.1  | 45.4     | Output | 0       |

Fig. 82: Default process image, EL3356-0010 / EP3356-0022

Note regarding EL/EP3356: No switching of *SampleMode* in the Ctrl word

**Function of the variables**

**Variable:** Status

**Meaning:** The status word (SW) is located in the input process image, and is transmitted from terminal/box to the controller.

| Bit            | SW. 15                                   | SW. 14 | SW. 13                | SW. 12 | SW. 11 | SW. 10 | SW. 9 | SW. 8                     | SW. 7                          | SW. 6                    | SW. 5 | SW. 4 | SW. 3                  | SW. 2 | SW. 1                    | SW. 0 |
|----------------|--|--------|-----------------------|--------|--------|--------|-------|---------------------------|--------------------------------|--------------------------|-------|-------|------------------------|-------|--------------------------|-------|
| <b>Name</b>    | TxPDO Toggle                             | -      | Sync Error            | -      | -      | -      | -     | Steady State              | Calibration in progress        | Error                    | -     | -     | Data invalid           | -     | Overrange                | -     |
| <b>Meaning</b> | Toggles 0→1→0 with each updated data set | -      | Synchronization error |        |        |        |       | Idling recognition [▶.77] | Calibration [▶.80] in progress | Collective error display | -     | -     | Input data are invalid | -     | Measuring range exceeded | -     |

**Variable:** Value

**Meaning:** Calculated 32-bit DINT load value in unit [1], with sign

**Variable:** Value (Real)

**Meaning:** Calculated 32-bit fixed point REAL load value with mantissa and exponent in unit [1]

The format matches the REAL format of IEC 61131-3, which in turn is based on the REAL format of IEC 559. A REAL number (single precision) is defined as follows (See also Beckhoff InfoSys: [TwinCAT PLC Control: standard data types](#)). In accordance with IEC 61131 this 32-bit variable can be directly linked with a FLOAT variable of the PLC.

|                                    |      |          |                                 |
|------------------------------------|------|----------|---------------------------------|
| <b>Bitposition (from the left)</b> | 1    | 8        | 23 (+1 „hidden bit“, see IE559) |
| <b>Function</b>                    | Sign | Exponent | Mantissa                        |

**Variable:** WcState

**Meaning:** Cyclic diagnostic variable; „0“ indicates correct data transmission

**Variable:** Status

**Meaning:** State of the EtherCAT device; State.3 = TRUE indicates correct operation in OP

**Variable:** AdsAddr

**Meaning:** AmsNet address of the EtherCAT device from AmsNetId (in this case: 192.168.0.20.5.1) and port (in this case: 1003)

**Variable:** Ctrl

**Meaning:** The control word (CW) is located in the output process image, and is transmitted from the controller to the terminal/box.

| Bit            | CW. 15 | CW. 14 | CW. 13 | CW. 12 | CW. 11 | CW. 10 | CW. 9 | CW. 8 | CW. 7 | CW. 6 | CW. 5 | CW. 4 | CW. 3       | CW. 2  | CW. 1                 | CW. 0                                   |   |
|----------------|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------------|--|-----------------------|---|---|
| <b>Name</b>    |        |        |        |        |        |        |       |       |       |       |       |       | Tara        | Sample Mode                                    | Input Freeze          | Disable Calibration                     | Start Calibration                       |
| <b>Meaning</b> |        |        |        |        |        |        |       |       |       |       |       |       | starts tare | mode switching (EL3356-010 and EP3356-022only) | stops the measurement | Switches the automatic self-calibration | Starts the self-calibration immediately |

See also the [example program \[▶ 113\]](#) for the dissection of the Status and CTRL variable.

**Variants (Predefined PDO)**

**Fixed-point representation of the load**

The display of the load value can also be converted already in the terminal/box into a point representation. To do this the input PDOs are to be changed as follows:

The screenshot shows the Beckhoff configuration software interface. On the left, a tree view shows the configuration structure with 'RMB Value (Real)' selected. The main window displays a table of PDOs with the following columns: Index, Size, Offs, and Name. The 'Value (Real)' entry is highlighted in red. Below this table, a text box indicates 'Predefined PDO Assignment: 'Standard (REAL)'. At the bottom, another table lists variables with their online status, addresses, types, sizes, and I/O directions.

| Index     | Size | Offs | Name                 |
|-----------|------|------|----------------------|
| ...       | 0.1  | 0.0  | ...                  |
| 0x6000:02 | 0.1  | 0.1  | Status__Overrange    |
| ...       | 0.1  | 0.2  | ...                  |
| 0x6000:04 | 0.1  | 0.3  | Status__Data invalid |
| ...       | 0.1  | 0.4  | ...                  |

| Name         | Online                   | Type        | Size | >Addr... | In/Out | Use |
|--------------|--------------------------|-------------|------|----------|--------|-----|
| Status       | 0x0148 (328)             | Status_4096 | 2.0  | 39.1     | Input  | 0   |
| Value (Real) | 0.000000 (2.802597e-045) | REAL        | 4.0  | 41.0     | Input  | 0   |
| WcState      | 0                        | BOOL        | 0.1  | 1522.1   | Input  | 0   |
| State        | 0x0008 (8)               | UINT        | 2.0  | 1550.0   | Input  | 0   |
| AdsAddr      | C0 A8 00 14 05 01 EA 03  | AMSADDRESS  | 8.0  | 1552.0   | Input  | 0   |
| Ctrl         | 0x0000 (0)               | Ctrl_4097   | 2.0  | 39.0     | Output | 0   |

Fig. 83: Load value in fixed-point representation

**Variable:** Value (Real)

**Meaning:** Calculated 32-bit fixed point REAL load value with mantissa and exponent in unit [1]

The format matches the REAL format of IEC 61131-3, which in turn is based on the REAL format of IEC 559. A REAL number (single precision) is defined as follows (See also Beckhoff InfoSys: TwinCAT PLC Control: standard data types). This 32-bit variable can be linked directly with a FLOAT variable of the PLC according to IEC61131.

|                                 |      |          |                                   |
|---------------------------------|------|----------|-----------------------------------|
| <b>Bit position (from left)</b> | 1    | 8        | 23 (+1 „hidden bit“, see IEC 559) |
| <b>Function</b>                 | Sign | Exponent | Mantissa                          |

**Voltage measurement**

The EL/EP3356 can also be used as a 2-channel analog input terminal/box for voltage measurement, see Notes [▶ 89].

**PDO Assignment (0x1C12):**

- 0x1600
- 0x1601

**PDO Content (0x1A00):**

| Index     | Size | Offs | Name              |
|-----------|------|------|-------------------|
| ---       | 0.1  | 0.0  | ---               |
| 0x6000:02 | 0.1  | 0.1  | Status__Overrange |
| ---       | 0.1  | 0.2  | ---               |

**Predefined PDO Assignment: '2x AnalogIn (Standard)'**

PDO Assignment

PDO Configuration

Load PDO info from device

Sync Unit Assignment...

| Name               | Online                 | Type         | Size | >Addr... | In/Out | User ID |
|--------------------|------------------------|--------------|------|----------|--------|---------|
| Underrange         | 0                      | BIT          | 0.1  | 39.0     | Input  | 0       |
| Overrange          | 0                      | BIT          | 0.1  | 39.1     | Input  | 0       |
| Error              | 0                      | BIT          | 0.1  | 39.6     | Input  | 0       |
| TxPDO Toggle       | 1                      | BIT          | 0.1  | 40.7     | Input  | 0       |
| Value              | 1534251392             | DINT         | 4.0  | 41.0     | Input  | 0       |
| Underrange         | 0                      | BIT          | 0.1  | 45.0     | Input  | 0       |
| Overrange          | 0                      | BIT          | 0.1  | 45.1     | Input  | 0       |
| Error              | 0                      | BIT          | 0.1  | 45.6     | Input  | 0       |
| TxPDO Toggle       | 1                      | BIT          | 0.1  | 46.7     | Input  | 0       |
| Value              | 36086140               | DINT         | 4.0  | 47.0     | Input  | 0       |
| WcState            | 0                      | BIT          | 0.1  | 1522.1   | Input  | 0       |
| InputToggle        | 1                      | BIT          | 0.1  | 1524.1   | Input  | 0       |
| State              | 8                      | UINT         | 2.0  | 1548.0   | Input  | 0       |
| AdsAddr            | 172.17.214.253.3.1:... | AMSADDR      | 8.0  | 1550.0   | Input  | 0       |
| netId              | 172.17.214.253.3.1     | AMSNETID     | 6.0  | 1550.0   | Input  | 0       |
| port               | 0x03e9                 | WORD         | 2.0  | 1556.0   | Input  | 0       |
| Ctrl               | 0x0000 (0)             | Ctrl_BCBE... | 2.0  | 39.0     | Output | 0       |
| Start calibrati... | 0                      | BIT          | 0.1  | 39.0     | Output | 0       |
| Disable calibr...  | 0                      | BIT          | 0.1  | 39.1     | Output | 0       |
| Input freeze       | 0                      | BIT          | 0.1  | 39.2     | Output | 0       |
| Sample mode        | 0                      | BIT          | 0.1  | 39.3     | Output | 0       |
| Tara               | 0                      | BIT          | 0.1  | 39.4     | Output | 0       |

Fig. 84: Voltage measurement

| Variable     | Meaning   |
|--------------|---|
| Underrange   | Measurement is below range  |
| Overrange    | Measuring range exceeded  |
| Error        | Collective error display  |
| TxPDO Toggle | Toggles 0→1→0 with each updated data set  |
| Value        | Right-justified voltage value over the respective measuring range (Range of values 0x80.00.00.00...0...0x7F.FF.FF.FF)<br>Channel 1: supply voltage<br>Channel 2: bridge voltage |

**Distributed Clocks**

In DC mode (Distributed Clocks) the process data x1A03 *Timestamp* must be activated.

The screenshot shows the configuration interface for the DC mode. The 'PDO Assignment (0x1C13)' section has a list of PDOs with checkboxes. '0x1A03' is checked and highlighted with a red box. The 'PDO Content (0x1A00)' section shows a list of PDOs with their indices, sizes, offsets, and names. 'Status\_Data invalid' is highlighted at index 0x6000:04. Below the configuration, a table lists process data variables:

| Name          | Online                                  | Type        | Size |
|---------------|---|-------------|------|
| Status        | 0x0100 (256)                            | Status_4096 | 2.0  |
| Value         | 0x0000005C (92)                         | DINT        | 4.0  |
| Timestamp     | 0x055A21B5240B6120 (385657779971121440) | ULINT       | 8.0  |
| WcState       | 0                                       | BOOL        | 0.1  |
| State         | 0x0054 (84)                             | UINT        | 2.0  |
| AdsAddr       | C0 A8 00 14 05 01 EB 03                 | AMSADDRESS  | 8.0  |
| DcOutputShift | 0xFFFF6D840 (-600000)                   | DINT        | 4.0  |
| DcInputShift  | 0x004630C0 (4600000)                    | DINT        | 4.0  |
| Ctrl          | 0x0000 (0)                              | Ctrl 4098   | 2.0  |

Also, the variables *DcOutputShift* and *DcInputShift* are displayed in the process data in DC mode. Upon activation of the configuration these are calculated once in the unit [ns] on the basis of the set EtherCAT cycle time (observe assigned task!) and DC shift times from the EtherCAT master settings. In the *InputBased* operating mode, *DcInputShift* indicates by how many nanoseconds [ns] before or after the global Sync the terminal/box determines your process data. For further information on this, see the [EtherCAT system description](#).

