BECKHOFF New Automation Technology

Documentation | EN

# EL33xx-00x0

Analog Thermocouple Input Terminals (open-circuit recognition, 1, 2, 4 ch.)


2021-07-16 | Version: 5.1

# Table of contents

# 1 Foreword

## 1.1 Product overview Analog Thermocouple Input Terminals

EL3311 [▸ 17]
1 channel thermocouple input terminal

EL3312 [▸ 35]
2 channel thermocouple input terminal

EL3314 [▸ 53]
4 channel thermocouple input terminal

EL3314-0002 [▸ 72]
4-channel input terminal, thermocouple, high-precision, electrically isolated

EL3314-0010 [▸ 91]
4 channel thermocouple input terminal, high-precision

EL3314-0020 [▸ 110]
4 channel thermocouple input terminal, high-precision, with Beckhoff calibration certificate [▸ 201]

EL3314-0030 [▸ 129]
4 channel thermocouple input terminal, high-precision, with external calibration certificate [▸ 201]

EL3314-0090 [▸ 148]
4 channel thermocouple input terminal, TwinSAFE Single Channel

EL3318 [▸ 168]
8 channel HD thermocouple input terminal

## 1.2 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**

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH. Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

**Patent Pending**

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

EtherCAT®

EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

**Copyright**

## 1.3 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.

## 1.4 Documentation issue status

| Version | Comment |
|---|---|
| 5.1 | - Update “Object description and parameterization”<br>- Update structure<br>- Update revision status |
| 5.0 | - Update structure<br>- Update chapter “Technical data”<br>- Update chapter “Version identification” |
| 4.9 | - Update structure<br>- Update chapter “Technical data”, specification notes added<br>- EL3314-0030 added |
| 4.8 | - Update structure<br>- Update chapter “Technical data”<br>- EL3314-0020 added<br>- Update chapter “Technology Temperature measurement with thermocouples” |
| 4.7 | - Update structure: chapter “introduction” |
| 4.6 | - Update chapter “Technical data”<br>- Chapter "Commissioning": addenda subchapter "Basics about signal isolators, barriers"<br>- Update chapter “Object description”<br>- Update structure |
| 4.5 | - Update chapter “Technical data”<br>- Update structure |
| 4.4 | - Update chapter “UL notice”<br>- Update chapter “Firmware compatibility”<br>- Update structure |
| 4.3 | - Update chapter “Operation with an external cold junction”<br>- Update structure<br>- Update revision status |
| 4.2 | - Update chapter “Technical data”<br>- Update chapter “Wire break detection”<br>- Update chapter “TwinSAFE SC”<br>- Update revision status |
| 4.1 | - Update chapter “Technical data” |
| 4.0 | - EL3314-0002 added<br>- Update chapter “Technical data”<br>- Example program added |
| 3.9 | - Update chapter “Object description and parameterization”<br>- Update chapter “Commissioning” |
| 3.8 | - Update chapter “Object description”<br>- Update structure<br>- Update revision status |
| 3.7 | - EL3314-0090 added<br>- Update chapter “Technical data”<br>- Update revision status |
| 3.6 | - Update chapter "Technical data"<br>- Addenda chapter "Instructions for ESD protection"<br>- Chapter “Analog technical notices - specifications” replaced by chapter “Notices on analog specifications”<br>- Update revision status |
| 3.5 | - Update chapter “Object description and parameterization”<br>- External cold junction compensation added to be available for EL3314-0010 |
| 3.4 | - Update chapter "Notes on the documentation"<br>- Correction of Technical data<br>- Addenda chapter "TwinCAT Quick Start"<br>- Update revision status |
| 3.3 | - Addenda chapter “Operation with an external reference point”<br>- Update structure |
| 3.2 | - Addenda chapter “Analog technical notices - specifications”<br>- Update chapter "Technical data"<br>- Update revision status |
| 3.1 | - Update chapter "Technical data"Update revision status<br>- Corrections in chapter "Calculation of process data" |

| Version | Comment |
|---|---|
| 3.0 | - First publication in PDF format<br>- Update structure<br>- Corrections in chapter "Calculation of process data" |
| 2.6 | - Update chapter "Technical data"<br>- Addenda chapter "Installation instructions for enhanced mechanical load capacity"<br>- Update structure<br>- Update revision status |
| 2.5 | - Update chapter "LEDs and connection"<br>- Update revision status |
| 2.4 | - Update chapter "Process data"<br>- Update chapter "Technical data" |
| 2.3 | - Update chapter "Technical data" |
| 2.2 | - Update chapter "Object description" and "Technical data": |
| 2.1 | - EL3314-0010 added<br>- Update chapter "Process data" |
| 2.1 | - EL3314-0010 added<br>- Update chapter "Process data" |
| 2.0 | - EL3318 added<br>- Update Technical data<br>- Update chapter "Process data" |
| 1.9 | - Update Technical data<br>- New structure |
| 1.8 | - Addenda technical notes |
| 1.7 | - Addenda technical notes |
| 1.6 | - Addenda technical notes |
| 1.5 | - Addenda technical notes |
| 1.4 | - Addenda Technical data and CoE objects |
| 1.3 | - Connection diagrams corrected |
| 1.2 | - Technical data added |
| 1.1 | - Technical data added (CoE objects) |
| 1.0 | - Technical data added, first public issue |
| 0.1 | - Provisional documentation for EL33xx |

# 1.5 Version identification of EtherCAT devices

## 1.5.1 General notes on marking

**Designation**

A Beckhoff EtherCAT device has a 14-digit designation, made up of

- family key
- type
- version
- revision

| Example | Family | Type | Version | Revision |
|---|---|---|---|---|
| EL3314-0000-0016 | EL terminal (12 mm, non-pluggable connection level) | 3314 (4-channel thermocouple terminal) | 0000 (basic type) | 0016 |
| ES3602-0010-0017 | ES terminal (12 mm, pluggable connection level) | 3602 (2-channel voltage measurement) | 0010 (high-precision version) | 0017 |
| CU2008-0000-0000 | CU device | 2008 (8-port fast ethernet switch) | 0000 (basic type) | 0000 |

**Notes**

- The elements mentioned above result in the **technical designation**. EL3314-0000-0016 is used in the example below.
- EL3314-0000 is the order identifier, in the case of “-0000” usually abbreviated to EL3314. “-0016” is the EtherCAT revision.
- The **order identifier** is made up of
  - family key (EL, EP, CU, ES, KL, CX, etc.)
  - type (3314)
  - version (-0000)
- The **revision** -0016 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
  In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
  Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave Information) in the form of an XML file, which is available for download from the Beckhoff web site.
  From 2014/01 the revision is shown on the outside of the IP20 terminals, see Fig. *“EL5021 EL terminal, standard IP20 IO device with batch number and revision ID (since 2014/01)”*.
- The type, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

## 1.5.2 Version identification of EL terminals

The serial number/ data code for Beckhoff IO devices is usually the 8-digit number printed on the device or on a sticker. The serial number indicates the configuration in delivery state and therefore refers to a whole production batch, without distinguishing the individual modules of a batch.

Structure of the serial number: **KK YY FF HH**

KK - week of production (CW, calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with
Ser. no.: 12063A02: 12 - production week 12 06 - production year 2006 3A - firmware version 3A 02 - hardware version 02

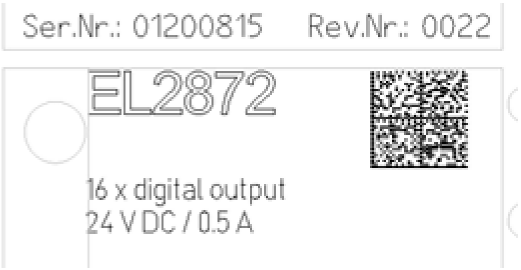



Fig. 1: EL2872 with revision 0022 and serial number 01200815

### 1.5.3 Beckhoff Identification Code (BIC)

The Beckhoff Identification Code (BIC) is increasingly being applied to Beckhoff products to uniquely identify the product. The BIC is represented as a Data Matrix Code (DMC, code scheme ECC200), the content is based on the ANSI standard MH10.8.2-2016.

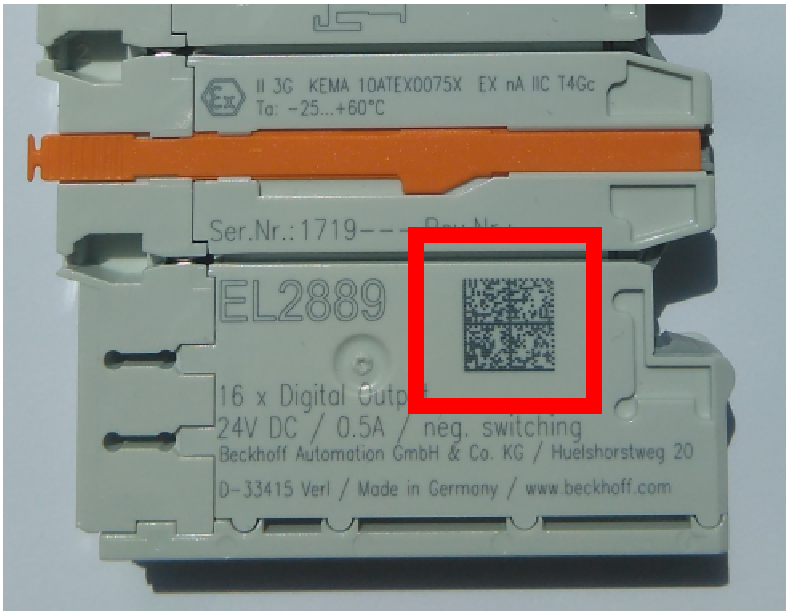



Fig. 2: BIC as data matrix code (DMC, code scheme ECC200)

The BIC will be introduced step by step across all product groups.

Depending on the product, it can be found in the following places:

- on the packaging unit
- directly on the product (if space suffices)
- on the packaging unit and the product

The BIC is machine-readable and contains information that can also be used by the customer for handling and product management.

Each piece of information can be uniquely identified using the so-called data identifier (ANSI MH10.8.2-2016). The data identifier is followed by a character string. Both together have a maximum length according to the table below. If the information is shorter, spaces are added to it. The data under positions 1 to 4 are always available.

Following information is possible, positions 1 to 4 are always present, the other according to need of production:

| Posi-tion | Type of information | Explanation | Data identifier | Number of digits incl. data identifier | Example |
|---|---|---|---|---|---|
| 1 | Beckhoff order number | **Beckhoff order number** | 1P | 8 | 1P072222 |
| 2 | Beckhoff Traceability Number (BTN) | **Unique serial number, see note below** | S | 12 | SBTNk4p562d7 |
| 3 | Article description | **Beckhoff article description, e.g. EL1008** | 1K | 32 | 1KEL1809 |
| 4 | Quantity | **Quantity in packaging unit, e.g. 1, 10, etc.** | Q | 6 | Q1 |
| 5 | Batch number | Optional: Year and week of production | 2P | 14 | 2P401503180016 |
| 6 | ID/serial number | Optional: Present-day serial number system, e.g. with safety products | 51S | 12 | 51S678294 |
| 7 | Variant number | Optional: Product variant number on the basis of standard products | 30P | 32 | 30PF971, 2*K183 |
| ... | | | | | |

Further types of information and data identifiers are used by Beckhoff and serve internal processes.

### Structure of the BIC

Example of composite information from positions 1 to 4 and with the above given example value on position 6. The data identifiers are highlighted in bold font:

**1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

Accordingly as DMC:

Fig. 3: Example DMC **1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

### BTN

An important component of the BIC is the Beckhoff Traceability Number (BTN, position 2). The BTN is a unique serial number consisting of eight characters that will replace all other serial number systems at Beckhoff in the long term (e.g. batch designations on IO components, previous serial number range for safety products, etc.). The BTN will also be introduced step by step, so it may happen that the BTN is not yet coded in the BIC.

**NOTE**

This information has been carefully prepared. However, the procedure described is constantly being further developed. We reserve the right to revise and change procedures and documentation at any time and without prior notice. No claims for changes can be made from the information, illustrations and descriptions in this information.

## 1.5.4 Electronic access to the BIC (eBIC)

### Electronic BIC (eBIC)

The Beckhoff Identification Code (BIC) is applied to the outside of Beckhoff products in a visible place. If possible, it should also be electronically readable.

Decisive for the electronic readout is the interface via which the product can be electronically addressed.

### K-bus devices (IP20, IP67)

Currently, no electronic storage and readout is planned for these devices.

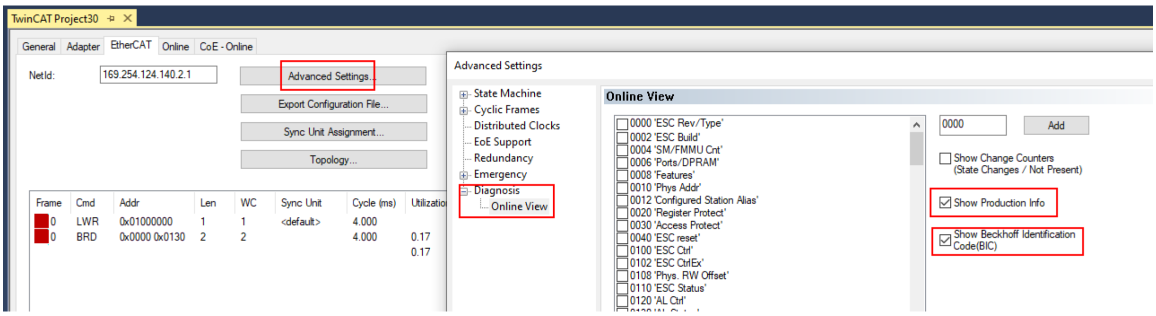
### EtherCAT devices (IP20, IP67)

All Beckhoff EtherCAT devices have a so-called ESI-EEPROM, which contains the EtherCAT identity with the revision number. Stored in it is the EtherCAT slave information, also colloquially known as ESI/XML configuration file for the EtherCAT master. See the corresponding chapter in the EtherCAT system manual (chapter 3) for the relationships.

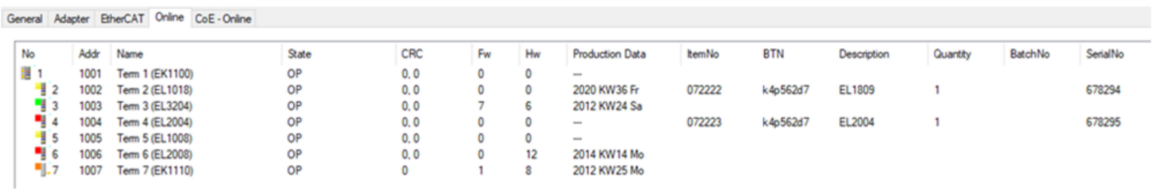
The eBIC is also stored in the ESI-EEPROM. The eBIC was introduced into the Beckhoff I/O production (terminals, boxes) from 2020; widespread implementation is expected in 2021.

The user can electronically access the eBIC (if existent) as follows:

- With all EtherCAT devices, the EtherCAT master (TwinCAT) can read the eBIC from the ESI-EEPROM
    - From TwinCAT 4024.11, the eBIC can be displayed in the online view.
    - To do this,
      check the checkbox "Show Beckhoff Identification Code (BIC)" under
      EtherCAT → Advanced Settings → Diagnostics:




    - The BTN and its contents are then displayed:




    - Note: as can be seen in the illustration, the production data HW version, FW version and production date, which have been programmed since 2012, can also be displayed with "Show Production Info".
- In the case of EtherCAT devices with CoE directory, the object 0x10E2:01 can additionally by used to display the device's own eBIC; the PLC can also simply access the information here:

- The device must be in SAFEOP/OP for access:

| Index | Name | Flags | Value |
| --- | --- | --- | --- |
| 1000 | Device type | RO | 0x015E1389 (22942601) |
| 1008 | Device name | RO | ELM3704-0000 |
| 1009 | Hardware version | RO | 00 |
| 100A | Software version | RO | 01 |
| 100B | Bootloader version | RO | J0.1.27.0 |
| + 1011:0 | Restore default parameters | RO | > 1 < |
| + 1018:0 | Identity | RO | > 4 < |
| − 10E2:0 | Manufacturer-specific Identification C... | RO | > 1 < |
| 10E2:01 | SubIndex 001 | RO | 1P158442SBTN0008jekp1KELM3704 Q1 2P482001000016 |
| + 10F0:0 | Backup parameter handling | RO | > 1 < |
| + 10F3:0 | Diagnosis History | RO | > 21 < |
| 10F8 | Actual Time Stamp | RO | 0x170bfb277e |

- the object 0x10E2 will be introduced into stock products in the course of a necessary firmware revision.

- Note: in the case of electronic further processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
The new BIC information is additionally written as a category in the ESI-EEPROM during the device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored with the help of a category according to ETG.2010. ID 03 indicates to all EtherCAT masters that they must not overwrite these data in case of an update or restore the data after an ESI update.
The structure follows the content of the BIC, see there. This results in a memory requirement of approx. 50..200 bytes in the EEPROM.
- Special cases
  - If multiple, hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC Information.
  - If multiple, non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC Information.
  - If the device consists of several sub-devices with their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

**Profibus/Profinet/DeviceNet… Devices**

Currently, no electronic storage and readout is planned for these devices.

# 2 Product description

## 2.1 EL3311

### 2.1.1 Introduction

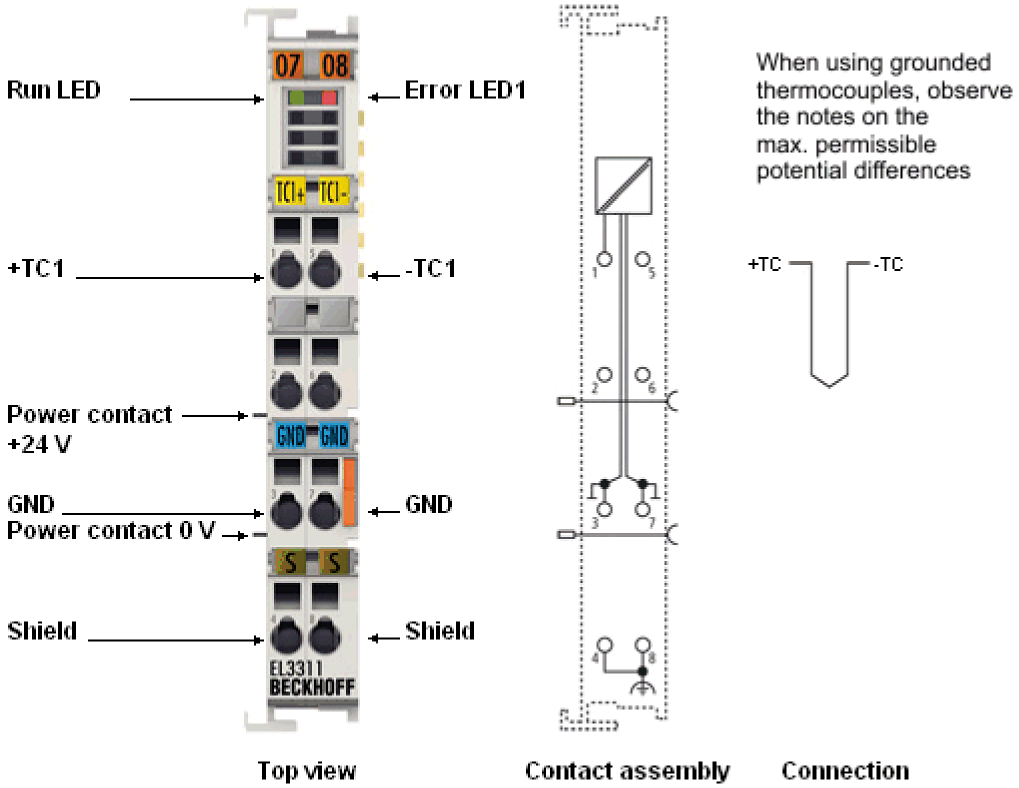



Fig. 4: EL3311

**1 channel analog thermocouple input terminals with open-circuit recognition**

The EL3311 analog input terminals allow the direct connection of thermocouples. The EtherCAT Terminals circuit can operate thermocouple sensors using the 2-wire technique. Linearization over the full temperature range is realized with the aid of a microprocessor. The temperature range can be selected freely. The error LEDs indicate a broken wire. Compensation for the cold junction is made through an internal temperature measurement at the terminals. The EL33xx can also be used for mV measurement.

**Quick links**


- EtherCAT basics
- Technology EL33xx [▶ 188]
- CoE object description and parameterization [▶ 329]
- Process data and operation modes [▶ 313]

## 2.1.2 Technical data

### 2.1.2.1 General technical data

| Analog inputs | EL3311 |
|---|---|
| Number of inputs | 1 |
| Thermocouple sensor types, measured variables | Types B, C, E, J, K, L, N, R, S, T, U (default setting type K), mV measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 16-bit |
| Conversion time | approx. 2.5 s to 20 ms,<br>depending on the configuration and filter setting; default: approx. 250 ms |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes |
| Supports NoCoEStorage [▸ 218] function | yes, from firmware 01 |

| Voltage measurement | EL3311 |
|---|---|
| Measuring range, technically usable | approx. ± 78 mV |
| Measuring ranges (nominal) and resolution | ± 30 mV (1 µV per digit, thus max. 32.768 mV can be displayed)<br>± 60 mV (2 µV per digit, thus max. 65.536 mV can be displayed)<br>± 75 mV (4 µV per digit, thus max. 131 mV can be displayed, observe technical measuring range)<br>The measuring ranges 30 and 60 mV are executed in software to increase the resolution and always use the same electrical measuring range of ± 75 mV. |
| Measurement uncertainty | See Measurement ±30 mV...±75 mV [▸ 20] |

| Temperature measurement | EL3311 |
|---|---|
| Electrical measuring range used | ± 75 mV |
| Measuring ranges | Type B: +200...+1800 °C<br>Type C: 0...+2320 °C<br>Type E: -100...+1000°C<br>Type J: -100...+1200 °C<br>Type K: -200…+1370 °C (preset)<br>Type L: 0...+900 °C<br>Type N: -100…+1300 °C<br>Type R: -50...+1767 °C<br>Type S: -50...+1760 °C<br>Type T: -200…+400 °C<br>Type U: 0...+600 °C |
| Resolution | Temperature display 0.1/0.01 °C per digit, preset 0.1 °C<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 21] |

| Supply and potentials | | EL3311 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3311 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 16 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3311 |
|---|---|
| Permissible ambient temperature range during operation | --25 °C...+60 °C (extended temperature range), from firmware 06 |
| Permissible ambient temperature range during storage | -40°C … +85°C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3311 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▸ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | variable |

| Standards and approvals | EL3311 |
|---|---|
| Protection class | IP20 |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also Installation instructions for enhanced mechanical load capacity [▸ 226] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▸ 205]<br>cULus [▸ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

### 2.1.2.2 Measurement ±30 mV...±75 mV

**Specification ±30 mV**

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±30 mV |
|---|---|---|
| Measuring range, nominal | | -30…+30 mV |
| Measuring range, end value (full scale value) | | 30 mV |
| PDO resolution | | 1 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.24%$_{FSV}$ typ. ≈ < ± 0.070 mV |
| | @ 55 °C ambient temperature[1] | < ±026%$_{FSV}$ typ. ≈ < ± 0.077 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

**Specification ±60 mV**

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±60 mV |
|---|---|---|
| Measuring range, nominal | | -60…+60 mV |
| Measuring range, end value (full scale value) | | 60 mV |
| PDO resolution | | 2 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.16%$_{FSV}$ typ. ≈ < ± 0.094 mV |
| | @ 55 °C ambient temperature[1] | < ±0.17%$_{FSV}$ typ. ≈ < ± 0.10 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

**Specification ±75 mV**

| Measurement mode | | ±75 mV |
|---|---|---|
| Measuring range, nominal | | -75…+75 mV |
| Measuring range, end value (full scale value) | | 75 mV |
| PDO resolution | | 4 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.14%$_{FSV}$ typ. ≈ < ± 0.11 mV |
| | @ 55 °C ambient temperature[1] | < ±0.15%$_{FSV}$ typ. ≈ < ± 0.12 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.1.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

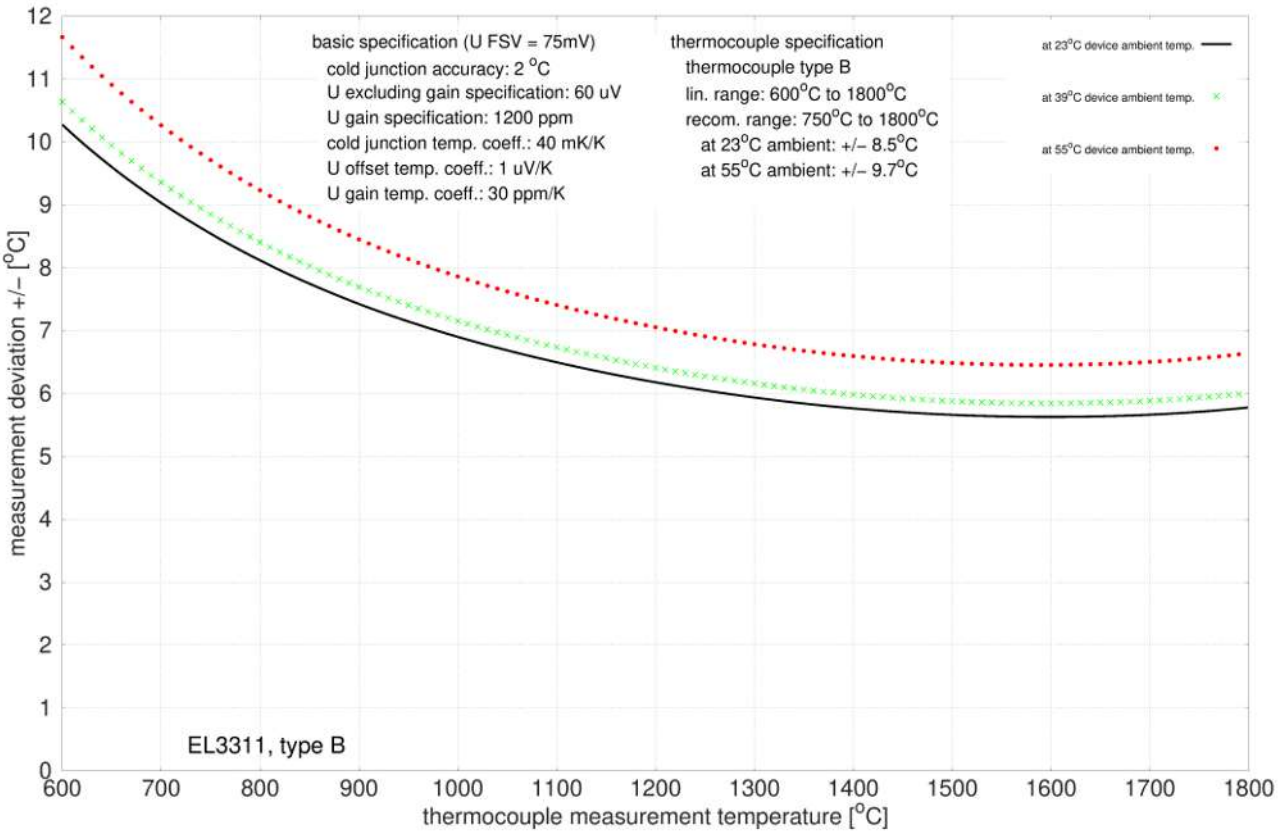
In the EL3311 each channel has its own cold junction sensor.

| **Measurement mode** | | **Cold junction** |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±2.0 °C |
| Temperature coefficient | Tk | < 40 mK/K |

## Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | +600 °C ≈ 1.792 mV … +1800 °C ≈ 13.591 mV |
| Measuring range, end value (full scale value) | | +1800 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type B: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 8.5 K ≈ ± 0.47 $\%_{FSV}$ |
| | *@ 55 °C ambient temperature* | ± 9.7 K ≈ ± 0.54 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

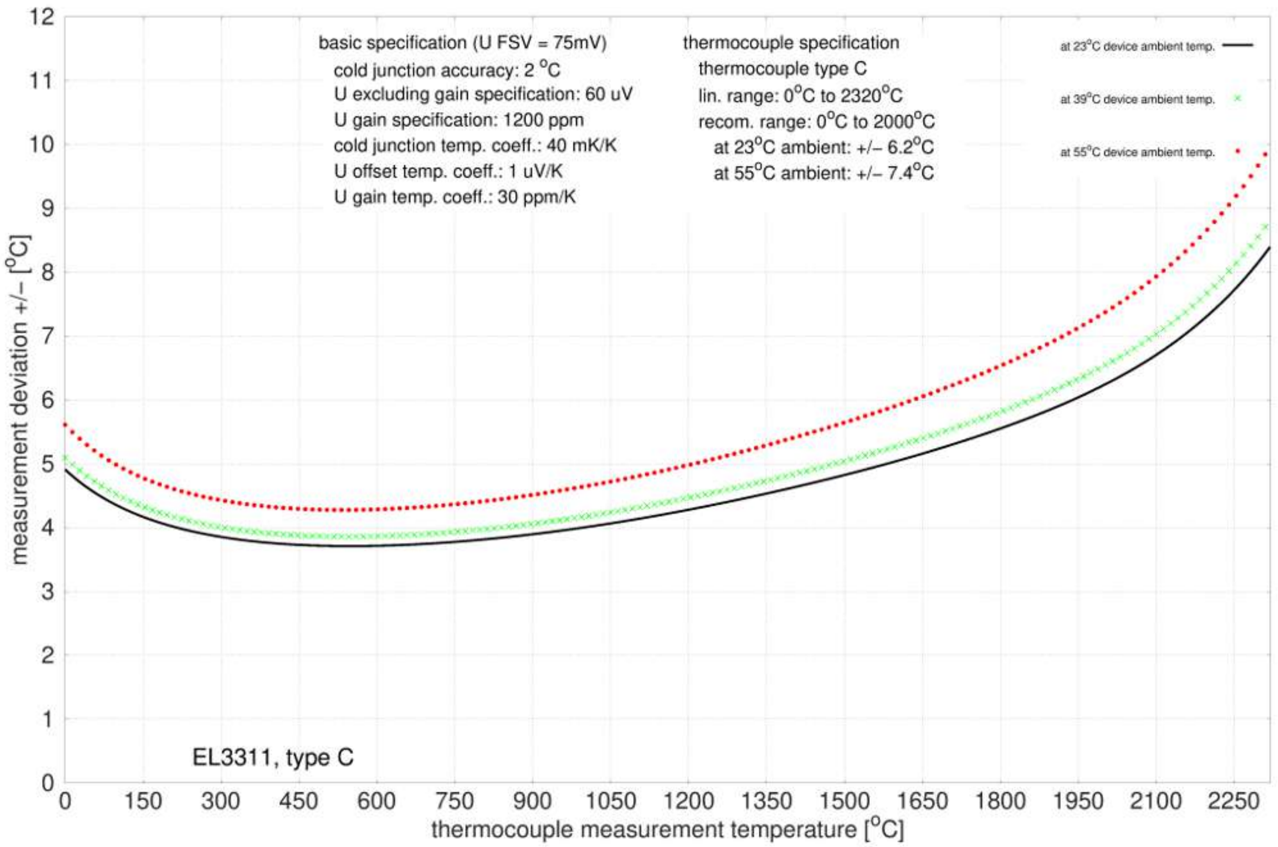
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type C: approx. 0.07 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.2 K ≈ ± 0.27 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.4 K ≈ ± 0.32 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

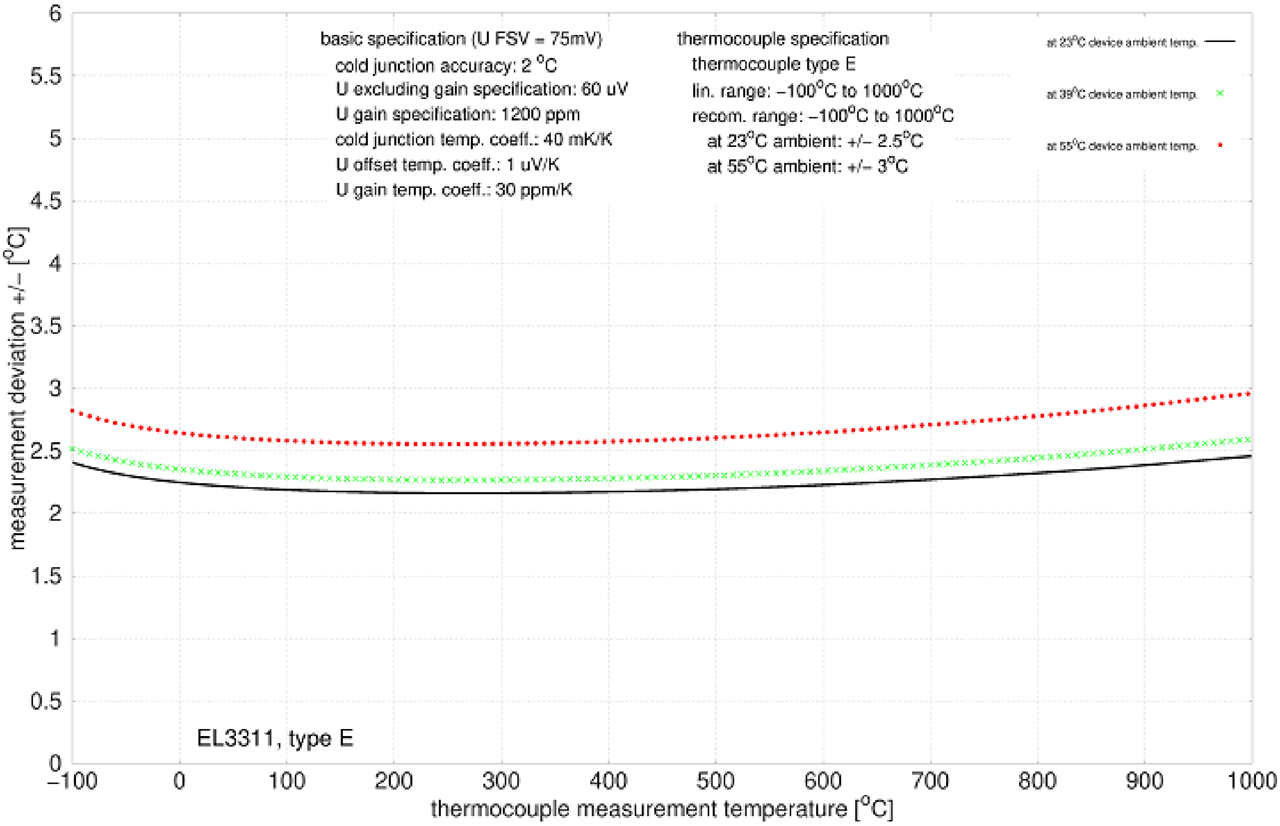
Measurement uncertainty for thermocouple type C:



## Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -5.237 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type E: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

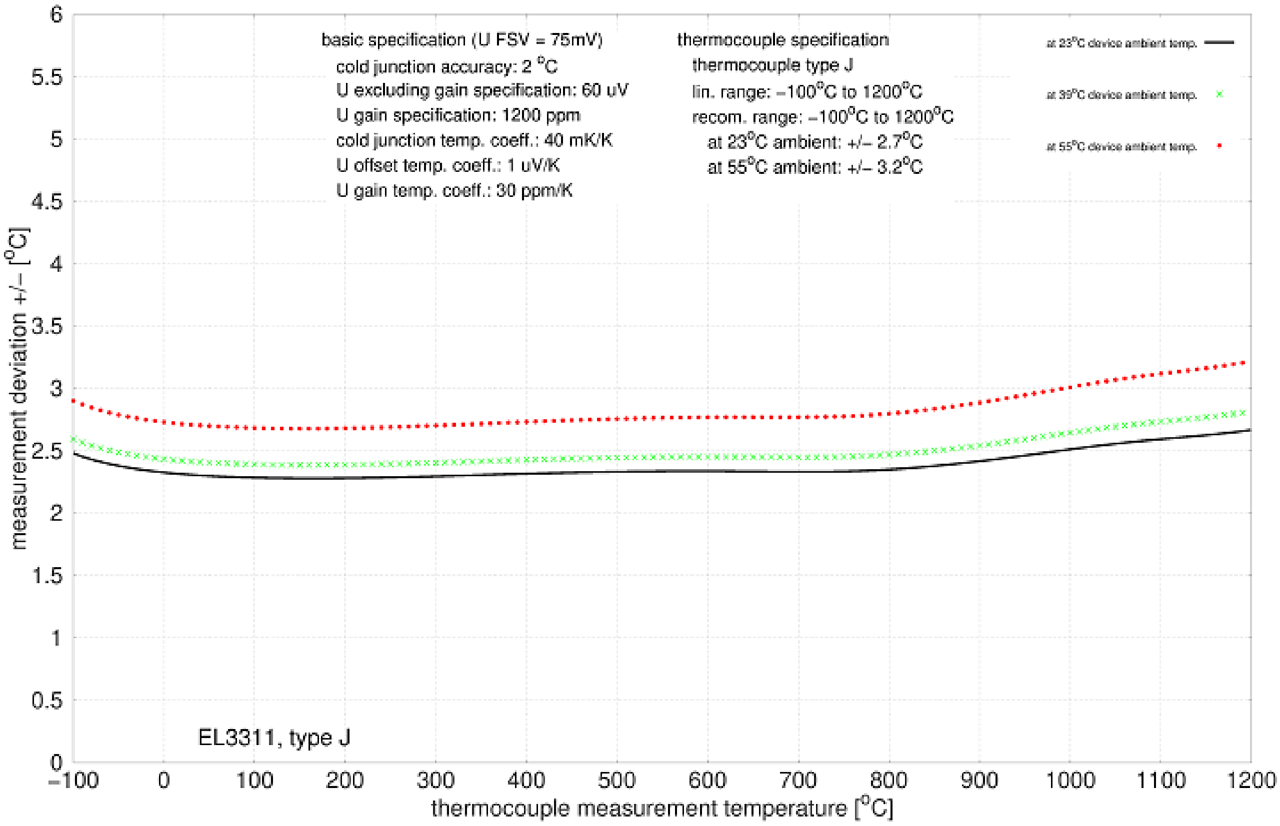
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -4.632 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type J: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.7 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.2 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

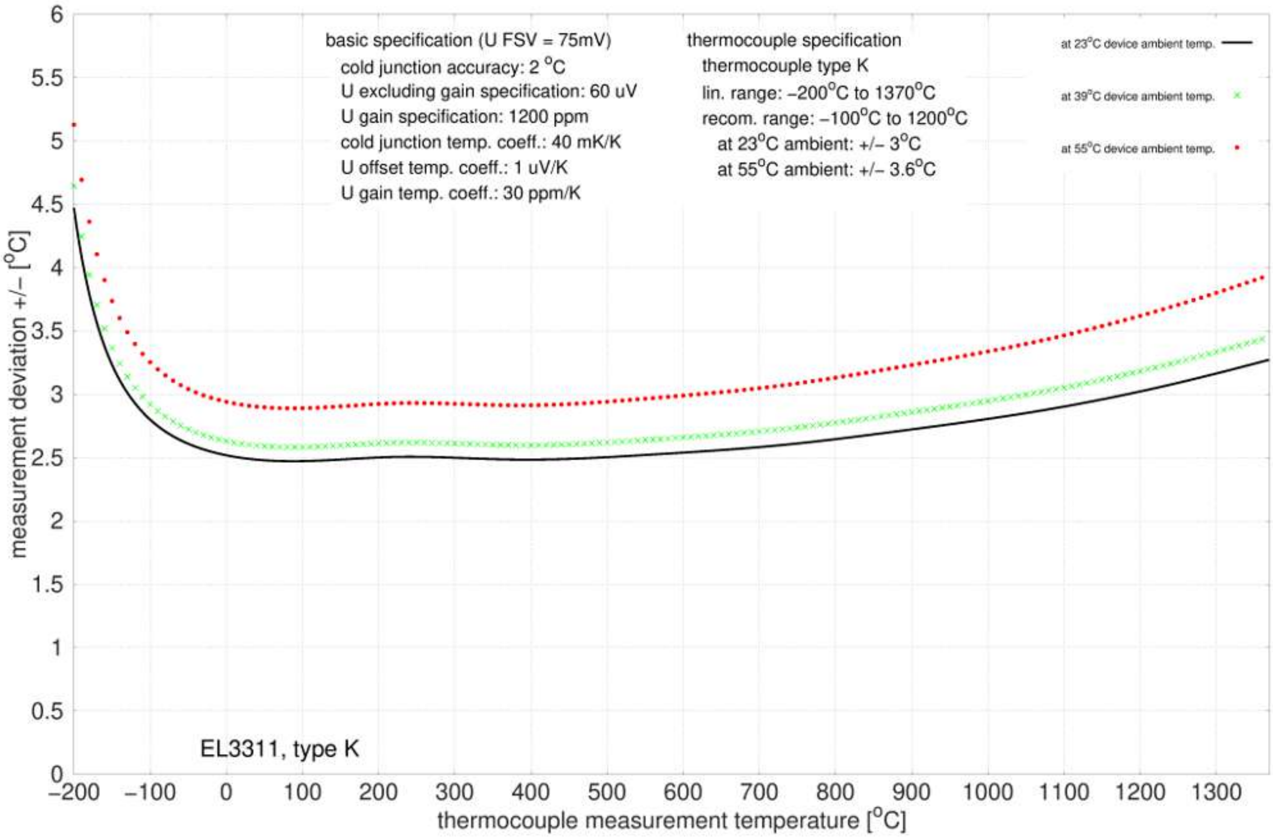
Measurement uncertainty for thermocouple type J:



## Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.891 mV … +1370 °C ≈ 54.818 mV |
| Measuring range, end value (full scale value) | | +1370 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.22 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.26 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

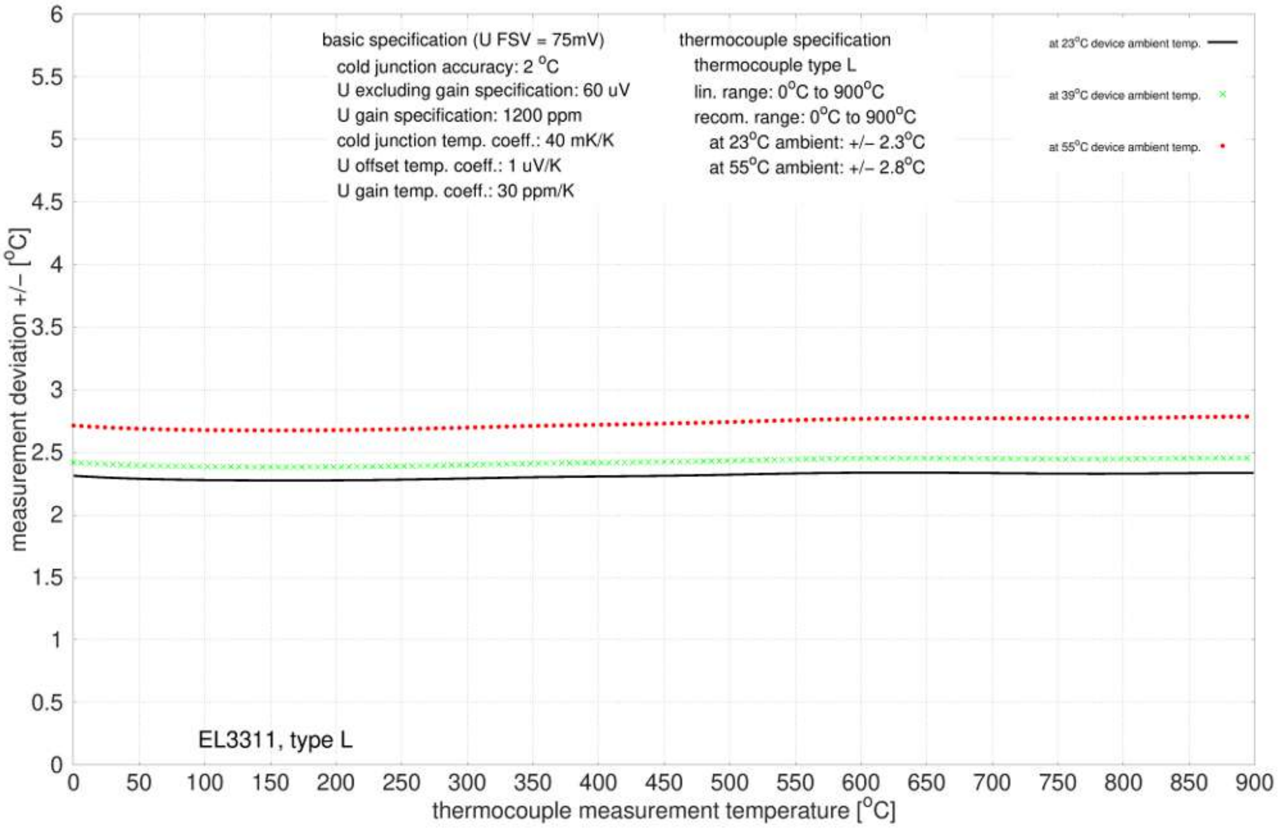
Measurement uncertainty for thermocouple type K:



## Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type L: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.26 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.8 K ≈ ± 0.31 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

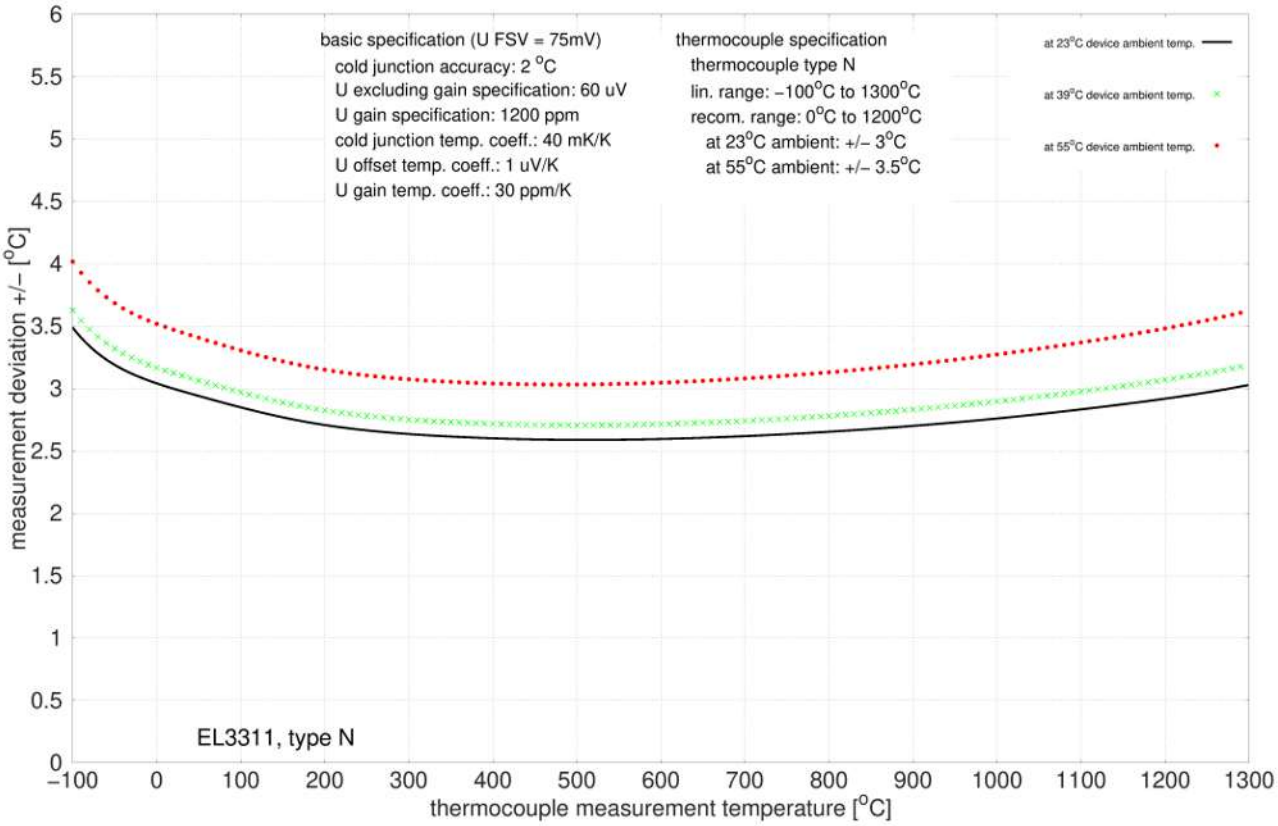
Measurement uncertainty for thermocouple type L:



## Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -2.406 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type N: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

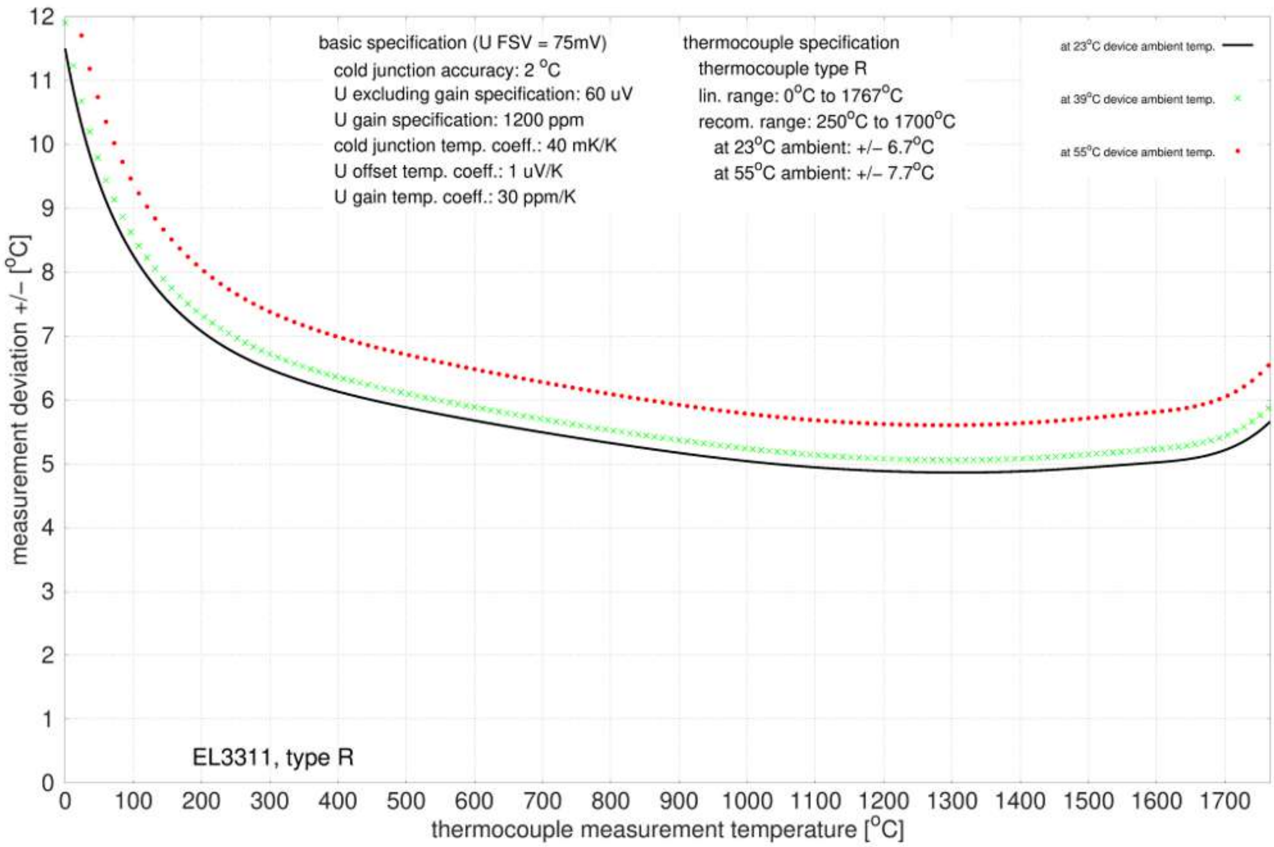
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1767 °C ≈ 21.089 mV |
| Measuring range, end value (full scale value) | | +1767 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type R: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.7 K ≈ ± 0.38 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.7 K ≈ ± 0.44 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

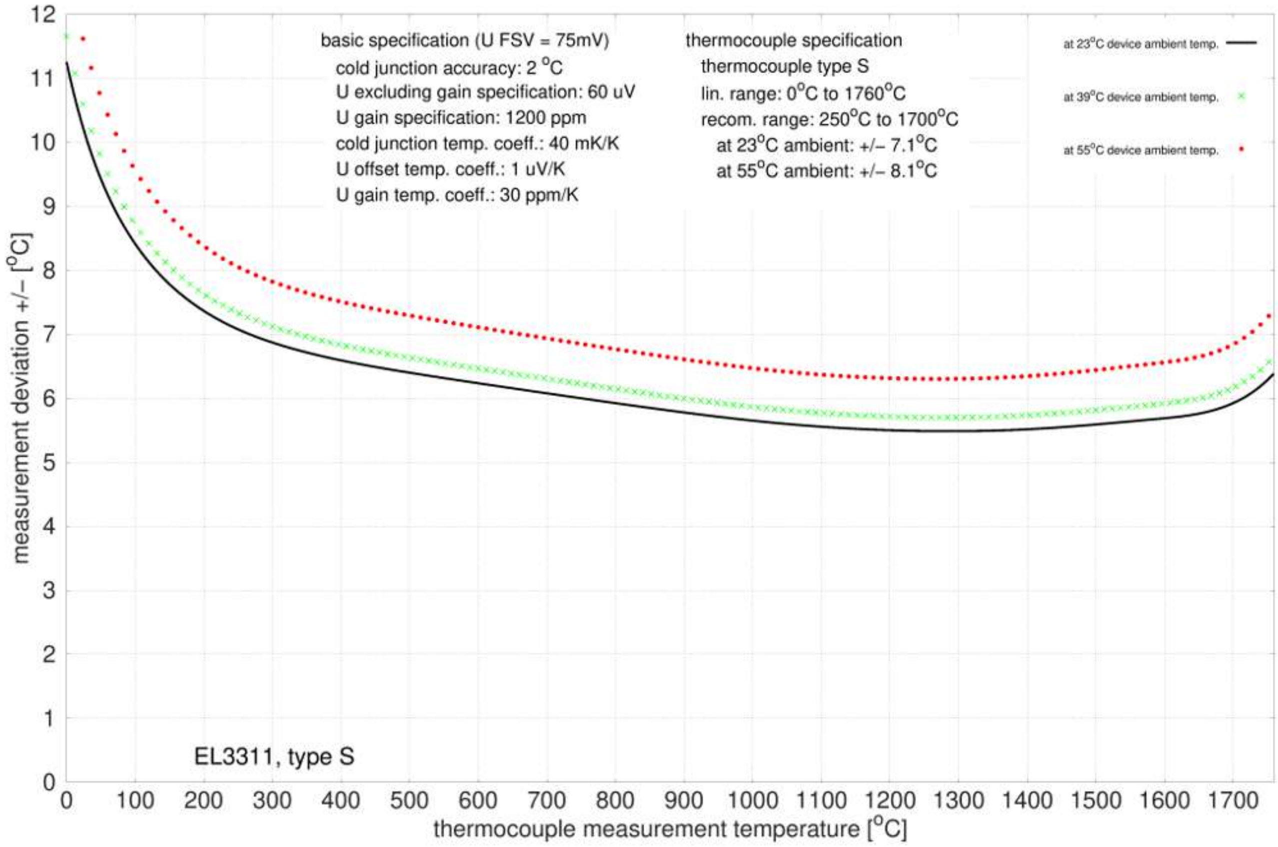
Measurement uncertainty for thermocouple type R:



## Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1760 °C ≈ 17.947 mV |
| Measuring range, end value (full scale value) | | +1760 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type S: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 7.1 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 8.1 K ≈ ± 0.46 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

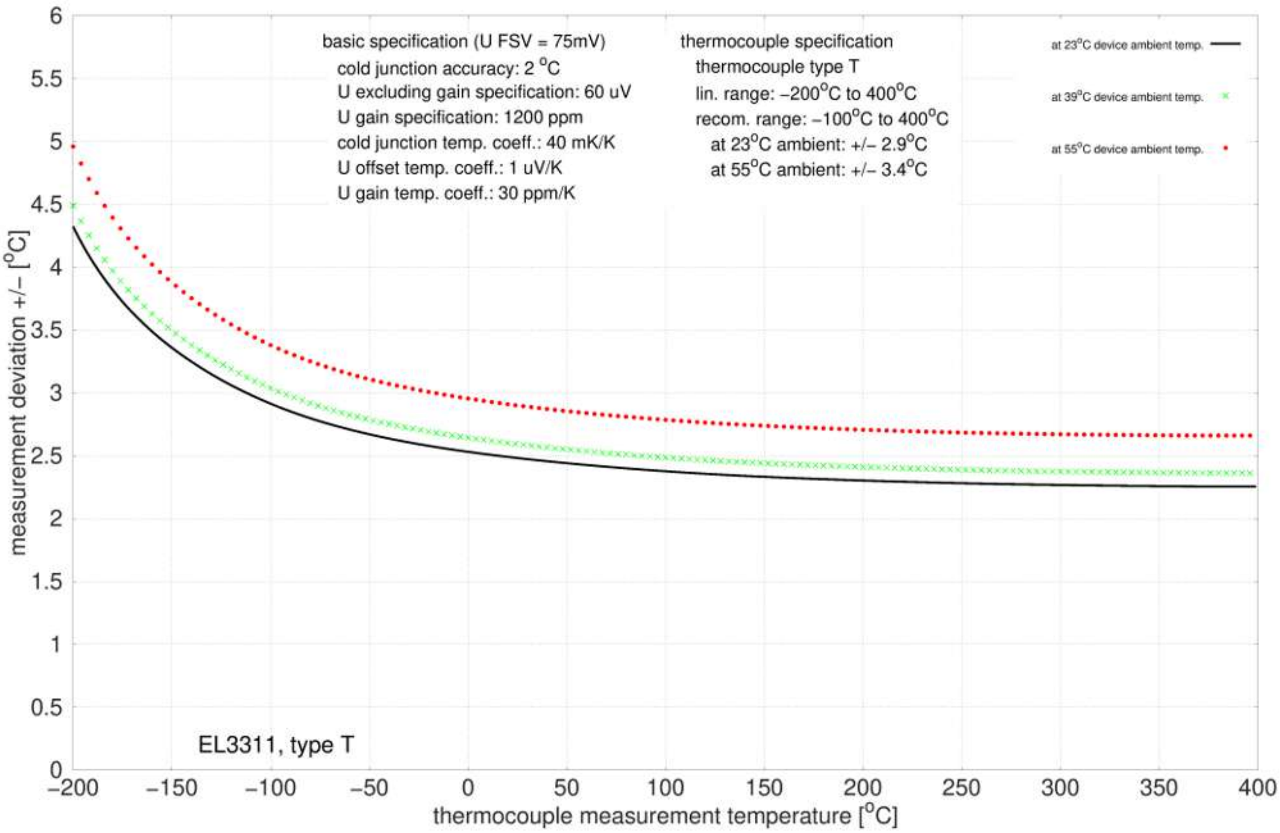
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.603 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.9 K ≈ ± 0.73 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.4 K ≈ ± 0.85 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

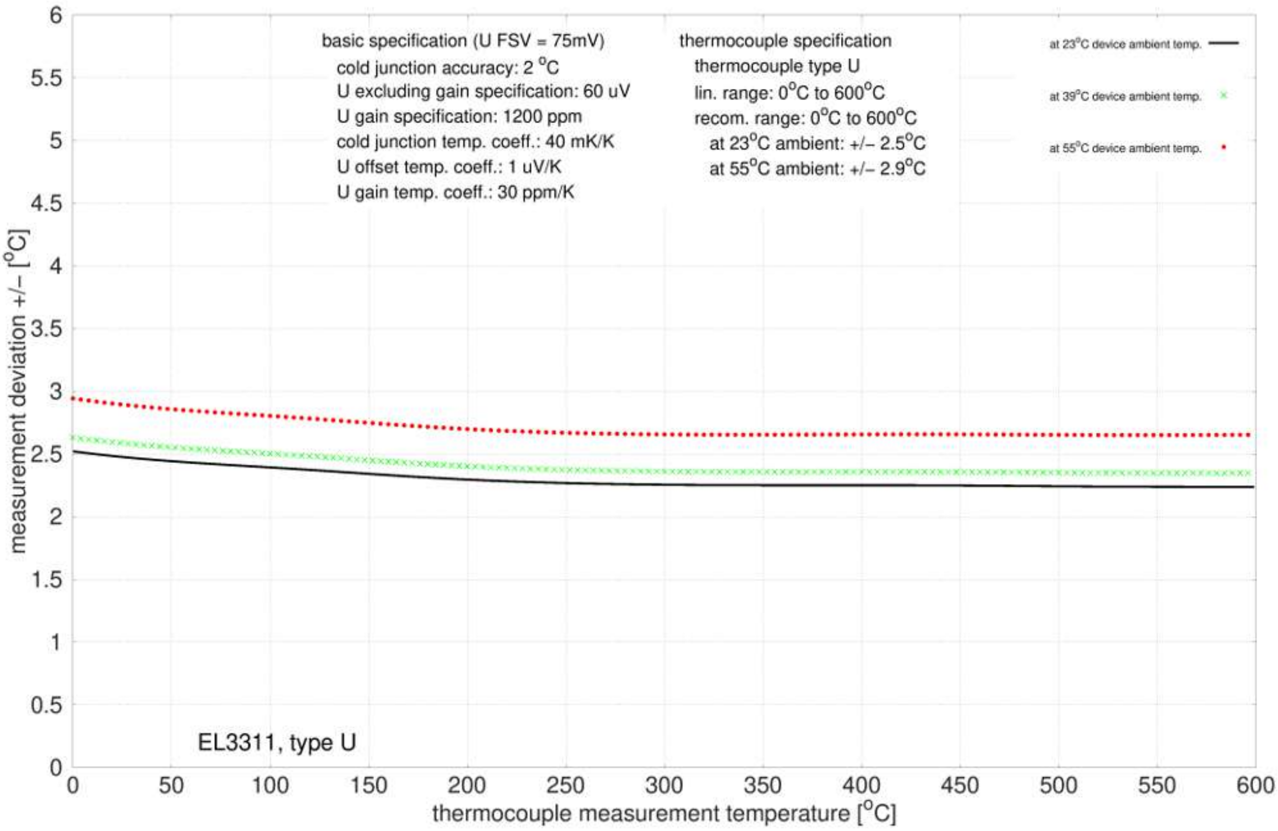
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type U: approx. 0.02 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.42 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



### 2.1.3 Connection

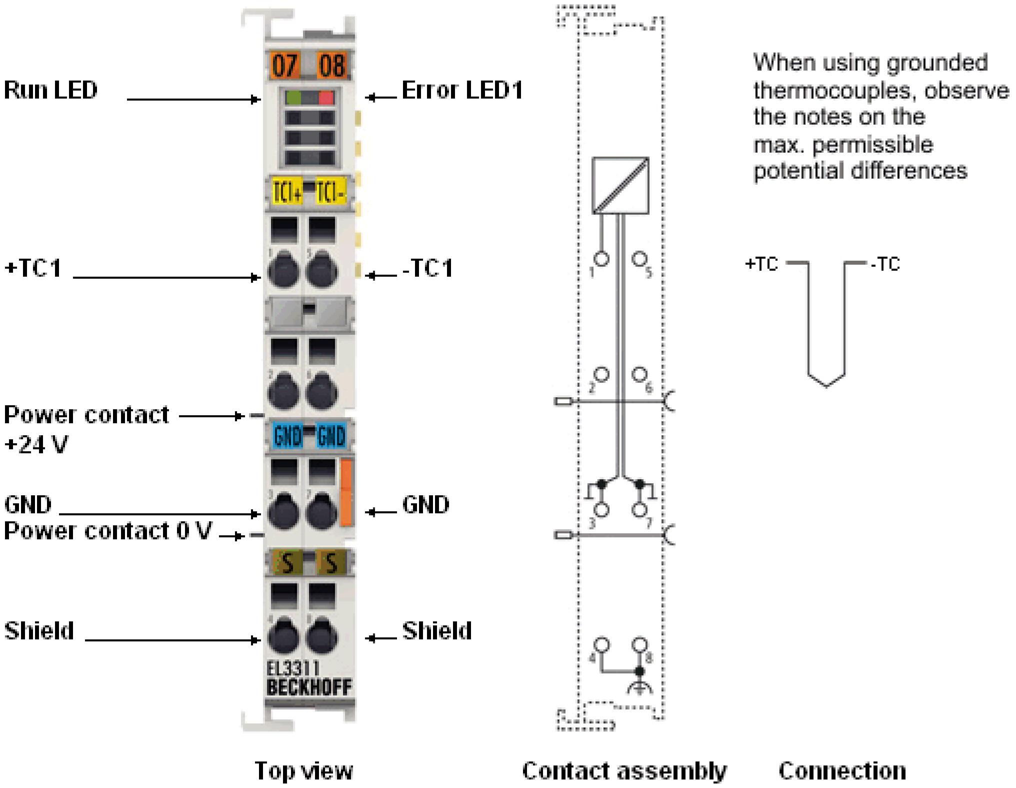



Fig. 5: EL3311

**EL3311 - Connection**

| Terminal point | No. | Comment |
|---|---|---|
| Input +TC1 | 1 | Input +TC1 |
| n. c. | 2 | not connected |
| GND | 3 | Ground (internally connected with terminal point 7) |
| Shield | 4 | Shield (internally connected to terminal point 8) |
| Input -TC1 | 5 | Input -TC1 |
| n. c. | 6 | not connected |
| GND | 7 | Ground (internally connected with terminal point 3) |
| Shield | 8 | Shield (internally connected to terminal point 4) |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.1.4 Display, diagnostics

**EL3311 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve | |

# 2.2 EL3312

## 2.2.1 Introduction

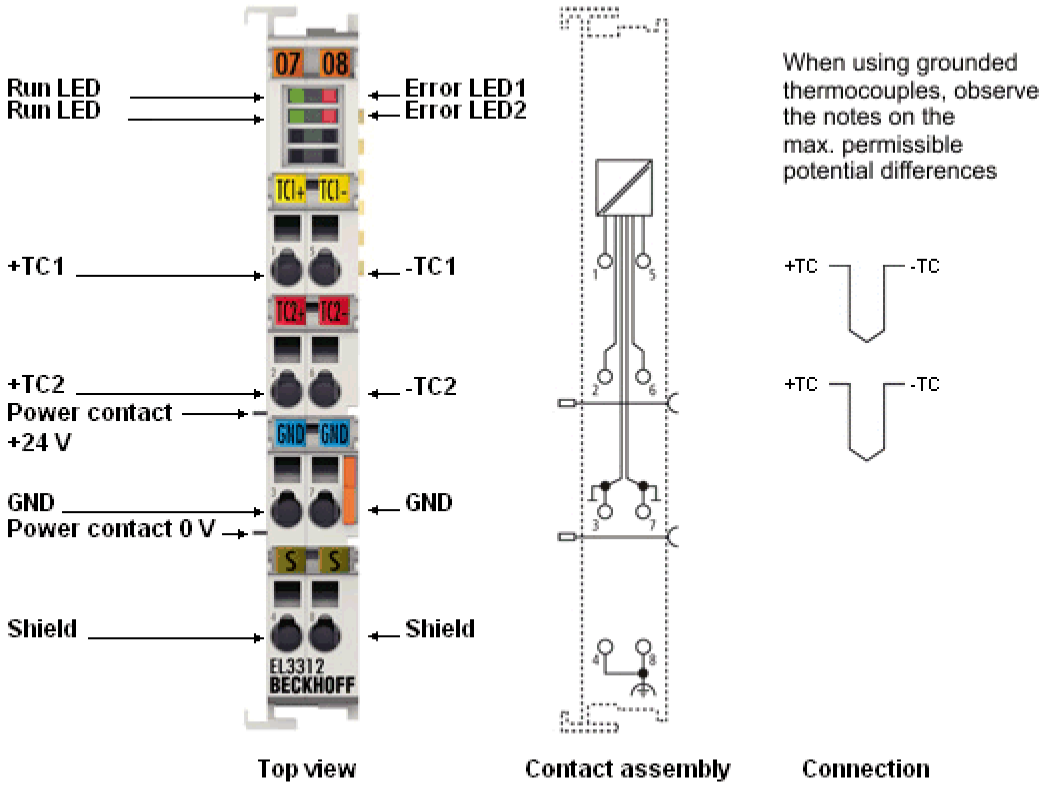



Fig. 6: EL3312

**2 channel analog thermocouple input terminals with open-circuit recognition**

The EL3312 analog input terminals allow the direct connection of thermocouples. The EtherCAT Terminals circuit can operate thermocouple sensors using the 2-wire technique. Linearization over the full temperature range is realized with the aid of a microprocessor. The temperature range can be selected freely. The error LEDs indicate a broken wire. Compensation for the cold junction is made through an internal temperature measurement at the terminals. The EL33xx can also be used for mV measurement.

**Quick links**

- EtherCAT basics
- Technology EL33xx [▸ 188]
- CoE object description and parameterization [▸ 337]
- Process data and operation modes [▸ 313]

## 2.2.2 Technical data

### 2.2.2.1 General technical data

| Analog inputs | EL3312 |
|---|---|
| Number of inputs | 1 |
| Thermocouple sensor types, measured variables | Types B, C, E, J, K, L, N, R, S, T, U (default setting type K), mV measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 16-bit |
| Conversion time | approx. 2.5 s to 20 ms,<br>depending on the configuration and filter setting; default: approx. 250 ms |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes |
| Supports NoCoEStorage [▶ 218] function | yes, from firmware 01 |

| Voltage measurement | EL3312 |
|---|---|
| Measuring range, technically usable | approx. ± 78 mV |
| Measuring ranges (nominal) and resolution | ± 30 mV (1 µV per digit, thus max. 32.768 mV can be displayed)<br>± 60 mV (2 µV per digit, thus max. 65.536 mV can be displayed)<br>± 75 mV (4 µV per digit, thus max. 131 mV can be displayed, observe technical measuring range)<br>The measuring ranges 30 and 60 mV are executed in software to increase the resolution and always use the same electrical measuring range of ± 75 mV. |
| Measurement uncertainty | See Measurement ±30 mV...±75 mV [▶ 38] |

| Temperature measurement | EL3312 |
|---|---|
| Electrical measuring range used | ± 75 mV |
| Measuring ranges | Type B: +200...+1800 °C<br>Type C: 0...+2320 °C<br>Type E: -100...+1000°C<br>Type J: -100...+1200 °C<br>Type K: -200…+1370 °C (preset)<br>Type L: 0...+900 °C<br>Type N: -100…+1300 °C<br>Type R: -50...+1767 °C<br>Type S: -50...+1760 °C<br>Type T: -200…+400 °C<br>Type U: 0...+600 °C |
| Resolution | Temperature display 0.1/0.01 °C per digit, preset 0.1 °C<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Measurement uncertainty | See Thermocouples measurement [▶ 39] |

| Supply and potentials | | EL3312 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br><br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL331 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 16 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3312 |
|---|---|
| Permissible ambient temperature range during operation | --25 °C...+60 °C (extended temperature range), from firmware 06 |
| Permissible ambient temperature range during storage | -40°C … +85°C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3312 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▸ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | variable |

| Standards and approvals | EL3312 |
|---|---|
| Protection class | IP20 |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also Installation instructions for enhanced mechanical load capacity [▸ 226] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▸ 205]<br>cULus [▸ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

## 2.2.2.2 Measurement ±30 mV...±75 mV

### Specification ±30 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±30 mV |
|---|---|---|
| Measuring range, nominal | | -30…+30 mV |
| Measuring range, end value (full scale value) | | 30 mV |
| PDO resolution | | 1 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.24%$_{FSV}$ typ. ≈ < ± 0.070 mV |
| | @ 55 °C ambient temperature[1] | < ±026%$_{FSV}$ typ. ≈ < ± 0.077 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±60 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±60 mV |
|---|---|---|
| Measuring range, nominal | | -60…+60 mV |
| Measuring range, end value (full scale value) | | 60 mV |
| PDO resolution | | 2 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.16%$_{FSV}$ typ. ≈ < ± 0.094 mV |
| | @ 55 °C ambient temperature[1] | < ±0.17%$_{FSV}$ typ. ≈ < ± 0.10 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±75 mV

| Measurement mode | | ±75 mV |
|---|---|---|
| Measuring range, nominal | | -75…+75 mV |
| Measuring range, end value (full scale value) | | 75 mV |
| PDO resolution | | 4 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.14%$_{FSV}$ typ. ≈ < ± 0.11 mV |
| | @ 55 °C ambient temperature[1] | < ±0.15%$_{FSV}$ typ. ≈ < ± 0.12 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.2.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

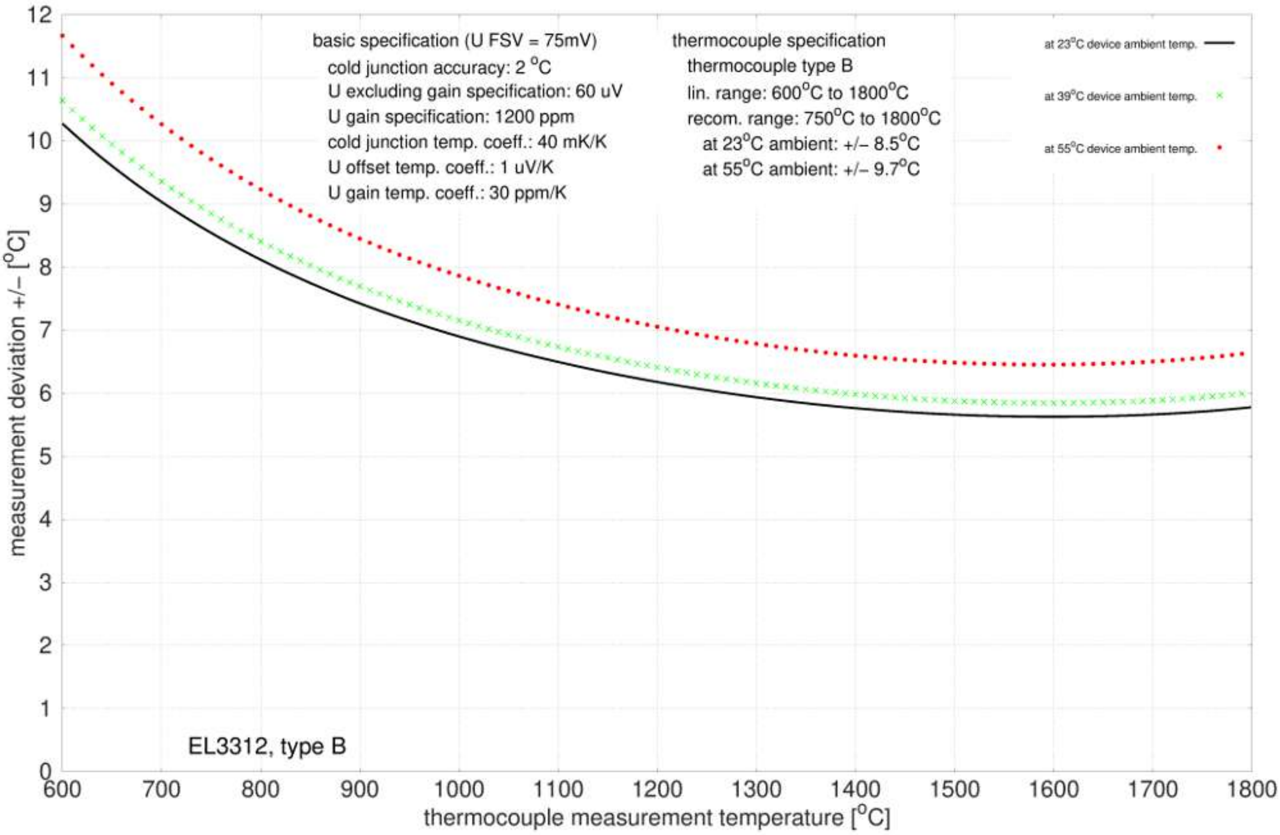
In the EL3312 each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±2.0 °C |
| Temperature coefficient | Tk | < 40 mK/K |

## Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | +600 °C ≈ 1.792 mV … +1800 °C ≈ 13.591 mV |
| Measuring range, end value (full scale value) | | +1800 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type B: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 8.5 K ≈ ± 0.47 $\%_{FSV}$ |
| | *@ 55 °C ambient temperature* | ± 9.7 K ≈ ± 0.54 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

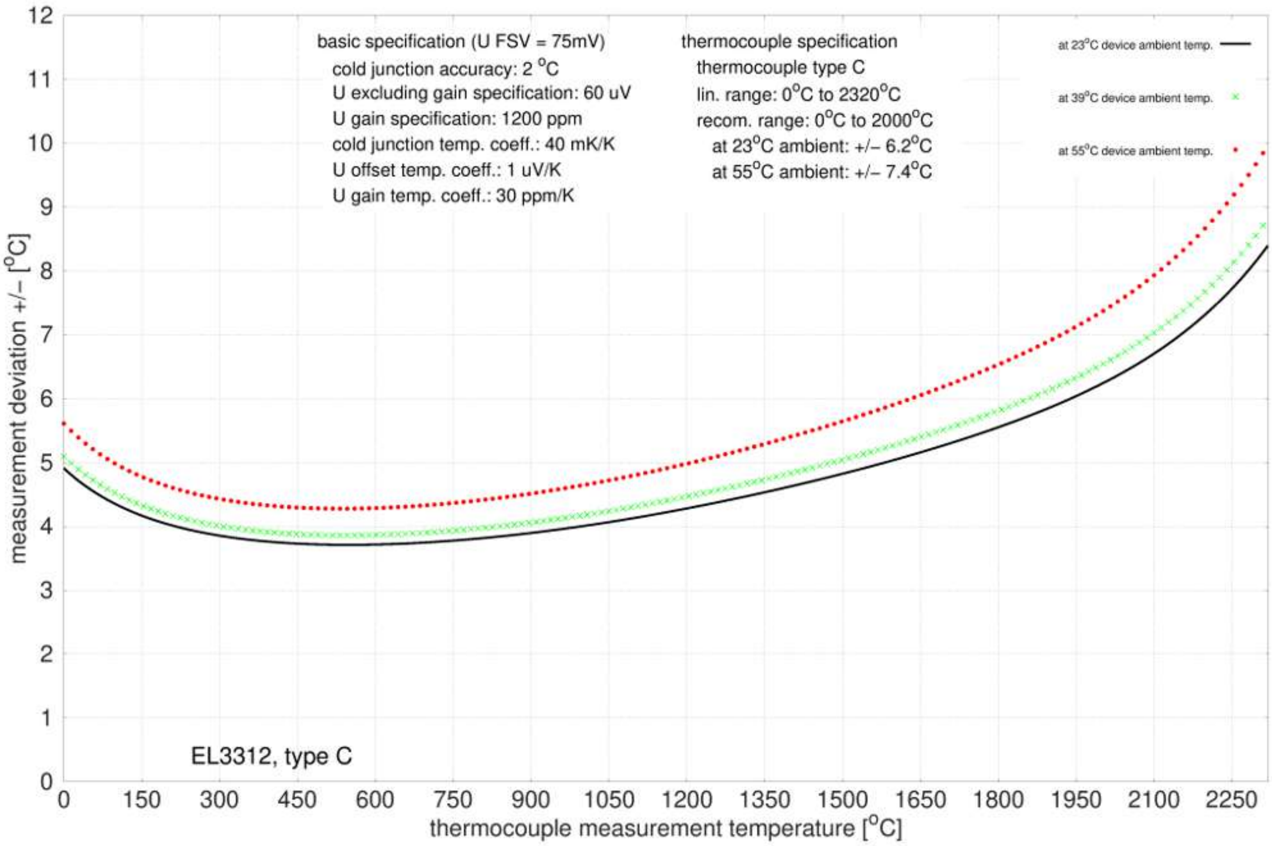
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type C: approx. 0.07 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.2 K ≈ ± 0.27 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.4 K ≈ ± 0.32 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