Since the EL3356-0010/EP3356-0022 is not DC-triggered but determines the timestamp itself, these values have no meaning in the EL3356-0010/EP3356-0022.

**Sync Manager (SM)**

**PDO Assignment**

**Inputs: SM3, PDO Assignment 0x1C13**

| Index            | Index of excluded PDOs                         | Size (byte.bit) | Name                                     | PDO content<br>Index - Name   |
|------------------|--|-----------------|--|---|
| 0x1A00 (default) | -  | 2.0             | RMB Status (Resistor Measurement Bridge) | 0x6000:02 [▶ 103] - Overrange<br>0x6000:04 [▶ 103] - Data invalid<br>0x6000:07 [▶ 103] - Error<br>0x6000:08 [▶ 103] - Calibration in progress<br>0x6000:09 [▶ 103] - Steady State<br>0x1C32:20 [▶ 100] - Sync Error<br>0x1800:09 [▶ 100] - TxPDO Toggle |
| 0x1A01 (default) | 0x1A02<br>0x1A04<br>0x1A05<br>0x1A06<br>0x1A07 | 4.0             | RMB Value (INT 32)                       | 0x6000:11 [▶ 103] - Value   |
| 0x1A02           | 0x1A01<br>0x1A04<br>0x1A05<br>0x1A06<br>0x1A07 | 4.0             | RMB Value (Real)                         | 0x6000:12 [▶ 103] - Value   |
| 0x1A03           | 0x1A04<br>0x1A05<br>0x1A06<br>0x1A07           | 8.0             | RMB Timestamp                            | 0x6000:13 [▶ 103] - Value   |
| 0x1A04           | 0x1A00<br>0x1A01<br>0x1A02<br>0x1A03<br>0x1A05 | 6.0             | AI Standard Channel 1 (Analog Input)     | 0x6010:01 [▶ 103] - Underrange<br>0x6010:02 [▶ 103] - Overrange<br>0x6010:07 [▶ 103] - Error<br>0x6010:10 [▶ 103] - TxPDO Toggle<br>0x6010:11 [▶ 103] - Value   |
| 0x1A05           | 0x1A00<br>0x1A01<br>0x1A02<br>0x1A03<br>0x1A04 | 4.0             | AI Standard Channel 1 (Analog Input)     | 0x6010:11 [▶ 103] - Value   |
| 0x1A06           | 0x1A00<br>0x1A01<br>0x1A02<br>0x1A03<br>0x1A07 | 6.0             | AI Standard Channel 2 (Analog Input)     | 0x6020:01 [▶ 103] - Underrange<br>0x6020:02 [▶ 103] - Overrange<br>0x6020:07 [▶ 103] - Error<br>0x6020:10 [▶ 103] - TxPDO Toggle<br>0x6020:11 [▶ 103] - Value   |
| 0x1A07           | 0x1A00<br>0x1A01<br>0x1A02<br>0x1A03<br>0x1A06 | 4.0             | AI Standard Channel 2 (Analog Input)     | 0x6020:11 [▶ 103] - Value   |

**Outputs: SM2, PDO-Zuordnung 0x1C12**

| Index            | Index ausgeschlossener PDOs | Größe (Byte.Bit) | Name                                      | PDO Inhalt   |
|------------------|-----------------------------|------------------|---|--|
| 0x1600 (default) | -                           | 2.0              | RMB Control (Resistor Measurement bridge) | 0x7000:01 [▶ 103] - Start calibration<br>0x7000:02 [▶ 103] - Disable calibration<br>0x7000:03 [▶ 103] - Input freeze<br>0x7000:04 [▶ 103] - Sample Mode (only EL3356-0010/EP3356-0022)<br>0x7000:05 [▶ 103] - Tara |

## 6.12 Object description and parameterization

### ● EtherCAT XML Device Description

**i** The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

### ● Parameterization via the CoE list (CAN over EtherCAT)

**i** The EtherCAT device is parameterized via the CoE - Online tab [[▶ 63](#)] (double-click on the respective object) or via the Process Data [[▶ 60](#)] tab (allocation of PDOs).

#### Index 1011 Restore default parameters

| Index (hex) | Name  | Meaning  | Data type | Flags | Default                        |
|-------------|---|--|-----------|-------|--------------------------------|
| 1011:0      | <a href="#">Restore default parameters</a><br><a href="#">▶ 118</a> | Restore the default settings in the EtherCAT slave   | UINT8     | RO    | 0x01 (1 <sub>dec</sub> )       |
| 1011:01     | SubIndex 001  | If this object is set to " <b>0x64616F6C</b> " ("Set Value Dialog") all terminal/box-specific objects are reset to their delivery state. | UINT32    | RW    | 0x00000000 (0 <sub>dec</sub> ) |

#### Index 8000 RMB Settings

| Index (hex) | Name  | Meaning   | Data type | Flags | Default  |
|-------------|---|---|-----------|-------|--|
| 8000:0      | RMB Settings  | Max. subindex   | UINT8     | RO    | 0x32 (50 <sub>dec</sub> )                      |
| 8000:01     | Mode0 enable filter                                   | 0: No filters active. The terminal/box operates cycle synchronous   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )                       |
| 8000:02     | Mode1 enable filter (Only EL3356-0010, EP3356-0022)   | 1: The filter settings of subindex 0x8000:11 or 0x8000:12 are active.   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )                       |
| 8000:03     | Mode0 enable averager                                 | Activates hardware averager   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )                       |
| 8000:04     | Mode1 enable averager (Only EL3356-0010, EP3356-0022) |   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )                       |
| 8000:05     | Symmetric reference potential                         | Activates <a href="#">symmetric measurement</a> [ <a href="#">▶ 67</a> ]  | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )                       |
| 8000:11     | Mode0 filter settings                                 | 0: FIR 50 Hz  | UINT16    | RW    | 0x0000 (0 <sub>dec</sub> )                     |
| 8000:12     | Mode1 filter settings (Only EL3356-0010, EP3356-0022) | 1: FIR 60 Hz<br>2: IIR 1<br>3: IIR 2<br>4: IIR 3<br>5: IIR 4<br>6: IIR 5<br>7: IIR 6<br>8: IIR 7<br>9: IIR 8<br><br>10: Dynamic IIR<br>11: PDO Filter frequency<br><a href="#">see filters</a> [ <a href="#">▶ 67</a> ] | UINT16    | RW    | 0x0000 (0 <sub>dec</sub> )                     |
| 8000:13     | Dynamic filter change time                            | Sampling rate of dynamic filter switching<br>Scaling 0.01 ms (100 = 1 s)<br><br>(only if <a href="#">filters</a> [ <a href="#">▶ 67</a> ] are active and "dynamic IIR" is selected)                                     | UINT16    | RW    | 0x000A (10 <sub>dec</sub> )                    |
| 8000:14     | Dynamic filter delta                                  | Limit value of dynamic filter switching<br><br>(only if <a href="#">filters</a> [ <a href="#">▶ 67</a> ] are active and "dynamic IIR" is selected)  | REAL32    | RW    | 0x41A00000 (1101004800 <sub>dec</sub> ) = 20.0 |
| 8000:21     | Gain  | Scaling factor  | REAL32    | RW    | 0x3F800000 (1065353216 <sub>dec</sub> ) = 1.0  |
| 8000:22     | Tara  | Offset of process data value  | REAL32    | RW    | 0x00000000 (0 <sub>dec</sub> ) = 0.0           |

| Index (hex) | Name                   | Meaning  | Data type | Flags | Default  |
|-------------|------------------------|--|-----------|-------|--|
| 8000:23     | Rated output           | Nominal sensitivity of sensor element in mV/V  | REAL32    | RW    | 0x40000000<br>(1073741824 <sub>dec</sub> )<br>= 2.0      |
| 8000:24     | Nominal load           | Nominal load of force transducer/load cell/etc.<br>(e.g. in kg or N, ...)  | REAL32    | RW    | 0x40A00000<br>(1084227584 <sub>dec</sub> )<br>= 5.0      |
| 8000:25     | Zero balance           | Zero point offset in mV/V  | REAL32    | RW    | 0x00000000<br>(0 <sub>dec</sub> ) = 0.0                  |
| 8000:26     | Gravity of earth       | Current gravity of earth (default 9.806650)  | REAL32    | RW    | 0x411CE80A<br>(1092413450 <sub>dec</sub> )<br>= 9.806650 |
| 8000:27     | Scale factor           | This factor is for rescaling of the process data,<br>e.g. for changing the indication from "kg" to "g",<br>you shall enter the factor "1000" here.   | REAL32    | RW    | 0x447A0000<br>(1148846080 <sub>dec</sub> )<br>= 1000.0   |
| 8000:28     | Reference load         | Reference weight for manual calibration  | REAL32    | RW    | 0x40A00000<br>(1084227584 <sub>dec</sub> )<br>= 5.0      |
| 8000:29     | Steady state window    | Time constant for the "steady state" bit ( <u>Idling<br/>recognition</u> [► 77])   | UINT16    | RW    | 0x03E8<br>(1000 <sub>dec</sub> )                         |
| 8000:2A     | Steady state tolerance | Tolerance window for the "steady state" bit  | UINT32    | RW    | 0x00000005<br>(5 <sub>dec</sub> )                        |
| 8000:31     | Calibration interval   | Calibration interval for the automatic calibration of<br>the terminal/box (unit: 100 ms)<br>The automatic calibration can be prevented by<br>setting the process data bit "Disable calibration"  | UINT16    | RW    | 0x0708<br>(1800 <sub>dec</sub> )                         |
| 8000:32     | Test interval          | This object contains the testing interval for the<br>cyclic self test of the terminal/box<br><br>This interval is always a multiple (default: 10 <sub>dec</sub> ) of<br>the calibration interval (0x8000:31) So the delivery<br>state of the testing interval result from 10 x 180 s<br>= 1800 s.<br><br>The self test can be prevented by setting the<br>process data bit "Disable calibration" | UINT16    | RW    | 0x000A (10 <sub>dec</sub> )                              |

## Index 8010, 8020 AI Settings

| Index (hex) | Name                      | Meaning  | Data type | Flags | Default                            |
|-------------|---------------------------|--|-----------|-------|------------------------------------|
| 80n0:0      | AI Settings               | Max. subindex  | UINT8     | RO    | 0x18 (24 <sub>dec</sub> )          |
| 80n0:01     | Enable user scale         | User scale is enabled, if bit is set   | BOOLEAN   | RW    | 0x00 (0 <sub>dec</sub> )           |
| 80n0:06     | Enable filter             | Activates filter   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )           |
| 80n0:0A     | Enable user calibration   | User calibration is enabled, if bit is set   | BOOLEAN   | RW    | 0x00 (0 <sub>dec</sub> )           |
| 80n0:0B     | Enable vendor calibration | Vendor calibration is enabled, if bit is set   | BOOLEAN   | RW    | 0x01 (1 <sub>dec</sub> )           |
| 80n0:11     | User scale offset         | User scale offset  | INT32     | RW    | 0x00000000 (0 <sub>dec</sub> )     |
| 80n0:12     | User scale gain           | User scale gain<br>The gain is represented in fixed-point format, with the factor 2 <sup>-16</sup> .<br>A value of 1 for the gain factor therefore corresponds to 65535 <sub>dec</sub> (0x00010000 <sub>hex</sub> ) and is limited to 0x7FFFF.   | INT32     | RW    | 0x00010000 (65536 <sub>dec</sub> ) |
| 80n0:15     | Filter settings           | This object defines the digital filter settings, if it is activated with index 0x80n0:06 [► 102] .<br><br>The possible settings are numbered consecutively<br><br>0: 50 Hz FIR<br>1: 60 Hz FIR<br>2: IIR 1<br>3: IIR 2<br>4: IIR 3<br>5: IIR 4<br>6: IIR 5<br>7: IIR 6<br>8: IIR 7<br>9: IIR 8 | UINT16    | RW    | 0x0000 (0 <sub>dec</sub> )         |
| 80n0:17     | User calibration offset   | User calibration offset  | INT32     | RW    | 0x00000000 (0 <sub>dec</sub> )     |
| 80n0:18     | User calibration gain     | User calibration gain  | INT16     | RW    | 0x4000 (16384 <sub>dec</sub> )     |

## Command object, Index FB00 RMB Command

| Index (hex) | Name        | Meaning  | Data type       | Flags | Default                  |
|-------------|-------------|--|-----------------|-------|--------------------------|
| FB00:0      | RMB Command | Max. subindex  | UINT8           | RO    | 0x03 (3 <sub>dec</sub> ) |
| FB00:01     | Request     | Via the request object, commands can be sent to the terminal/box<br>Command:<br>- 0x0101: Zero adjustment<br>- 0x0102: Calibration<br>- 0x0001 Tara setting<br>- 0x0002 Tara setting (Data are saved into the EEPROM)<br>see <a href="#">commands</a> [► 67] | OCTET-STRING[2] | RW    | {0}                      |
| FB00:02     | Status      | State of the current executed command<br>0: Command executed without errors<br>255: Execution of command   | UINT8           | RO    | 0x00 (0 <sub>dec</sub> ) |
| FB00:03     | Response    | Optional return value of the command   | OCTET-STRING[4] | RO    | {0}                      |

**Input data, Index 6000 RMB Inputs**

| Index (hex) | Name                    | Meaning   | Data type | Flags | Default                                 |
|-------------|-------------------------|---|-----------|-------|---|
| 6000:0      | RMB Inputs              | Max. subindex   | UINT8     | RO    | 0x13 (19 <sub>dec</sub> )               |
| 6000:02     | Overrange               | The measuring value has reached its terminal/box value                                      | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:04     | Data invalid            | The indicated process data are not valid, e.g. during calibration                           | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:07     | Error                   | An error has occurred   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:08     | Calibration in progress | Calibration in progress. The process data indicate the last valid measuring value           | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:09     | Steady state            |   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:0E     | Sync error              | TRUE: In the last cycle the synchronization was not correct (only in DC-Mode)               | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:10     | TxPDO Toggle            | The TxPDO Toggle is toggled by the slave, if the data of the corresponding PDO was updated. | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )                |
| 6000:11     | Value                   | Measuring value as 32 Bit SIGNED INTEGER  | INT32     | RO    | 0x61746144 (1635017028 <sub>dec</sub> ) |
| 6000:12     | Value (Real)            | Measuring value as REAL   | REAL32    | RO    | 0x00000000 (0 <sub>dec</sub> )          |
| 6000:13     | Timestamp               | Timestamp of current measuring value (only EL3356-0010/EP3356-0022 in DC-Mode)              | UINT64    | RO    |   |

**Input data Index 6010, 6020 AI Inputs**

| Index (hex) | Name         | Meaning   | Data type | Flags | Default                        |
|-------------|--------------|---|-----------|-------|--------------------------------|
| 60n0:0      | AI Inputs    | Max. subindex   | UINT8     | RO    | 0x11 (17 <sub>dec</sub> )      |
| 60n0:01     | Underrange   | Value falls below the measuring range   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )       |
| 60n0:02     | Overrange    | Measurement range is exceeded.  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )       |
| 60n0:07     | Error        | An error has occurred, e.g.:<br>- Over- / underrange $U_{dif}$<br>- Over- / underrange $U_{ref}$<br>- the external $U_{ref}$ is too low (between -1 V and +1 V)<br>- Data invalid | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )       |
| 60n0:10     | TxPDO Toggle | The TxPDO Toggle is toggled by the slave, if the data of the corresponding PDO was updated.   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )       |
| 60n0:11     | Value        | 32 Bit measuring value  | INT32     | RO    | 0x00000000 (0 <sub>dec</sub> ) |

**Output data, Index 7000 RMB Outputs**

| Index (hex) | Name                | Meaning   | Data type | Flags | Default                  |
|-------------|---------------------|---|-----------|-------|--------------------------|
| 7000:0      | RMB Outputs         | Max. subindex   | UINT8     | RO    | 0x05 (5 <sub>dec</sub> ) |
| 7000:01     | Start calibration   | The calibration can be started manually with a rising edge. Therefore, an automatic start of the calibration at an inappropriate point of time can be prevented.  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> ) |
| 7000:02     | Disable calibration | 0: The automatic calibration is active<br>1: The automatic calibration is inactive  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> ) |
| 7000:03     | Input freeze        | The process data and the digital filter will be frozen  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> ) |
| 7000:04     | Sample mode         | Selection of the sampling mode:<br><br>0: 10.5 kHz High precision<br>1: 105 kHz Low latency   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> ) |
| 7000:05     | Tara                | The process data can be set to zero with a rising edge. The tara value is not stored in the EEPROM and is lost after a reset of the terminal/box  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> ) |
| 7000:11     | Filter frequency    | Filter frequency of the variable PDO filter in 0.1 Hz, see filter [▶ 67]<br><br>Wertebereich:<br>value range: 1 ... 2000 (equates to 0,1 ... 200 Hz)<br><br>From a value 0 or >2000, the filter behaves like a 50 Hz FIR filter | UINT16    | RO    | 0x00 (0 <sub>dec</sub> ) |

**Information-/diagnostic data, Index 801E, 802E AI Internal data**

| Index (hex) | Name             | Meaning       | Data type | Flags | Default                        |
|-------------|------------------|---------------|-----------|-------|--------------------------------|
| 801E:0      | AI Internal data | Max. subindex | UINT8     | RO    | 0x01 (1 <sub>dec</sub> )       |
| 801E:01     | ADC raw value 1  | ADC raw value | INT32     | RO    | 0x00000000 (0 <sub>dec</sub> ) |

**Index 9000 RMB Info data**

| Index (hex) | Name          | Meaning            | Data type | Flags | Default                        |
|-------------|---------------|--------------------|-----------|-------|--------------------------------|
| 9000:0      | RMB Info data | Max. subindex      | UINT8     | RO    | 0x11 (17 <sub>dec</sub> )      |
| 9000:11     | mV/V          | Current mV/V value | REAL32    | RO    | 0x00000000 (0 <sub>dec</sub> ) |

**Index A000 RMB Diag data**

| Index (hex) | Name                           | Meaning   | Data type | Flags | Default                   |
|-------------|--------------------------------|---|-----------|-------|---------------------------|
| A000:0      | RMB Diag data                  | Max. subindex   | UINT8     | RO    | 0x18 (24 <sub>dec</sub> ) |
| A000:11     | No internal referencnce supply | No internal reference voltage at ADC input (U <sub>Ref</sub> channel) | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:12     | No internal referencnce bridge | No internal reference voltage at ADC input (U <sub>Dif</sub> channel) | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:13     | No external reference supply   | The external reference voltage is below ±1 V                          | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:15     | Overrange bridge               | Overranged measuring value in the bridge section                      | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:16     | Underrange bridge              | Underranged measuring value in the bridge section                     | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:17     | Overrange supply               | Overranged measuring value of the reference voltage                   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |
| A000:18     | Underrange supply              | Underranged measuring value of the reference voltage                  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )  |

**Vendor configuration data, Index 801F, 802F AI Vendor data**

| Index (hex) | Name               | Meaning                      | Data type | Flags | Default                               |
|-------------|--------------------|------------------------------|-----------|-------|---------------------------------------|
| 801F:0      | AI Vendor data     | Max. subindex                | UINT8     | RO    | 0x02 (2 <sub>dec</sub> )              |
| 801F:01     | Calibration offset | Offset (vendor calibration)) | INT32     | RW    | 0x01E10000 (31522816 <sub>dec</sub> ) |
| 801F:02     | Calibration gain   | Gain (vendor calibration))   | INT16     | RW    | 0x4000 (16384 <sub>dec</sub> )        |

**Standard objects, Index 1000 Device type**

| Index (hex) | Name        | Meaning  | Data type | Flags | Default                               |
|-------------|-------------|--|-----------|-------|---------------------------------------|
| 1000:0      | Device type | Device type of the EtherCAT slave: The low word contains the CoE profile used (5001). The high word contains the module profile according to the modular device profile. | UINT32    | RO    | 0x01681389 (23597961 <sub>dec</sub> ) |

**Index 1008 Device name**

| Index (hex) | Name        | Meaning                           | Data type | Flags | Default         |
|-------------|-------------|-----------------------------------|-----------|-------|-----------------|
| 1008:0      | Device name | Device name of the EtherCAT slave | STRING    | RO    | EL3356 / EP3356 |

**Index 1009 Hardware version**

| Index (hex) | Name             | Meaning                                | Data type | Flags | Default |
|-------------|------------------|--|-----------|-------|---------|
| 1009:0      | Hardware version | Hardware version of the EtherCAT slave | STRING    | RO    | 00      |

**Index 100A Software version**

| Index (hex) | Name             | Meaning                                | Data type | Flags | Default |
|-------------|------------------|--|-----------|-------|---------|
| 100A:0      | Software version | Firmware version of the EtherCAT slave | STRING    | RO    | 01      |

**Index 1018 Identity**

| Index (hex) | Name          | Meaning   | Data type | Flags | Default                                |
|-------------|---------------|---|-----------|-------|--|
| 1018:0      | Identity      | Information for identifying the slave   | UINT8     | RO    | 0x04 (4 <sub>dec</sub> )               |
| 1018:01     | Vendor ID     | Vendor ID of the EtherCAT slave   | UINT32    | RO    | 0x00000002 (2 <sub>dec</sub> )         |
| 1018:02     | Product code  | Product code of the EtherCAT slave  | UINT32    | RO    | 0x0D1C3052 (219951186 <sub>dec</sub> ) |
| 1018:03     | Revision      | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal/box number, the high word (bit 16-31) refers to the device description  | UINT32    | RO    | 0x00100000 (1048576 <sub>dec</sub> )   |
| 1018:04     | Serial number | Serial number of the EtherCAT slave; the low byte (bit 0-7) of the low word contains the year of production, the high byte (bit 8-15) of the low word contains the week of production, the high word (bit 16-31) is 0 | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )         |

**Index 10F0 Backup parameter handling**

| Index (hex) | Name                      | Meaning   | Data type | Flags | Default                        |
|-------------|---------------------------|---|-----------|-------|--------------------------------|
| 10F0:0      | Backup parameter handling | Information for standardized loading and saving of backup entries | UINT8     | RO    | 0x01 (1 <sub>dec</sub> )       |
| 10F0:01     | Checksum                  | Checksum across all backup entries of the EtherCAT slave          | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> ) |