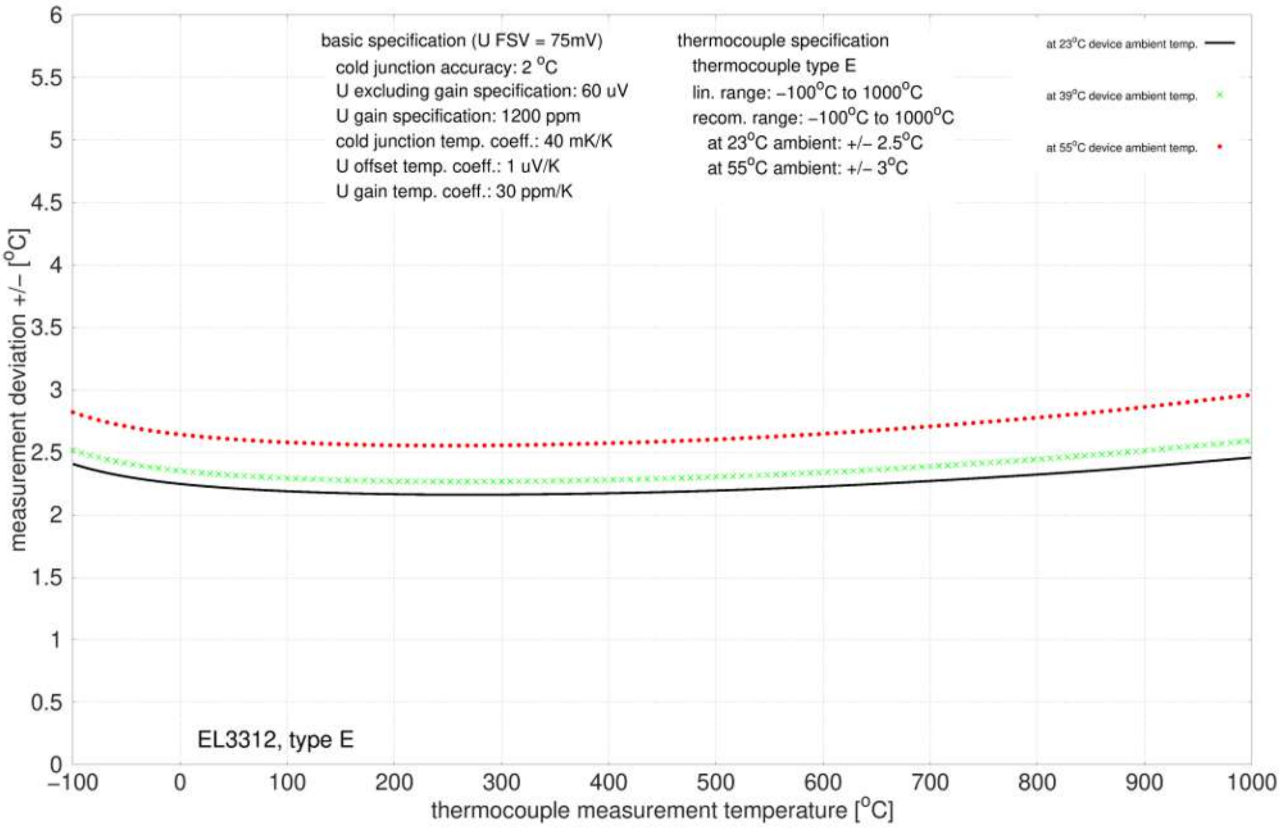
Measurement uncertainty for thermocouple type C:



## Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -5.237 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type E: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

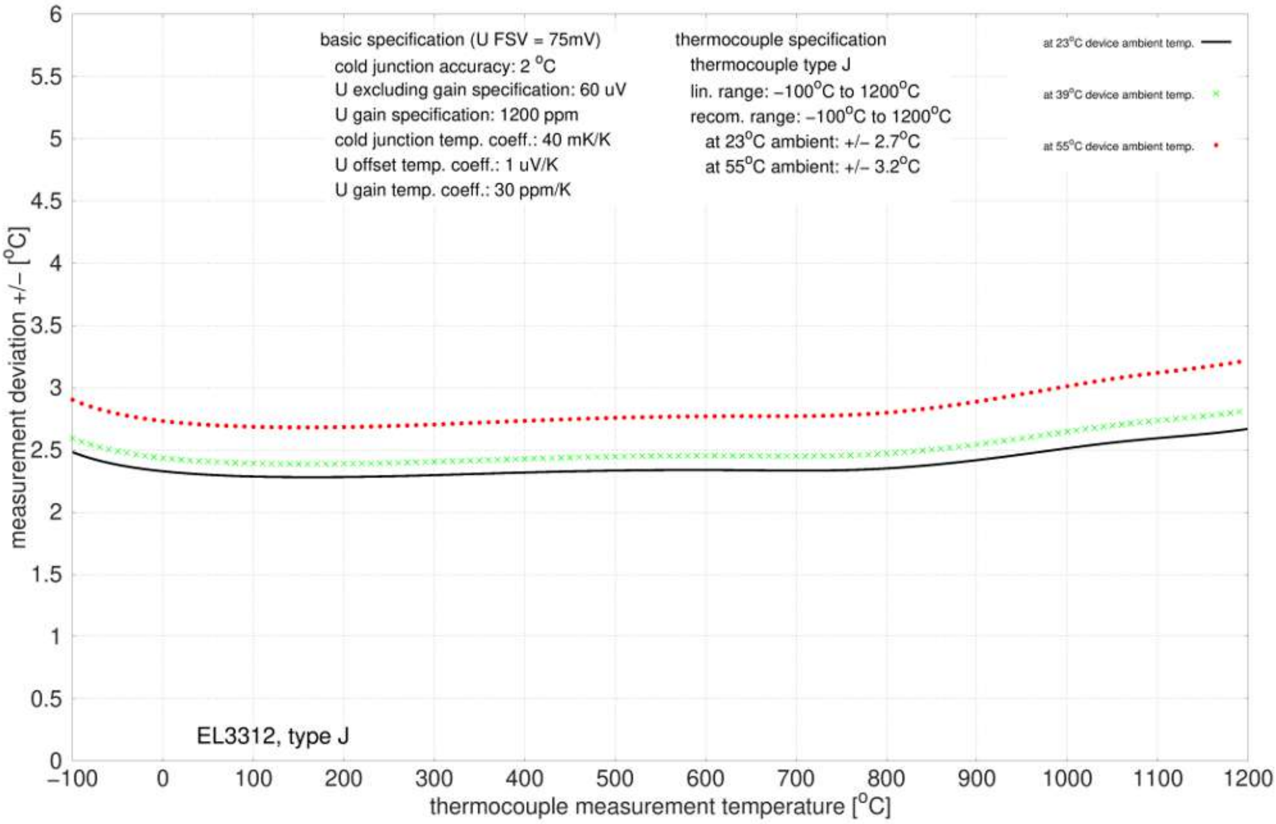
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -4.632 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type J: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.7 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.2 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

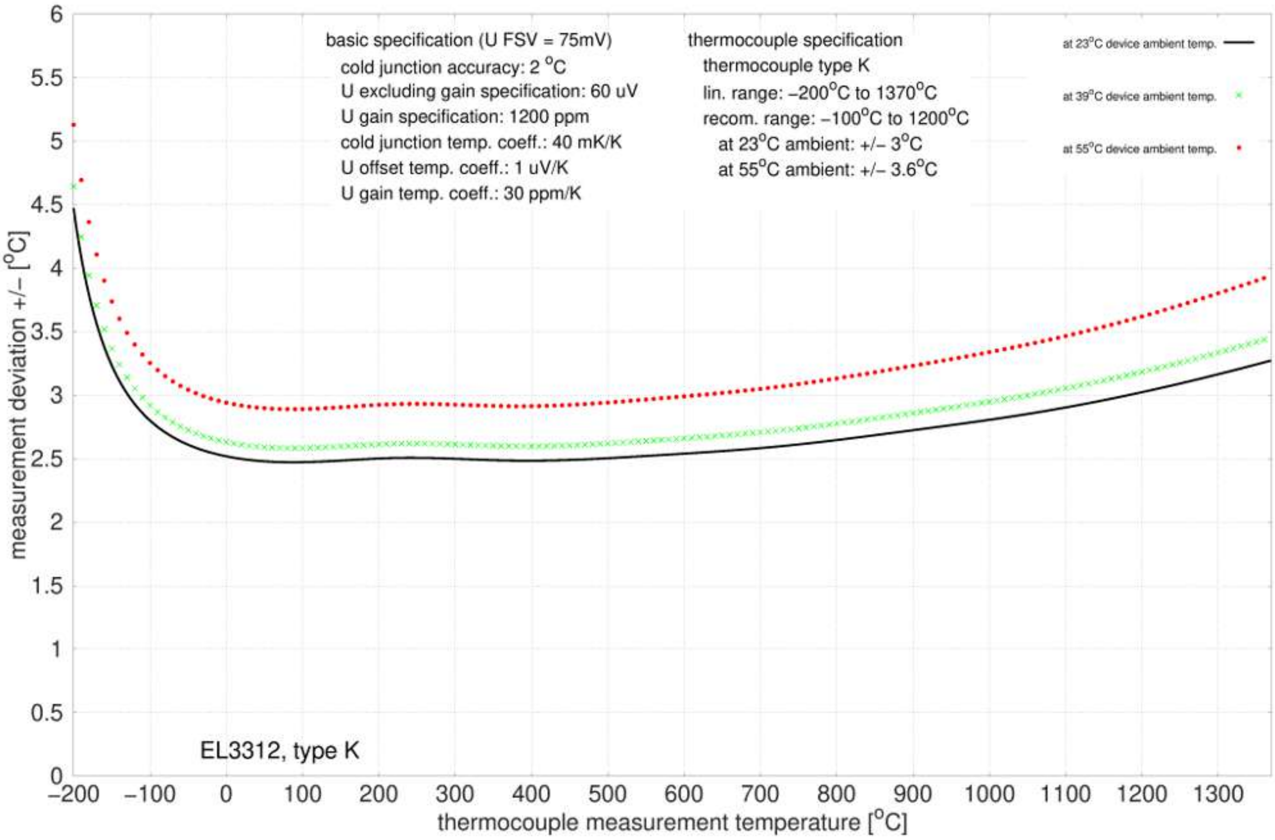
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.891 mV … +1370 °C ≈ 54.818 mV |
| Measuring range, end value (full scale value) | | +1370 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.22 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.26 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

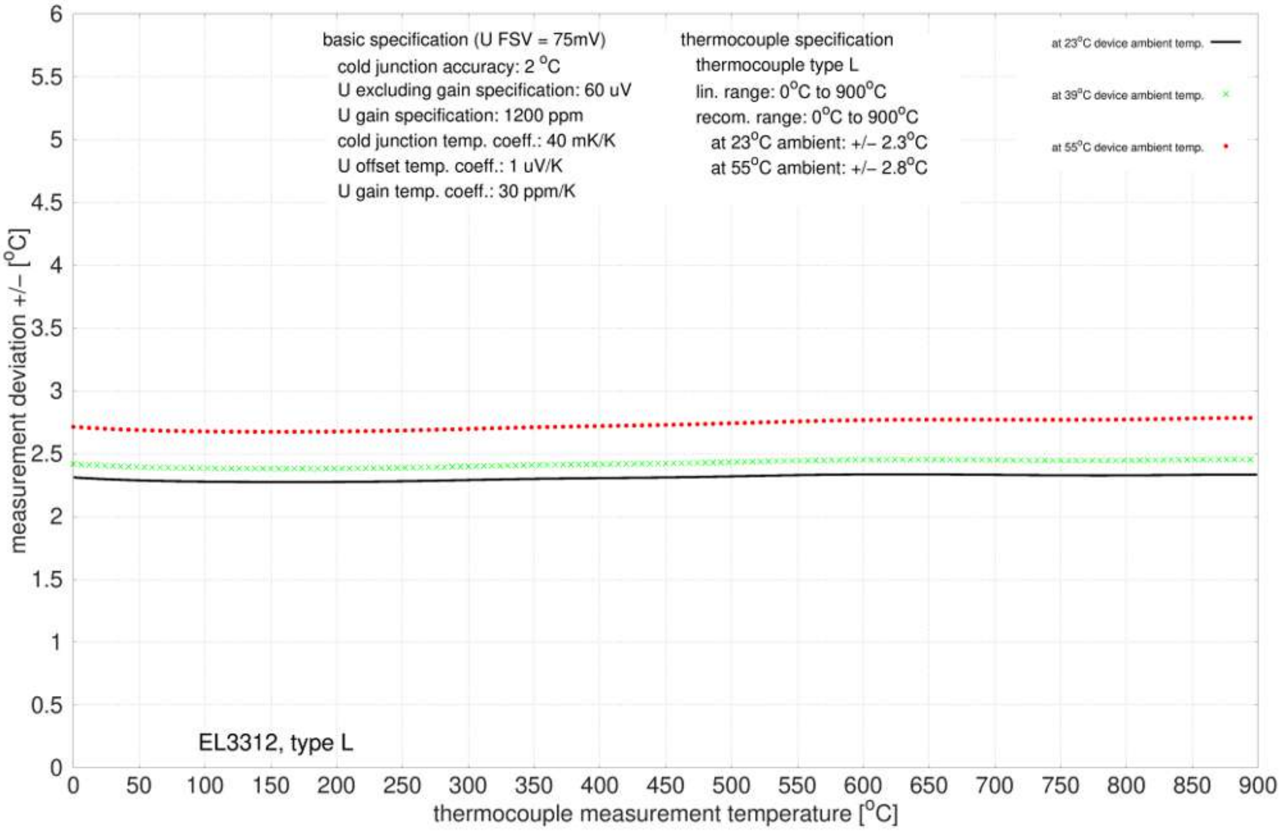
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type L: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.26 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.8 K ≈ ± 0.31 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

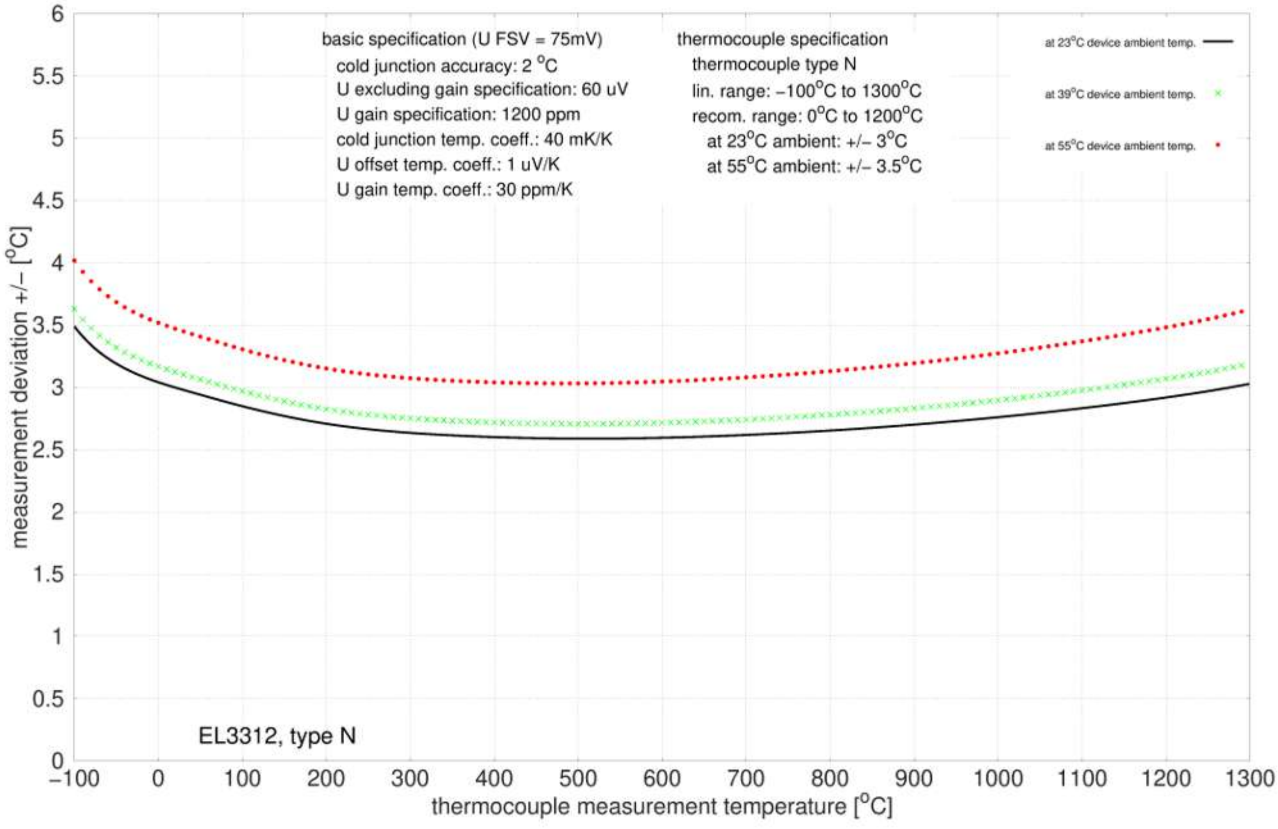
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -2.406 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type N: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$ = 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

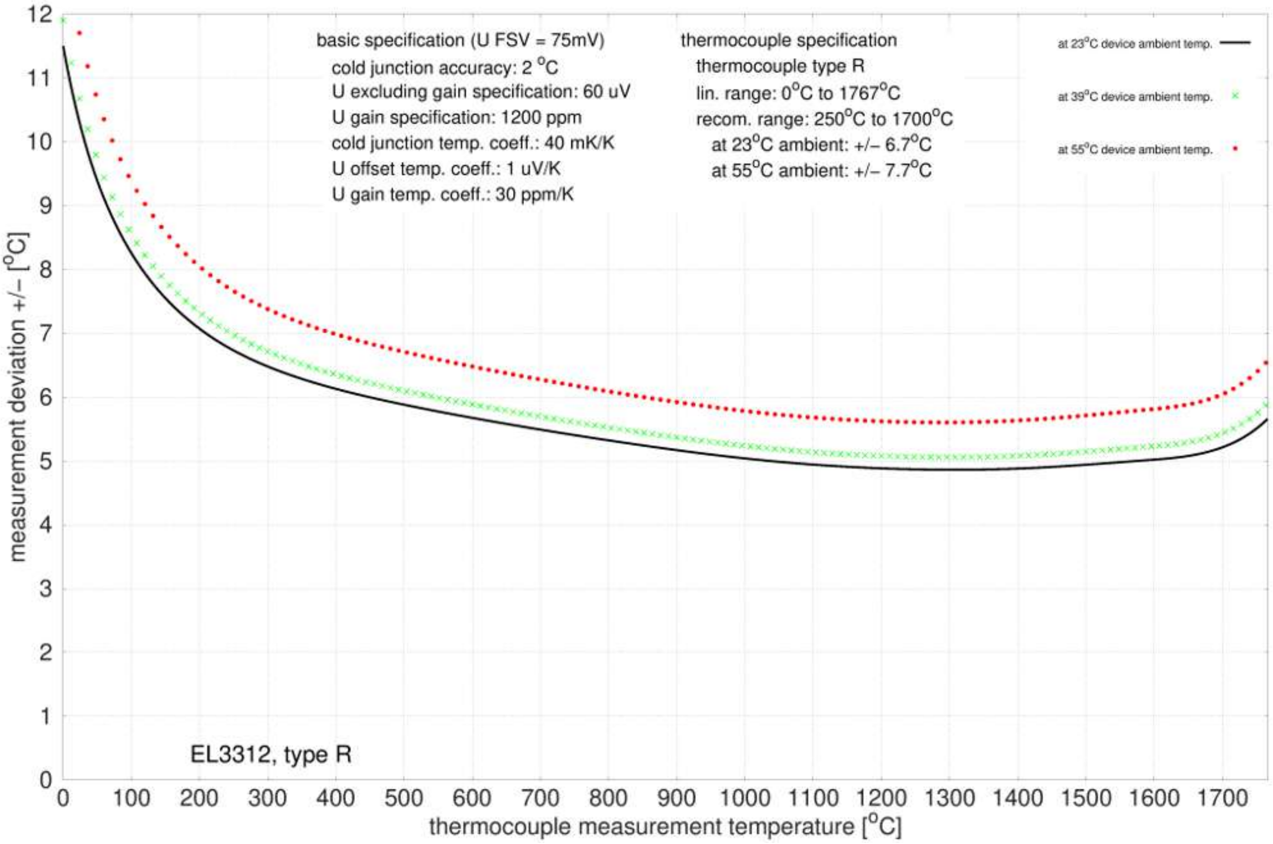
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1767 °C ≈ 21.089 mV |
| Measuring range, end value (full scale value) | | +1767 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type R: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.7 K ≈ ± 0.38 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.7 K ≈ ± 0.44 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

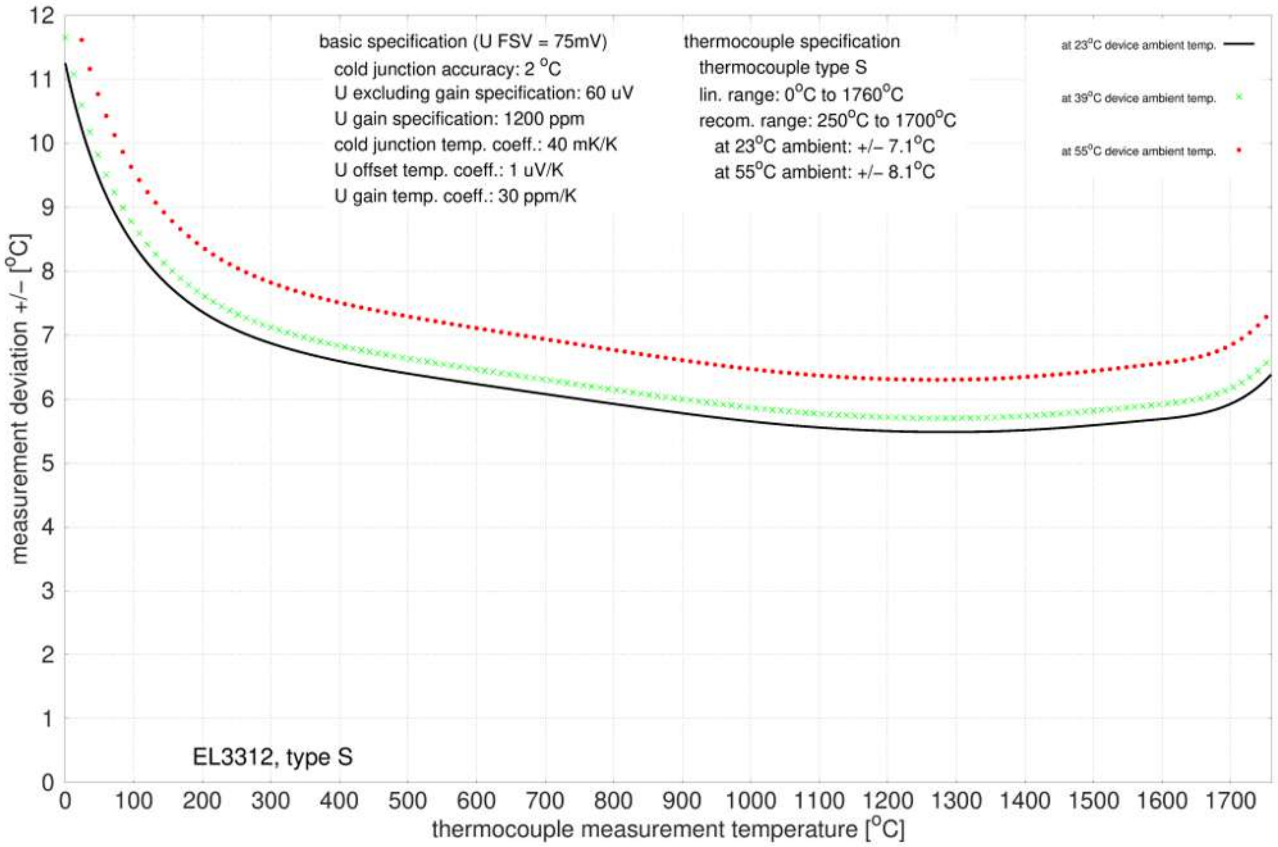
Measurement uncertainty for thermocouple type R:



### Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1760 °C ≈ 17.947 mV |
| Measuring range, end value (full scale value) | | +1760 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type S: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 7.1 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 8.1 K ≈ ± 0.46 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

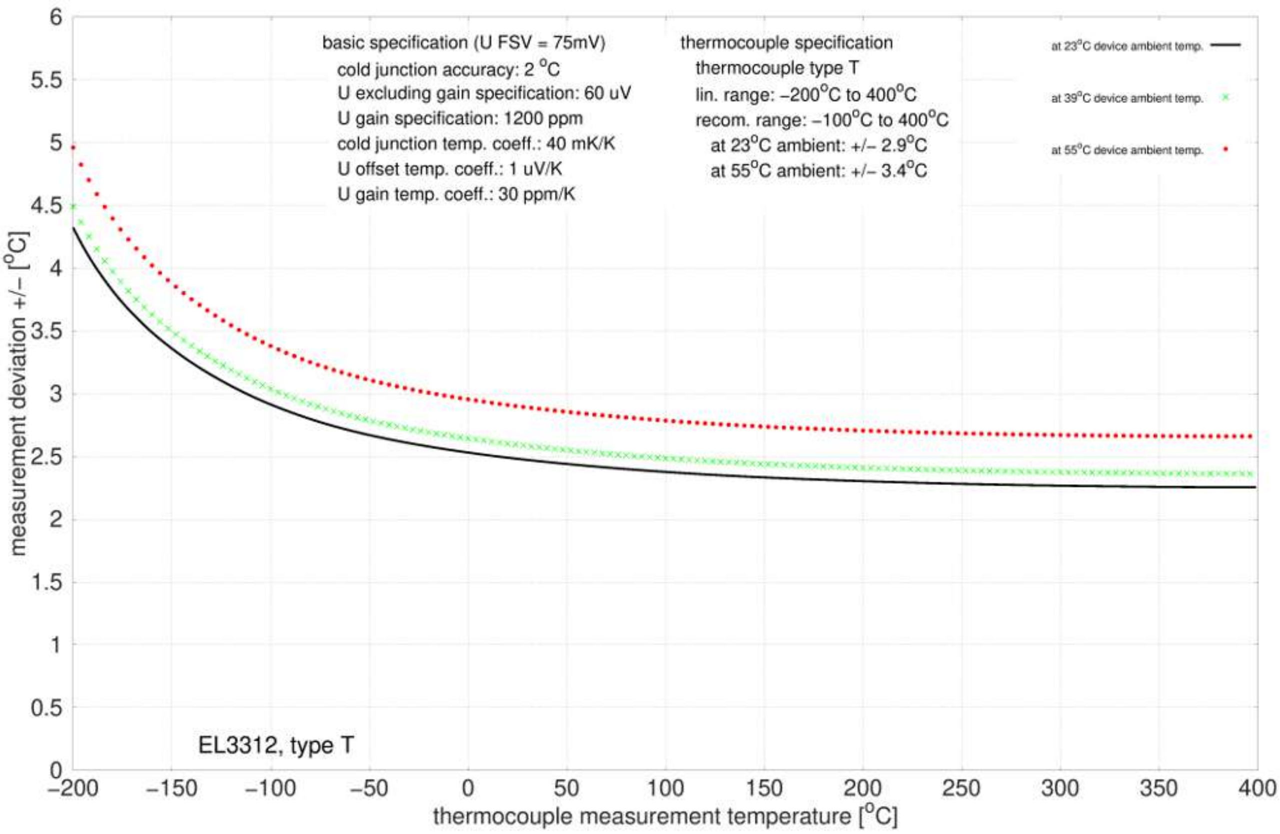
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.603 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.9 K ≈ ± 0.73 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.4 K ≈ ± 0.85 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

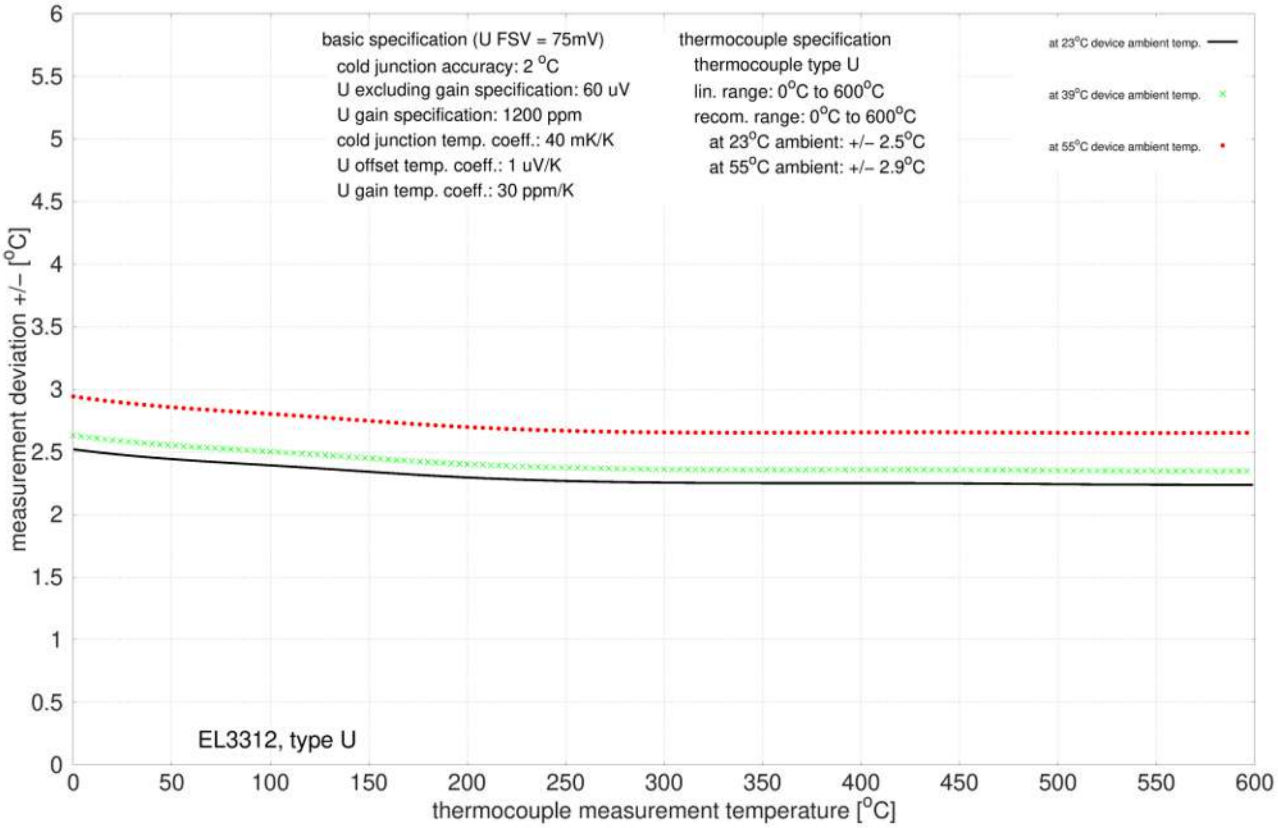
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type U: approx. 0.02 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.42 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.2.3 Connection

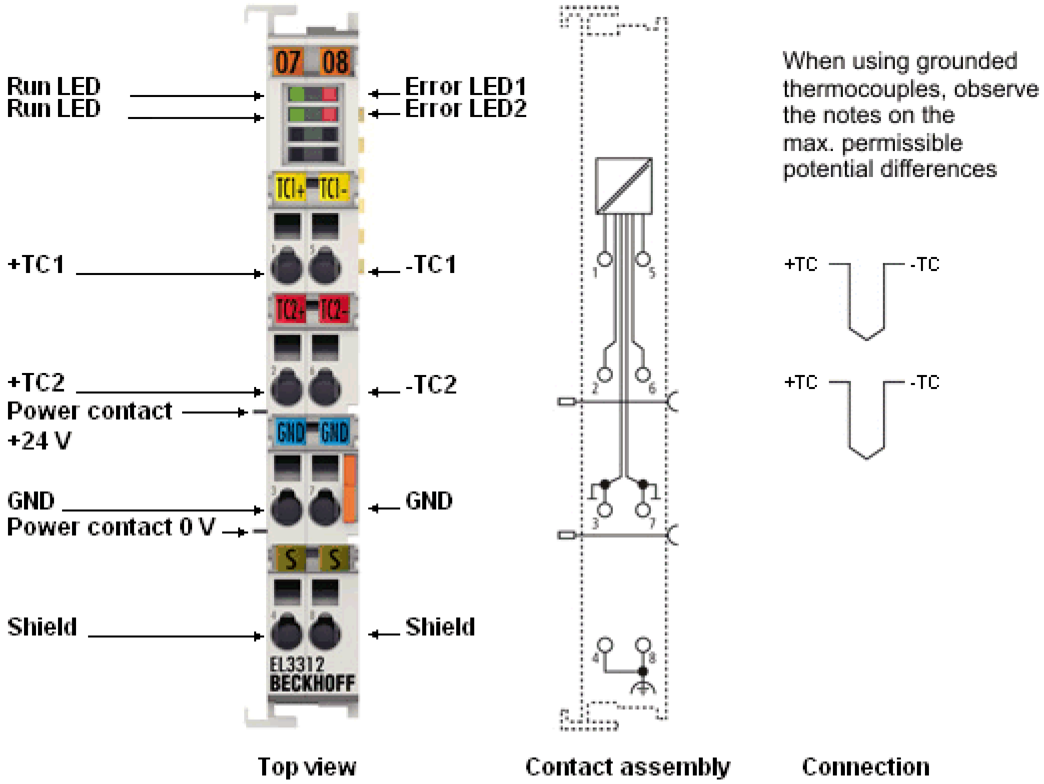



Fig. 7: EL3312

**EL3312 - Connection**

| Terminal point | No. | Comment |
|---|---|---|
| Input +TC1 | 1 | Input +TC1 |
| Input  +TC2 | 2 | Input +TC2 |
| GND | 3 | Ground (internally connected with terminal point 7) |
| Shield | 4 | Shield (internally connected to terminal point 8) |
| Input -TC1 | 5 | Input -TC1 |
| Input  -TC2 | 6 | Input -TC2 |
| GND | 7 | Ground (internally connected with terminal point 3) |
| Shield | 8 | Shield (internally connected to terminal point 4) |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.2.4 Display, diagnostics

**EL3312 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1, ERROR2 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve | |

# 2.3 EL3314

## 2.3.1 Introduction

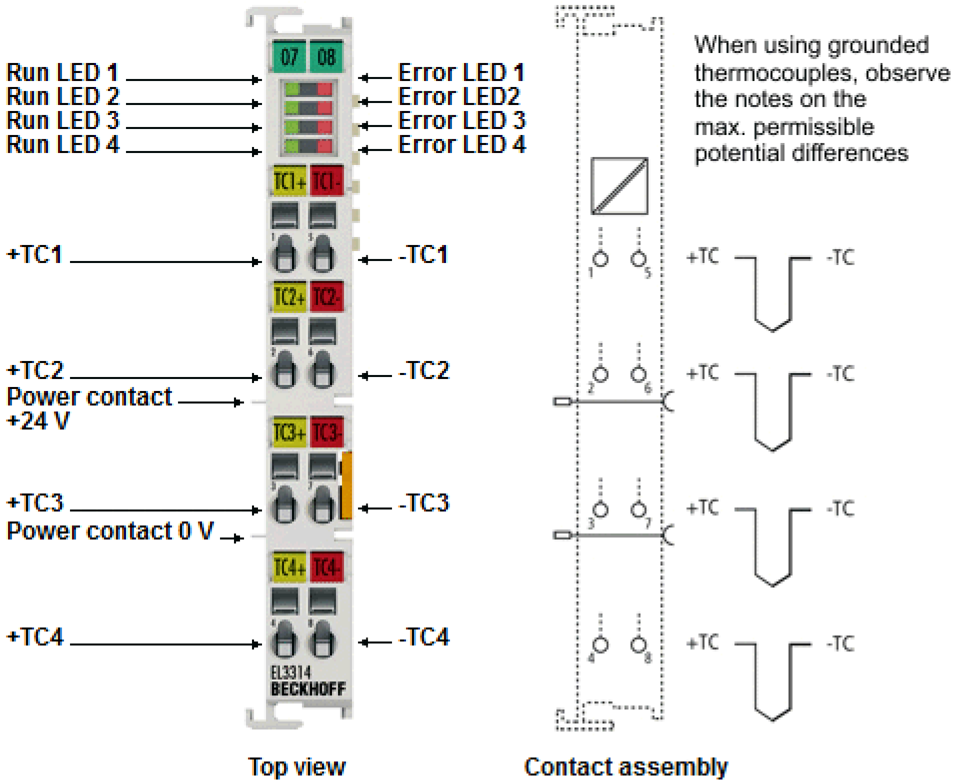



Fig. 8: EL3314

**4-channel analog thermocouple input terminals with open-circuit recognition**

The EL3314 analog input terminals allow the direct connection of thermocouples. The EtherCAT Terminals circuit can operate thermocouple sensors using the 2-wire technique. Linearization over the full temperature range is realized with the aid of a microprocessor. The temperature range can be selected freely. The error LEDs indicate a broken wire. Cold junction compensation is made through an internal temperature measurement at the terminals. The EL33xx can also be used for mV measurement.

With the EL3314-0010, Beckhoff offers a high-precision variant [▶ 93] of the 4 channel thermocouple input terminal.