**Index 1600 RMB RxPDO-Map Control**

| Index (hex) | Name                  | Meaning  | Data type        | Flags | Default                  |
|-------------|-----------------------|--|------------------|-------|--------------------------|
| 1600:0      | RMB RxPDO-Map Control | PDO Mapping RxPDO-Map control  | UINT8            | RO    | 0x07 (7 <sub>dec</sub> ) |
| 1600:01     | Subindex 001          | 1. PDO Mapping entry (object 0x7000 (RMB outputs), entry 0x01 (Start calibration))   | OCTET-STRING[10] | RO    | 0x7000:01, 1             |
| 1600:02     | Subindex 002          | 2. PDO Mapping entry (object 0x7000 (RMB outputs), entry 0x02 (Disable calibration)) | OCTET-STRING[10] | RO    | 0x7000:02, 1             |
| 1600:03     | Subindex 003          | 3. PDO Mapping entry (object 0x7000 (RMB outputs), entry 0x03 (Input freeze))        | OCTET-STRING[10] | RO    | 0x7000:03, 1             |
| 1600:04     | Subindex 004          | 4. PDO Mapping entry (1 bits align)  | OCTET-STRING[10] | RO    | 0x0000:00, 1             |
| 1600:05     | Subindex 005          | 5. PDO Mapping entry (object 0x7000 (RMB outputs), entry 0x05 (Tara))                | OCTET-STRING[10] | RO    | 0x7000:05, 1             |
| 1600:06     | Subindex 006          | 6. PDO Mapping entry (3 bits align)  | OCTET-STRING[10] | RO    | 0x0000:00, 3             |
| 1600:07     | Subindex 007          | 7. PDO Mapping entry (8 bits align)  | OCTET-STRING[10] | RO    | 0x0000:00, 8             |

**Index 1601 RMB RxPDO-Map-Filter frequency**

| Index (hex) | Name                           | Meaning  | Data type        | Flags | Default                  |
|-------------|--------------------------------|--|------------------|-------|--------------------------|
| 1601:0      | RMB RxPDO-Map Filter frequency | PDO Mapping RxPDO-Map Filter frequency   | UINT8            | RO    | 0x01 (1 <sub>dec</sub> ) |
| 1601:01     | Subindex 001                   | 1. PDO Mapping entry (object 0x7000 (RMB outputs), entry 0x11 (Start calibration)) | OCTET-STRING[10] | RO    | 0x7000:11, 16            |

**Index 1800 RMB TxPDO-Par Status**

| Index (hex) | Name                 | Meaning   | Data type        | Flags | Default                       |
|-------------|----------------------|---|------------------|-------|-------------------------------|
| 1800:0      | RMB TxPDO-Par Status | PDO Parameter TxPDO 1   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )      |
| 1800:06     | Exclude TxPDOs       | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 1 | OCTET-STRING[10] | RO    | 04 1A 05 1A 06 1A 07 1A 00 00 |

**Index 1801 RMB TxPDO-Par Value (INT 32)**

| Index (hex) | Name                        | Meaning   | Data type        | Flags | Default                          |
|-------------|-----------------------------|---|------------------|-------|----------------------------------|
| 1801:0      | RMB TxPDO-Par Value (INT32) | PDO Parameter TxPDO 2   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1801:06     | Exclude TxPDOs              | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 2 | OCTET-STRING[10] | RO    | 02 1A 04 1A 05<br>1A 06 1A 07 1A |

**Index 1802 RMB TxPDO-Par Value (Real)**

| Index (hex) | Name                       | Meaning   | Data type        | Flags | Default                          |
|-------------|----------------------------|---|------------------|-------|----------------------------------|
| 1802:0      | RMB TxPDO-Par Value (Real) | PDO Parameter TxPDO 3   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1802:06     | Exclude TxPDOs             | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 3 | OCTET-STRING[10] | RO    | 01 1A 04 1A 05<br>1A 06 1A 07 1A |

**Index 1803 RMB TxPDO-Par Timestamp**

| Index (hex) | Name                    | Meaning   | Data type        | Flags | Default                          |
|-------------|-------------------------|---|------------------|-------|----------------------------------|
| 1803:0      | RMB TxPDO-Par Timestamp | PDO Parameter TxPDO 4   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1803:06     | Exclude TxPDOs          | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 4 | OCTET-STRING[10] | RO    | 04 1A 05 1A 06<br>1A 07 1A 00 00 |

**Index 1804 AI TxPDO-Par Standard Ch. 1**

| Index (hex) | Name                       | Meaning   | Data type        | Flags | Default                          |
|-------------|----------------------------|---|------------------|-------|----------------------------------|
| 1804:0      | AI TxPDO-Par Standard Ch.1 | PDO Parameter TxPDO 5   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1804:06     | Exclude TxPDOs             | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 5 | OCTET-STRING[10] | RO    | 05 1A 00 1A 01<br>1A 02 1A 03 1A |

**Index 1805 AI TxPDO-Par Compact Ch.1**

| Index (hex) | Name                      | Meaning   | Data type        | Flags | Default                          |
|-------------|---------------------------|---|------------------|-------|----------------------------------|
| 1805:0      | AI TxPDO-Par Compact Ch.1 | PDO Parameter TxPDO 6   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1805:06     | Exclude TxPDOs            | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 6 | OCTET-STRING[10] | RO    | 04 1A 00 1A 01<br>1A 02 1A 03 1A |

**Index 1806 AI TxPDO-Par Standard Ch.2**

| Index (hex) | Name                       | Meaning   | Data type        | Flags | Default                          |
|-------------|----------------------------|---|------------------|-------|----------------------------------|
| 1806:0      | AI TxPDO-Par Standard Ch.2 | PDO Parameter TxPDO 7   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1806:06     | Exclude TxPDOs             | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 7 | OCTET-STRING[10] | RO    | 07 1A 00 1A 01<br>1A 02 1A 03 1A |

**Index 1807 AI TxPDO-Par Compact Ch.2**

| Index (hex) | Name                      | Meaning   | Data type        | Flags | Default                          |
|-------------|---------------------------|---|------------------|-------|----------------------------------|
| 1807:0      | AI TxPDO-Par Compact Ch.2 | PDO Parameter TxPDO 8   | UINT8            | RO    | 0x06 (6 <sub>dec</sub> )         |
| 1807:06     | Exclude TxPDOs            | This entry contains the TxPDOs (Index of the TxPDO Mapping objects) which shall not be transmitted with TxPDO 8 | OCTET-STRING[10] | RO    | 06 1A 00 1A 01<br>1A 02 1A 03 1A |

**Index 1A00 RMB TxPDO-Map Status**

| Index (hex) | Name                 | Meaning   | Data type        | Flags | Default                   |
|-------------|----------------------|---|------------------|-------|---------------------------|
| 1A00:0      | RMB TxPDO-Map Status | PDO Mapping RxPDO-Map Status  | UINT8            | RO    | 0x0C (12 <sub>dec</sub> ) |
| 1A00:01     | Subindex 001         | 1. PDO Mapping entry (1 bits align)   | OCTET-STRING[10] | RO    | 0x0000:00, 1              |
| 1A00:02     | Subindex 002         | 2. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x02 (Overrange))               | OCTET-STRING[10] | RO    | 0x6000:02, 1              |
| 1A00:03     | Subindex 003         | 3. PDO Mapping entry (1 bits align)   | OCTET-STRING[10] | RO    | 0x0000:00, 1              |
| 1A00:04     | Subindex 004         | 4. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x04 (Data invalid))            | OCTET-STRING[10] | RO    | 0x6000:04, 1              |
| 1A00:05     | Subindex 005         | 5. PDO Mapping entry (2 bits align)   | OCTET-STRING[10] | RO    | 0x0000:00, 2              |
| 1A00:06     | Subindex 006         | 6. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x07 (Error))                   | OCTET-STRING[10] | RO    | 0x6000:07, 1              |
| 1A00:07     | Subindex 007         | 7. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x08 (Calibration in progress)) | OCTET-STRING[10] | RO    | 0x6000:08, 1              |
| 1A00:08     | Subindex 008         | 8. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x09 (Steady state))            | OCTET-STRING[10] | RO    | 0x6000:09, 1              |
| 1A00:09     | Subindex 009         | 9. PDO Mapping entry (4 bits align)   | OCTET-STRING[10] | RO    | 0x0000:00, 4              |
| 1A00:0A     | Subindex 010         | 10. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x0E (Sync error))             | OCTET-STRING[10] | RO    | 0x6000:0E, 1              |
| 1A00:0B     | Subindex 011         | 11. PDO Mapping entry (1 bits align)  | OCTET-STRING[10] | RO    | 0x0000:00, 1              |
| 1A00:0C     | Subindex 012         | 12. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x10 (TxPDO Toggle))           | OCTET-STRING[10] | RO    | 0x6000:10, 1              |

**Index 1A01 RMB TxPDO-Map Value (INT32)**

| Index (hex) | Name                        | Meaning   | Data type | Flags | Default                  |
|-------------|-----------------------------|---|-----------|-------|--------------------------|
| 1A01:0      | RMB TxPDO-Map Value (INT32) | PDO Mapping Value (INT32)   | UINT8     | RW    | 0x01 (1 <sub>dec</sub> ) |
| 1A01:01     | SubIndex 001                | 1. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x11 (Value)) | UINT32    | RW    | 0x6000:11, 32            |

**Index 1A02 RMB TxPDO-Map Value (Real)**

| Index (hex) | Name                       | Meaning  | Data type | Flags | Default                  |
|-------------|----------------------------|--|-----------|-------|--------------------------|
| 1A02:0      | RMB TxPDO-Map Value (real) | PDO Mapping Value (real)   | UINT8     | RW    | 0x01 (1 <sub>dec</sub> ) |
| 1A02:01     | SubIndex 001               | 1. PDO Mapping entry (object 0x6000 (RMB inputs), entry 0x12 (Value (real))) | UINT32    | RW    | 0x6000:12, 32            |

**Index 1A03 RMB TxPDO-Map Timestamp**

| Index (hex) | Name                    | Meaning  | Data type | Flags | Default                  |
|-------------|-------------------------|--|-----------|-------|--------------------------|
| 1A03:0      | RMB TxPDO-Map Timestamp | PDO Mapping Value Timestamp                      | UINT8     | RW    | 0x01 (1 <sub>dec</sub> ) |
| 1A03:01     | SubIndex 001            | 1. PDO Mapping entry (object 0x0000, entry 0x00) | UINT64    | RW    | 0x0000:00, 64            |