**Quick links**

- EtherCAT basics
- Technology EL33xx [▶ 188]
- CoE object description and parameterization [▶ 345]
- Process data and operation modes [▶ 313]

## 2.3.2 Technical data

### 2.3.2.1 General technical data

| Analog inputs | EL3314 |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Types B, C, E, J, K, L, N, R, S, T, U (default setting type K), mV measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 16-bit |
| Conversion time | approx. 2.5 s to 20 ms,<br>depending on the configuration and filter setting; default: approx. 250 ms |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▸ 218] function | yes, from firmware 01 |

| Voltage measurement | EL3314 |
|---|---|
| Measuring range, technically usable | approx. ± 78 mV |
| Measuring ranges (nominal) and resolution | ± 30 mV (1 µV per digit, thus max. 32.768 mV can be displayed)<br>± 60 mV (2 µV per digit, thus max. 65.536 mV can be displayed)<br>± 75 mV (4 µV per digit, thus max. 131 mV can be displayed, observe technical measuring range)<br>The measuring ranges 30 and 60 mV are executed in software to increase the resolution and always use the same electrical measuring range of ± 75 mV. |
| Measurement uncertainty | See Measurement ±30 mV...±75 mV [▸ 57] |

| Temperature measurement | EL3314 |
|---|---|
| Electrical measuring range used | ± 75 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -100...+1000°C<br>Type J: -100...+1200 °C<br>Type K: -270…+1370 °C (preset)<br>Type L: 0...+900 °C<br>Type N: -100…+1300 °C<br>Type R: -50...+1767 °C<br>Type S: -50...+1760 °C<br>Type T: -200…+400 °C<br>Type U: 0...+600 °C |
| Resolution | Temperature display 0.1/0.01 °C per digit, preset 0.1 °C<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 58] |

| Supply and potentials | | EL3314 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br><br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3314 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 16 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3314 |
|---|---|
| Permissible ambient temperature range during operation | --25 °C...+60 °C (extended temperature range), from firmware 06 |
| Permissible ambient temperature range during storage | -40°C … +85°C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | variable |

| Standards and approvals | EL3314 |
|---|---|
| Protection class | IP20 |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also Installation instructions for enhanced mechanical load capacity [▶ 226] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▶ 205]<br>cULus [▶ 203]<br>IECEx [▶ 207]<br>cFMus [▶ 208] |

## Ex markings

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc<br>II 3 D Ex tc IIIC T135 °C Dc |
| IECEx | Ex nA IIC T4 Gc<br>Ex tc IIIC T135 °C Dc |
| cFMus | Class I, Division 2, Groups A, B, C, D<br>Class I, Zone 2, AEx/Ex ec IIC T4 Gc |

| **Extended features** | **EL3314** |
|---|---|
| *Pluggable* connection level | - |
| Electrical isolation | EL3314-0002 |
| TwinSAFE SC | EL3314-0090 |
| Calibration certificate | EL3314-0030 |

### 2.3.2.2 Measurement ±30 mV...±75 mV

**Specification ±30 mV**

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±30 mV |
|---|---|---|
| Measuring range, nominal | | -30…+30 mV |
| Measuring range, end value (full scale value) | | 30 mV |
| PDO resolution | | 1 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.24%$_{FSV}$ typ. ≈ < ± 0.070 mV |
| | @ 55 °C ambient temperature | < ±026%$_{FSV}$ typ. ≈ < ± 0.077 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

**Specification ±60 mV**

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±60 mV |
|---|---|---|
| Measuring range, nominal | | -60…+60 mV |
| Measuring range, end value (full scale value) | | 60 mV |
| PDO resolution | | 2 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.16%$_{FSV}$ typ. ≈ < ± 0.094 mV |
| | @ 55 °C ambient temperature | < ±0.17%$_{FSV}$ typ. ≈ < ± 0.10 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

**Specification ±75 mV**

| Measurement mode | | ±75 mV |
|---|---|---|
| Measuring range, nominal | | -75…+75 mV |
| Measuring range, end value (full scale value) | | 75 mV |
| PDO resolution | | 4 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.14%$_{FSV}$ typ. ≈ < ± 0.11 mV |
| | @ 55 °C ambient temperature | < ±0.15%$_{FSV}$ typ. ≈ < ± 0.12 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.3.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

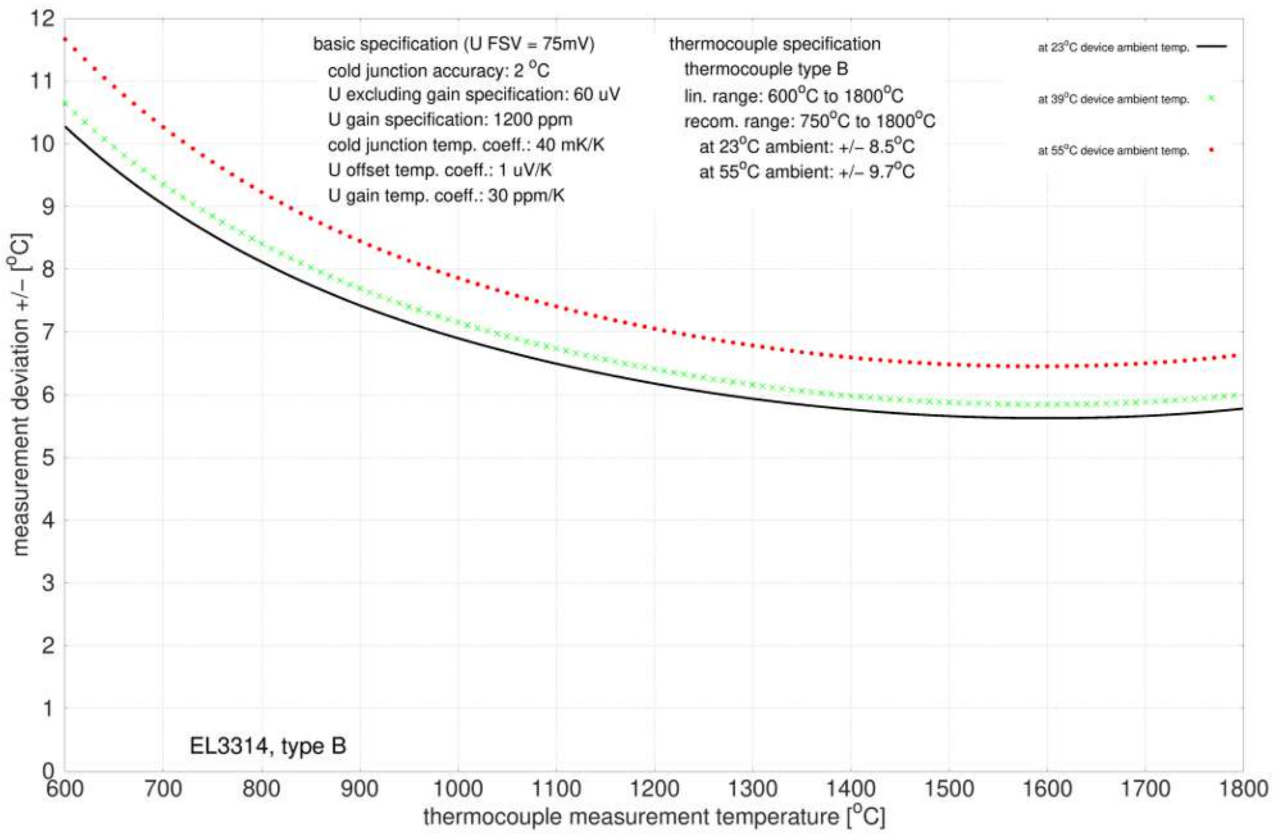
In the EL3314 and EL3314-0090, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±2.0 °C |
| Temperature coefficient | Tk | < 40 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | +600 °C ≈ 1.792 mV … +1800 °C ≈ 13.591 mV |
| Measuring range, end value (full scale value) | | +1800 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type B: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 8.5 K ≈ ± 0.47 $\%_{FSV}$ |
| | *@ 55 °C ambient temperature* | ± 9.7 K ≈ ± 0.54 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

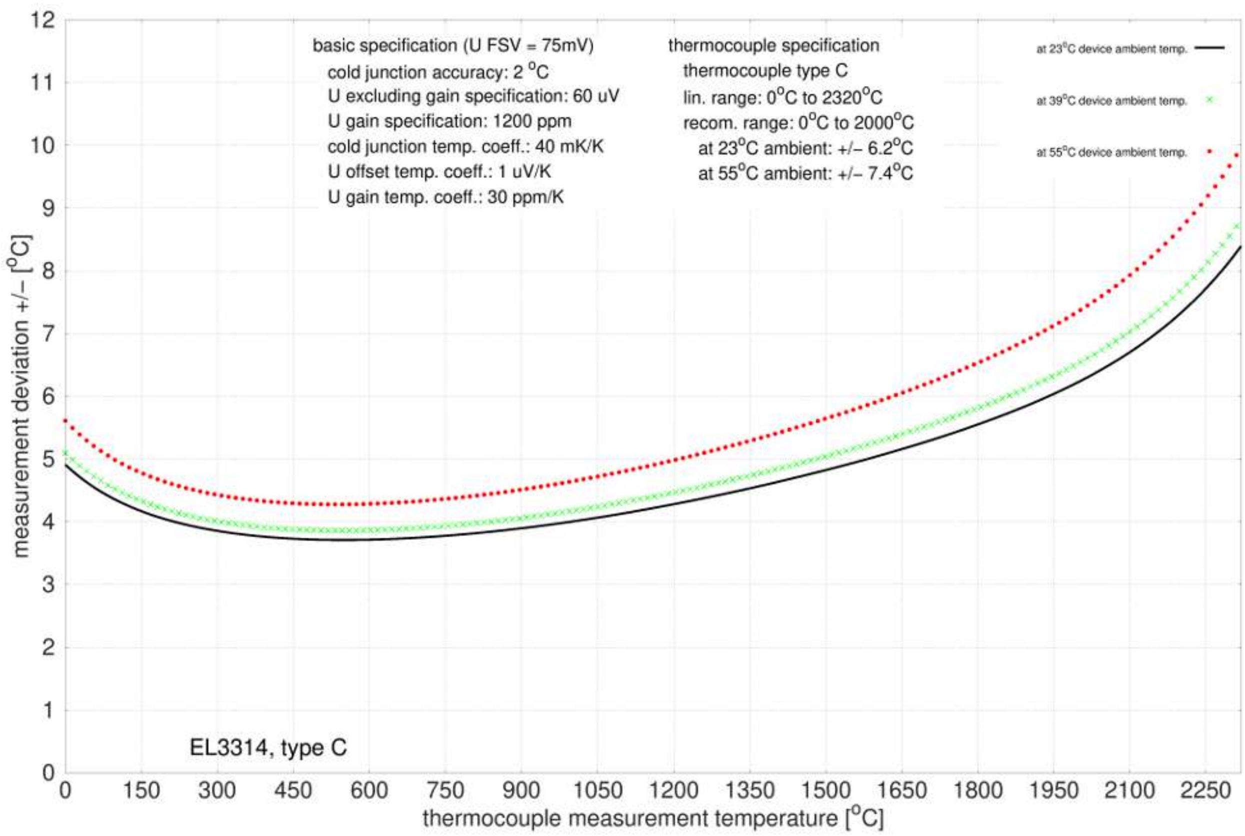
Measurement uncertainty for thermocouple type B:



## Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type C: approx. 0.07 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.2 K ≈ ± 0.27 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.4 K ≈ ± 0.32 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

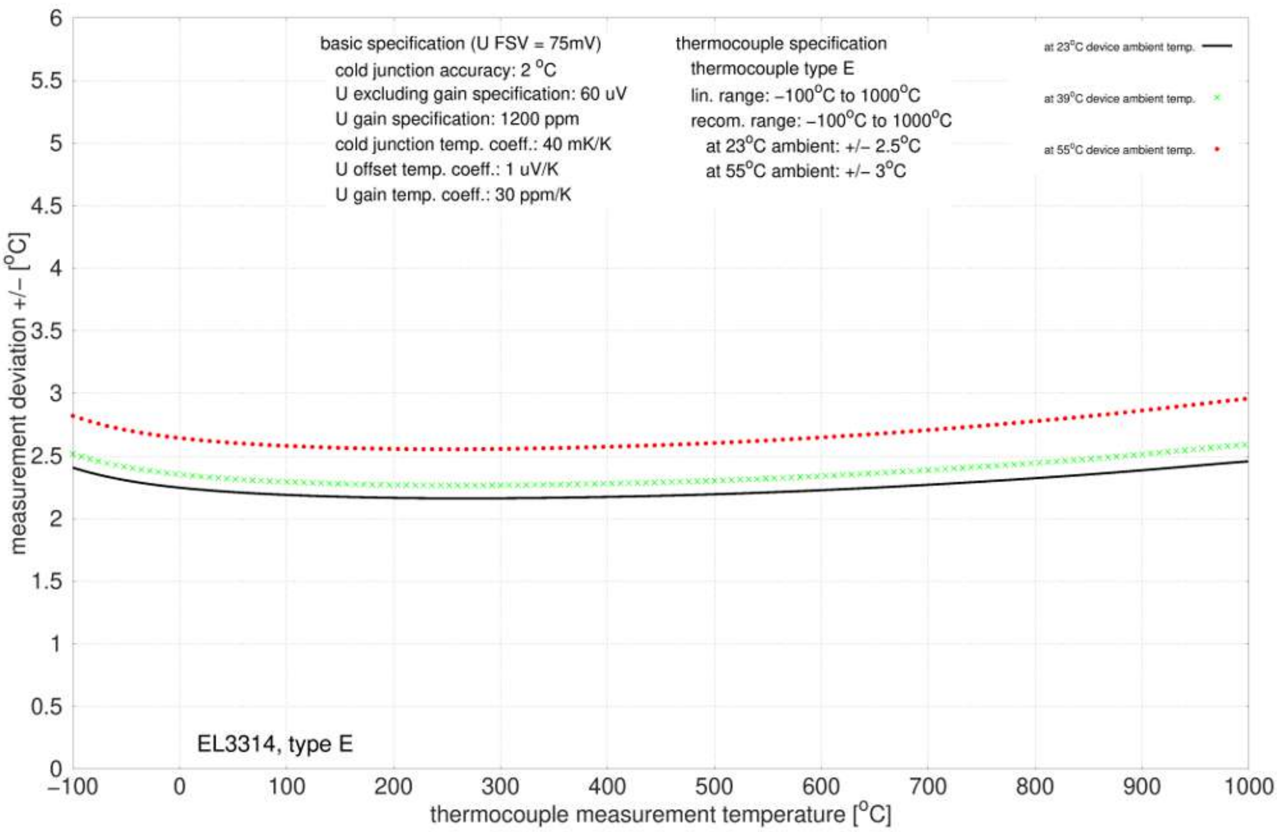
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -5.237 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type E: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

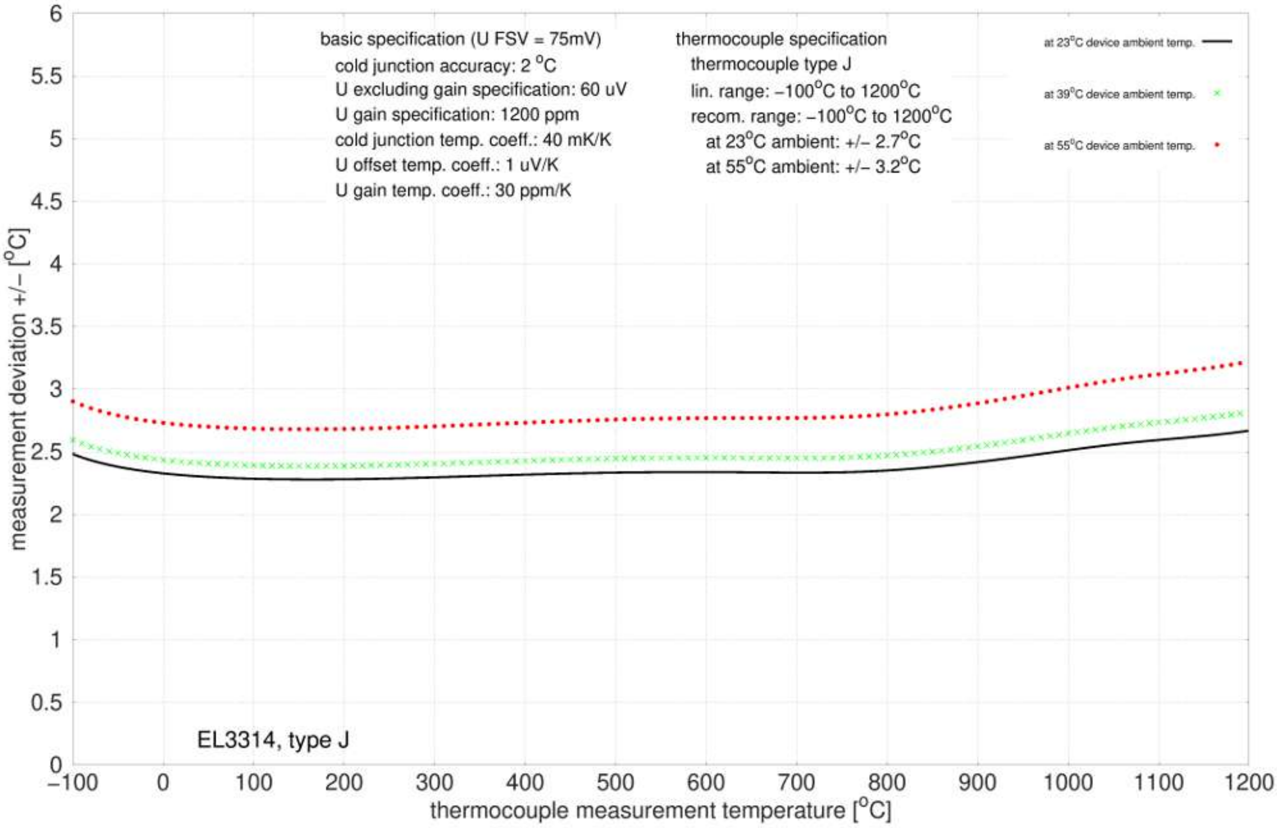
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -4.632 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type J: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.7 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.2 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

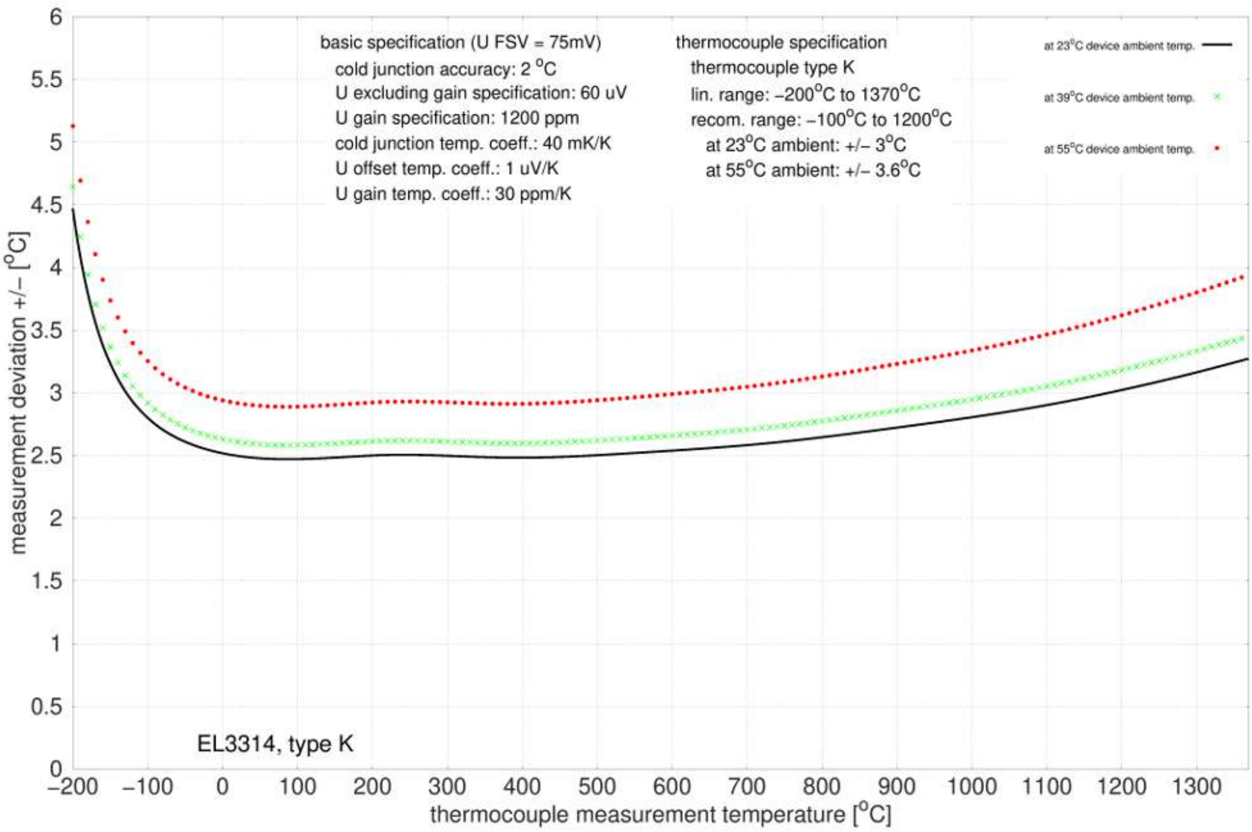
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.891 mV … +1370 °C ≈ 54.818 mV |
| Measuring range, end value (full scale value) | | +1370 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.22 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.26 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at* $T_{amb}$*= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

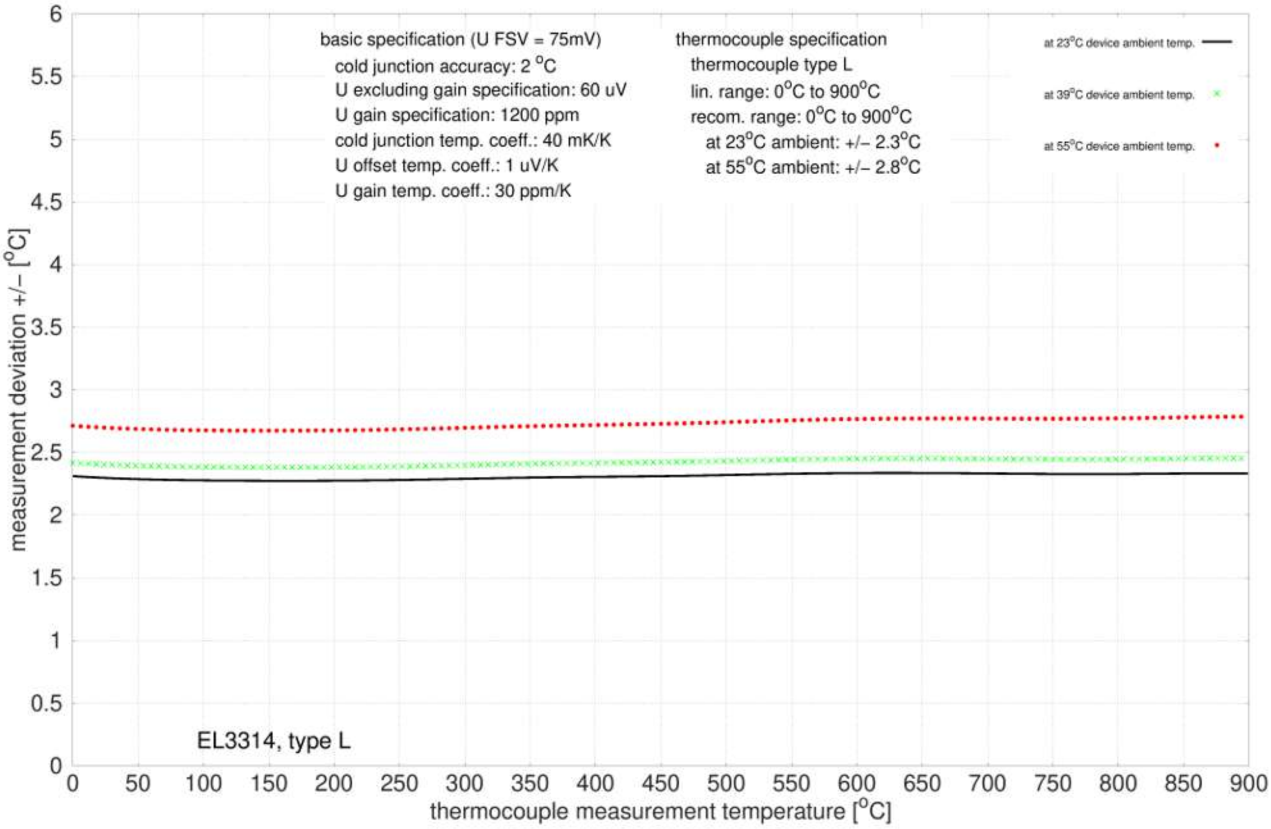
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type L: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.26 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.8 K ≈ ± 0.31 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

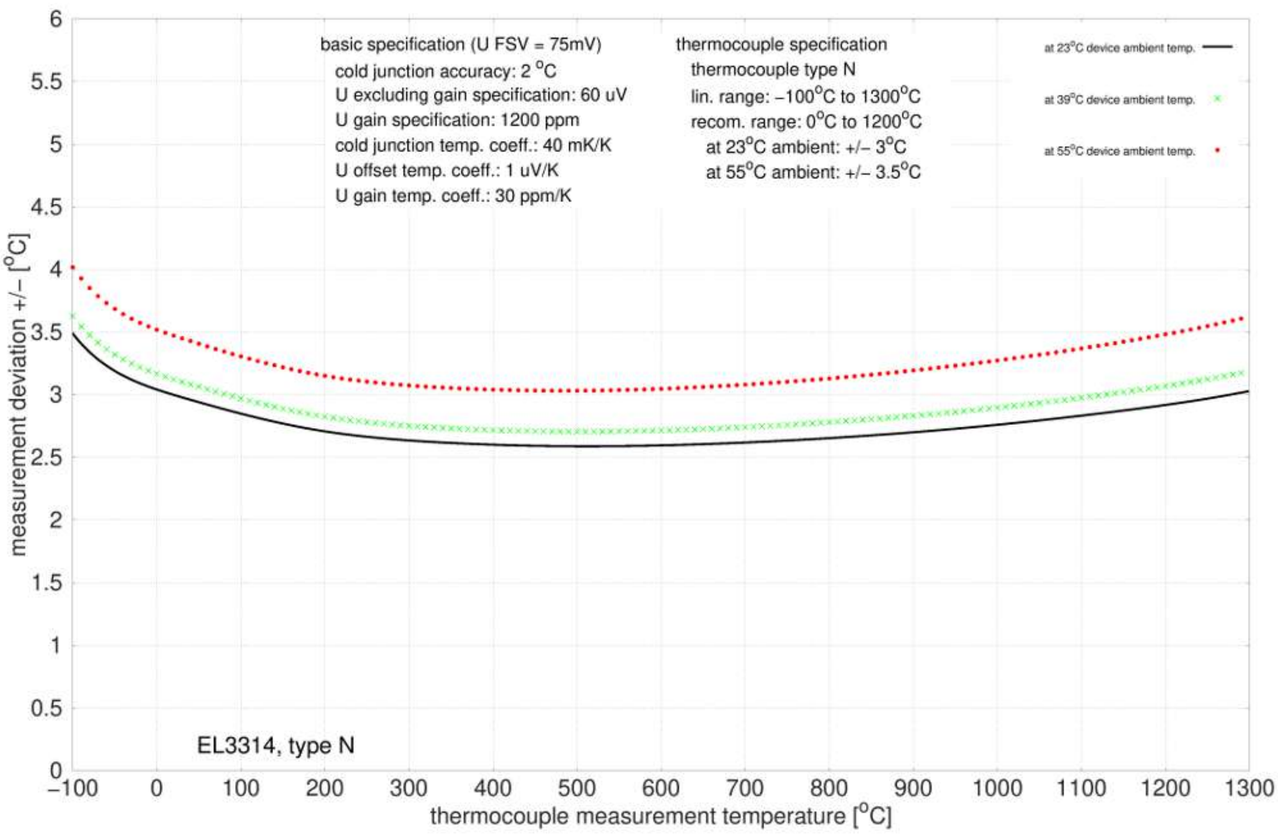
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -2.406 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type N: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

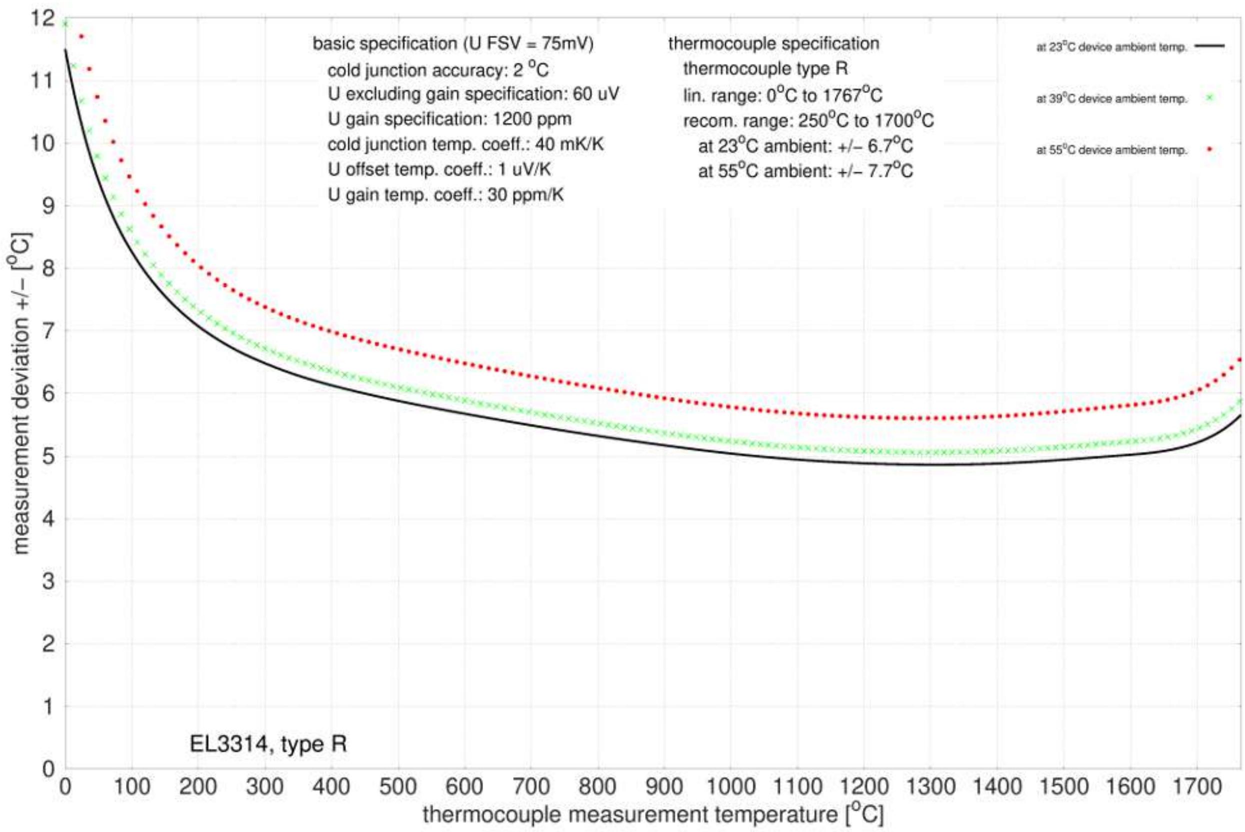
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1767 °C ≈ 21.089 mV |
| Measuring range, end value (full scale value) | | +1767 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type R: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.7 K ≈ ± 0.38 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.7 K ≈ ± 0.44 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

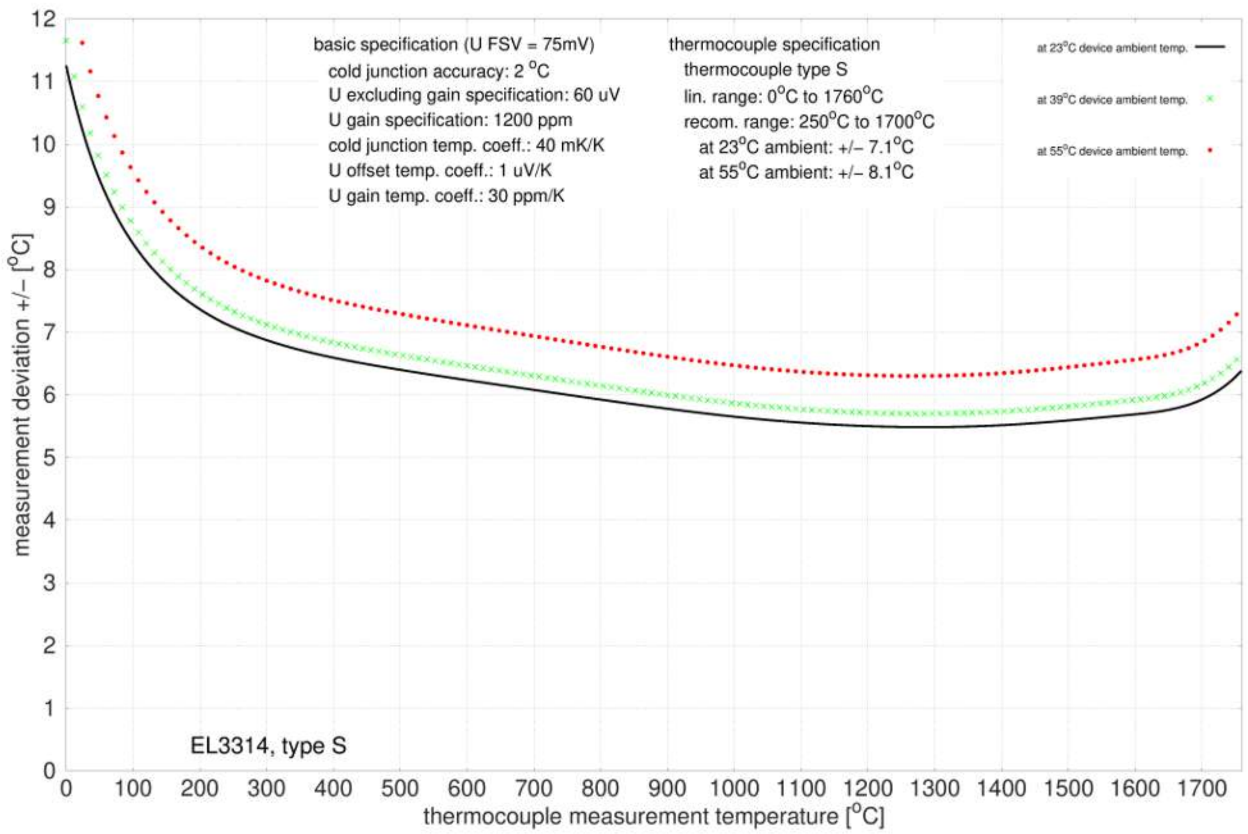
Measurement uncertainty for thermocouple type R:



### Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1760 °C ≈ 17.947 mV |
| Measuring range, end value (full scale value) | | +1760 °C |
| Measuring range, recommended | | +s250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type S: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 7.1 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 8.1 K ≈ ± 0.46 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

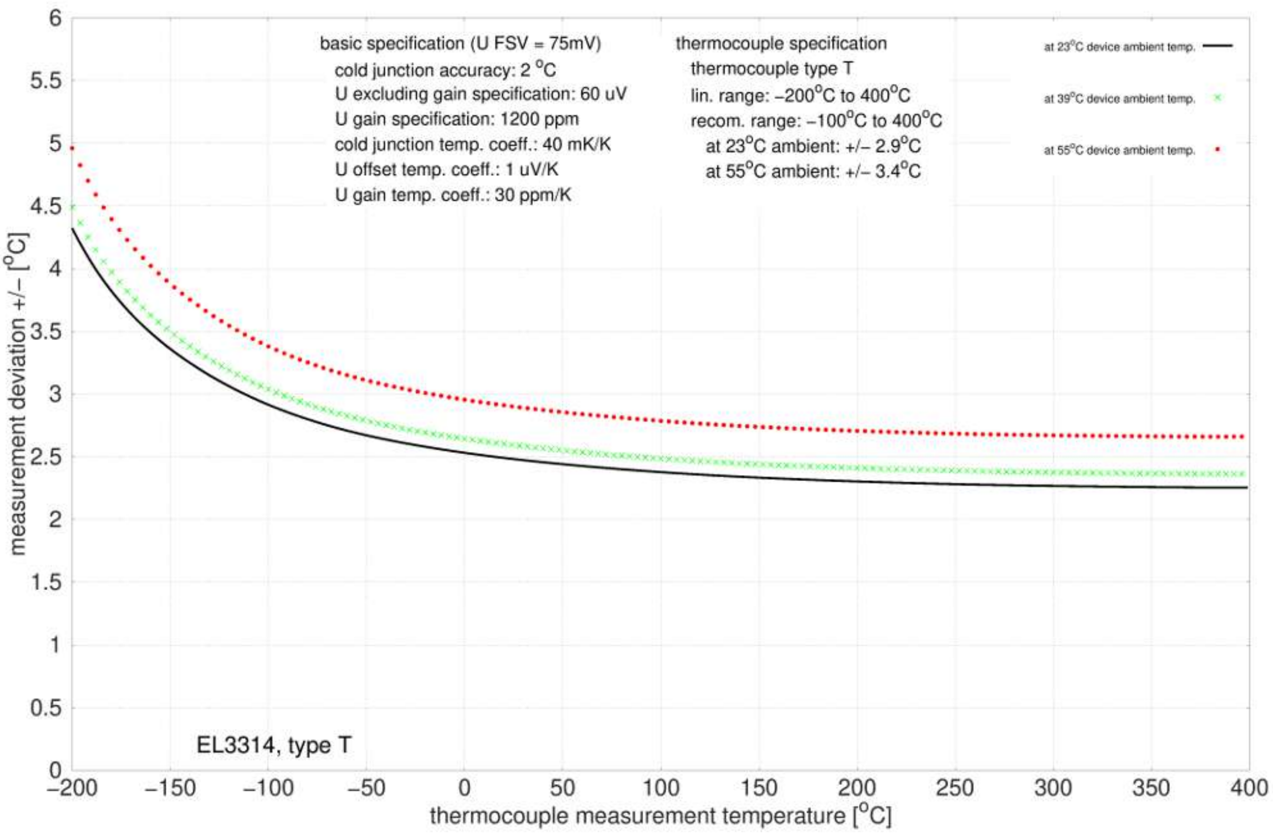
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.603 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.9 K ≈ ± 0.73 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.4 K ≈ ± 0.85 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

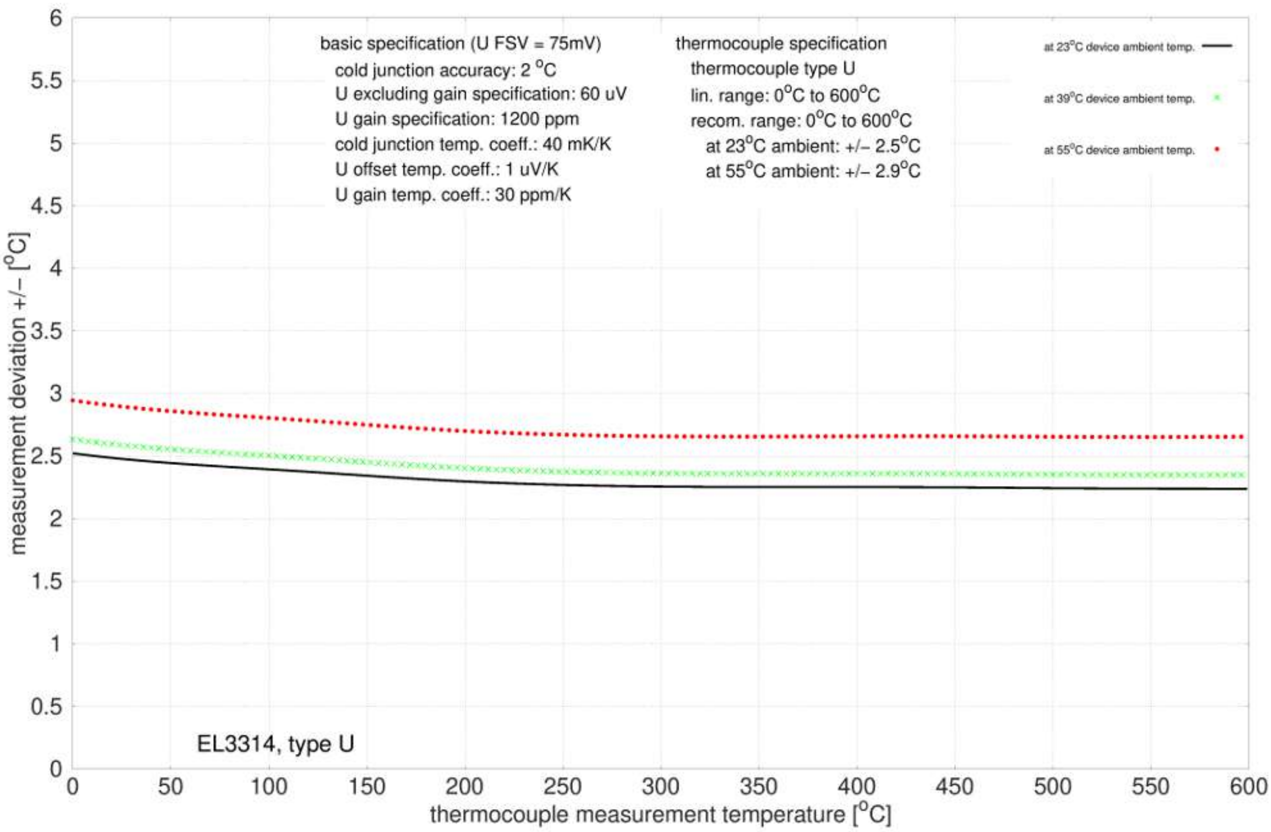
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type U: approx. 0.02 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.42 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.3.3 Connection

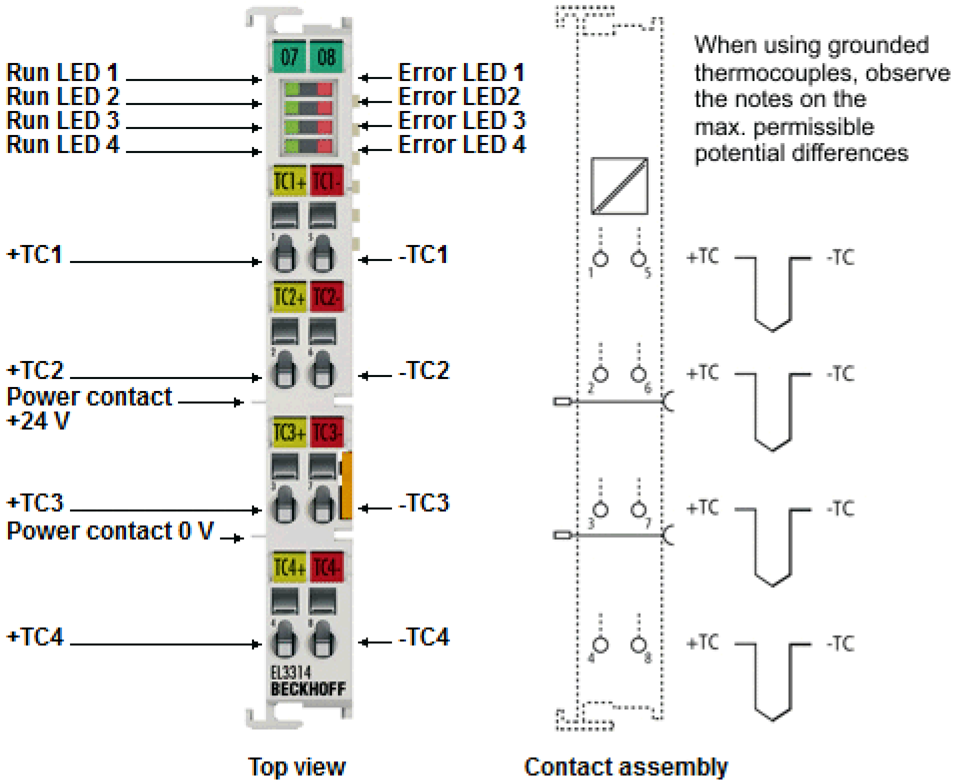



Fig. 9: EL3314

**EL3314 - Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.3.4 Display, diagnostics

**EL3314 n- LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP =** function for mailbox communication and different default settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP =** normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-4 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

## 2.4 EL3314-0002

### 2.4.1 Introduction

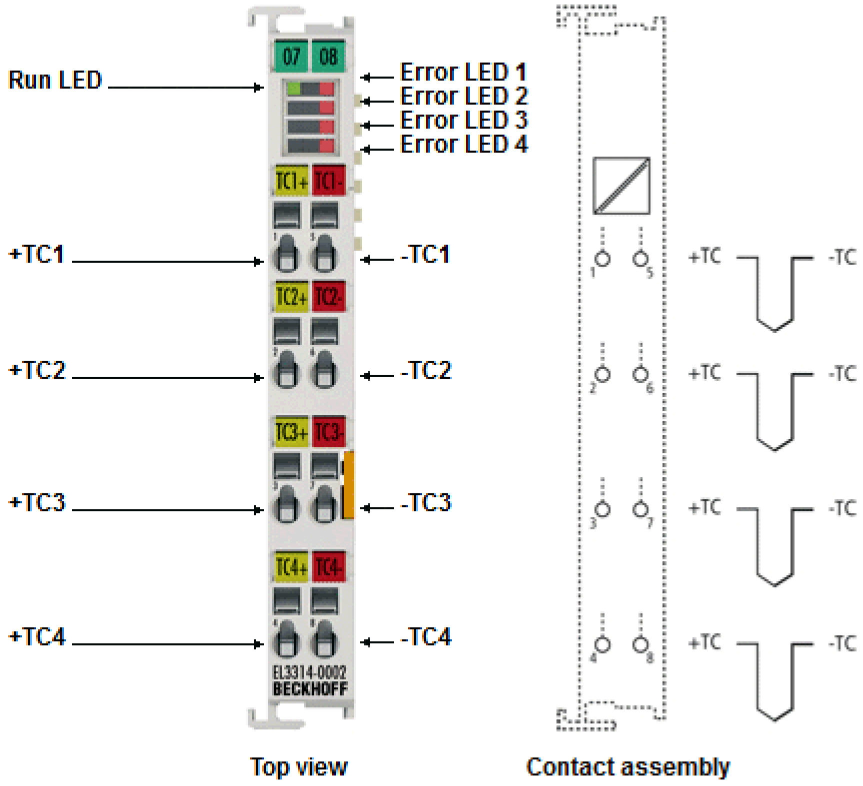



Fig. 10: EL3314-0002

**4-channel input terminal, thermocouple, high-precision, electrically isolated**

The EL3314-0002 analog input terminal allows the direct connection of four thermocouples in 2-wire configuration. The channels are electrically isolated from each other and from the E-bus, thus preventing adverse effects and damage due to cross currents. Various types of thermocouple are supported; the conversion of the voltage to temperature is already carried out within the terminal. Wire breakage is signaled by error LEDs and on the fieldbus. The cold junction compensation is carried out by an internal precise temperature measurement at the connection terminals; however, operation with an external cold junction or voltage measurement without cold junction calculation is also possible.

For high-precision measurements please note the following:

- Before delivery the EL3314-0010 is calibrated against a high-precision reference voltage
- The terminal is set to 0.01°C/digit ("high resolution") as standard
- The assured accuracy applies to the following settings
  - 50 Hz filter
  - 23 ± 5 °C ambient temperature
  - horizontal installation position
- In addition it has the following features
  - an additional software-based "MC filter" can be used for smoothing the measured value
  - external cold junction compensation is possible
- We advise against the use of compensation wires, because they reduce the measuring accuracy of the EL3314-0010
- We recommend using thermocouples with suitable accuracy

**Quick links**

• EtherCAT basics

• Technology EL33xx [▸ 188]

• Process data and operation modes [▸ 313]

• CoE object description and parameterization [▸ 353]

## 2.4.2 Technical data

### 2.4.2.1 General technical data

| Analog inputs | EL3314-0002 |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Type B, C, E, J, K, L, N, R, S, T, U (preset: type K), voltage measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 24-bit |
| Conversion time | approx. 1.6 s to 5 ms depending on configuration and filter setting;<br>Preset: approx. 110 ms at 50/ 60 Hz |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 2.5...4000 Hz, adjustable, notch characteristic; preset 50/60 Hz |
| Open-circuit recognition | yes (can be disabled) |
| Supports CoE Interface [▶ 218] function | tbd |
| Special features | high-precision, electrical isolation |

| Voltage measurement | EL3314-0002 |
|---|---|
| Measuring ranges | ± 78 mV<br>± 2.5 V |
| Resolution | 1 µV per digit |
| Measurement uncertainty | See Measurement ±78 mV...±2.5 V [▶ 76] |

| Temperature measurement | EL3314-0002 |
|---|---|
| Electrical measuring range used | ± 78 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -270...+1000°C<br>Type J: -210...+1200 °C<br>Type K: -270…+1372 °C (preset)<br>Type L: -50...+900 °C<br>Type N: -270…+1300 °C<br>Type R: -50...+1768 °C<br>Type S: -50...+1768 °C<br>Type T: -270…+400 °C<br>Type U: -50...+600 °C |
| Resolution | Temperature display 0.1/0.01/0.001 °C per digit, preset 0.01 °C |
| Measurement uncertainty | See Thermocouples measurement [▶ 77] |

| Supply and potentials | EL3314-0002 |
|---|---|
| Power supply for the electronics | via the E-bus |
| Current consumption via E-bus | typ. 200 mA |
| Electrical isolation | 2.5 kV functional isolation (test voltage 7 s channel/channel and channel/fieldbus, production test) |
| Max. potential ±TC to ground | 2.5 kV (test voltage production test) |
| Max. differential voltage between the ±TC inputs | ±15 V continuous |

| Communication | EL3314-0002 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 24 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3314-0002 |
|---|---|
| Permissible temperature range during operation | 0 °C...+ 55 °C |
| Permissible temperature range during storage | -25 °C ... + 85 °C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314-0002 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | In order to ensure the increased measuring accuracy, the terminal must be installed in the prescribed Prescribed installation position EL3314-0002/ EL3314-0010 [▶ 234]! |

| Standards and approvals | EL3314-0002 |
|---|---|
| Protection class | IP20 |
| 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 |
| Marking / Approval | CE, UKCA, EAC |

| Extended features | EL3314-0002 |
|---|---|
| Pluggable connection level | - |
| Electrical isolation | yes |
| TwinSAFE SC | - |
| Calibration certificate | - |

### 2.4.2.2 Measurement ±78 mV...±2.5 V

#### Specification ±78 mV

| Measurement mode | | ±78 mV |
|---|---|---|
| Measuring range, nominal | | -78…+78 mV |
| Measuring range, end value (full scale value) | | 78 mV |
| PDO resolution | | 1 µV |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.06%$_{FSV}$ typ. |
| | @ 55 °C ambient temperature[1] | < ±0.13%$_{FSV}$ typ. |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±10 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 500 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 0.5 µV/K |
| | $Tk_{Offset}$ | < 15 ppm/K |

#### Specification ±2.5 V

The EL3314-0002 is not factory calibrated in the electrically available measuring range ±2.5V. However, the measuring range can be used after user adjustment.

| Measurement mode | ±2.5 V |
|---|---|
| Measuring range, nominal | -2.5…+2.5 V |
| Measuring range, end value (full scale value) | 2.5 V |
| PDO resolution | 1 µV |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.4.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

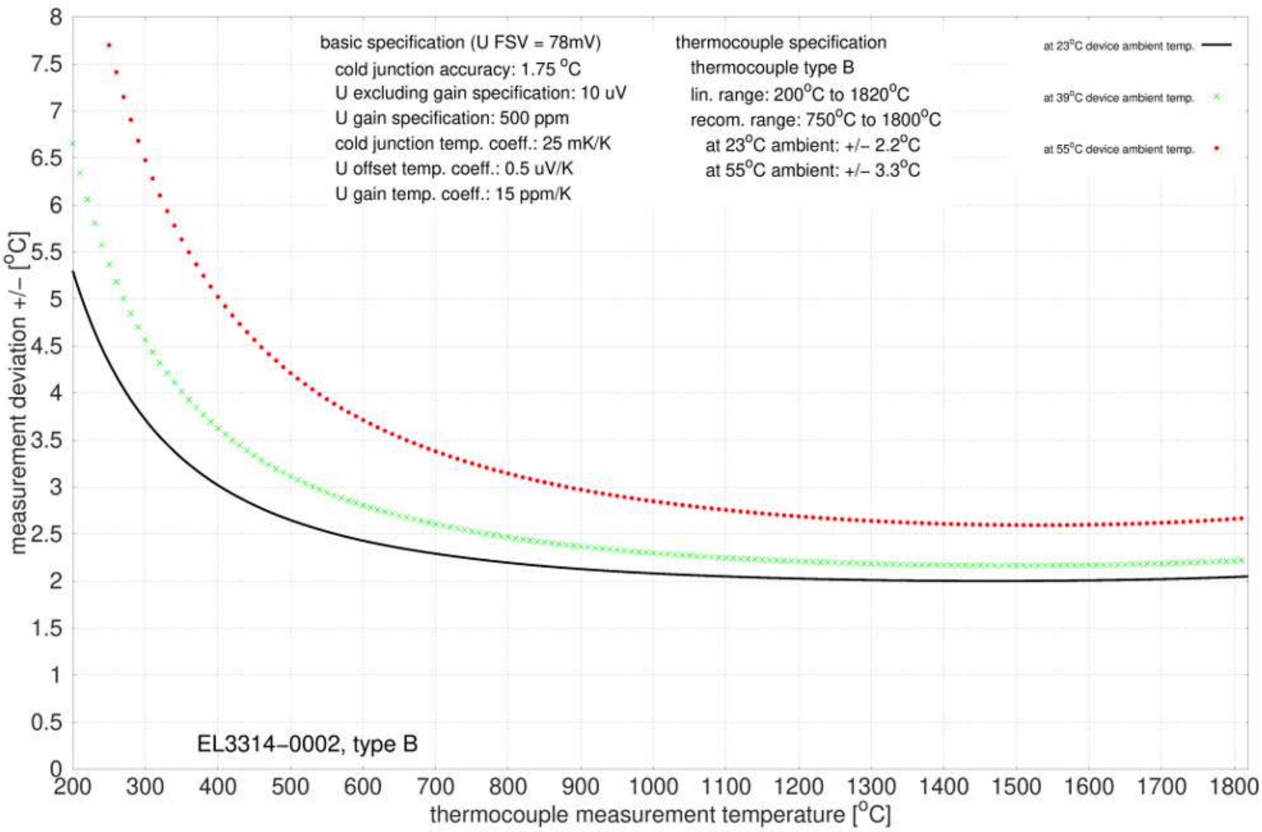
In the EL3314-0002, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±1.75 °C |
| Temperature coefficient | Tk | < 25 mK/K |

## Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | +200 °C ≈ 0.178 mV … +1820 °C ≈ 13.820 mV |
| Measuring range, end value (full scale value) | | +1820 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.3 K ≈ ± 0.18 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

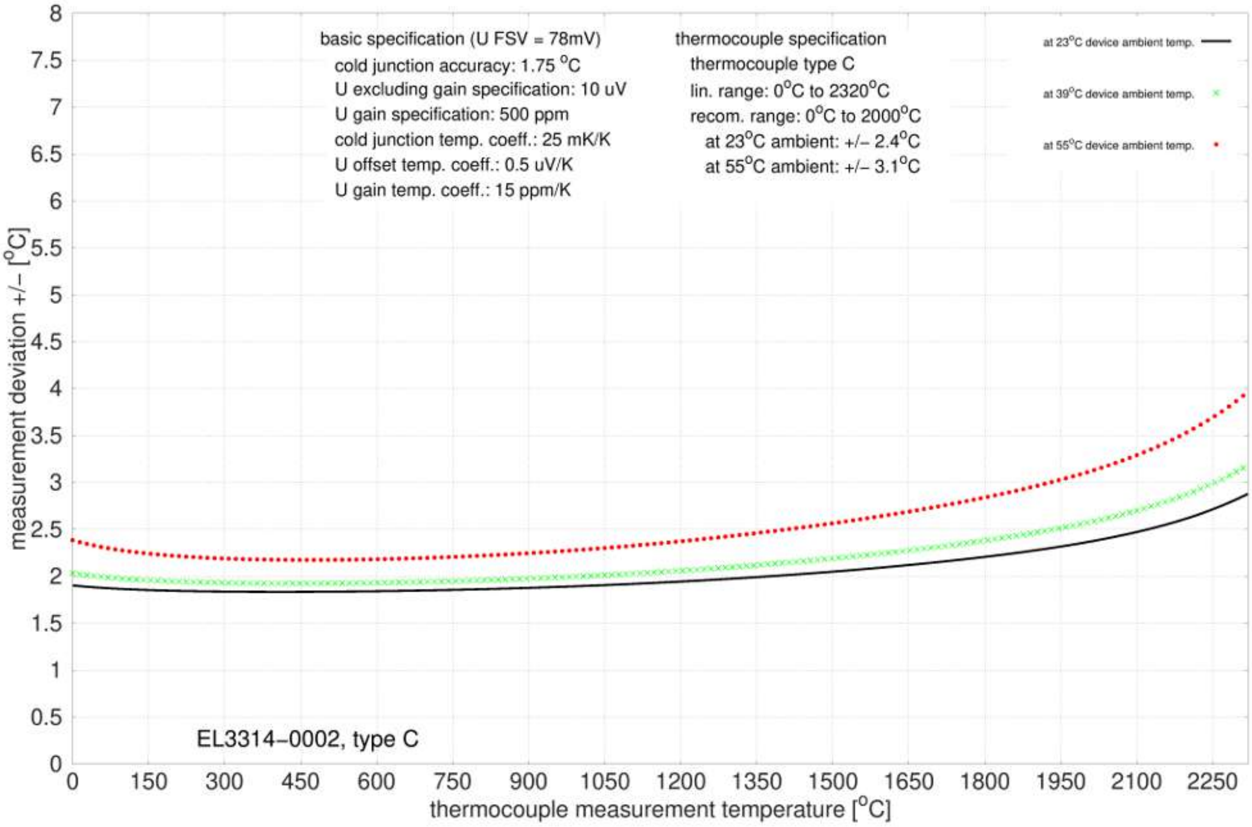
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.4 K ≈ ± 0.10 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.1 K ≈ ± 0.13 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

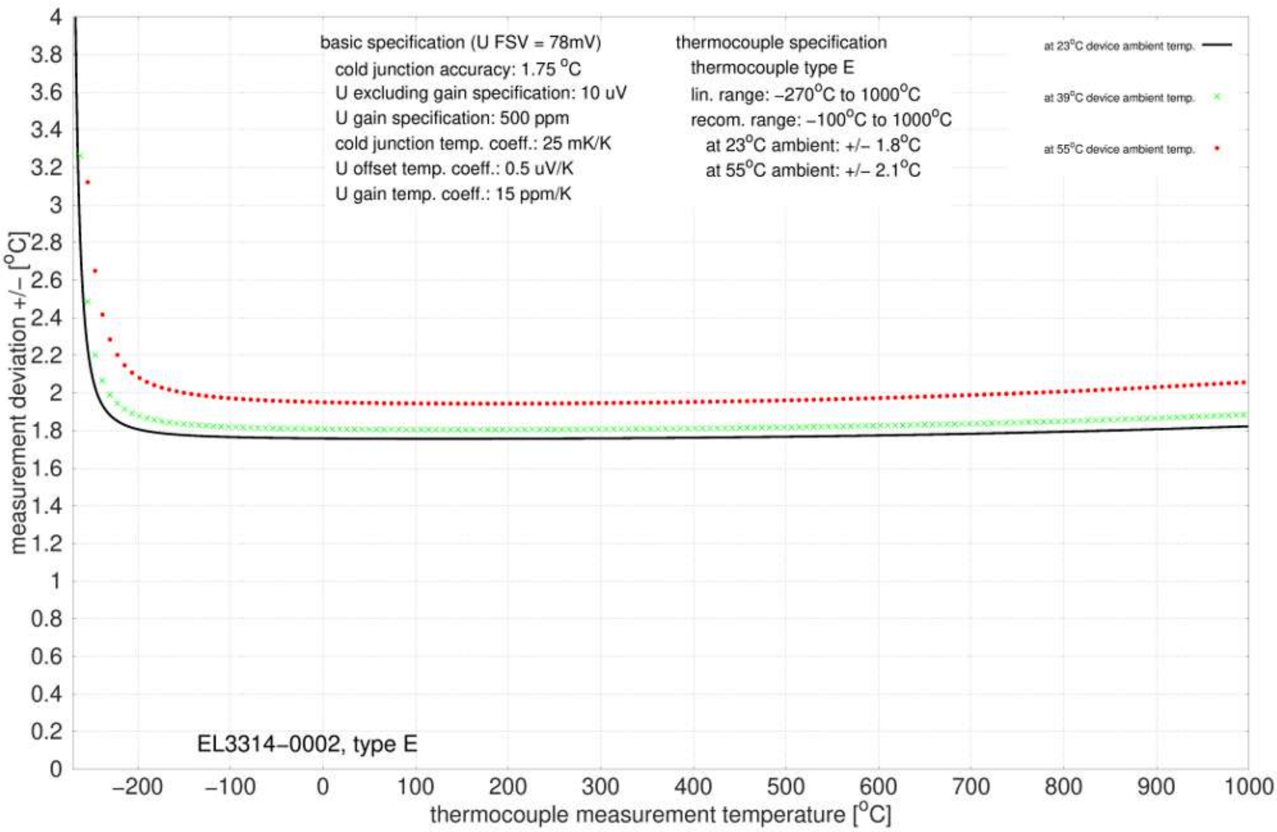
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -9.835 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.8 K ≈ ± 0.18 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.1 K ≈ ± 0.21 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

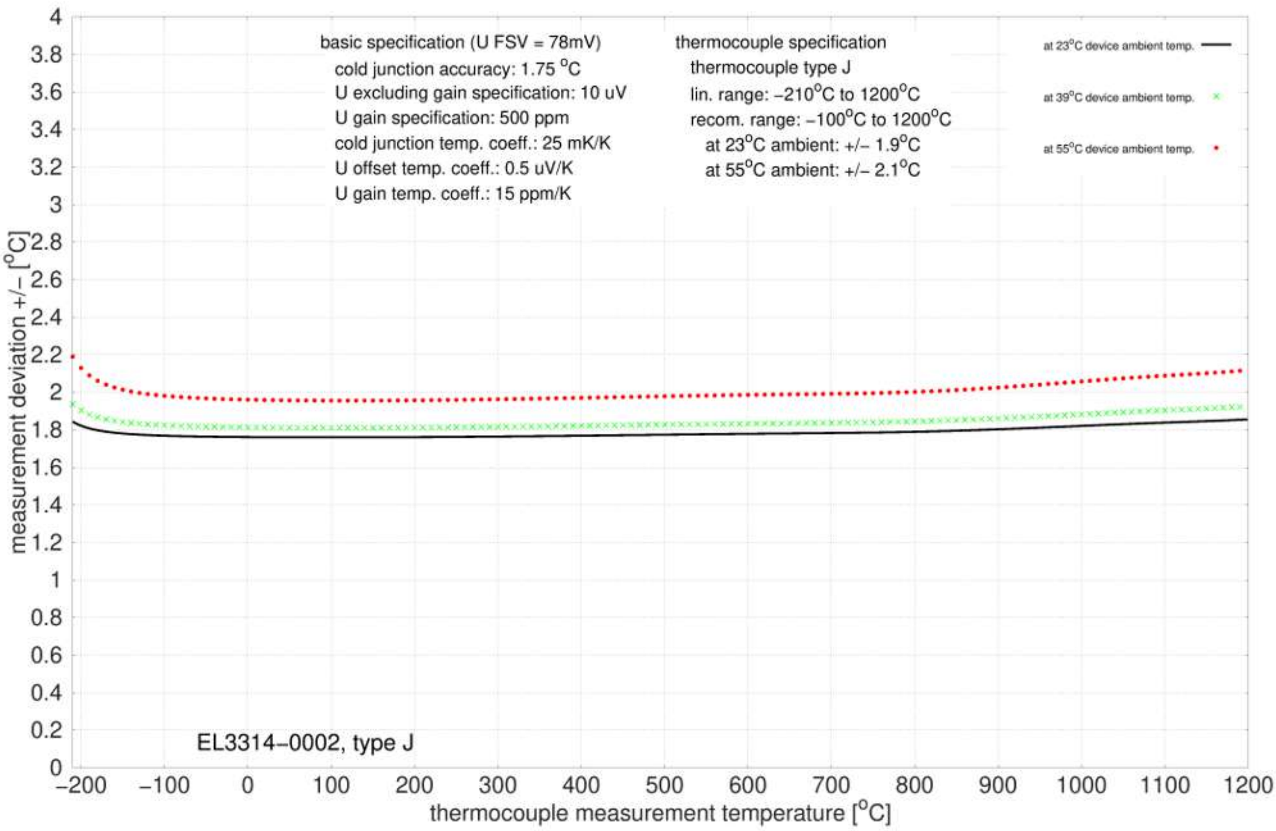
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -210 °C ≈ -8.095 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.9 K ≈ ± 0.16 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.1 K ≈ ± 0.18 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

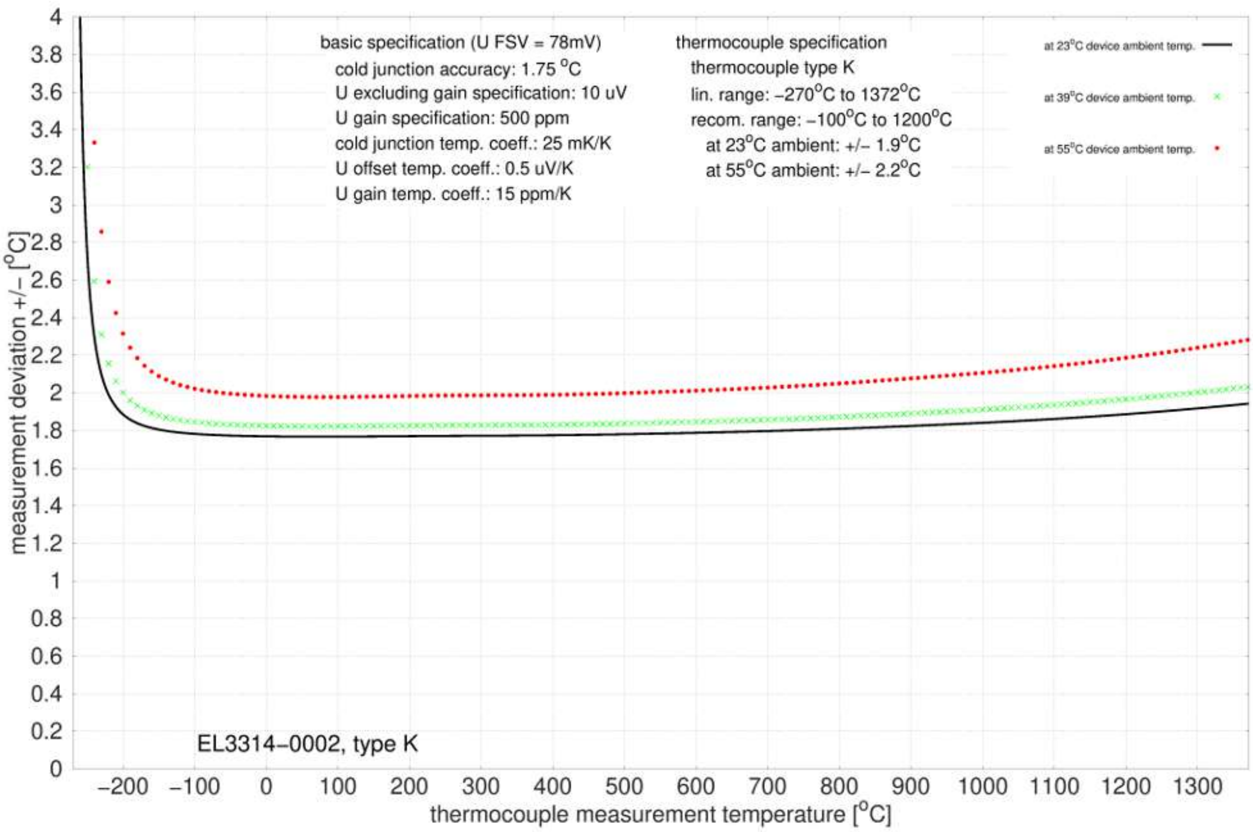
Measurement uncertainty for thermocouple type J:



## Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.458 mV … +1372 °C ≈ 54.886 mV |
| Measuring range, end value (full scale value) | | +1372 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.9 K ≈ ± 0.14 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.2 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

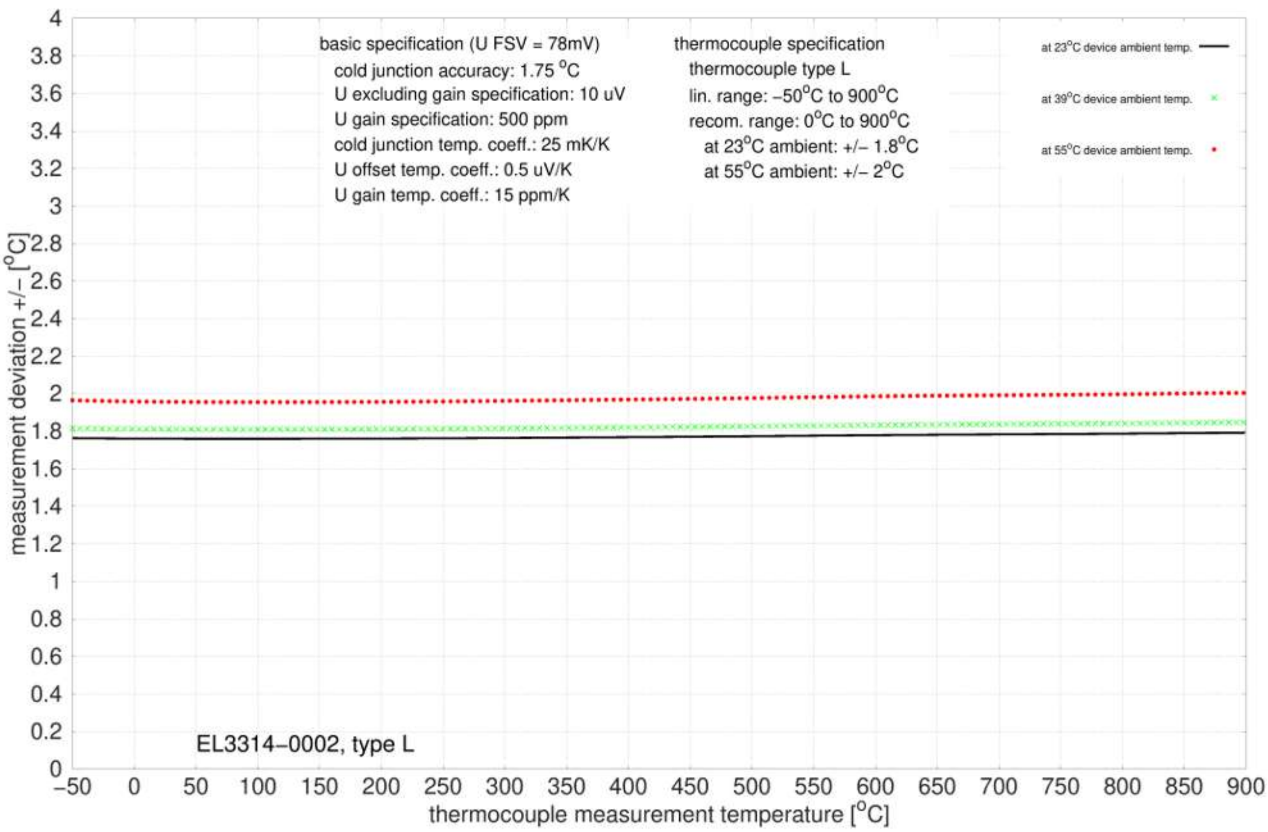
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -2.510 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.8 K ≈ ± 0.20 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.22 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

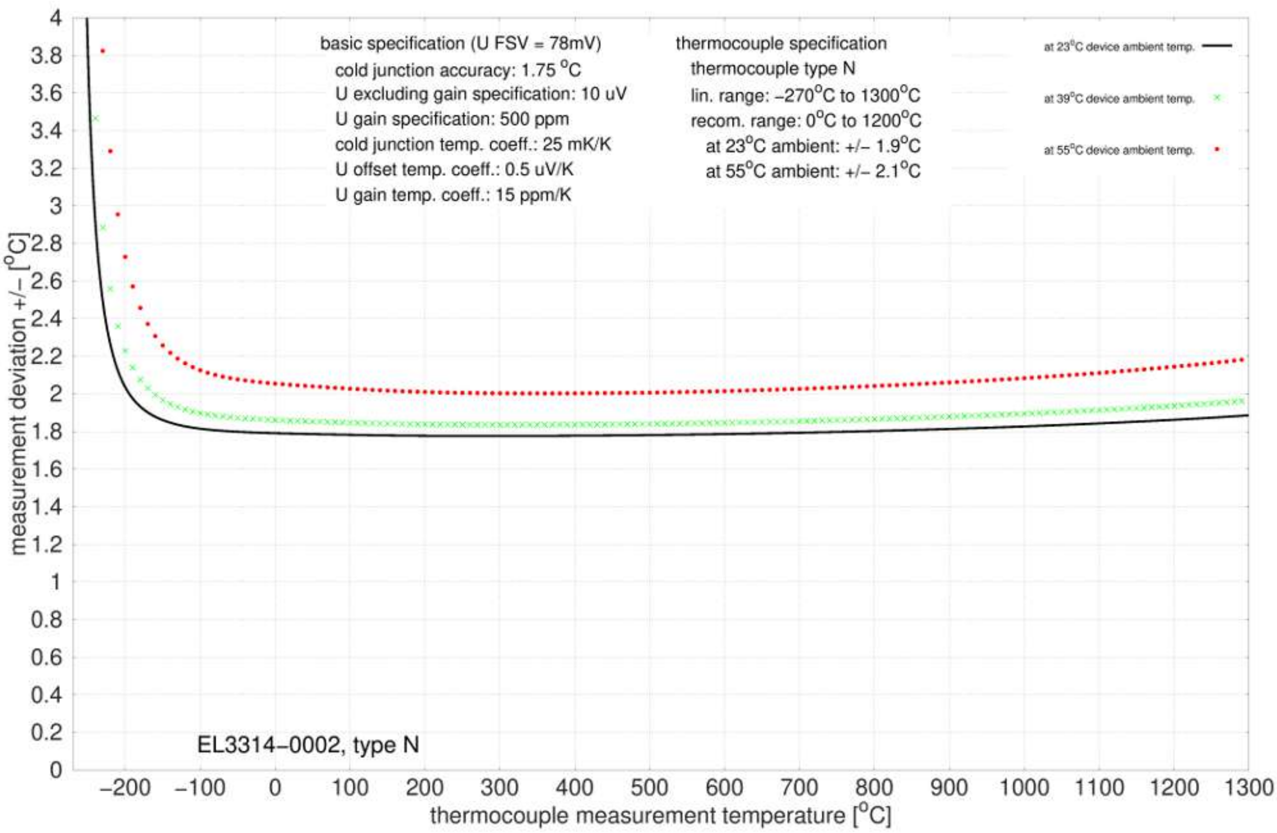
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -4.346 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.9 K ≈ ± 0.15 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.1 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

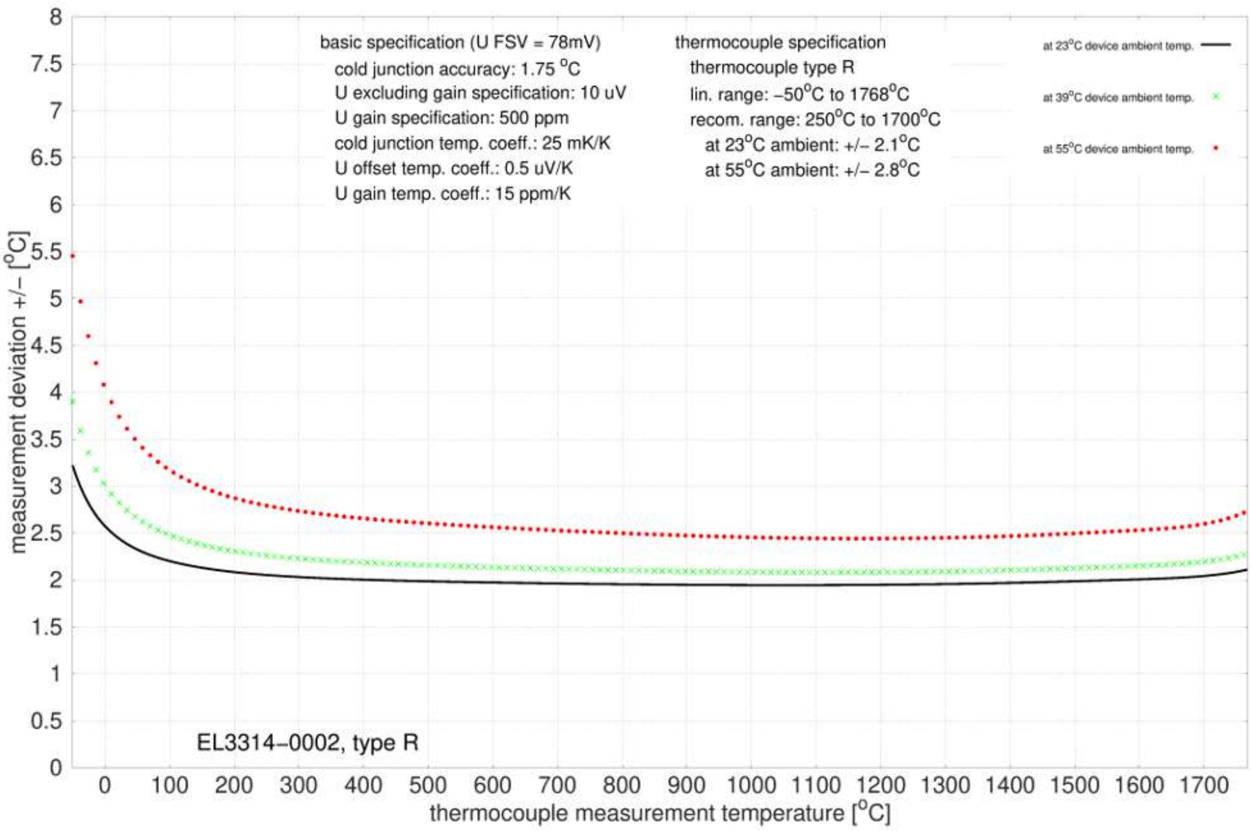
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.226 mV … +1768 °C ≈ 21.101 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.1 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.8 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

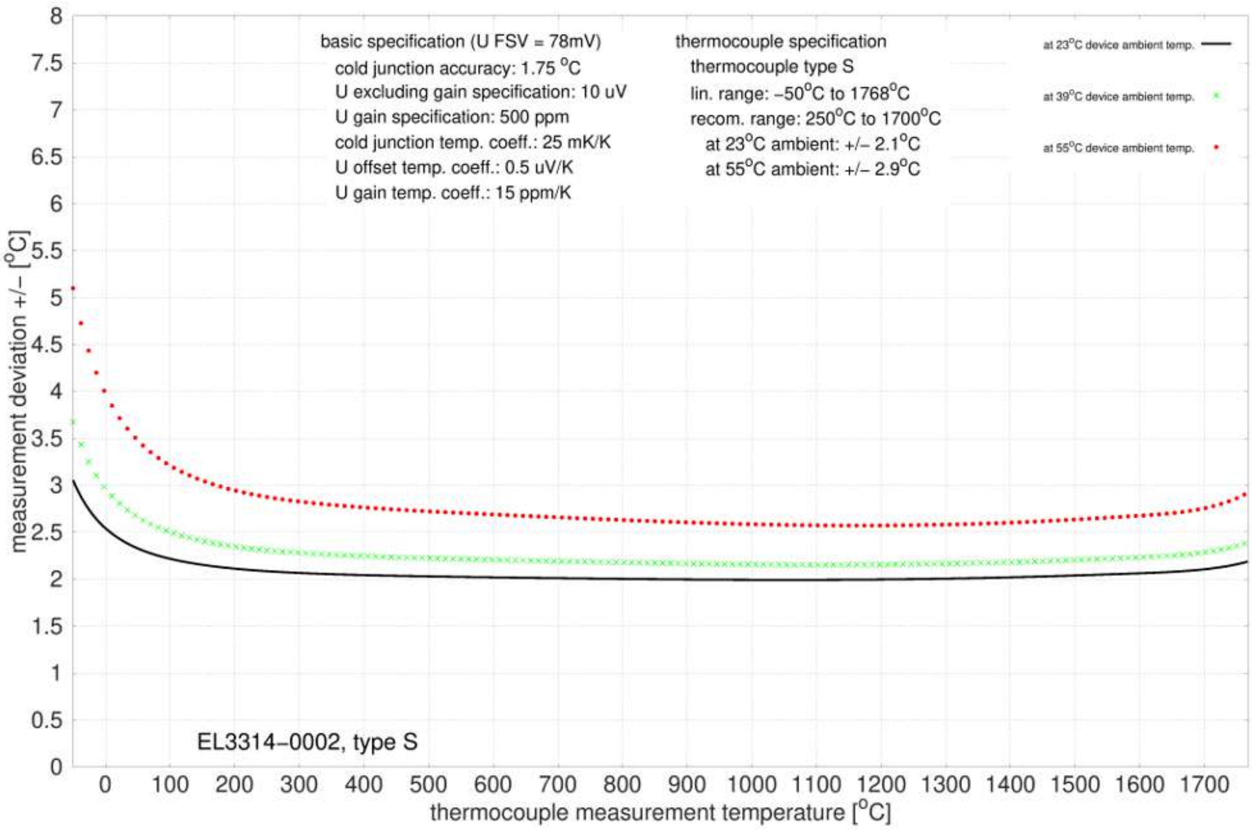
Measurement uncertainty for thermocouple type R:



## Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.236 mV … +1768 °C ≈ 18.693 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.1 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

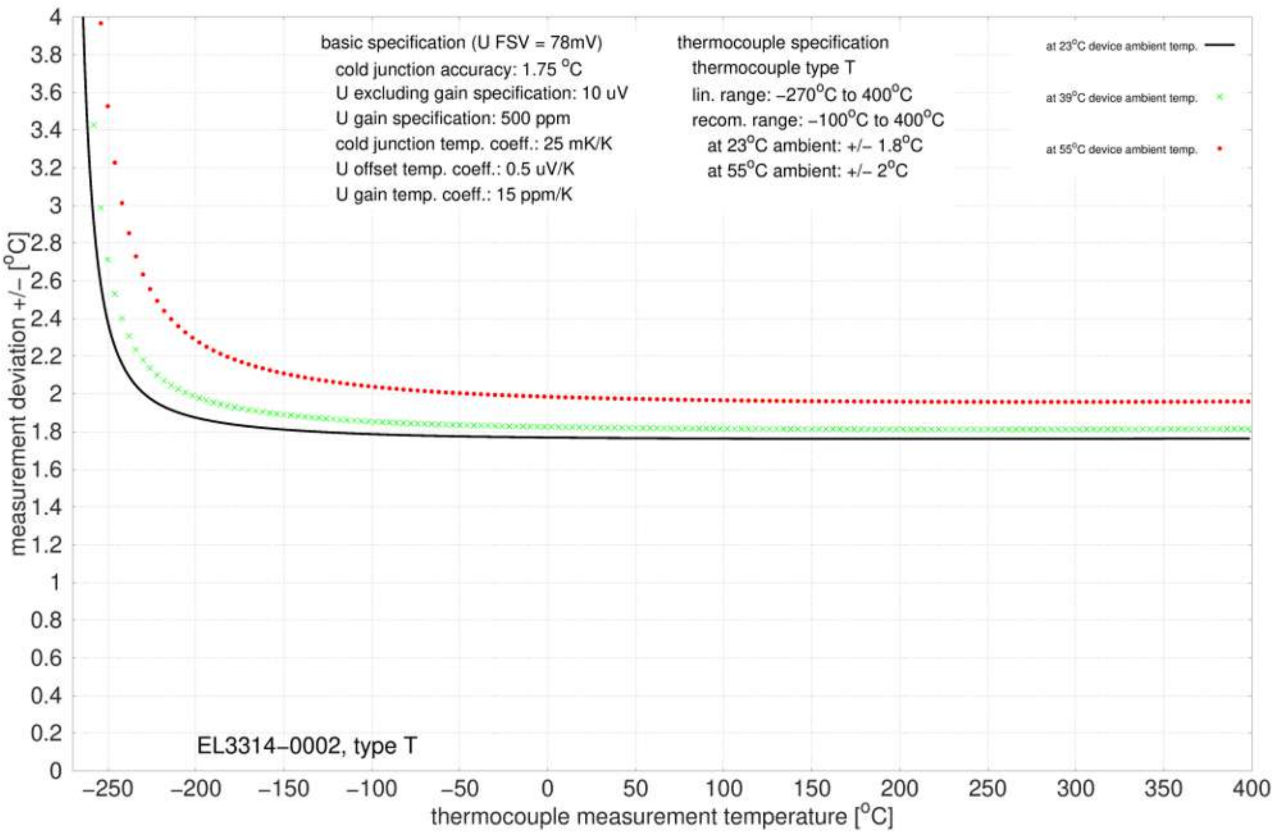
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.258 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.8 K ≈ ± 0.45 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.50 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