**Index 1A04 AI TxPDO-Map Standard Ch.1**

| Index (hex) | Name                               | Meaning  | Data type | Flags | Default                  |
|-------------|------------------------------------|--|-----------|-------|--------------------------|
| 1A04:0      | AI supply TxPDO-Map Standard Ch. 1 | PDO Mapping TxPDO Standard Ch. 1   | UINT8     | RW    | 0x07 (7 <sub>dec</sub> ) |
| 1A04:01     | SubIndex 001                       | 1. PDO Mapping entry (object 0x6010 (AI supply Inputs), entry 0x01 (Underrange)) | UINT32    | RW    | 0x6010:01, 1             |
| 1A04:02     | SubIndex 002                       | 2. PDO Mapping entry (object 0x6010 (AI supply Inputs), entry 0x02 (Overrange))  | UINT32    | RW    | 0x6010:02, 1             |
| 1A04:03     | SubIndex 003                       | 3. PDO Mapping entry (4 bits align)  | UINT32    | RW    | 0x0000:00, 4             |
| 1A04:04     | SubIndex 004                       | 4. PDO Mapping entry (object 0x6010 (AI supply Inputs), entry 0x04 (Error))      | UINT32    | RW    | 0x6010:07, 1             |
| 1A04:05     | SubIndex 005                       | 5. PDO Mapping entry (8 bits align)  | UINT32    | RW    | 0x0000:00, 8             |
| 1A04:06     | SubIndex 006                       | 6. PDO Mapping entry (object 0x6010, entry 0x10 (TxPDO Toggle))                  | UINT32    | RW    | 0x6010:10, 1             |
| 1A04:07     | SubIndex 007                       | 7. PDO Mapping entry (object 0x6010, entry 0x11 (Value))                         | UINT32    | RW    | 0x6010:11, 32            |

**Index 1A05 AI TxPDO-Map Compact Ch.1**

| Index (hex) | Name                              | Meaning  | Data type | Flags | Default                  |
|-------------|-----------------------------------|--|-----------|-------|--------------------------|
| 1A05:0      | AI supply TxPDO-Map Compact Ch. 1 | PDO Mapping TxPDO Compact Ch. 1                          | UINT8     | RW    | 0x01 (1 <sub>dec</sub> ) |
| 1A05:01     | SubIndex 001                      | 1. PDO Mapping entry (object 0x6010, entry 0x11 (Value)) | UINT32    | RW    | 0x6010:11, 32            |

**Index 1A06 AI TxPDO-Map Standard Ch.2**

| Index (hex) | Name                               | Meaning  | Data type | Flags | Default                  |
|-------------|------------------------------------|--|-----------|-------|--------------------------|
| 1A06:0      | AI supply TxPDO-Map Standard Ch. 2 | PDO Mapping TxPDO Standard Ch. 2   | UINT8     | RW    | 0x07 (7 <sub>dec</sub> ) |
| 1A06:01     | SubIndex 001                       | 1. PDO Mapping entry (object 0x6020 (AI supply Inputs), entry 0x01 (Underrange)) | UINT32    | RW    | 0x6020:01, 1             |
| 1A06:02     | SubIndex 002                       | 2. PDO Mapping entry (object 0x6020 (AI supply Inputs), entry 0x02 (Overrange))  | UINT32    | RW    | 0x6020:02, 1             |
| 1A06:03     | SubIndex 003                       | 3. PDO Mapping entry (4 bits align)  | UINT32    | RW    | 0x0000:00, 4             |
| 1A06:04     | SubIndex 004                       | 4. PDO Mapping entry (object 0x6020 (AI supply Inputs), entry 0x04 (Error))      | UINT32    | RW    | 0x6020:07, 1             |
| 1A06:05     | SubIndex 005                       | 5. PDO Mapping entry (8 bits align)  | UINT32    | RW    | 0x0000:00, 8             |
| 1A06:06     | SubIndex 006                       | 6. PDO Mapping entry (object 0x6020, entry 0x10 (TxPDO Toggle))                  | UINT32    | RW    | 0x6020:10, 1             |
| 1A06:07     | SubIndex 007                       | 7. PDO Mapping entry (object 0x6020, entry 0x11 (Value))                         | UINT32    | RW    | 0x6020:11, 32            |

**Index 1A07 AI TxPDO-Map Compact Ch.2**

| Index (hex) | Name                              | Meaning  | Data type | Flags | Default                  |
|-------------|-----------------------------------|--|-----------|-------|--------------------------|
| 1A07:0      | AI supply TxPDO-Map Compact Ch. 2 | PDO Mapping TxPDO Compact Ch. 2                          | UINT8     | RW    | 0x01 (1 <sub>dec</sub> ) |
| 1A07:01     | SubIndex 001                      | 1. PDO Mapping entry (object 0x6020, entry 0x11 (Value)) | UINT32    | RW    | 0x6020:11, 32            |

**Index 1C00 Sync manager type**

| Index (hex) | Name              | Meaning   | Data type | Flags | Default                  |
|-------------|-------------------|---|-----------|-------|--------------------------|
| 1C00:0      | Sync manager type | Usage of the Sync Manager channels                        | UINT8     | RO    | 0x04 (4 <sub>dec</sub> ) |
| 1C00:01     | SubIndex 001      | Sync-Manager Type Channel 1: Mailbox Write                | UINT8     | RO    | 0x01 (1 <sub>dec</sub> ) |
| 1C00:02     | SubIndex 002      | Sync-Manager Type Channel 2: Mailbox Read                 | UINT8     | RO    | 0x02 (2 <sub>dec</sub> ) |
| 1C00:03     | SubIndex 003      | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8     | RO    | 0x03 (3 <sub>dec</sub> ) |
| 1C00:04     | SubIndex 004      | Sync-Manager Type Channel 4: Process Data Read (Inputs)   | UINT8     | RO    | 0x04 (4 <sub>dec</sub> ) |

**Index 1C12 RxPDO assign**

| Index (hex) | Name         | Meaning  | Data type | Flags | Default                       |
|-------------|--------------|--|-----------|-------|-------------------------------|
| 1C12:0      | RxPDO assign | PDO Assign Inputs  | UINT8     | RW    | 0x01 (1 <sub>dec</sub> )      |
| 1C12:01     | Subindex 001 | 1. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object) | UINT16    | RW    | 0x1600 (5632 <sub>dec</sub> ) |
| 1C12:02     | Subindex 002 | 2. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object) | UINT16    | RW    | -                             |

**Index 1C13 TxPDO assign**

| Index (hex) | Name         | Meaning  | Data type | Flags | Default                       |
|-------------|--------------|--|-----------|-------|-------------------------------|
| 1C13:0      | TxPDO assign | PDO Assign Inputs  | UINT8     | RW    | 0x01 (1 <sub>dec</sub> )      |
| 1C13:01     | Subindex 001 | 1. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object) | UINT16    | RW    | 0x1A00 (6656 <sub>dec</sub> ) |
| 1C13:02     | Subindex 002 | 2. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object) | UINT16    | RW    | 0x1A01 (6657 <sub>dec</sub> ) |
| 1C13:03     | Subindex 003 | 3. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object) | UINT16    | RW    | -                             |

## Index 1C32 SM output parameter

| Index (hex) | Name                    | Meaning   | Data type | Flags | Default                             |
|-------------|-------------------------|---|-----------|-------|-------------------------------------|
| 1C32:0      | SM output parameter     | Synchronization parameter of the outputs  | UINT8     | RO    | 0x20 (32 <sub>dec</sub> )           |
| 1C32:01     | Sync mode               | Actual synchronization mode: <ul style="list-style-type: none"> <li>0: Free Run</li> <li>1: Synchron with SM 3 Event (no Outputs available)</li> <li>2: DC - Synchron with SYNC0 Event</li> <li>3: DC - Synchron with SYNC1 Event</li> </ul>  | UINT16    | RW    | 0x0001 (1 <sub>dec</sub> )          |
| 1C32:02     | Cycle time              | Cycle time (in ns): <ul style="list-style-type: none"> <li>Free Run: cycle time of the local timer</li> <li>Synchron with SM 2 Event: Cycle time of the master</li> <li>DC-Mode: SYNC0/SYNC1 Cycle time</li> </ul>  | UINT32    | RW    | 0x000C65D4 (812500 <sub>dec</sub> ) |
| 1C32:03     | Shift time              | Time between SYNC0-Event and Input Latch (in ns, only in DC-Mode)   | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C32:04     | Sync modes supported    | Supported synchronization modes: <ul style="list-style-type: none"> <li>Bit 0 = 1: Free Run is supported</li> <li>Bit 1 = 1: Synchron with SM 2 Event is supported</li> <li>Bit 2-3 = 01: DC-Mode is supported</li> <li>Bit 4-5 = 01: Input Shift with local event (Outputs available)</li> <li>Bit 4-5 = 10: Output Shift with SYNC1 Event (only DC mode)</li> <li>Bit 14 = 1: dynamic times (could be measured by writing 0x1C32:08)</li> </ul> | UINT16    | RO    | 0xC007 (49159 <sub>dec</sub> )      |
| 1C32:05     | Minimum cycle time      | Minimum cycle time supported (in ns)  | UINT32    | RO    | 0x0000C350 (50000 <sub>dec</sub> )  |
| 1C32:06     | Calc and copy time      | Minimum time between SYNC0 and SYNC1 event (in ns, only DC mode)  | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C32:07     | Minimum delay time      |   | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C32:08     | Command                 | <ul style="list-style-type: none"> <li>0: Measurement of the times will be stopped</li> <li>1: Measurement of the times will be started</li> </ul> <p>The Entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03 [<a href="#">▶ 111</a>], 0x1C33:06 [<a href="#">▶ 111</a>], 0x1C33:09 [<a href="#">▶ 111</a>] will be updated with the maximum measured values.</p> <p>The measured valued well be reset, if measured again</p>           | UINT16    | RW    | 0x0000 (0 <sub>dec</sub> )          |
| 1C32:09     | Maximum Delay time      | Time between SYNC1-Event and output latch (in ns, only in DC mode)  | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C32:0B     | SM event missed counter | Number of the missed SM-Events in state OPERATIONAL (only in DC Mode)   | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C32:0C     | Cycle exceeded counter  | Number of the exceeded cycles in state OPERATIONAL  | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C32:0D     | Shift too short counter | Number of the too short distances between SYNC0 and SYNC1 Event (only in DC Mode)   | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C32:20     | Sync error              | TRUE: In the last cycle the synchronization was not correct (only in DC-Mode)   | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )            |

**Index 1C33 SM input parameter**

| Index (hex) | Name                    | Meaning  | Data type | Flags | Default                             |
|-------------|-------------------------|--|-----------|-------|-------------------------------------|
| 1C33:0      | SM input parameter      | Synchronization parameter of the outputs   | UINT8     | RO    | 0x20 (32 <sub>dec</sub> )           |
| 1C33:01     | Sync mode               | Actual synchronization mode:<br><ul style="list-style-type: none"> <li>• 0: Free Run</li> <li>• 1: Synchron with SM 3 Event (no Outputs available)</li> <li>• 2: DC - Synchron with SYNC0 Event</li> <li>• 3: DC - Synchron with SYNC1 Event</li> <li>• 34: synchronous with SM 2 event (outputs available)</li> </ul>   | UINT16    | RW    | 0x0022 (34 <sub>dec</sub> )         |
| 1C33:02     | Cycle time              | same as <a href="#">0x1C32:02</a> [ <a href="#">▶ 110</a> ]  | UINT32    | RW    | 0x000C65D4 (812500 <sub>dec</sub> ) |
| 1C33:03     | Shift time              | Time between SYNC0 event and reading of the inputs (in ns, only DC mode)   | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C33:04     | Sync modes supported    | Supported synchronization modes:<br><ul style="list-style-type: none"> <li>• Bit 0: free run is supported</li> <li>• Bit 1: synchronous with SM 2 event is supported (outputs available)</li> <li>• Bit 1: synchronous with SM 3 event is supported (no outputs available)</li> <li>• Bit 2-3 = 01: DC mode is supported</li> <li>• Bit 4-5 = 01: input shift through local event (outputs available)</li> <li>• Bit 4-5 = 10: input shift with SYNC1 event (no outputs available)</li> <li>• Bit 14 = 1: dynamic times (measurement through writing of <a href="#">0x1C32:08</a> [<a href="#">▶ 110</a>] or <a href="#">1C33:08</a>)</li> </ul> | UINT16    | RO    | 0xC007 (49159 <sub>dec</sub> )      |
| 1C33:05     | Minimum cycle time      | same as <a href="#">0x1C32:05</a> [ <a href="#">▶ 110</a> ]  | UINT32    | RO    | 0x0000C350 (50000 <sub>dec</sub> )  |
| 1C33:06     | Calc and copy time      | Time between reading of the inputs and availability of the inputs for the master (in ns, only DC mode)   | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C33:07     | Minimum delay time      |  | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C33:08     | Command                 | same as <a href="#">0x1C32:08</a> [ <a href="#">▶ 110</a> ]  | UINT16    | RW    | 0x0000 (0 <sub>dec</sub> )          |
| 1C33:09     | Maximum Delay time      | Time between SYNC1 event and reading of the inputs (in ns, only DC mode)   | UINT32    | RO    | 0x00000000 (0 <sub>dec</sub> )      |
| 1C33:0B     | SM event missed counter | same as <a href="#">0x1C32:11</a> [ <a href="#">▶ 110</a> ]  | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C33:0C     | Cycle exceeded counter  | same as <a href="#">0x1C32:12</a> [ <a href="#">▶ 110</a> ]  | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C33:0D     | Shift too short counter | same as <a href="#">0x1C32:13</a> [ <a href="#">▶ 110</a> ]  | UINT16    | RO    | 0x0000 (0 <sub>dec</sub> )          |
| 1C33:20     | Sync error              | same as <a href="#">0x1C32:32</a> [ <a href="#">▶ 110</a> ]  | BOOLEAN   | RO    | 0x00 (0 <sub>dec</sub> )            |

**Index F000 Modular device profile**

| Index (hex) | Name                      | Meaning   | Data type | Flags | Default                     |
|-------------|---------------------------|---|-----------|-------|-----------------------------|
| F000:0      | Modular device profile    | General information for the modular device profile      | UINT8     | RO    | 0x02 (2 <sub>dec</sub> )    |
| F000:01     | Module index distance     | Index spacing of the objects of the individual channels | UINT16    | RO    | 0x0010 (16 <sub>dec</sub> ) |
| F000:02     | Maximum number of modules | Number of channels                                      | UINT16    | RO    | 0x0001 (1 <sub>dec</sub> )  |

**Index F008 Code word**

| Index (hex) | Name      | Meaning  | Data type | Flags | Default                        |
|-------------|-----------|----------|-----------|-------|--------------------------------|
| F008:0      | Code word | reserved | UINT32    | RW    | 0x00000000 (0 <sub>dec</sub> ) |

**Index F010 Module list**

| Index (hex) | Name         | Meaning       | Data type | Flags | Default                             |
|-------------|--------------|---------------|-----------|-------|-------------------------------------|
| F010:0      | Module list  | Max. subindex | UINT8     | RW    | 0x03 (3 <sub>dec</sub> )            |
| F010:01     | SubIndex 001 | RMB           | UINT32    | RW    | 0x00000172<br>(370 <sub>dec</sub> ) |
| F010:02     | SubIndex 002 | AI            | UINT32    | RW    | 0x0000012C<br>(300 <sub>dec</sub> ) |
| F010:03     | SubIndex 003 | AI            | UINT32    | RW    | 0x0000012C<br>(300 <sub>dec</sub> ) |

## 6.13 Example program

### Using the example programs

**i** This document contains sample applications of our products for certain areas of application. The application notes provided here are based on typical features of our products and only serve as examples. The notes contained in this document explicitly do not refer to specific applications. The customer is therefore responsible for assessing and deciding whether the product is suitable for a particular application. We accept no responsibility for the completeness and correctness of the source code contained in this document. We reserve the right to modify the content of this document at any time and accept no responsibility for errors and missing information.

In this example program an EP3356 is addressed by a PLC program (for TwinCAT 2). The Zip-file (<https://infosys.beckhoff.com/content/1033/ep3356/Resources/zip/1856737419.zip>) contains the PLC\*.pro and the System Manager\*.tsm. The terminal can be operated via simple visualization; the function *InputFreeze* is programmed out by way of example.

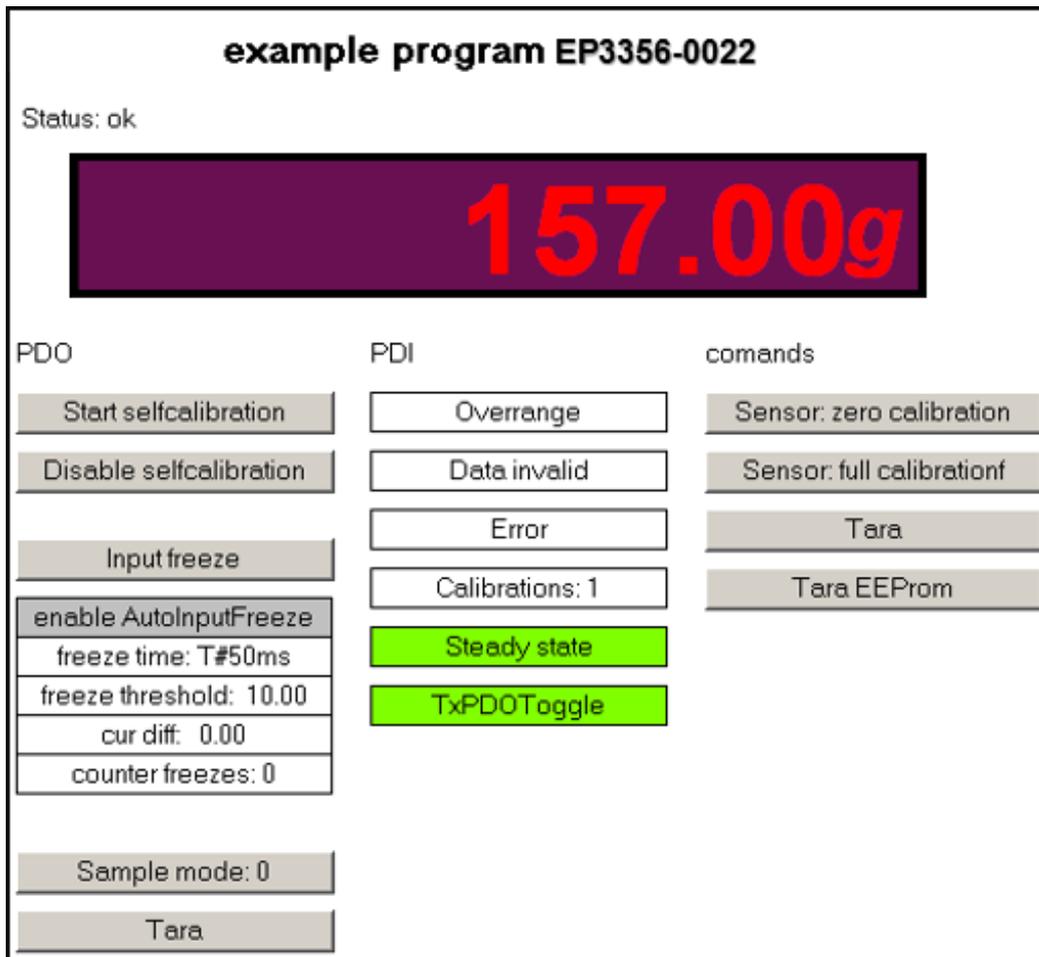


Fig. 85: Use of the example program

The EL3356 terminal is to be connected as shown below:

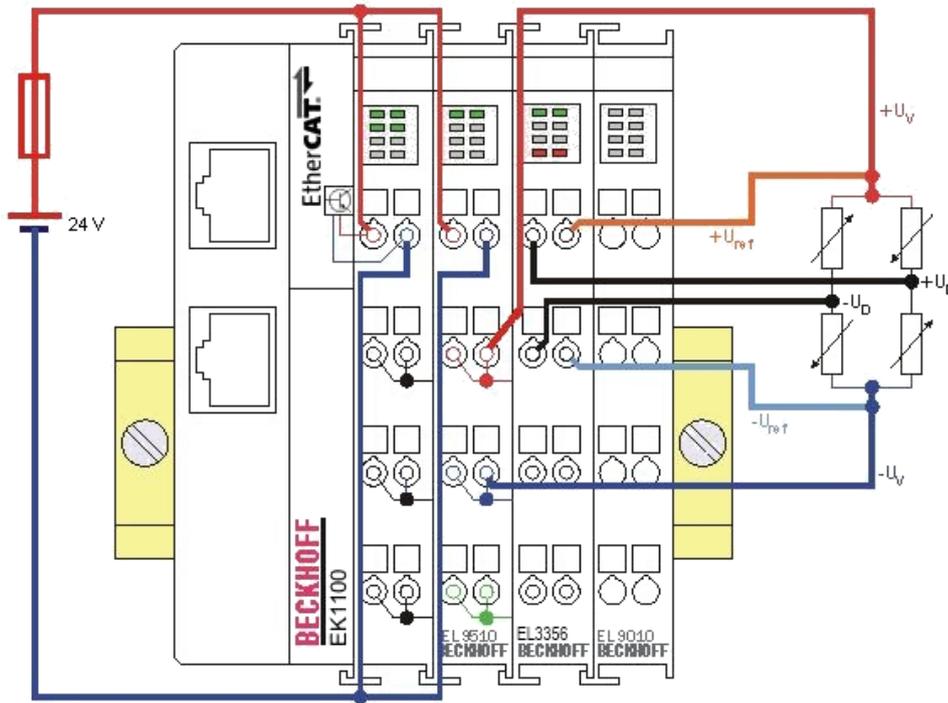


Fig. 86: EL3356: Connection of the load sensor/full bridge

An EL9510 power supply terminal is used here to feed the strain gauge with 10 V.

The EP3356 box is to be connected as shown below:

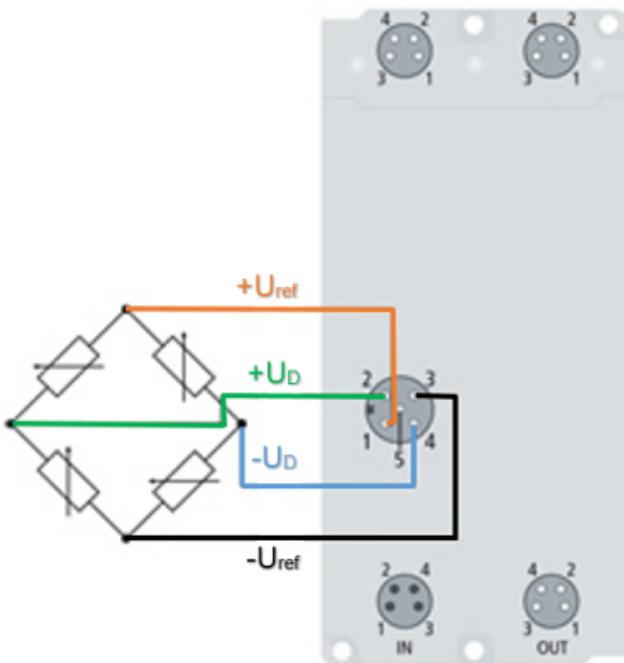


Fig. 87: EP3356: Connection of the load sensor/full bridge

The sensor power supply of 10 V is produced in EP3356.