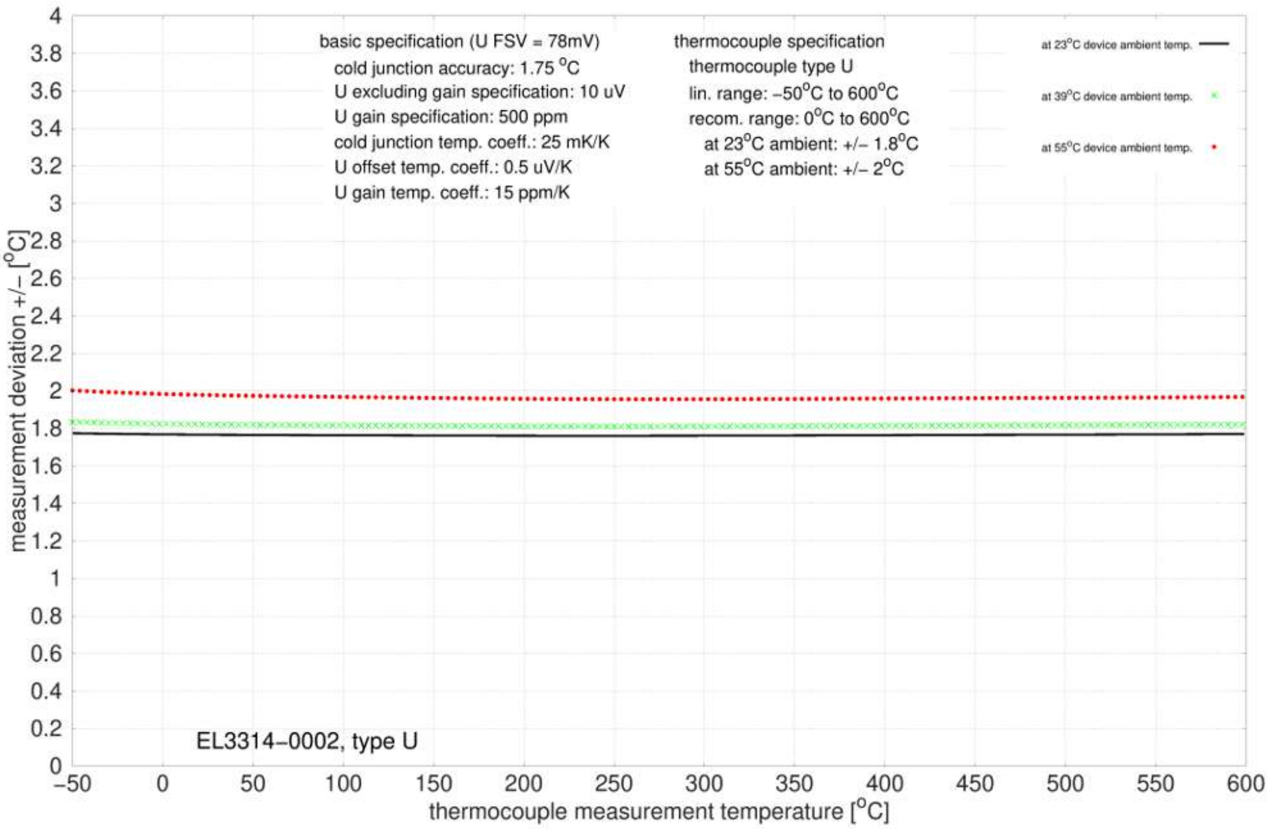
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -1.850 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.8 K ≈ ± 0.30 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.33 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.4.3 Connection

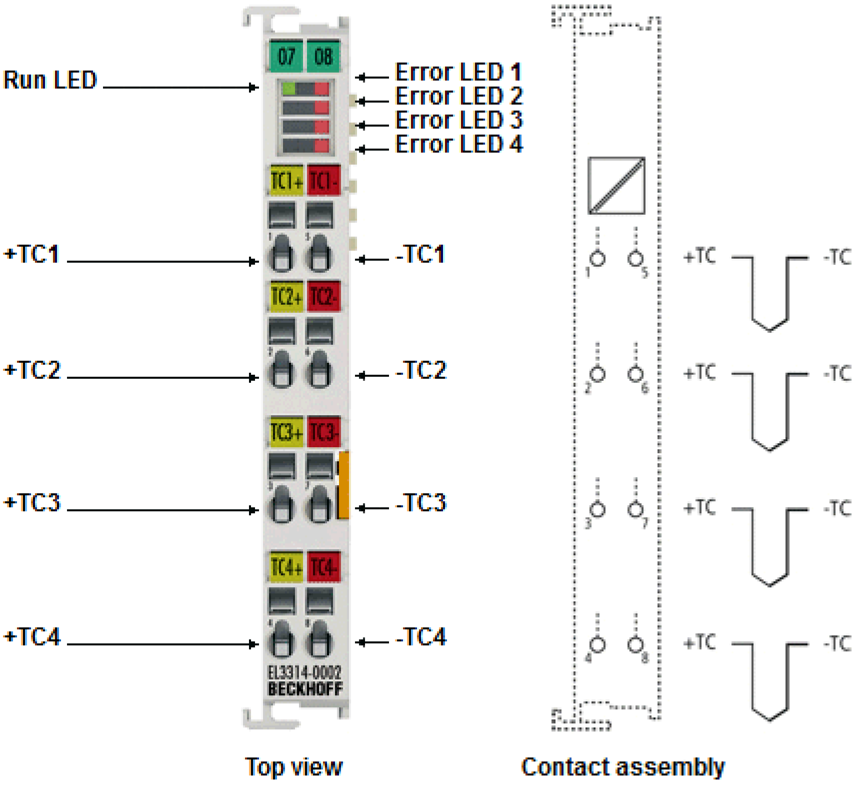



Fig. 11: EL3314-0002

**EL3314-0002 – Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.4.4 Display, diagnostics

**EL3314-0002 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP =** function for mailbox communication and different default settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP =** normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-4 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

# 2.5 EL3314-0010

## 2.5.1 Introduction

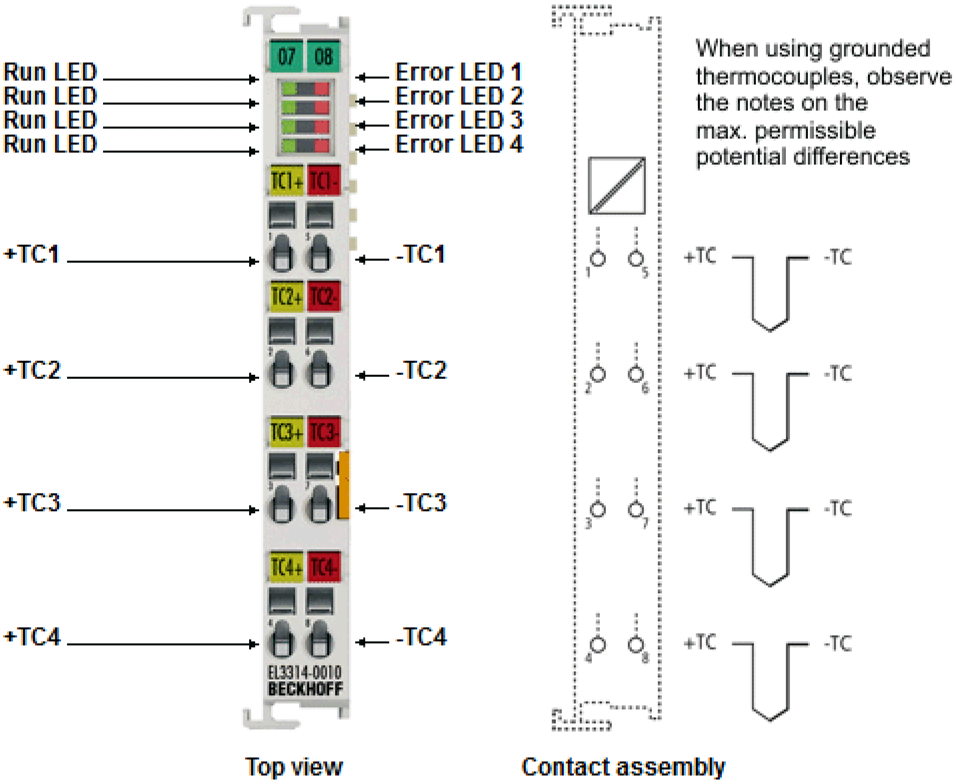



Fig. 12: EL3314-0010

**High-precision 4 channel analog input terminal for thermocouples, with open-circuit recognition**

The EL3314-0010 analog Input Terminal enables direct connection of thermocouples. Compared with the standard EL3314 model, it offers significantly more precise temperature measurements thanks to improved measuring circuit and more precise cold junction measurement. Otherwise the EL3314-0010 behaves similar to the EL3314.

For high-precision measurements please note the following:

- Before delivery the EL3314-0010 is calibrated against a high-precision reference voltage
- The terminal is set to 0.01°C/digit ("high resolution") as standard
- The assured accuracy applies to the following settings
  - 50 Hz filter
  - 23 ± 5 °C ambient temperature
  - horizontal installation position
- In addition it has the following features
  - an additional software-based "MC filter" can be used for smoothing the measured value
  - external cold junction compensation is possible (cold junction compensation, from FW03)
- We advise against the use of compensation wires, because they reduce the measuring accuracy of the EL3314-0010
- We recommend using thermocouples with suitable accuracy

**Quick links**

• EtherCAT basics

• Technology EL33xx [▶ 188]

• Process data and operation modes [▶ 313]

• CoE object description and parameterization [▶ 360]

## 2.5.2 Technical data

### 2.5.2.1 General technical data

| Analog inputs | EL3314-0010 |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Type B, C, E, J, K, L, N, R, S, T, U (preset: type K), voltage measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 24-bit |
| Conversion time | approx. 1.6 s to 5 ms depending on configuration and filter setting;<br>Preset: approx. 110 ms at 50/ 60 Hz |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz...30 kHz, adjustable, notch characteristic; preset 50 Hz |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▸ 218] function | tbd |
| Special features | High-precision |

| Voltage measurement | EL3314-0010 |
|---|---|
| Measuring range, technically usable | approx. ± 80 mV |
| Measuring range, nominal | ± 78 mV |
| Resolution | 10 nV per digit |
| Measurement uncertainty | See Measurement ±78 mV [▸ 95] |

| Temperature measurement | EL3314-0010 |
|---|---|
| Electrical measuring range used | ± 78 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -270...+1000°C<br>Type J: -210...+1200 °C<br>Type K: -270…+1372 °C (preset)<br>Type L: -50...+900 °C<br>Type N: -270…+1300 °C<br>Type R: -50...+1768 °C<br>Type S: -50...+1768 °C<br>Type T: -270…+400 °C<br>Type U: -50...+600 °C |
| Resolution | Temperature display 0.1/0.01/0.001 °C per digit, preset 0.01 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 96] |

| Supply and potentials | | EL3314-0010 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3314-0010 |
|---|---|
| Power supply for the electronics | via the E-bus |
| Current consumption via E-bus | typ. 200 mA |
| Electrical isolation | 500 V (E-bus/field voltage) |

| Environmental conditions | EL3314-0010 |
|---|---|
| Permissible temperature range during operation | 0 °C...+ 55 °C |
| Permissible temperature range during storage | -25 °C ... + 85 °C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314-0010 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | In order to ensure the increased measuring accuracy, the terminal must be installed in the prescribed installation position [▶ 234]! |

| Standards and approvals | EL3314-0010 |
|---|---|
| Protection class | IP20 |
| 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 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▶ 204]<br>cULus [▶ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

| Extended features | EL3314-0010 |
|---|---|
| Pluggable connection level | - |
| Electrical isolation | EL3314-0002 |
| TwinSAFE SC | - |
| Calibration certificate | EL3314-0030 (ISO17025 or DAkkS certificate) |

### 2.5.2.2 Measurement ±78 mV

**Specification ±78 mV**

| Measurement mode | | ±78 mV |
|---|---|---|
| Measuring range, nominal | | -78…+78 mV |
| Measuring range, end value (full scale value) | | 78 mV |
| PDO resolution | | 10 nV |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.06%$_{FSV}$ typ. |
| | @ 55 °C ambient temperature[1] | < ±0.13%$_{FSV}$ typ. |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±15 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 400 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 0.5 µV/K |
| | $Tk_{Offset}$ | < 15 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.5.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

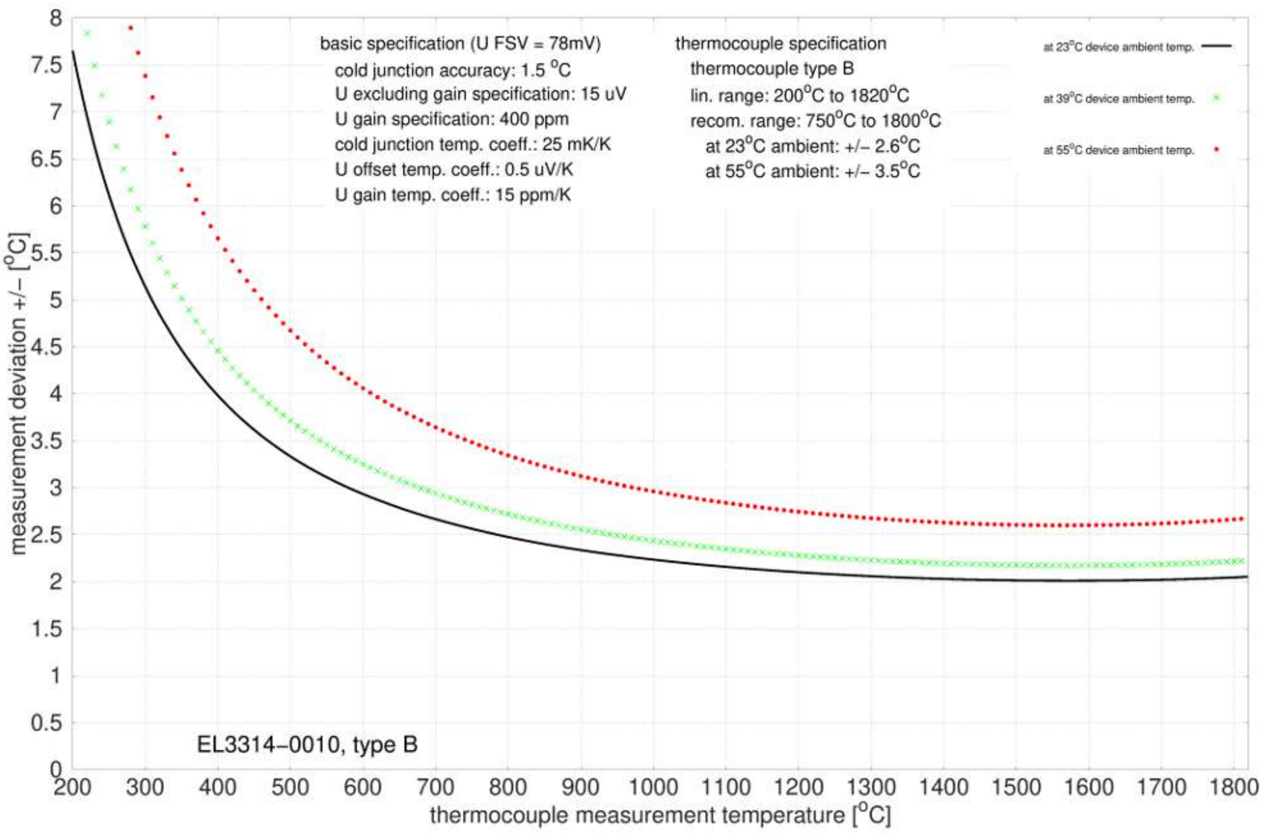
In the EL3314-0010, EL3314-0020 and EL3314-0030, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±1.5 °C |
| Temperature coefficient | Tk | < 25 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | +200 °C ≈ 0.178 mV … +1820 °C ≈ 13.820 mV |
| Measuring range, end value (full scale value) | | +1820 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.6 K ≈ ± 0.14 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.19 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

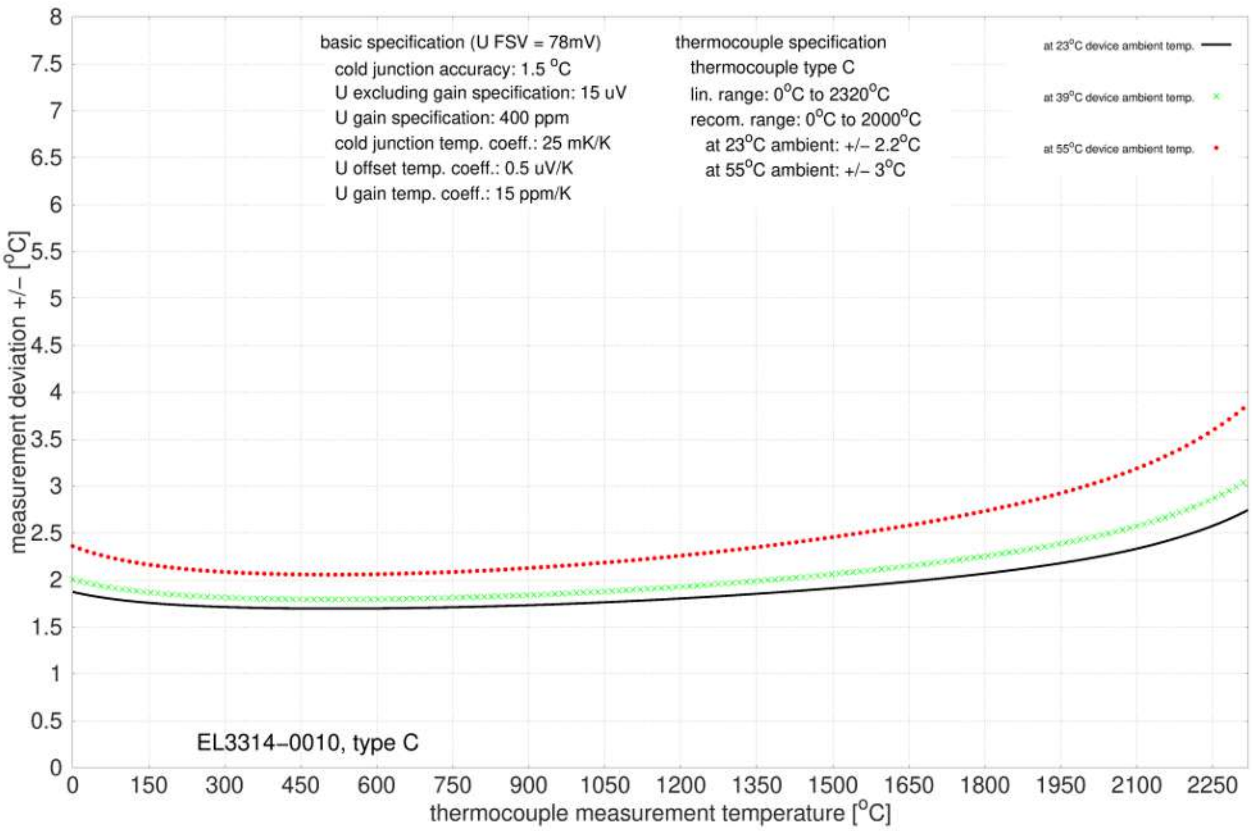
Measurement uncertainty for thermocouple type B:



## Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.10 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.13 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

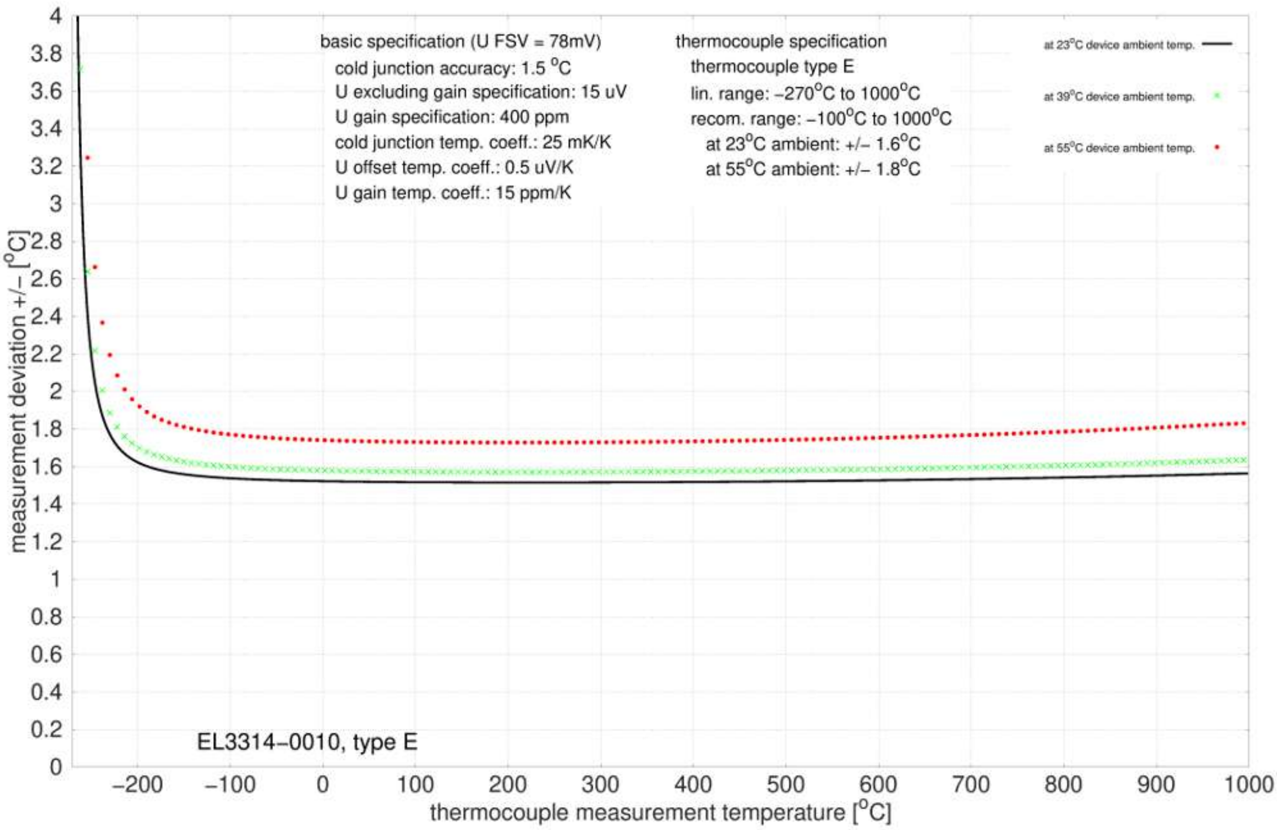
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -9.835 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.16 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.18 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

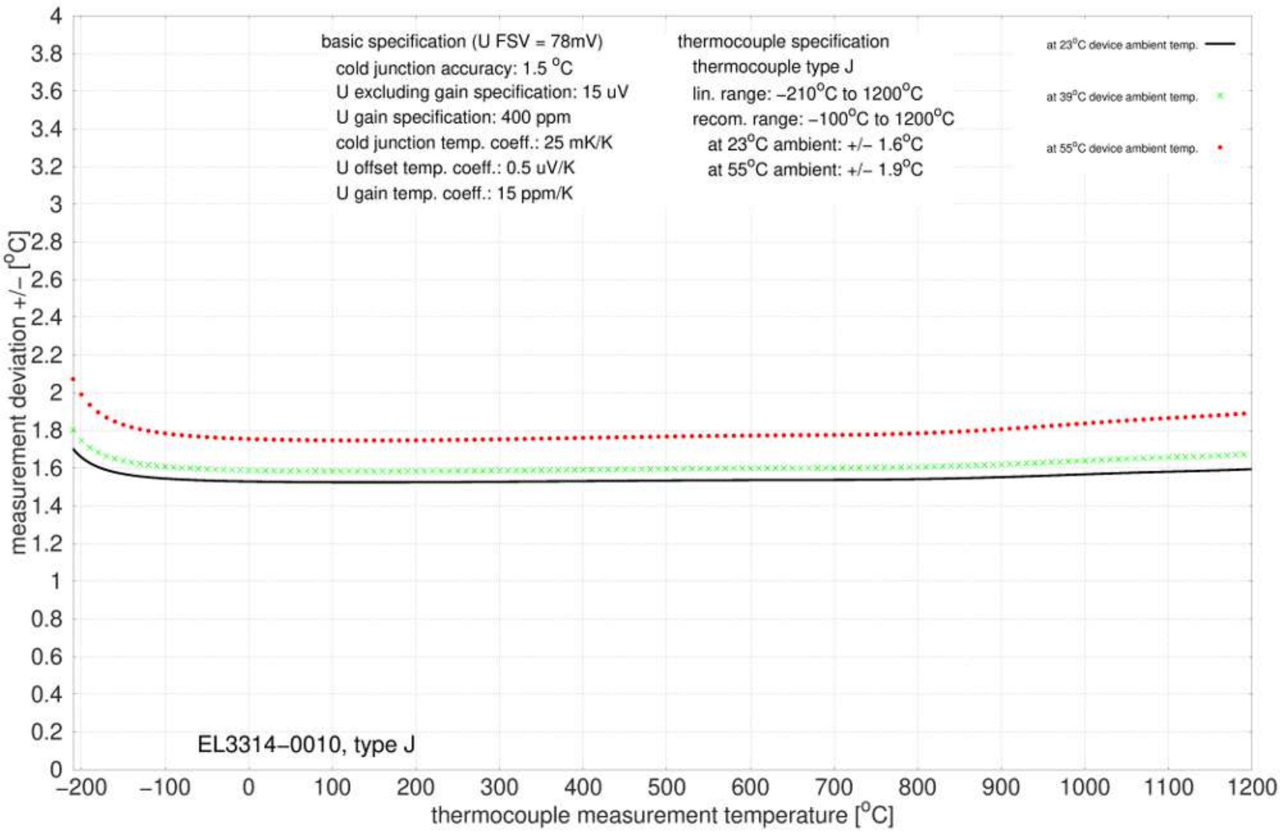
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -210 °C ≈ -8.095 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

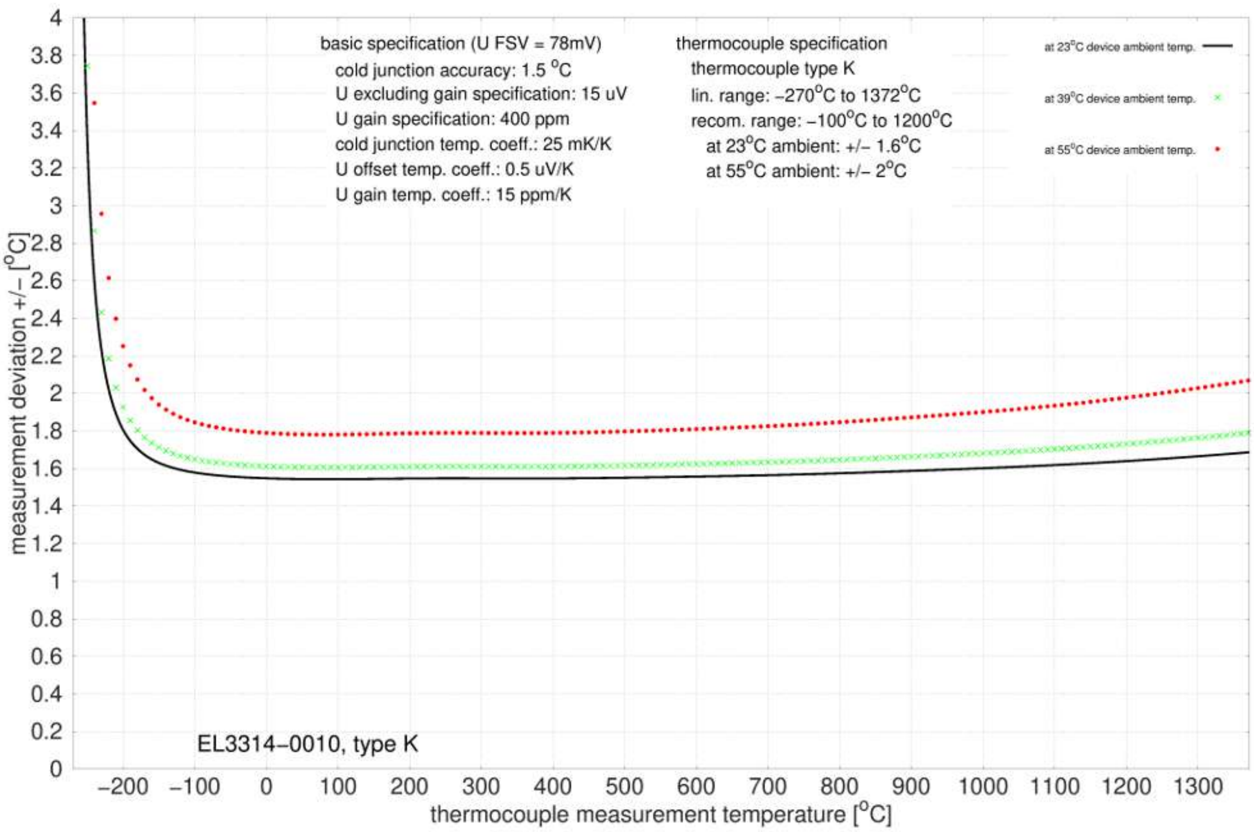
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.458 mV … +1372 °C ≈ 54.886 mV |
| Measuring range, end value (full scale value) | | +1372 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

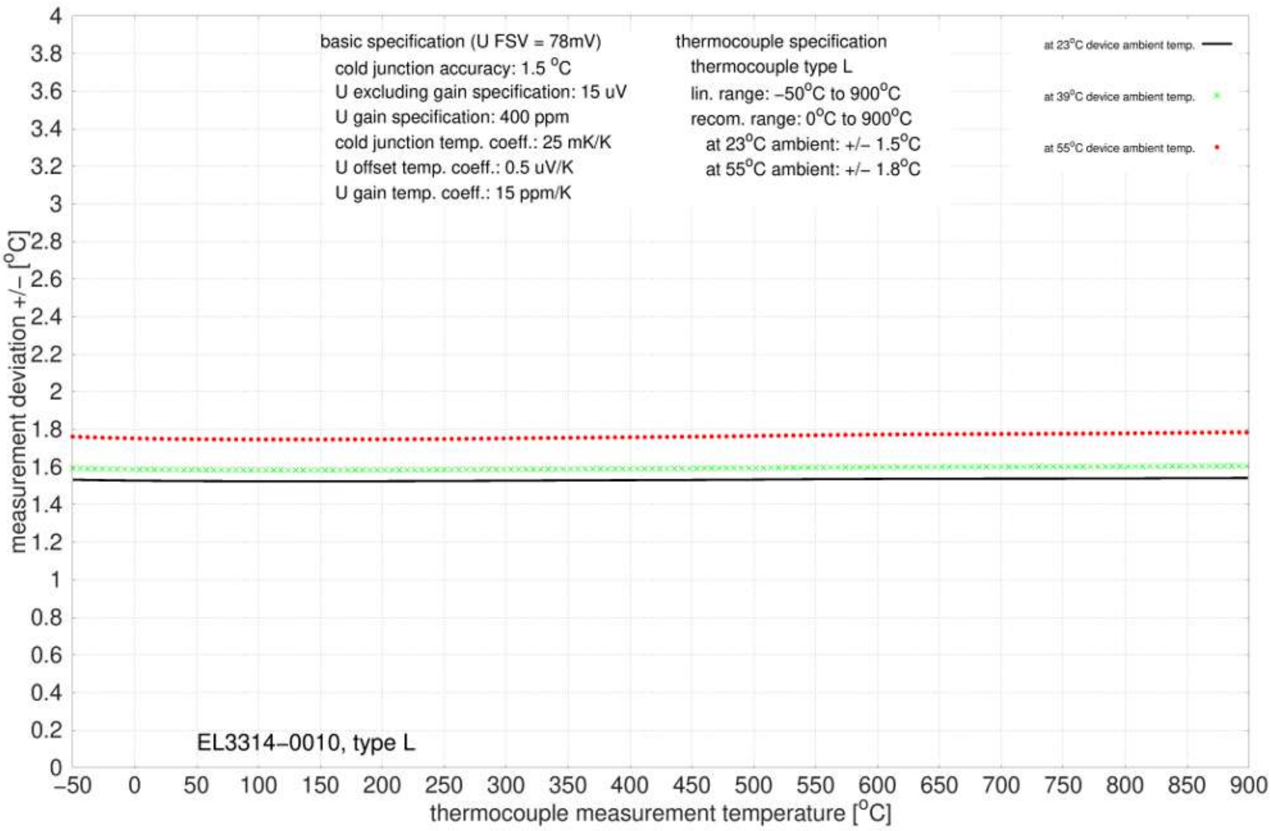
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -2.510 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.17 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.20 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

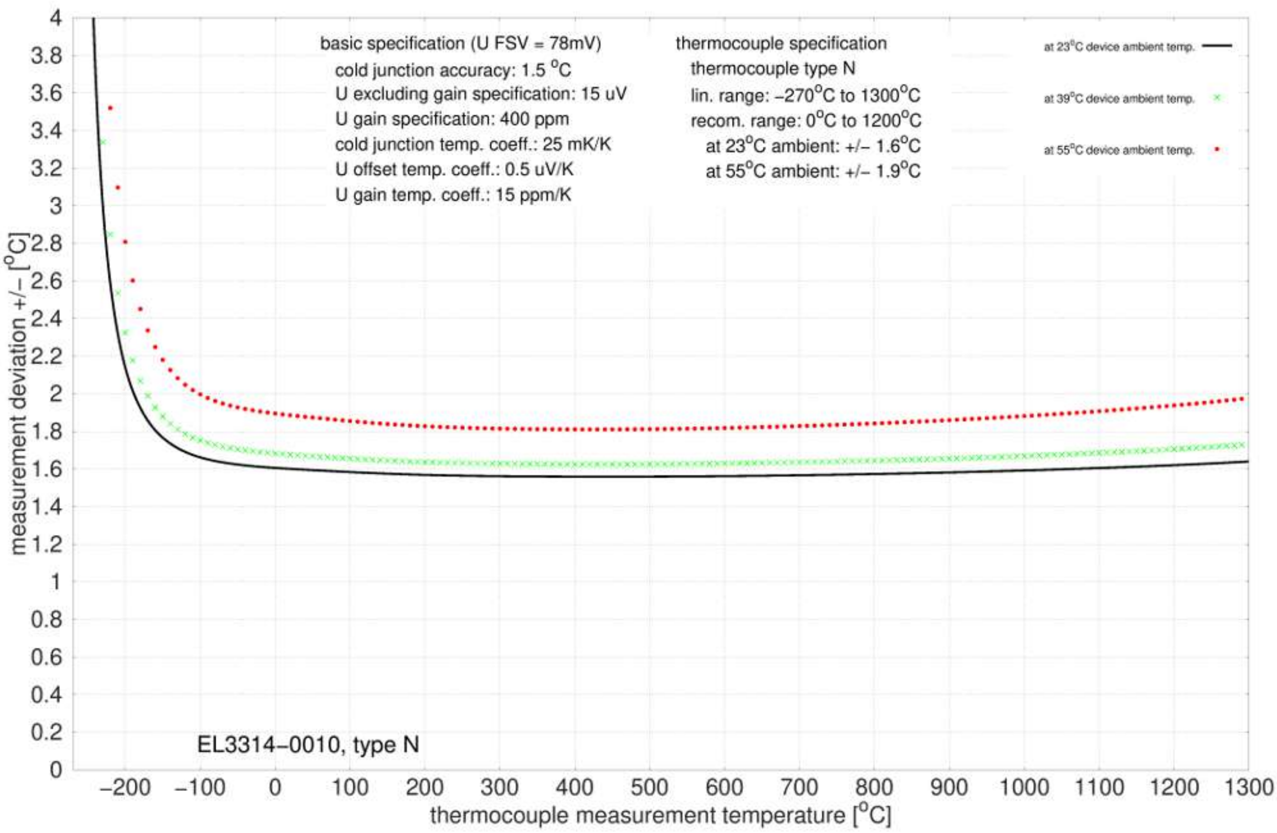
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -4.346 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

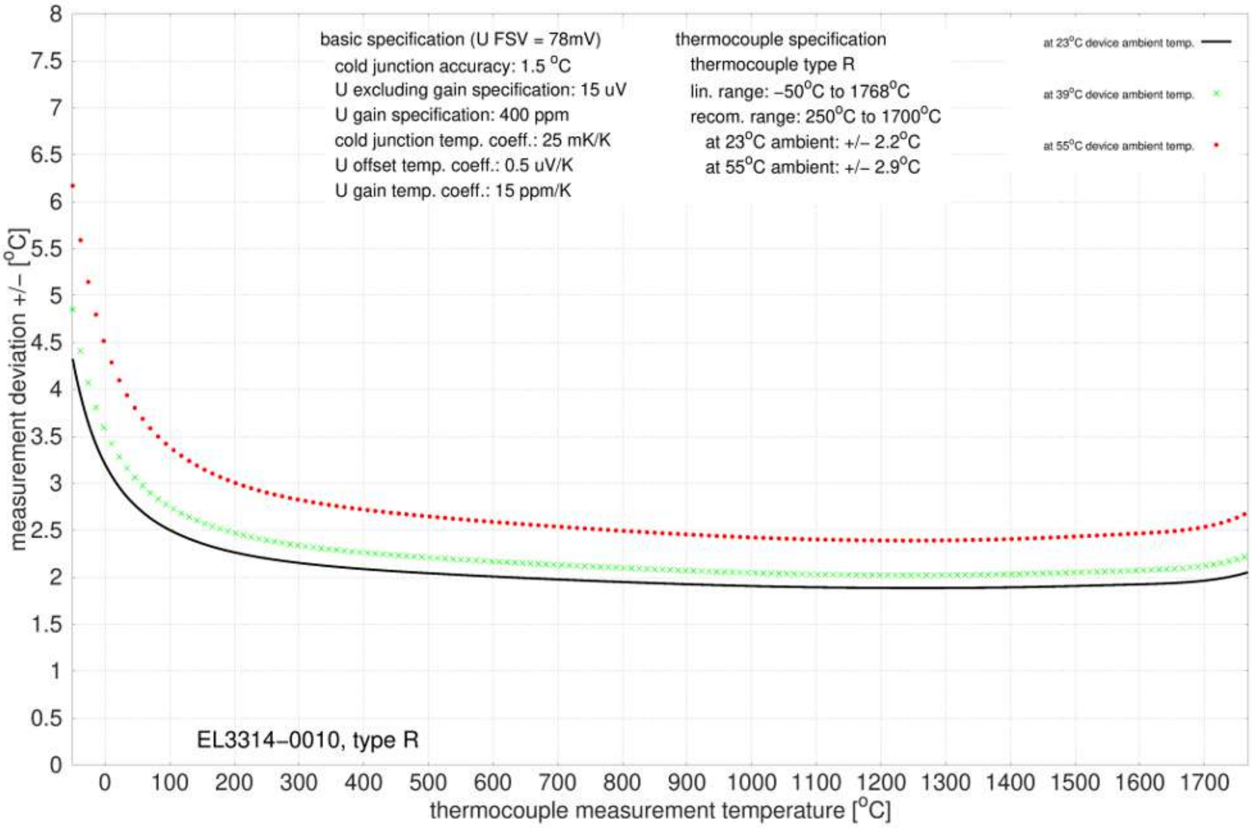
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.226 mV … +1768 °C ≈ 21.101 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