**Procedure for starting the program**

- After clicking the Download button, save the zip file locally on your hard disk, and unzip the \*.TSM (configuration) and the \*.PRO (PLC program) files into a temporary working folder
- Run the \*.TSM file and the \*.PRO file; the TwinCAT System Manger and TwinCAT PLC will open
- Connect the hardware in accordance with one of the two previous figures and connect the Ethernet adapter of your PC to the EtherCAT coupler / EtherCAT box (further information on this can be found in the corresponding coupler manuals)
- Select the local Ethernet adapter (with real-time driver, if one) under System configuration, I/O configuration, I/O devices, Device (EtherCAT); on the "Adapter" tab choose "Search...", select the appropriate adapter and confirm (see the following two figures)

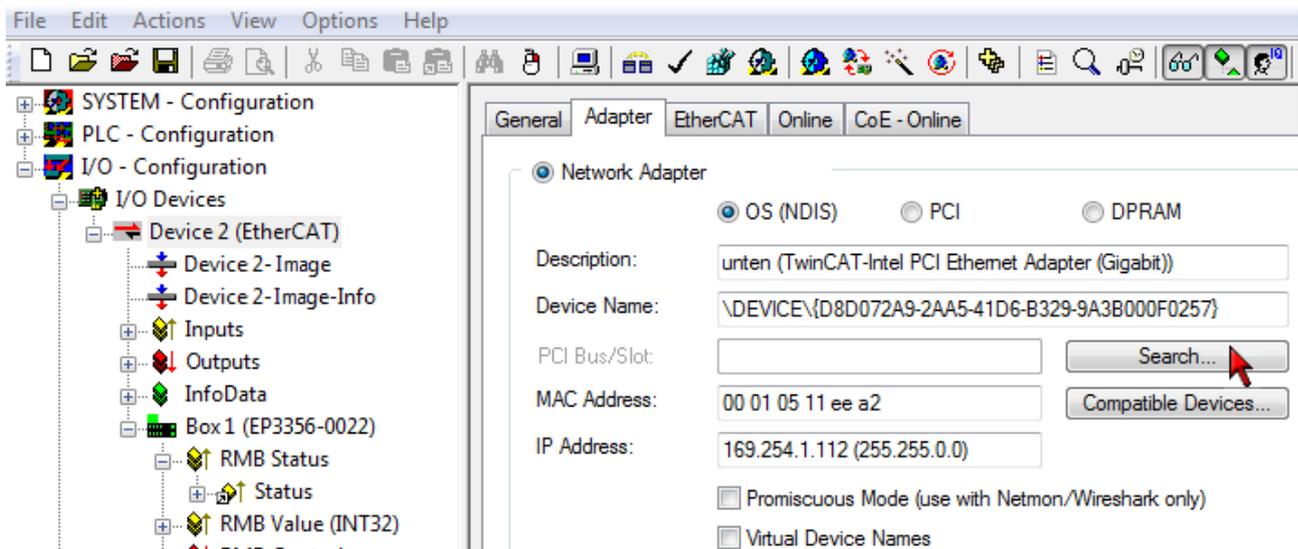


Fig. 88: Searching the Ethernet adapter



Fig. 89: Selection and confirmation of the Ethernet adapter

- Activation of the configuration and confirmation (see the following two figures)

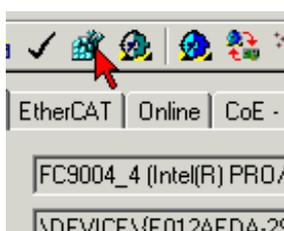


Fig. 90: Activation of the configuration

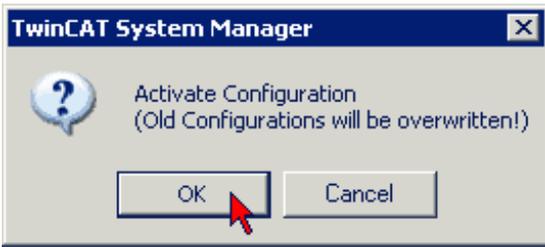


Fig. 91: Confirming the activation of the configuration

- Confirming new variable mapping, restart in RUN mode (see the following two figures)



Fig. 92: Generating variable mapping



Fig. 93: Restarting TwinCAT in RUN mode

- In TwinCAT PLC, under the "Project" menu, select "Rebuild all" to compile the project (see following figure)

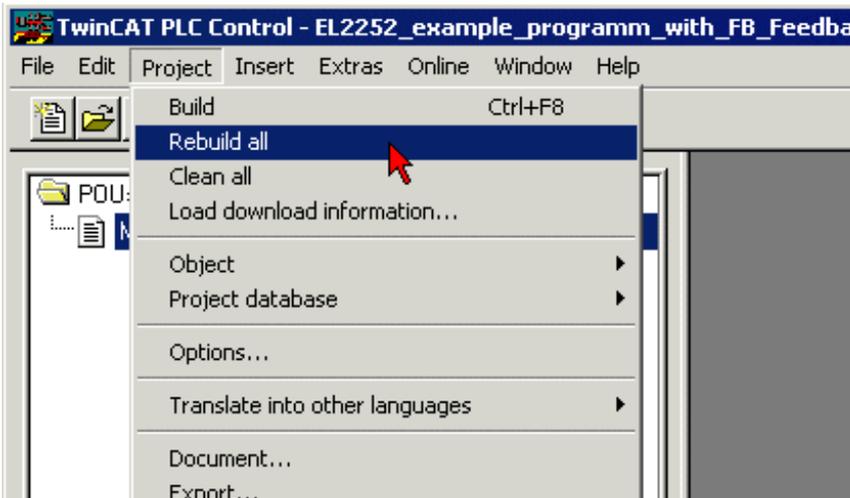


Fig. 94: Compile project

In TwinCAT PLC: log in with the "F11" button, confirm loading the program (see following figure), run the program with the "F5" button

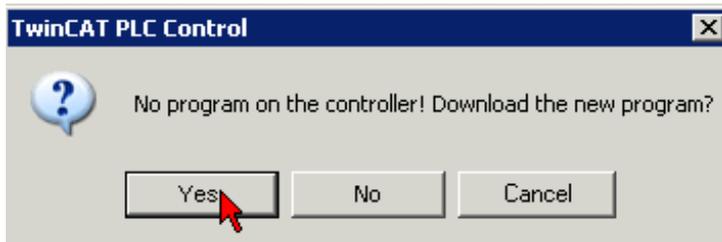


Fig. 95: Confirming program start

## 6.14 Restoring the delivery state

To restore the delivery state for backup objects in ELxxxx terminals / EPxxxx boxes, the CoE object *Restore default parameters, SubIndex 001* can be selected in the TwinCAT System Manager (Config mode).

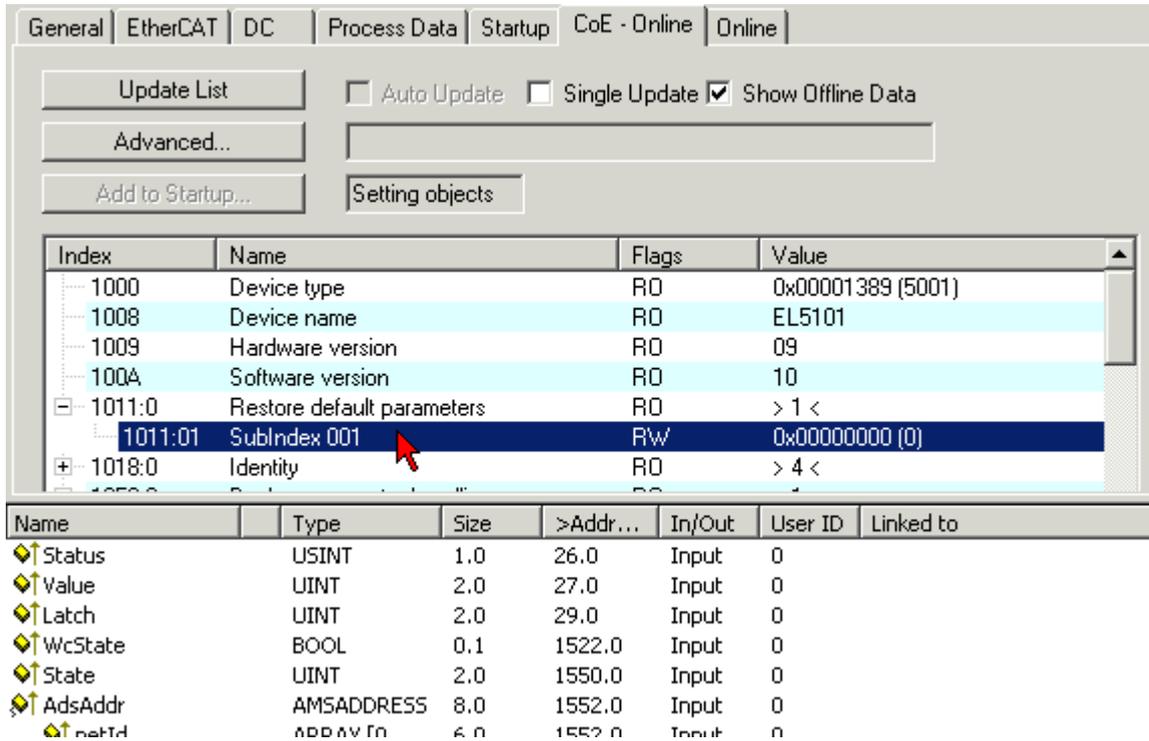


Fig. 96: Selecting the Restore default parameters PDO

Double-click on *SubIndex 001* to enter the Set Value dialog. Enter the value **1684107116** in field *Dec* or the value **0x64616F6C** in field *Hex* and confirm with OK.

All backup objects are reset to the delivery state.

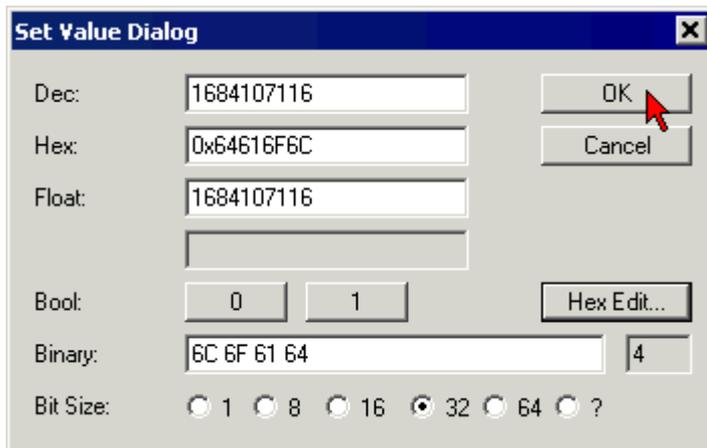


Fig. 97: Entering a restore value in the Set Value dialog

### Alternative restore value

In some older terminals / boxes the backup objects can be switched with an alternative restore value:

Decimal value: 1819238756

Hexadecimal value: 0x6C6F6164

An incorrect entry for the restore value has no effect.