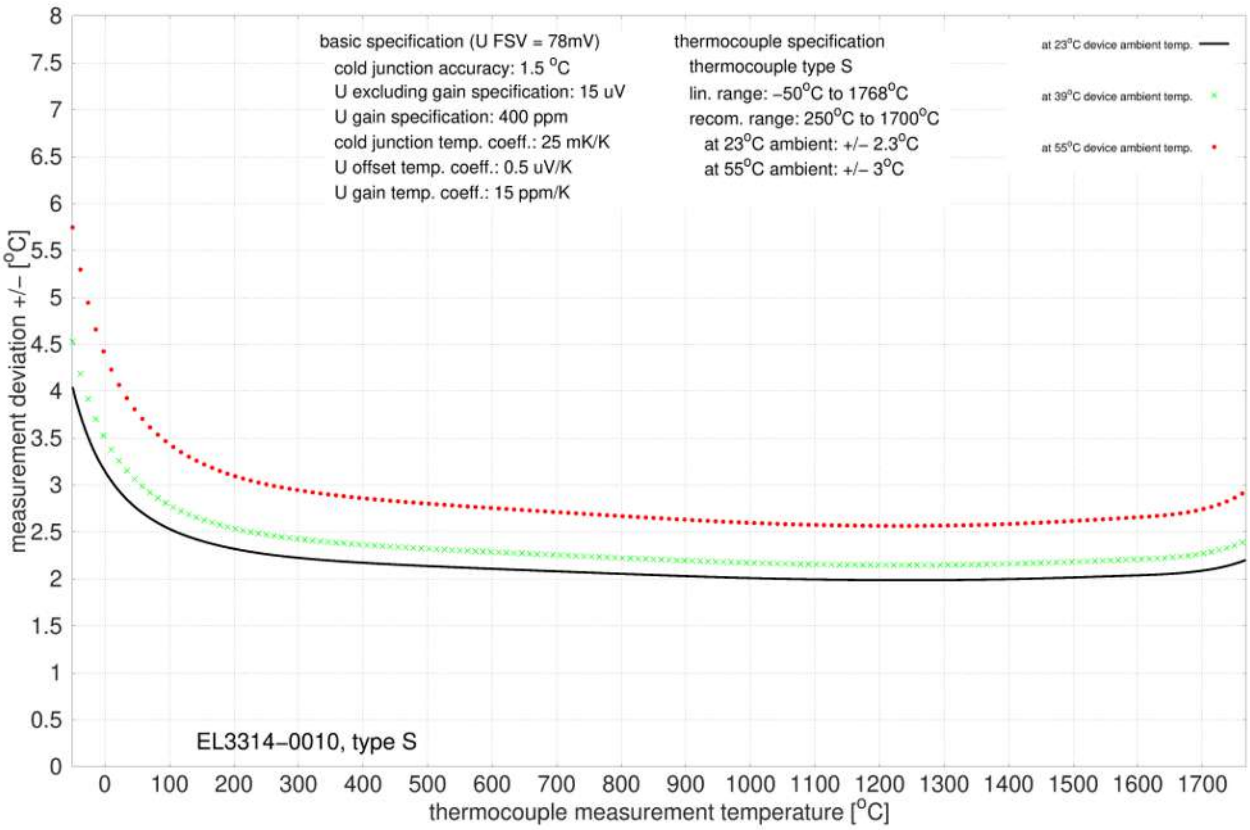
Measurement uncertainty for thermocouple type R:



### Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.236 mV … +1768 °C ≈ 18.693 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

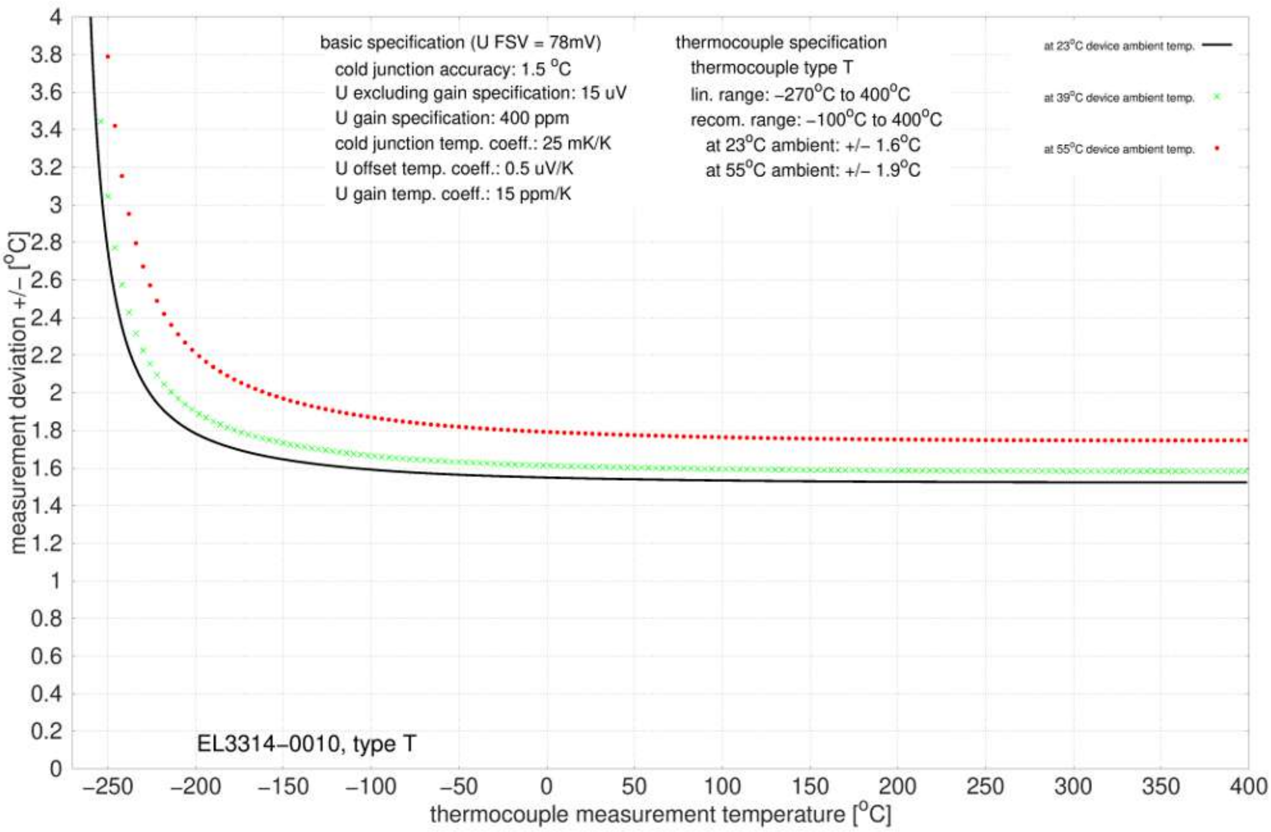
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.258 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

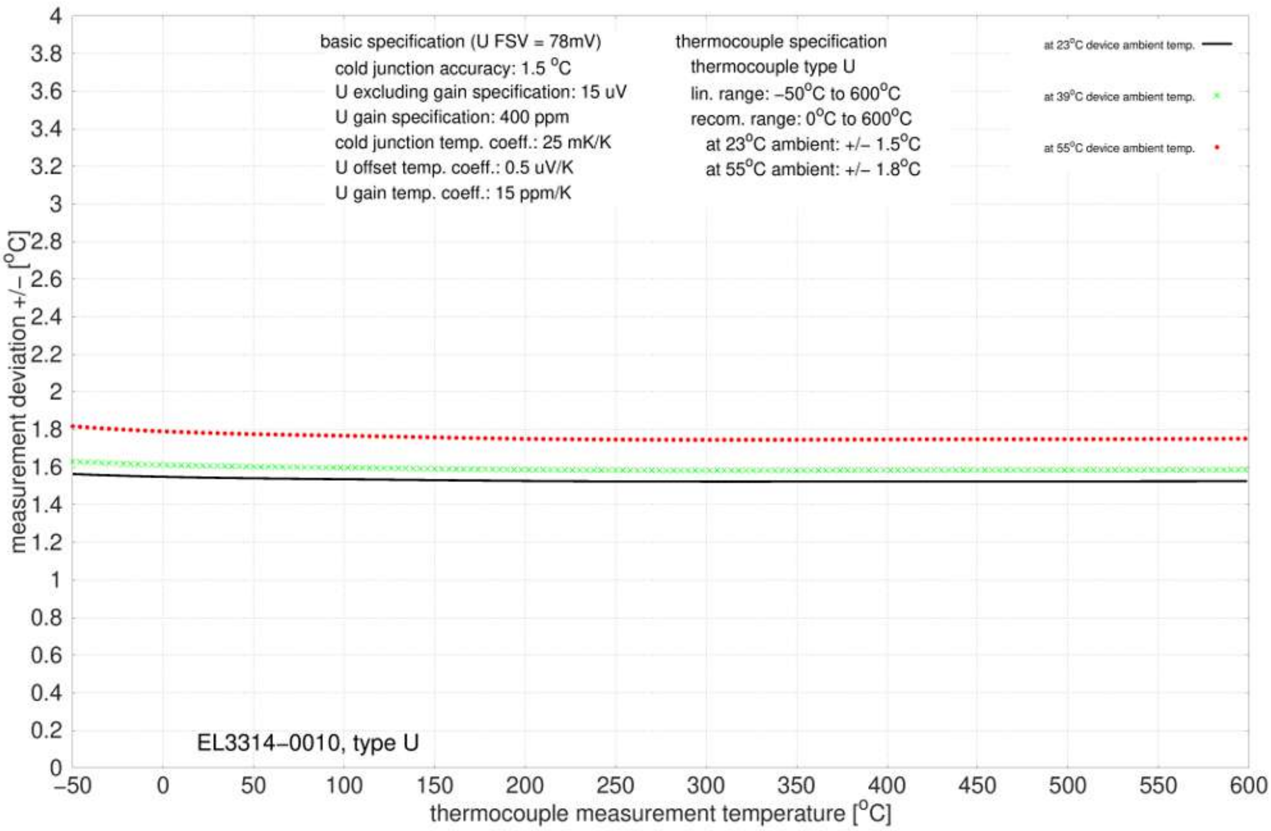
Measurement uncertainty for thermocouple type T:



**Specification - thermocouple type U**

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -1.850 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.5.3 Connection

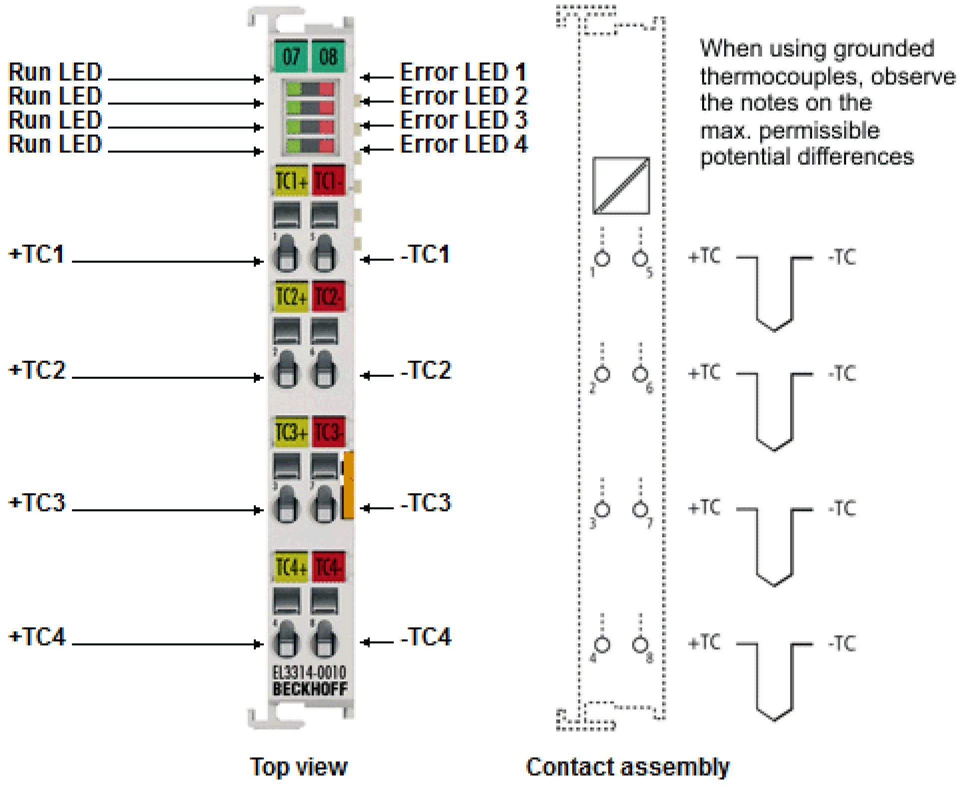



Fig. 13: EL3314-0010

**EL3314-0010 – Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.5.4 Display, diagnostics

**EL3314-0010 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP =** function for mailbox communication and different default settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP =** normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-4 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

## 2.6 EL3314-0020

### 2.6.1 Introduction

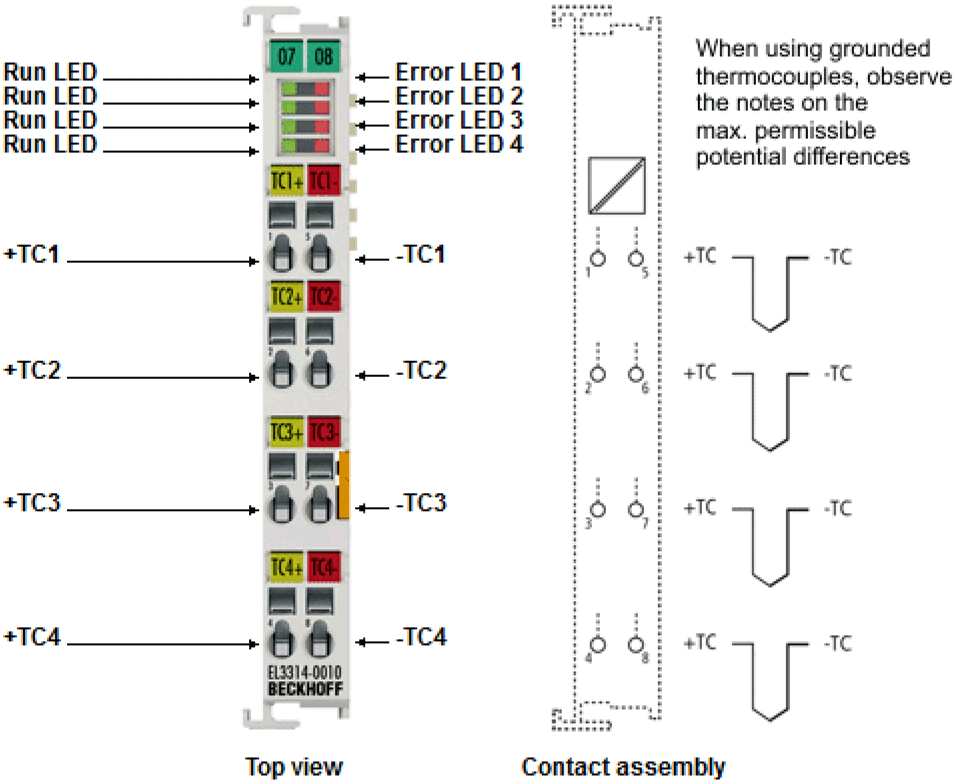



Fig. 14: EL3314-0020 (corresponds to EL3314-0010)

**High-precision 4 channel analog input terminal for thermocouples, with open-circuit recognition, with Beckhoff calibration certificate**

The EL3314-0020 analog input terminal is based on the EL3314-0010. It has the same characteristics. The EL3314-0020 is additionally supplied with a calibration certificate [▸ 201].

The EL3314-0010 analog Input Terminal enables direct connection of thermocouples. Compared with the standard EL3314 model, it offers significantly more precise temperature measurements thanks to improved measuring circuit and more precise cold junction measurement. Otherwise the EL3314-0010 or EL3314-0020 behaves similar to the EL3314.

For high-precision measurements please note the following:

- Before delivery the EL3314-0020 is calibrated against a high-precision reference voltage
- The terminal is set to 0.01°C/digit ("high resolution") as standard
- The assured accuracy applies to the following settings:
  - 50 Hz filter
  - 25 ± 5 °C ambient temperature
  - horizontal installation position
- In addition it has the following features
  - an additional software-based "MC filter" can be used for smoothing the measured value
  - external cold junction compensation (reference junction compensation is possible since FW03)
- We advise against the use of compensation wires, because they reduce the measuring accuracy of the EL3314-0020
- We recommend using thermocouples with suitable accuracy

**Quick links**


- EtherCAT basics
- Note on Beckhoff calibration certificates [▶ 201]
- Technology EL33xx [▶ 188]
- Process data [▶ 313]
- CoE object description and parameterization [▶ 360]

## 2.6.2 Technical data

### 2.6.2.1 General technical data

| Analog inputs | EL3314-0020 |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Type B, C, E, J, K, L, N, R, S, T, U (preset: type K), voltage measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 24-bit |
| Conversion time | approx. 1.6 s to 5 ms depending on configuration and filter setting;<br>Preset: approx. 110 ms at 50/ 60 Hz |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▸ 218] function | tbd |
| Special features | High-precision, calibration certificate [▸ 201] |

| Voltage measurement | EL3314-0020 |
|---|---|
| Measuring range, technically usable | approx. ± 80 mV |
| Measuring range, nominal | ± 78 mV |
| Resolution | 10 nV per digit |
| Measurement uncertainty | See Measurement ±78 mV [▸ 114] |

| Temperature measurement | EL3314-0020 |
|---|---|
| Electrical measuring range used | ± 78 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -270...+1000°C<br>Type J: -210...+1200 °C<br>Type K: -270…+1372 °C (preset)<br>Type L: -50...+900 °C<br>Type N: -270…+1300 °C<br>Type R: -50...+1768 °C<br>Type S: -50...+1768 °C<br>Type T: -270…+400 °C<br>Type U: -50...+600 °C |
| Resolution | Temperature display 0.1/0.01/0.001 °C per digit, preset 0.01 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 115] |

| Supply and potentials | | EL3314-0020 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3314-0020 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 24 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3314-0020 |
|---|---|
| Permissible temperature range during operation | 0 °C...+ 55 °C |
| Permissible temperature range during storage | -25 °C ... + 85 °C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314-0020 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | In order to ensure the increased measuring accuracy, the terminal must be installed in the prescribed installation position [▶ 234]! |

| Standards and approvals | EL3314-0020 |
|---|---|
| Protection class | IP20 |
| 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 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▶ 204]<br>cULus [▶ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

| Extended features | EL3314-0020 |
|---|---|
| Pluggable connection level | - |
| Electrical isolation | - |
| TwinSAFE SC | - |
| Calibration certificate [▶ 201] | yes (factory calibration certificate)<br>alternatively: EL3314-0030 (ISO17025 or DAkkS certificate) |

### 2.6.2.2 Measurement ±78 mV

**Specification ±78 mV**

| Measurement mode | | ±78 mV |
|---|---|---|
| Measuring range, nominal | | -78…+78 mV |
| Measuring range, end value (full scale value) | | 78 mV |
| PDO resolution | | 10 nV |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.06%$_{FSV}$ typ. |
| | @ 55 °C ambient temperature[1] | < ±0.13%$_{FSV}$ typ. |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±15 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 400 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 0.5 µV/K |
| | $Tk_{Offset}$ | < 15 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.6.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

**Specification of the internal cold junction measurement**

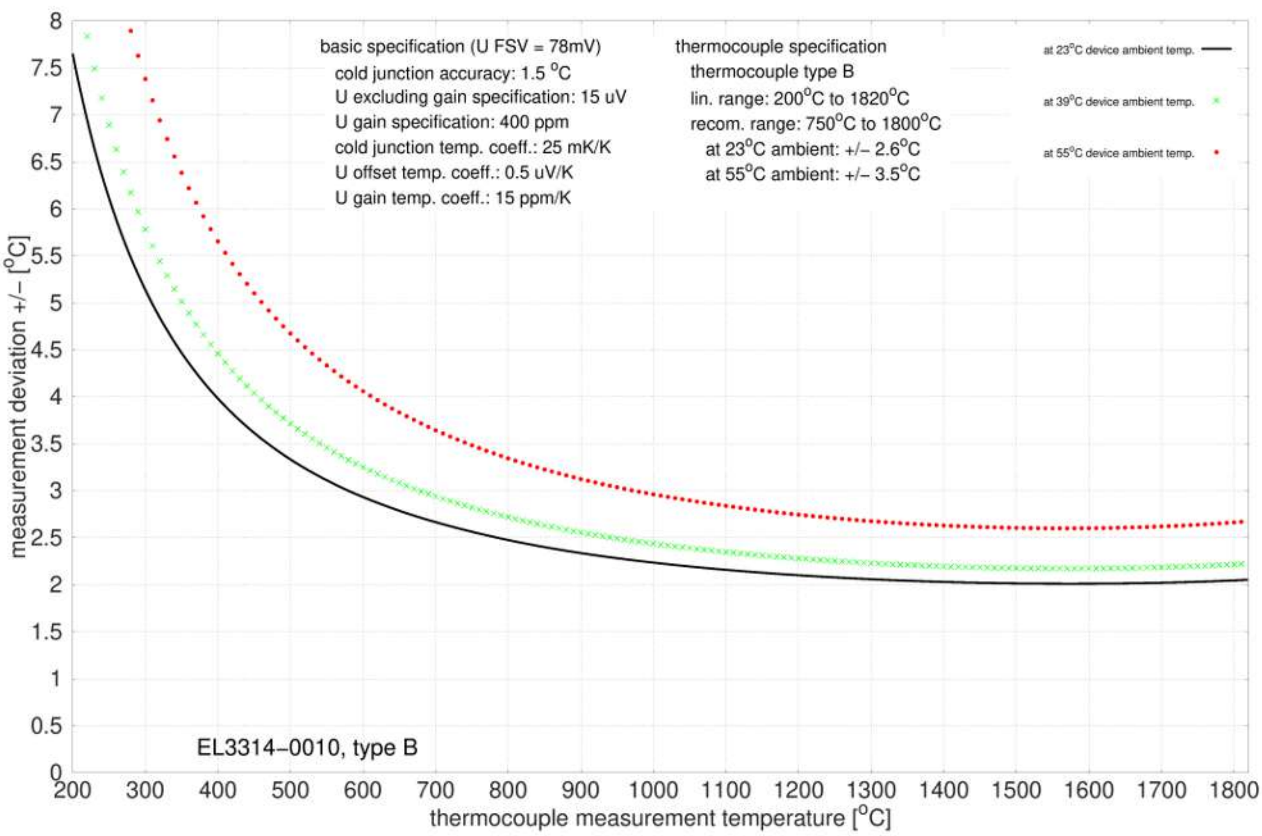
In the EL3314-0010, EL3314-0020 and EL3314-0030, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±1.5 °C |
| Temperature coefficient | Tk | < 25 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | +200 °C ≈ 0.178 mV … +1820 °C ≈ 13.820 mV |
| Measuring range, end value (full scale value) | | +1820 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.6 K ≈ ± 0.14 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.19 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

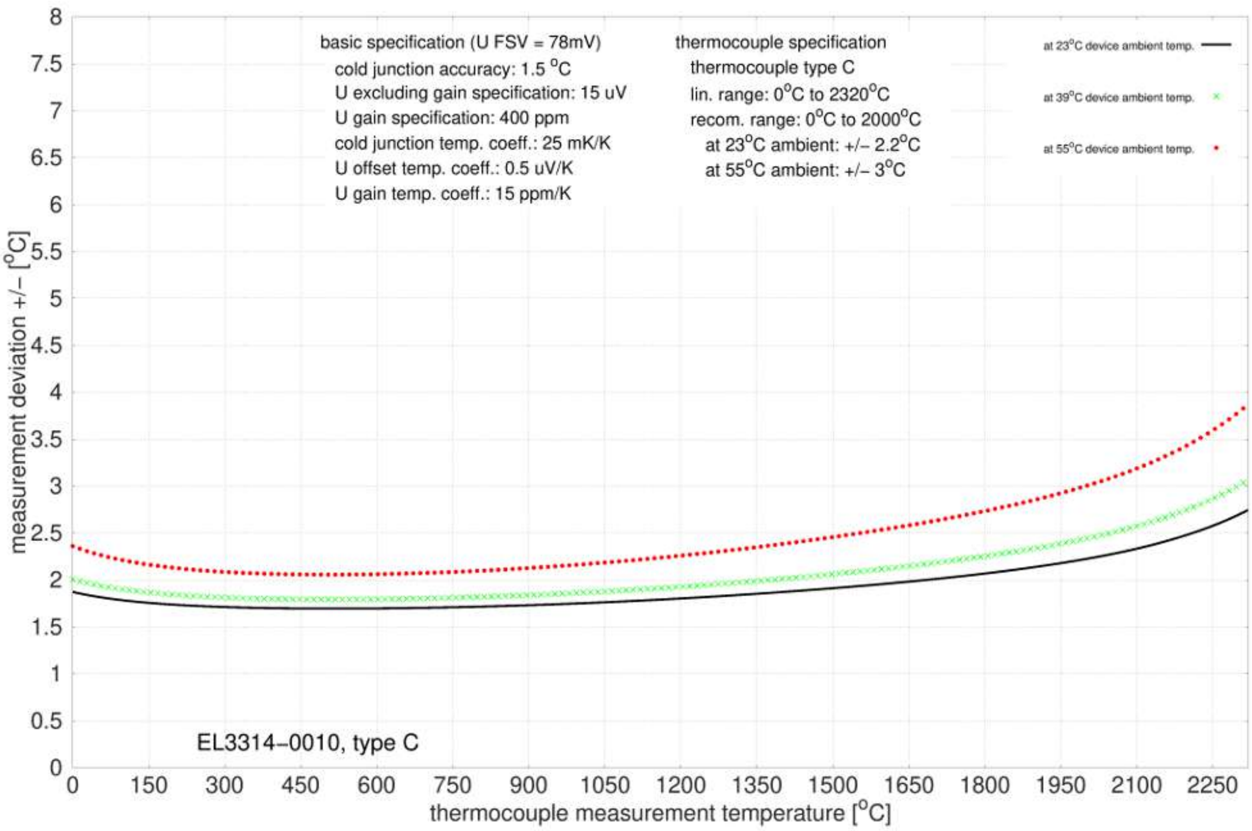
Measurement uncertainty for thermocouple type B:



## Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.10 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.13 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

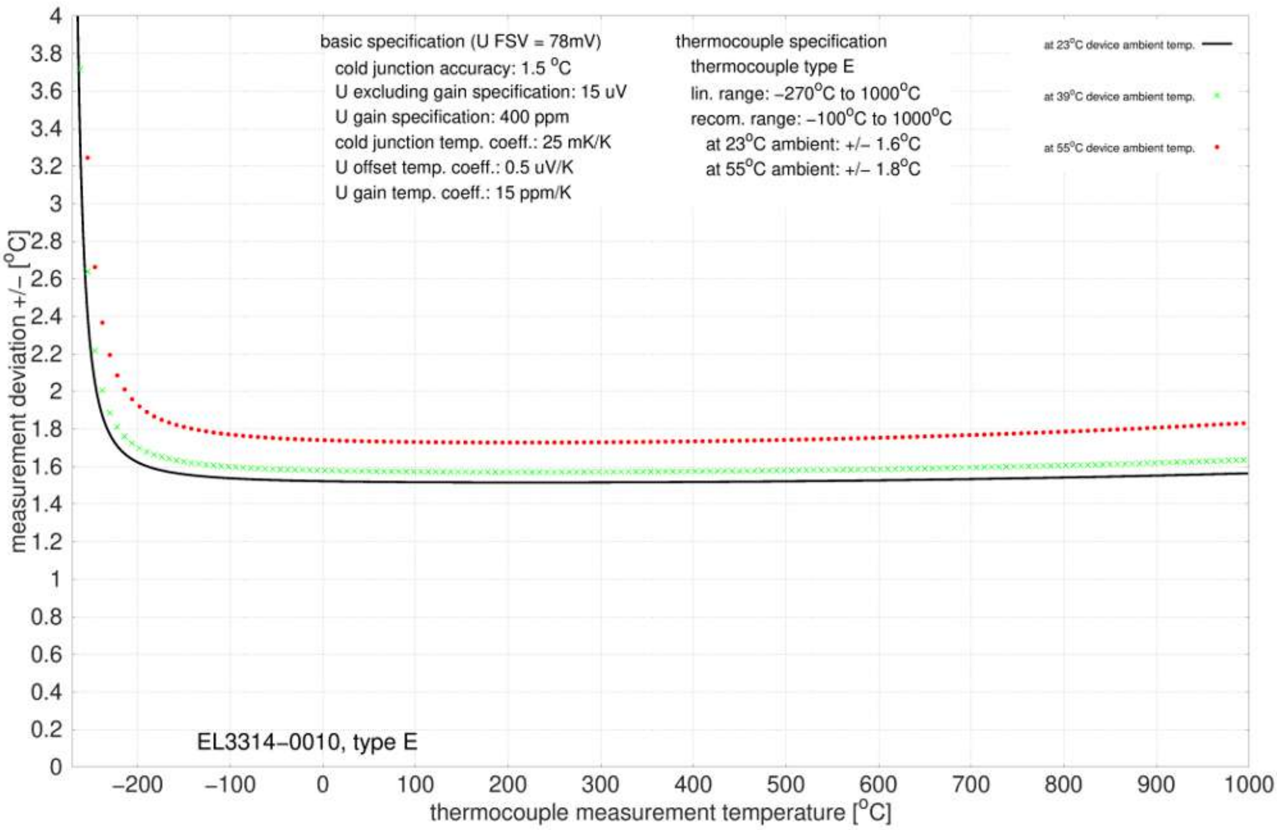
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -9.835 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.16 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.18 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

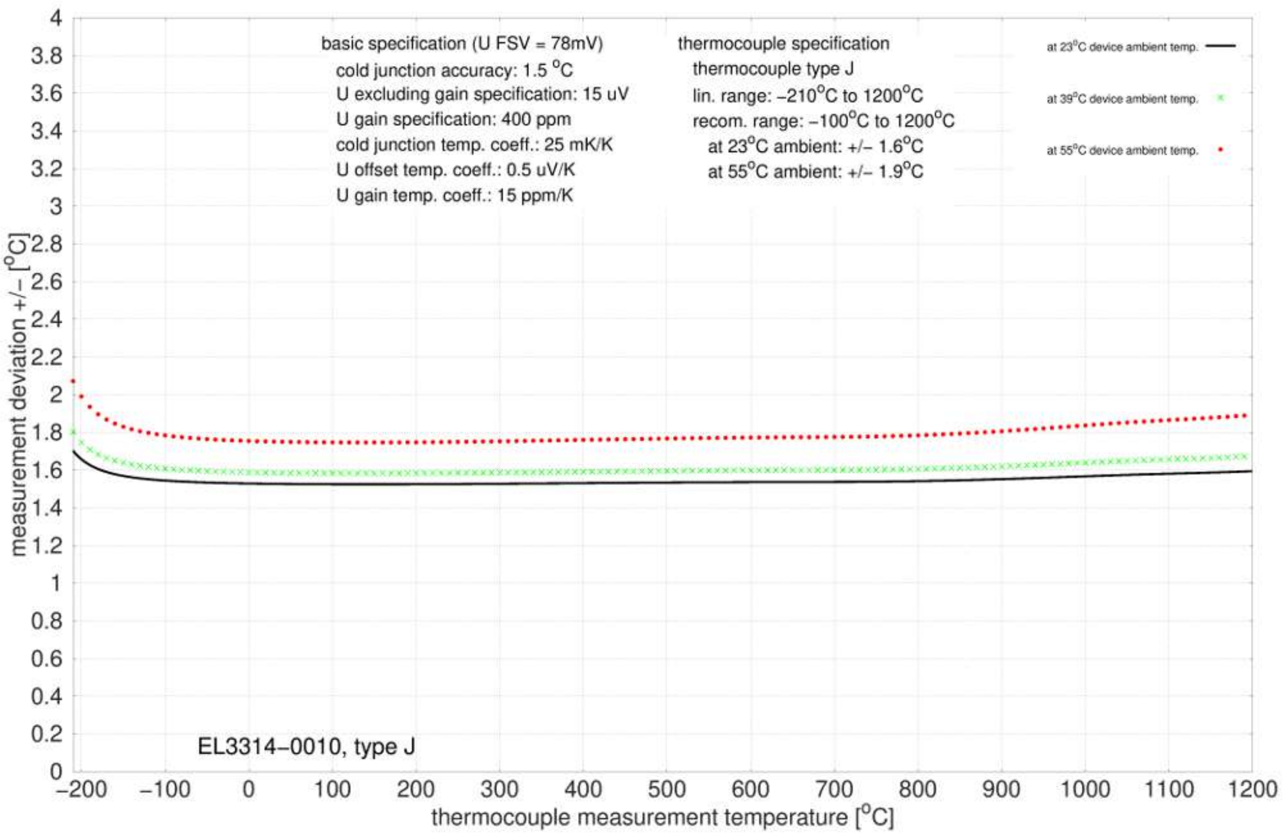
Measurement uncertainty for thermocouple type E:



## Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -210 °C ≈ -8.095 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

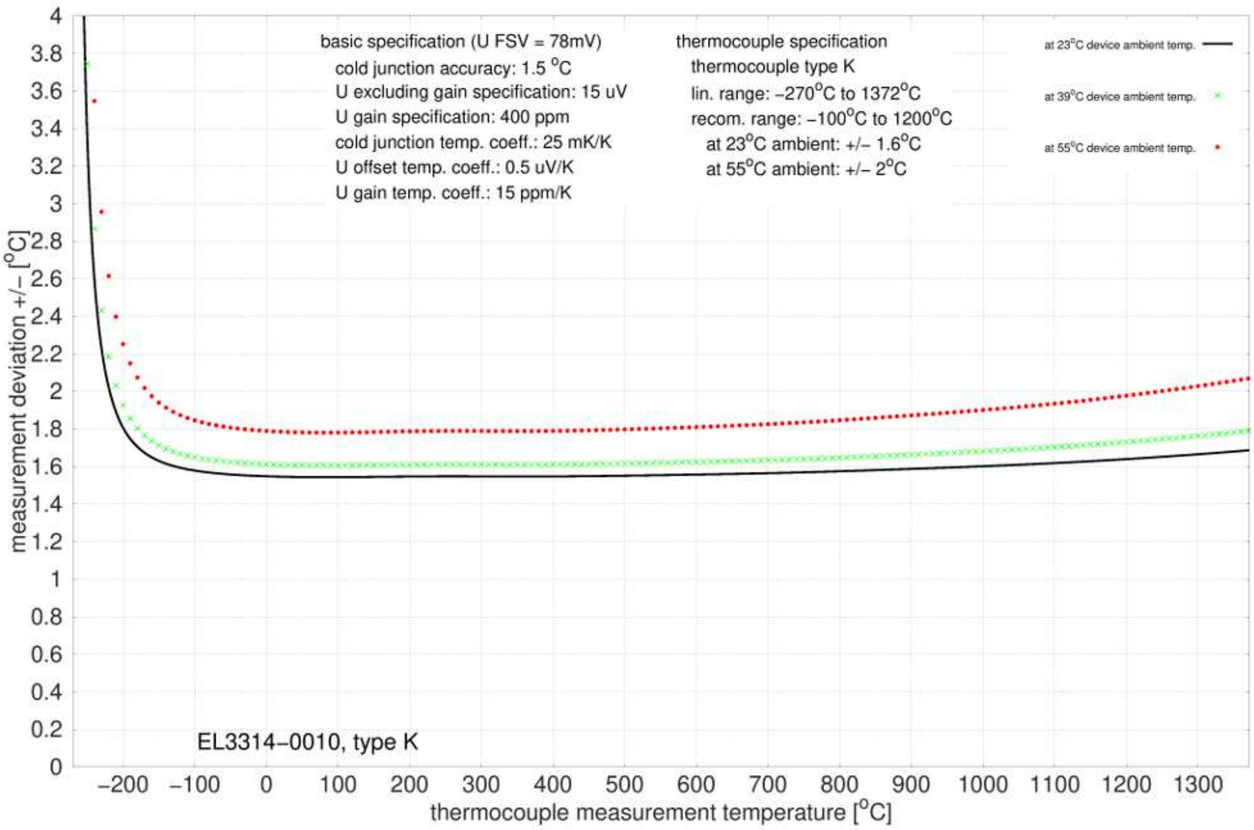
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.458 mV … +1372 °C ≈ 54.886 mV |
| Measuring range, end value (full scale value) | | +1372 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

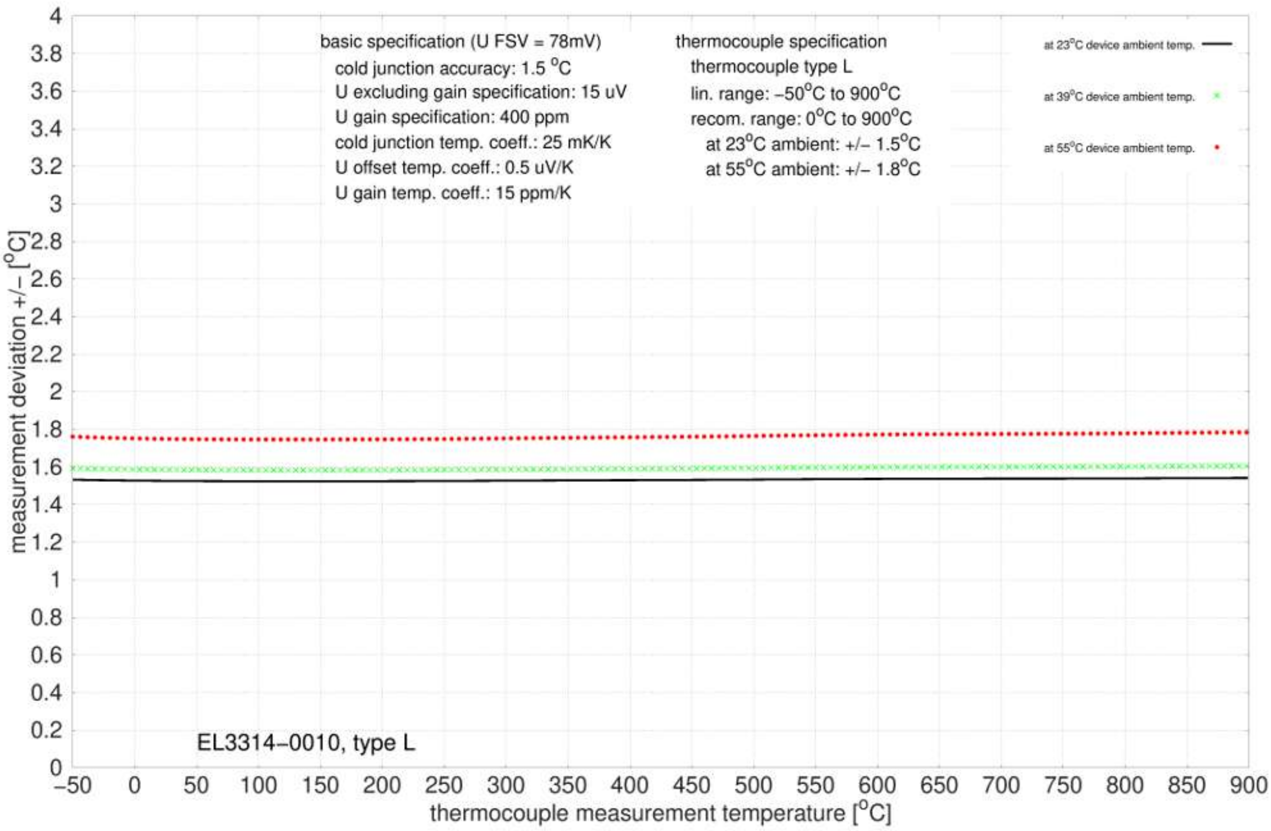
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -2.510 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.17 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.20 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

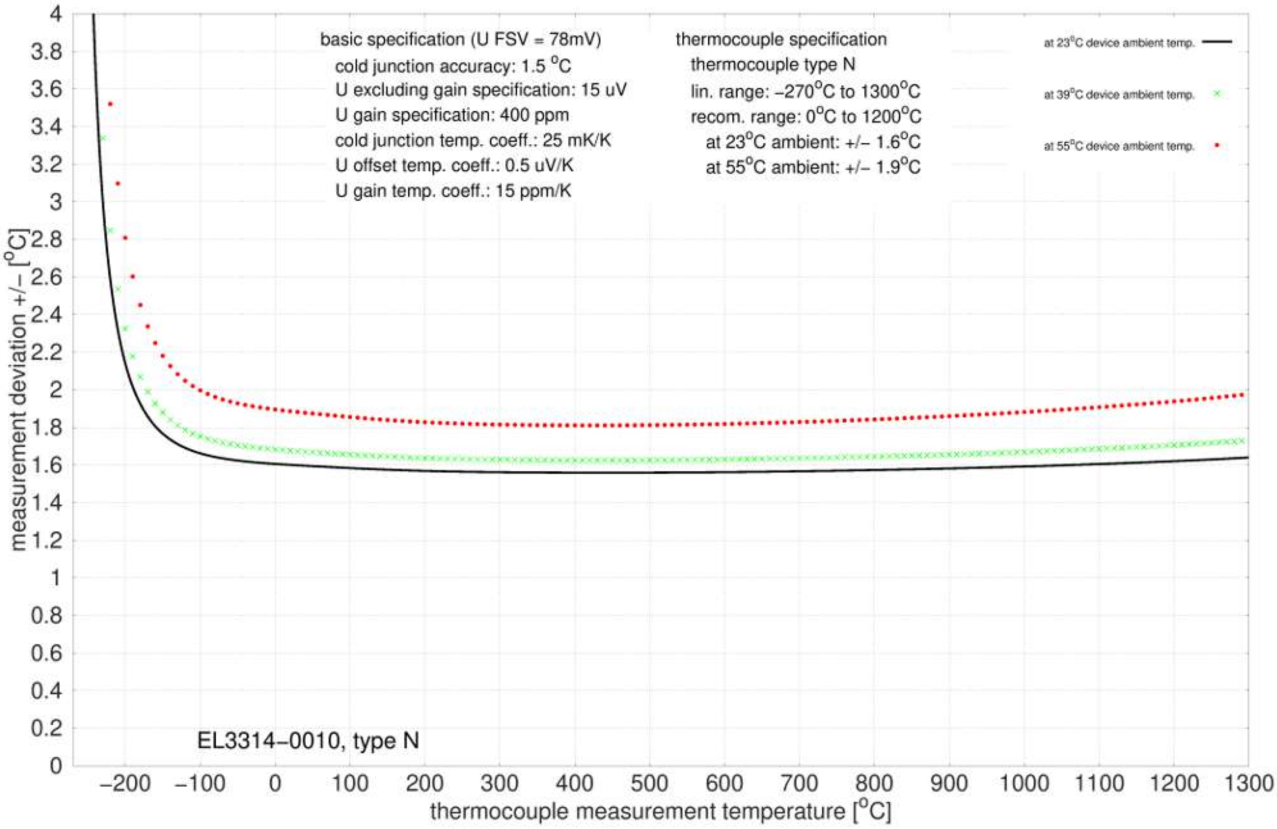
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -4.346 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