# 7 Appendix

## 7.1 General operating conditions

### Protection degrees (IP-Code)

The standard IEC 60529 (DIN EN 60529) defines the degrees of protection in different classes.

| 1. Number: dust protection and touch guard | Definition  |
|--|---|
| 0  | Non-protected   |
| 1  | Protected against access to hazardous parts with the back of a hand. Protected against solid foreign objects of Ø 50 mm   |
| 2  | Protected against access to hazardous parts with a finger. Protected against solid foreign objects of Ø 12.5 mm.  |
| 3  | Protected against access to hazardous parts with a tool. Protected against solid foreign objects Ø 2.5 mm.  |
| 4  | Protected against access to hazardous parts with a wire. Protected against solid foreign objects Ø 1 mm.  |
| 5  | Protected against access to hazardous parts with a wire. Dust-protected. Intrusion of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the device or to impair safety. |
| 6  | Protected against access to hazardous parts with a wire. Dust-tight. No intrusion of dust.  |

| 2. Number: water* protection | Definition  |
|------------------------------|---|
| 0                            | Non-protected   |
| 1                            | Protected against water drops   |
| 2                            | Protected against water drops when enclosure tilted up to 15°.  |
| 3                            | Protected against spraying water. Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects.   |
| 4                            | Protected against splashing water. Water splashed against the disclosure from any direction shall have no harmful effects   |
| 5                            | Protected against water jets  |
| 6                            | Protected against powerful water jets   |
| 7                            | Protected against the effects of temporary immersion in water. Intrusion of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water for 30 min. in 1 m depth. |

\*) These protection classes define only protection against water!

### Chemical Resistance

The Resistance relates to the Housing of the Fieldbus/EtherCAT Box and the used metal parts. In the table below you will find some typical resistance.

| Character                          | Resistance  |
|------------------------------------|---|
| Steam                              | at temperatures >100°C: not resistant                   |
| Sodium base liquor (ph-Value > 12) | at room temperature: resistant<br>> 40°C: not resistant |
| Acetic acid                        | not resistant   |
| Argon (technical clean)            | resistant   |

### Key

- resistant: Lifetime several months
- non inherently resistant: Lifetime several weeks
- not resistant: Lifetime several hours resp. early decomposition

## 7.2 EtherCAT Box- / EtherCAT P Box - Accessories

### Fixing

| Ordering information | Description                     |
|----------------------|---------------------------------|
| ZS5300-0001          | Mounting rail (500 mm x 129 mm) |

### Marking material, plugs

| Ordering information | Description   |
|----------------------|---|
| ZS5000-0000          | Fieldbus Box set M8 (contact labels, plugs)         |
| ZS5000-0002          | Fieldbus Box set M12 (contact labels, plugs)        |
| ZS5000-0010          | plugs M8, IP67 (50 pieces)                          |
| ZS5000-0020          | plugs M12, IP67 (50 pieces)                         |
| ZS5100-0000          | marking labels, not printed, 4 stripes at 10 pieces |
| ZS5100-xxxx          | printed marking labels, on request                  |

### Tools

| Ordering information | Description  |
|----------------------|--|
| ZB8800               | torque wrench for M8 cables with knurl, incl. ratchet                              |
| ZB8800-0001          | M12 ratchet for torque wrench ZB8800   |
| ZB8800-0002          | M8 ratchet (field assembly) for torque wrench ZB8800                               |
| ZB8801-0000          | torque wrench for hexagonal plugs, adjustable                                      |
| ZB8801-0001          | torque cable key, M8/wrench size 9, for torque wrench ZB8801-0000                  |
| ZB8801-0002          | torque cable key, M12/wrench size 13, for torque wrench ZB8801-0000                |
| ZB8801-0003          | torque cable key, M12 field assembly/wrench size 13, for torque wrench ZB8801-0000 |



### Further accessories

Further accessories may be found at the price list for Beckhoff fieldbus components and at the internet under <https://www.beckhoff.com>

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## Table of figures

|         |  |    |
|---------|--|----|
| Fig. 1  | EP3356-0022.....   | 8  |
| Fig. 2  | Strain gauge .....   | 10 |
| Fig. 3  | quarter, half and full bridge .....  | 11 |
| Fig. 4  | 4-conductor connection .....   | 12 |
| Fig. 5  | 6-conductor connection .....   | 12 |
| Fig. 6  | Example of a load cell.....  | 13 |
| Fig. 7  | Parallel connection of strain gauges.....                                    | 15 |
| Fig. 8  | EtherCAT tab --> Advanced settings --> Behavior --> Watchdog.....            | 18 |
| Fig. 9  | EtherCAT State Machine .....   | 20 |
| Fig. 10 | CoE-Online tab .....   | 23 |
| Fig. 11 | Startup list in the TwinCAT System Manager .....                             | 24 |
| Fig. 12 | Offline list .....   | 25 |
| Fig. 13 | Online list.....   | 25 |
| Fig. 14 | Dimensions of the EtherCAT Box Modules .....                                 | 27 |
| Fig. 15 | Mounting Rail ZS5300-000 .....   | 28 |
| Fig. 16 | EtherCAT Box with M8 connectors.....   | 29 |
| Fig. 17 | EtherCAT Box with M8 and M12 connectors.....                                 | 29 |
| Fig. 18 | 7/8" plug connectors .....   | 30 |
| Fig. 19 | ZB8801 torque socket wrench .....  | 30 |
| Fig. 20 | EtherCAT Box: M8, 30 mm housing .....  | 31 |
| Fig. 21 | EtherCAT Box: M860 mm housing (example: EP9214) .....                        | 31 |
| Fig. 22 | Coupler Box: M12 .....   | 31 |
| Fig. 23 | EtherCAT-LEDs .....  | 32 |
| Fig. 24 | EtherCAT Box, Connectors for power supply .....                              | 34 |
| Fig. 25 | Pin assignment M8, Power In and Power Out.....                               | 34 |
| Fig. 26 | EP92x4-0023, Connectors for Power In and Power Out .....                     | 36 |
| Fig. 27 | Pin assignment 7/8", Power In and Power Out.....                             | 36 |
| Fig. 28 | Status LEDs for power supply .....   | 37 |
| Fig. 29 | Power cable conductor losses .....   | 38 |
| Fig. 30 | ZK2030-xxxx-yyy - Conductor losses .....                                     | 39 |
| Fig. 31 | ZK1090-3131-0xxx .....   | 40 |
| Fig. 32 | ZK2020-3132-0xxx .....   | 41 |
| Fig. 33 | Selection of Beckhoff sensor cables.....                                     | 41 |
| Fig. 34 | UL label.....  | 42 |
| Fig. 35 | BG2000-0000, putting the cables .....  | 44 |
| Fig. 36 | BG2000-0000, fixing the cables.....  | 44 |
| Fig. 37 | BG2000-0000, mounting the protection enclosure .....                         | 45 |
| Fig. 38 | Analog volatge input M12, resistor bridge .....                              | 46 |
| Fig. 39 | LEDs EP3356-0022 .....   | 47 |
| Fig. 40 | Appending a new I/O device (I/O Devices-> right-click -> Append Device.....) | 49 |
| Fig. 41 | Selecting the device (EtherCAT) .....  | 49 |
| Fig. 42 | Appending a new box (Device -> right-click -> Append Box... ) .....          | 50 |
| Fig. 43 | Selecting a Box (e.g. EP6224-2022) .....                                     | 50 |
| Fig. 44 | TwinCAT Config mode display .....  | 52 |

|         |  |     |
|---------|--|-----|
| Fig. 45 | Scan Devices.....  | 53  |
| Fig. 46 | Note for automatic device scan .....   | 53  |
| Fig. 47 | detected Ethernet devices .....  | 53  |
| Fig. 48 | scan query after automatic creation of an EtherCAT device .....                  | 54  |
| Fig. 49 | online display example .....   | 54  |
| Fig. 50 | Master display after “Scan for boxes” .....                                      | 55  |
| Fig. 51 | Identical configuration.....   | 55  |
| Fig. 52 | Example correction dialog .....  | 56  |
| Fig. 53 | Example correction dialog with modifications .....                               | 57  |
| Fig. 54 | Configuring the process data.....  | 58  |
| Fig. 55 | Branch of the EtherCAT box to be configured .....                                | 59  |
| Fig. 56 | General tab.....   | 59  |
| Fig. 57 | EtherCAT tab.....  | 60  |
| Fig. 58 | Process Data tab .....   | 61  |
| Fig. 59 | Startup tab .....  | 63  |
| Fig. 60 | CoE - Online tab .....   | 64  |
| Fig. 61 | Advanced settings .....  | 65  |
| Fig. 62 | Online tab .....   | 65  |
| Fig. 63 | Max. input voltages.....   | 68  |
| Fig. 64 | Parallel connection with EL3356.....   | 68  |
| Fig. 65 | Parallel connection with EP3356 .....  | 69  |
| Fig. 66 | Block diagram of EP3356-0022.....  | 69  |
| Fig. 67 | Notch characteristic/amplitude curve and step response of the FIR filter.....    | 70  |
| Fig. 68 | Step response and Bode diagramm of the IIR filter.....                           | 71  |
| Fig. 69 | Effect of dynamic IIR filters .....  | 73  |
| Fig. 70 | Latency of the Analog-to-Digital converter.....                                  | 75  |
| Fig. 71 | Setting parameters in CoE belonging to the individual modes .....                | 75  |
| Fig. 72 | Sample mode switching.....   | 76  |
| Fig. 73 | Internal switch for increasing the measuring accuracy .....                      | 77  |
| Fig. 74 | Impulses on a load cell with and without InputFreeze .....                       | 78  |
| Fig. 75 | Load cell loaded and unloaded.....   | 79  |
| Fig. 76 | Adaptation to the sensor curve .....   | 80  |
| Fig. 77 | Measuring range.....   | 84  |
| Fig. 78 | Single-ended/differential typification .....                                     | 85  |
| Fig. 79 | 2/3/4-wire connection as single-ended or differential connection technology..... | 88  |
| Fig. 80 | Activation of DC and PDO timestamp in the TwinCAT System Manager.....            | 91  |
| Fig. 81 | EP3356 - process data selection in the TwinCAT System Manager .....              | 93  |
| Fig. 82 | Default process image, EL3356-0010 / EP3356-0022 .....                           | 94  |
| Fig. 83 | Load value in fixed-point representation .....                                   | 96  |
| Fig. 84 | Voltage measurement.....   | 97  |
| Fig. 85 | Use of the example program .....   | 113 |
| Fig. 86 | EL3356: Connection of the load sensor/full bridge .....                          | 114 |
| Fig. 87 | EP3356: Connection of the load sensor/full bridge.....                           | 114 |
| Fig. 88 | Searching the Ethernet adapter.....  | 115 |
| Fig. 89 | Selection and confirmation of the Ethernet adapter.....                          | 115 |
| Fig. 90 | Activation of the configuration.....   | 115 |

|         |   |     |
|---------|---|-----|
| Fig. 91 | Confirming the activation of the configuration.....   | 116 |
| Fig. 92 | Generating variable mapping.....                      | 116 |
| Fig. 93 | Restarting TwinCAT in RUN mode .....                  | 116 |
| Fig. 94 | Compile project.....                                  | 116 |
| Fig. 95 | Confirming program start.....                         | 117 |
| Fig. 96 | Selecting the Restore default parameters PDO.....     | 118 |
| Fig. 97 | Entering a restore value in the Set Value dialog..... | 118 |