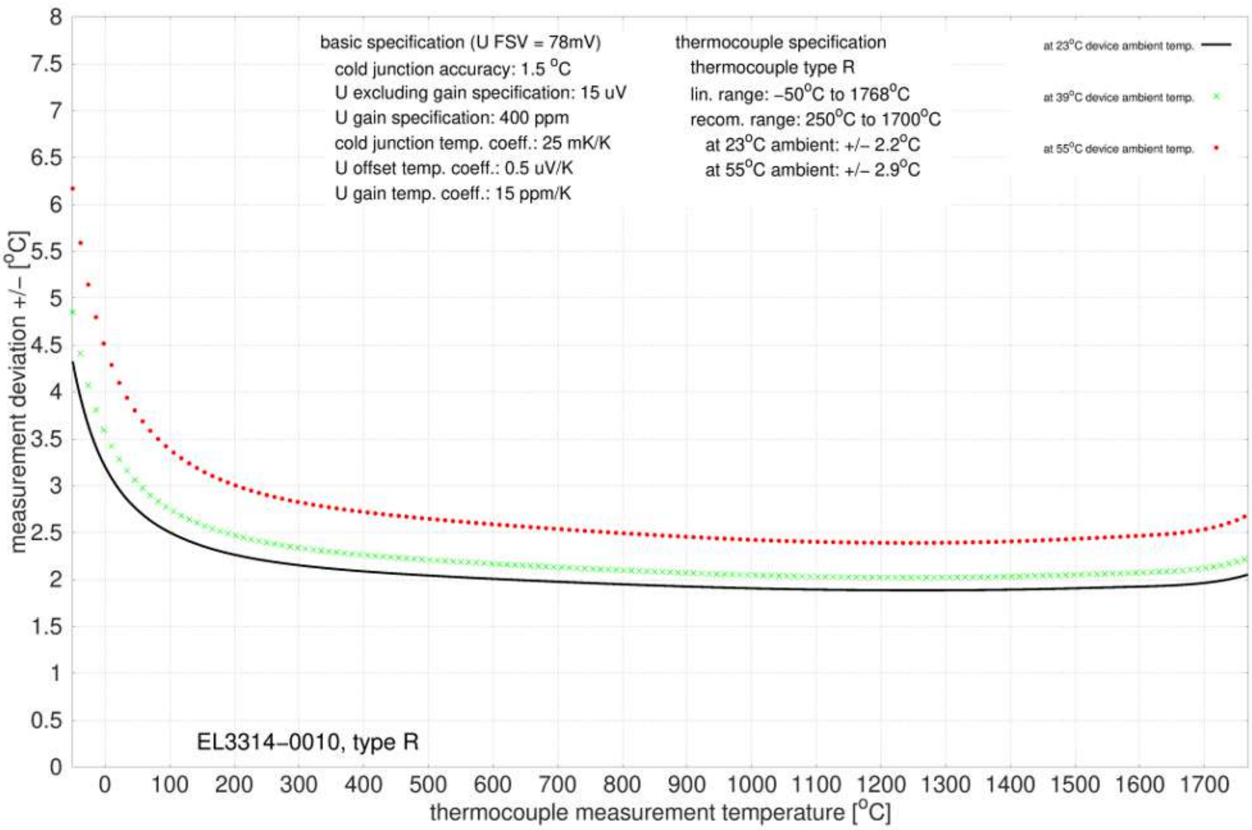
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.226 mV … +1768 °C ≈ 21.101 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

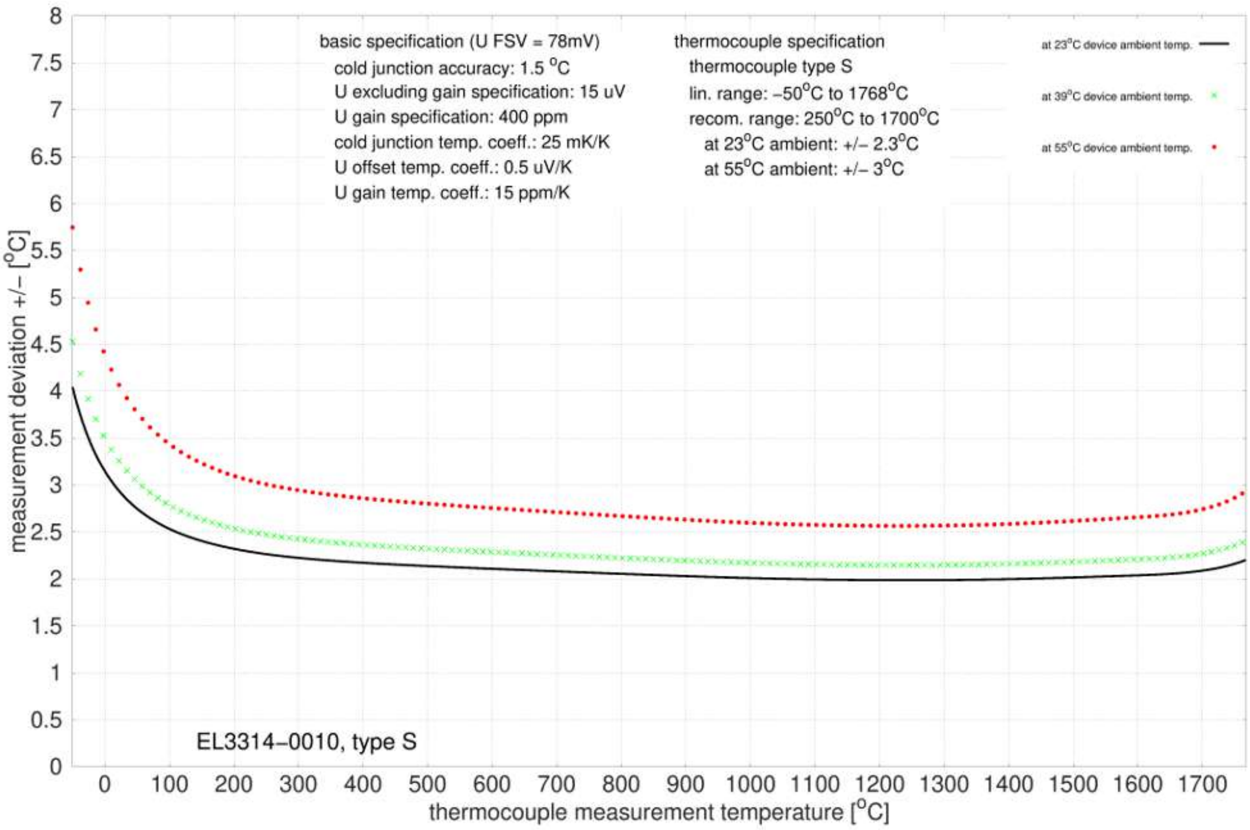
Measurement uncertainty for thermocouple type R:



## Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.236 mV … +1768 °C ≈ 18.693 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

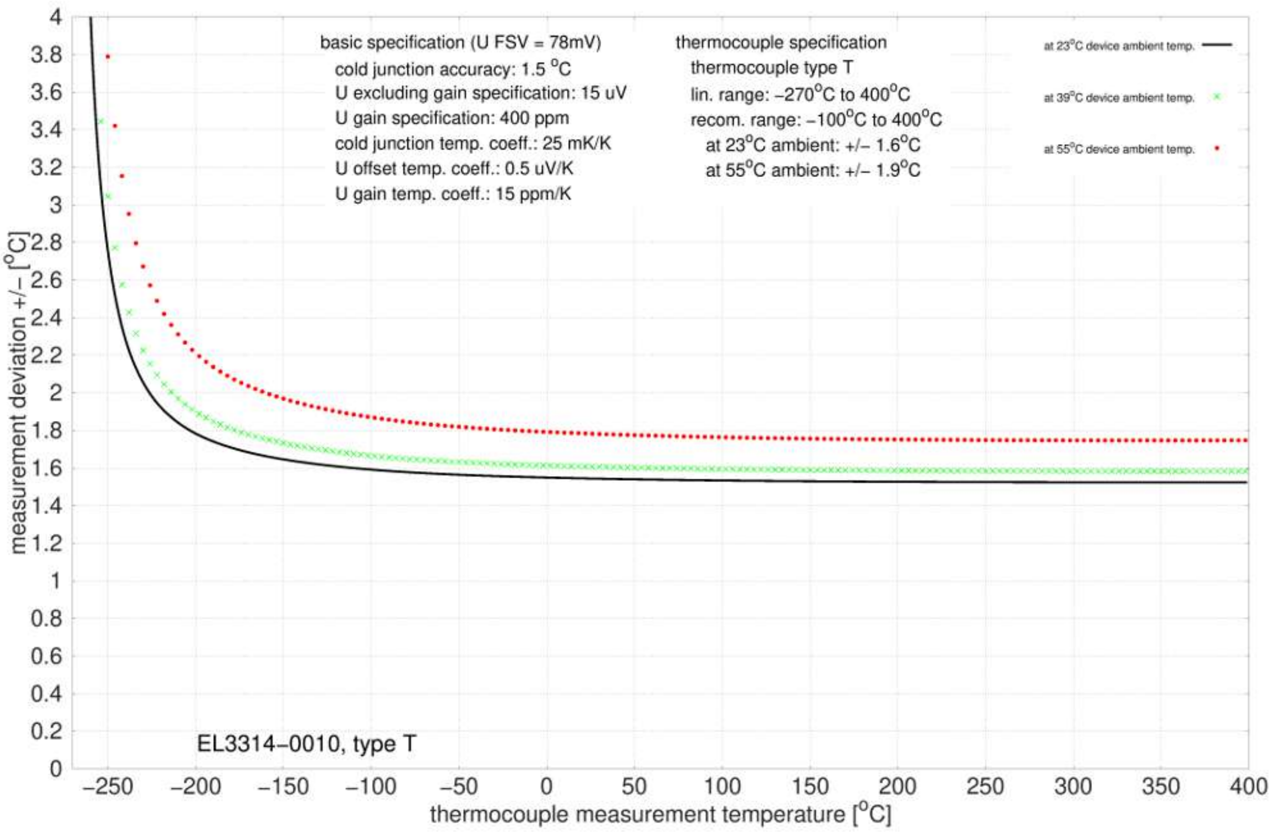
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.258 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

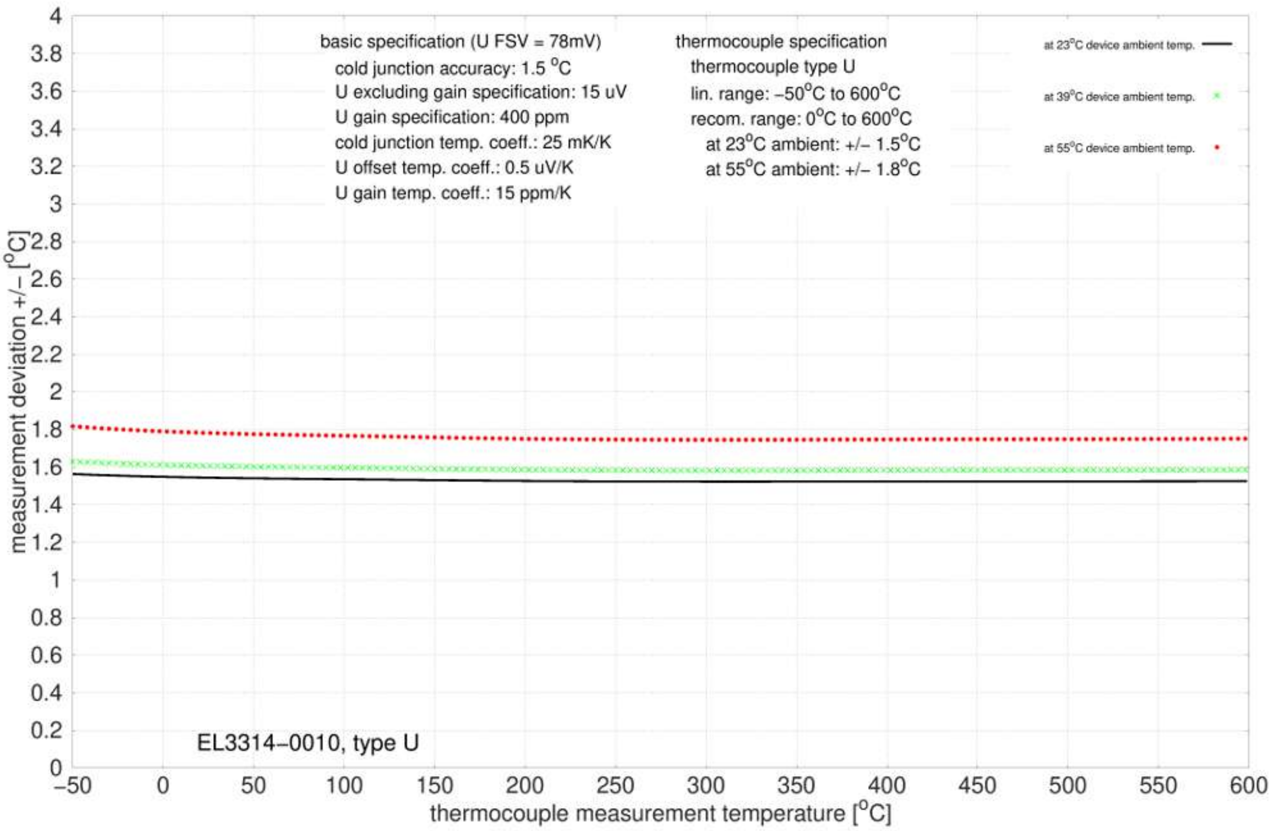
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -1.850 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



### 2.6.3 Connection

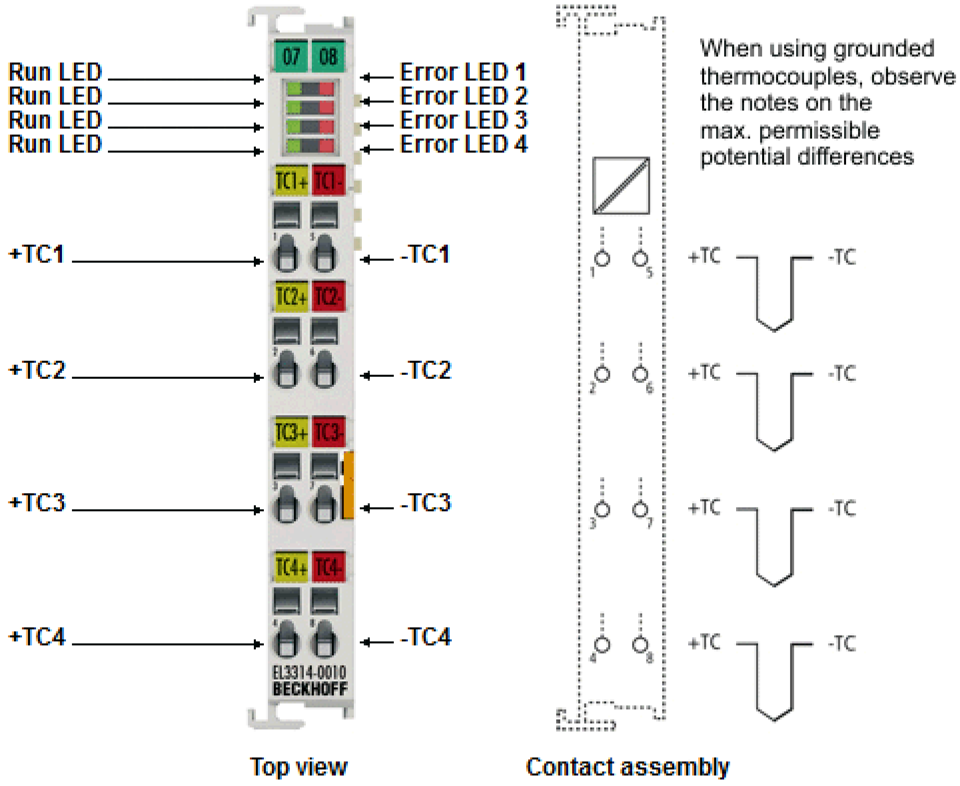



Fig. 15: EL3314-0020 (corresponds to EL3314-0010)

**EL3314 - Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.6.4 Display, diagnostics

**EL3314-0020 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-4 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

# 2.7 EL3314-0030

## 2.7.1 Introduction

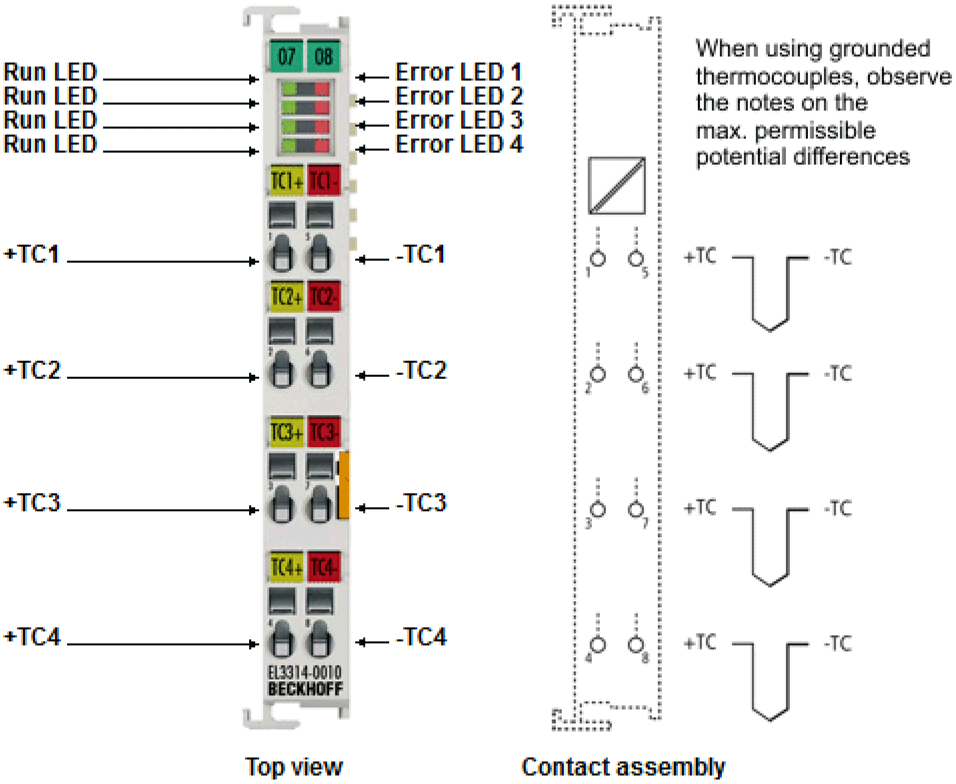



Fig. 16: EL3314-0030 (EL3314-0010)

**High-precision 4-channel analog input terminal for thermocouples, with open-circuit recognition, with external calibration certificate**

The EL3314-0030 analog input terminal is based on the EL3314-0010. It has the same characteristics. The EL3314-0030 is additionally supplied with an external calibration certificate.

The EL3314-0010 allows the direct connection of thermocouples. Compared with the standard EL3314 model, it offers significantly more precise temperature measurements thanks to improved measuring circuit and more precise cold junction measurement. Otherwise the EL3314-0030 behaves similar to the EL3314.

For high-precision measurements please note the following:

- Before delivery the EL3314-0030 is calibrated against a high-precision reference voltage
- The terminal is set to 0.01°C/digit ("high resolution") as standard
- The assured accuracy applies to the following settings
  - 50 Hz filter
  - 23 ± 5 °C ambient temperature
  - horizontal installation position
- In addition it has the following features
  - an additional software-based "MC filter" can be used for smoothing the measured value
  - external cold junction compensation is possible (cold junction compensation, from FW03)
- We advise against the use of compensation wires, because they reduce the measuring accuracy of the EL3314-0030
- We recommend using thermocouples with suitable accuracy

**Quick links**


• EtherCAT basics

• Note on Beckhoff calibration certificates [▶ 201]

• Technology EL33xx [▶ 188]

• Process data and operation modes [▶ 313]

• CoE object description and parameterization [▶ 360]

## 2.7.2 Technical data

### 2.7.2.1 General technical data

| **Analog inputs** | **EL3314-0030** |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Type B, C, E, J, K, L, N, R, S, T, U (preset: type K), voltage measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 24-bit |
| Conversion time | approx. 1.6 s to 5 ms depending on configuration and filter setting;<br>Preset: approx. 110 ms at 50/ 60 Hz |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▶ 218] function | tbd |
| Special features | High-precision, calibration certificate [▶ 201] |

| **Voltage measurement** | **EL3314-0030** |
|---|---|
| Measuring range, technically usable | approx. ± 80 mV |
| Measuring range, nominal | ± 78 mV |
| Resolution | 10 nV per digit |
| Measurement uncertainty | See Measurement ±78 mV [▶ 133] |

| **Temperature measurement** | **EL3314-0030** |
|---|---|
| Electrical measuring range used | ± 78 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -270...+1000°C<br>Type J: -210...+1200 °C<br>Type K: -270…+1372 °C (preset)<br>Type L: -50...+900 °C<br>Type N: -270…+1300 °C<br>Type R: -50...+1768 °C<br>Type S: -50...+1768 °C<br>Type T: -270…+400 °C<br>Type U: -50...+600 °C |
| Resolution | Temperature display 0.1/0.01/0.001 °C per digit, preset 0.01 °C |
| Measurement uncertainty | See Thermocouples measurement [▶ 134] |

| Supply and potentials | | EL3314-0030 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3314-0030 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 24 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3314-0030 |
|---|---|
| Permissible temperature range during operation | 0 °C...+ 55 °C |
| Permissible temperature range during storage | -25 °C ... + 85 °C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314-0030 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▸ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | In order to ensure the increased measuring accuracy, the terminal must be installed in the prescribed installation position [▸ 234]! |

| Standards and approvals | EL3314-0030 |
|---|---|
| Protection class | IP20 |
| 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 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▸ 204]<br>cULus [▸ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

| Extended features | EL3314-0030 |
|---|---|
| Pluggable connection level | - |
| Electrical isolation | - |
| TwinSAFE SC | - |
| Calibration certificate [▸ 201] | Yes (DAkkS or ISO17025) |

## 2.7.2.2 Measurement ±78 mV

### Specification ±78 mV

| Measurement mode | | ±78 mV |
|---|---|---|
| Measuring range, nominal | | -78…+78 mV |
| Measuring range, end value (full scale value) | | 78 mV |
| PDO resolution | | 10 nV |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.06%$_{FSV}$ typ. |
| | @ 55 °C ambient temperature[1] | < ±0.13%$_{FSV}$ typ. |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±15 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 400 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 0.5 µV/K |
| | $Tk_{Offset}$ | < 15 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

## 2.7.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

### Specification of the internal cold junction measurement

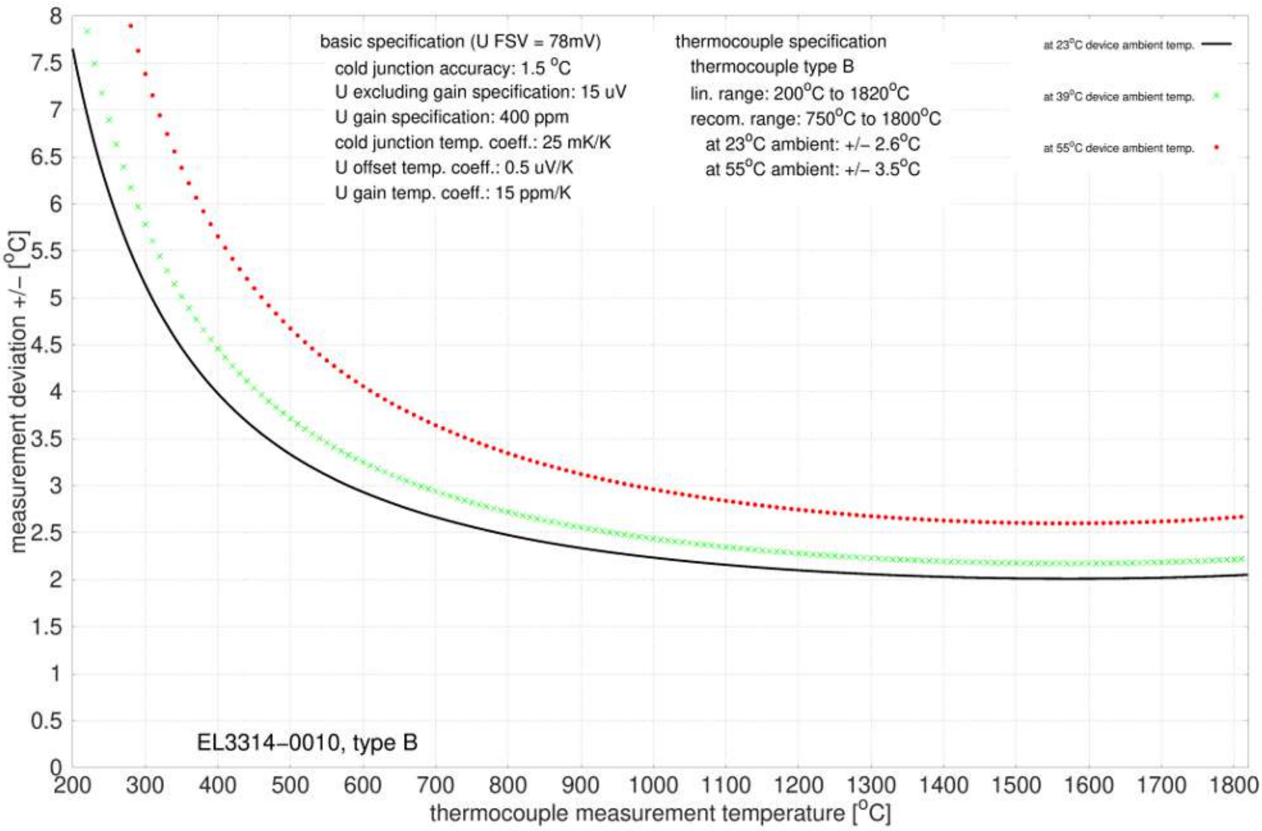
In the EL3314-0010, EL3314-0020 and EL3314-0030, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±1.5 °C |
| Temperature coefficient | Tk | < 25 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | +200 °C ≈ 0.178 mV … +1820 °C ≈ 13.820 mV |
| Measuring range, end value (full scale value) | | +1820 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.6 K ≈ ± 0.14 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.19 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

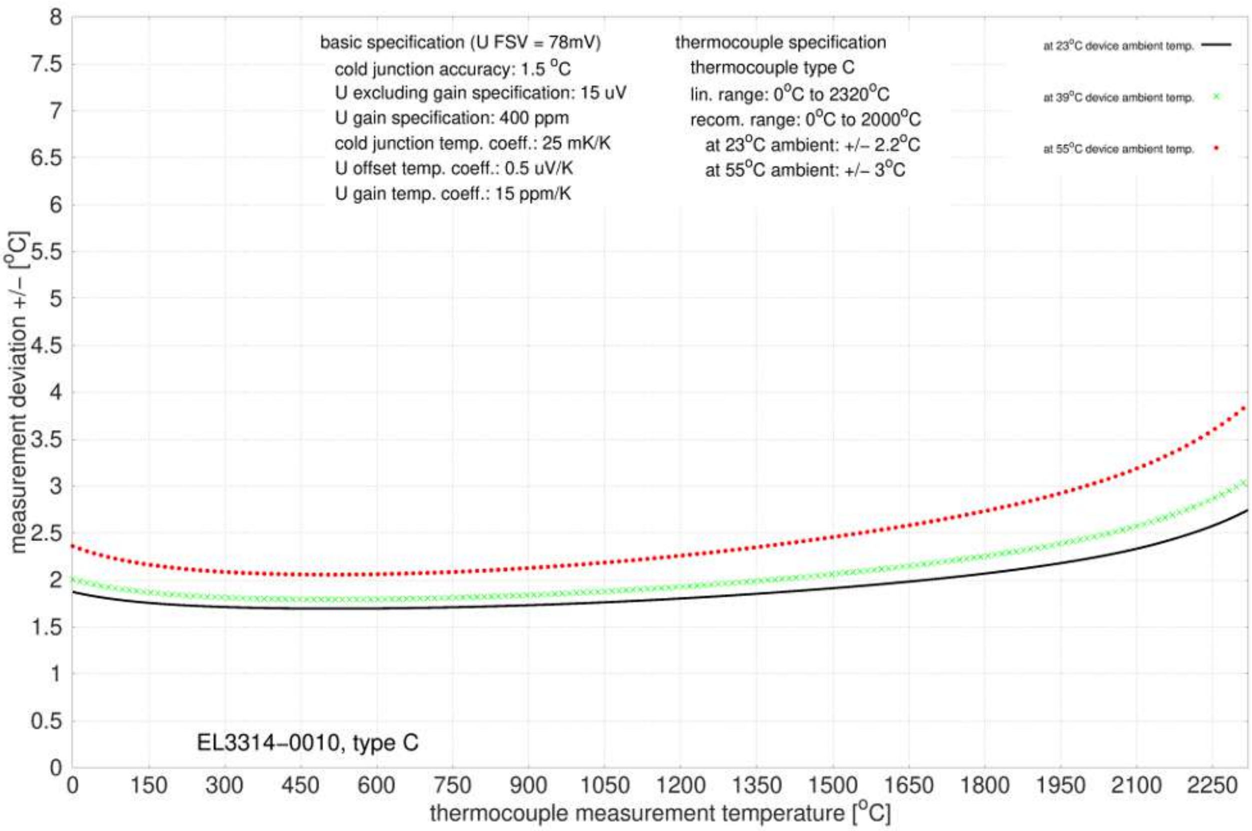
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.10 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.13 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

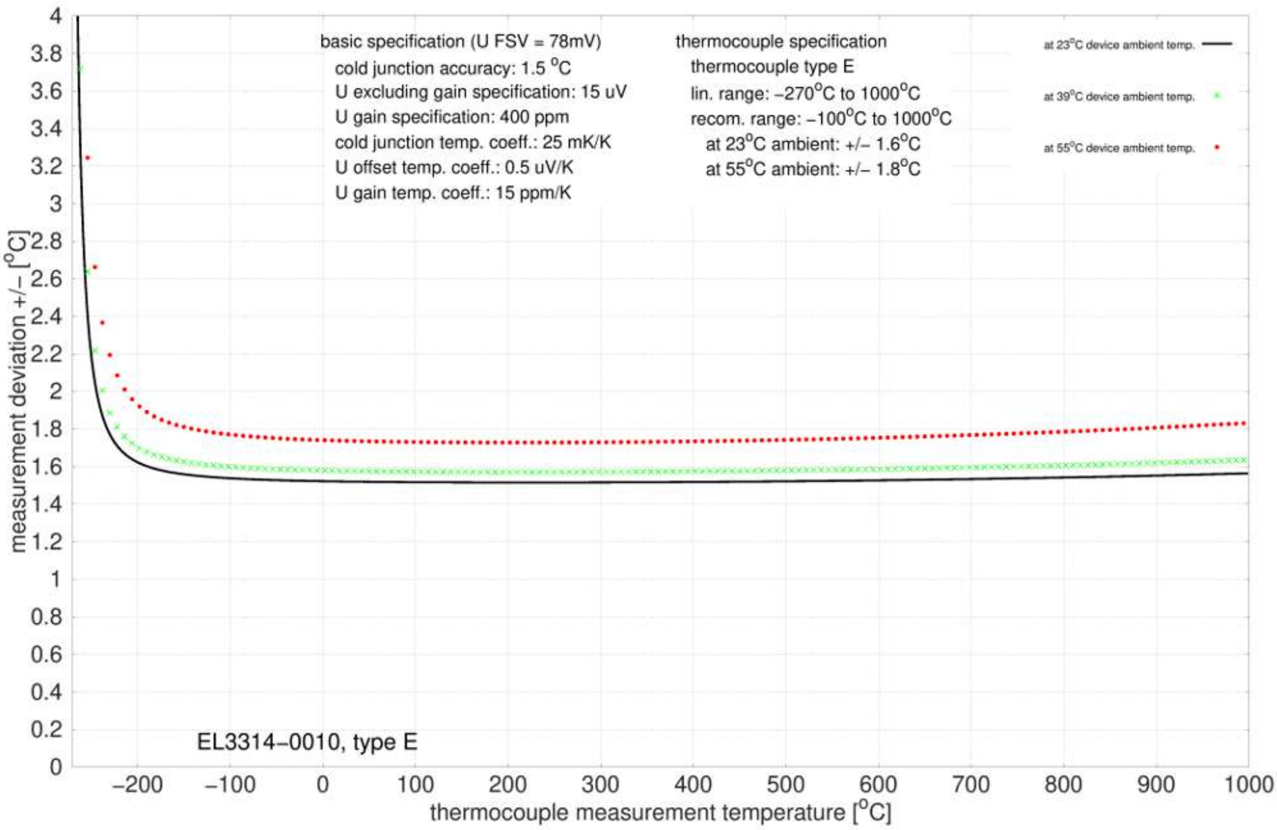
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -9.835 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.16 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.18 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

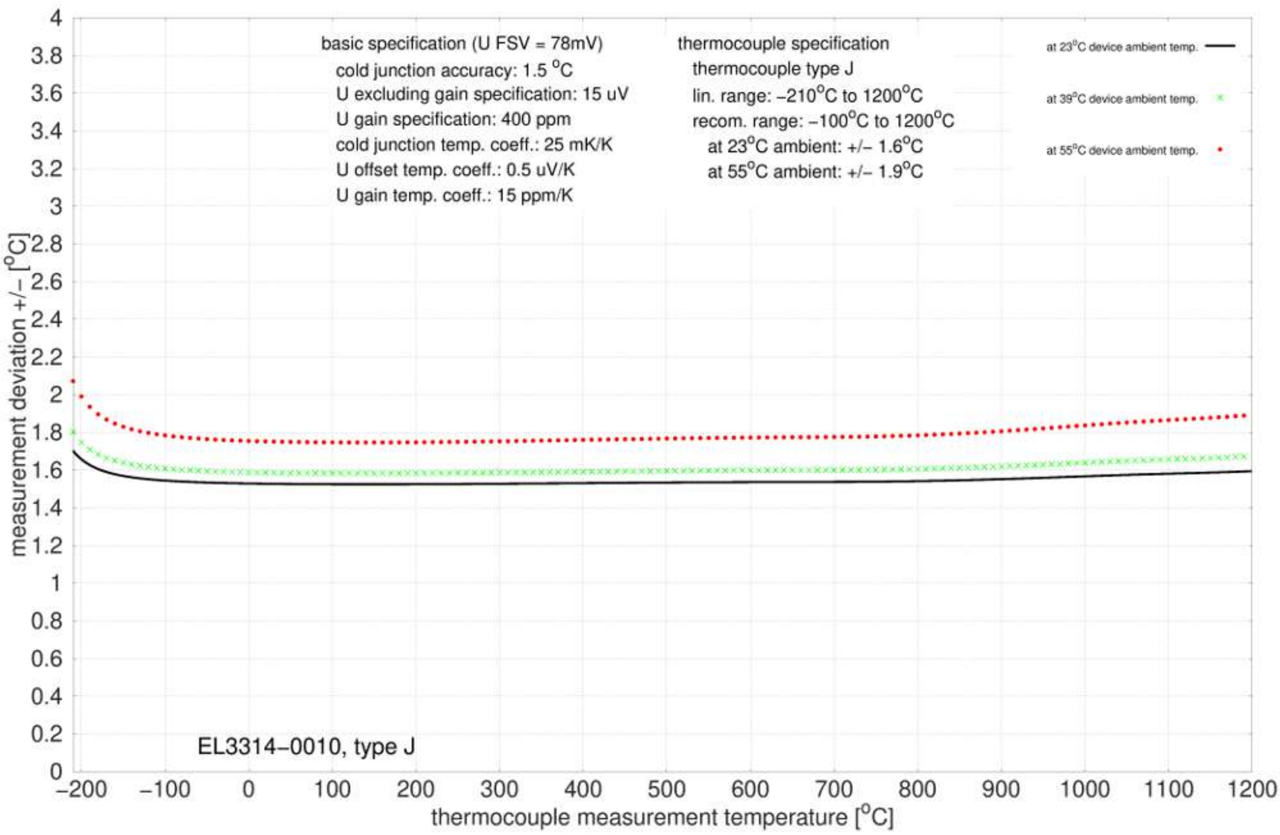
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -210 °C ≈ -8.095 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.16 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

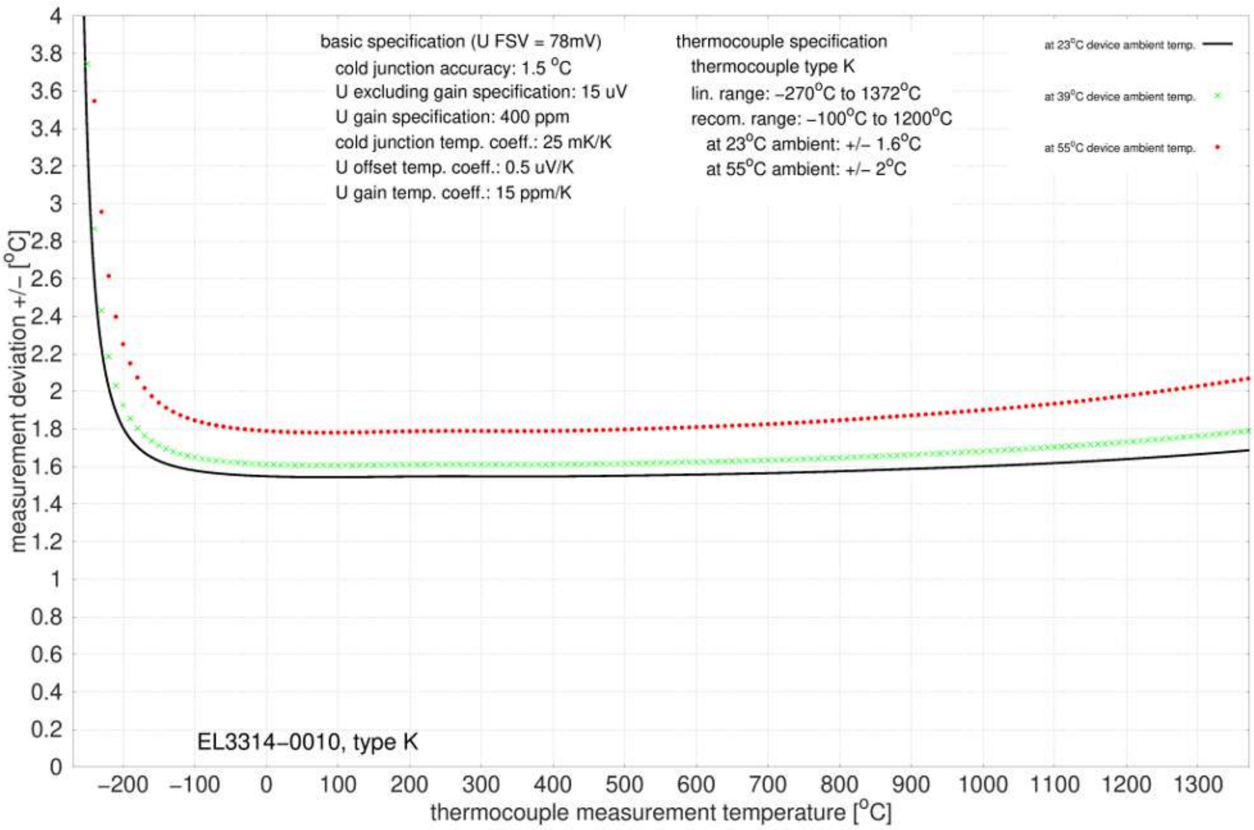
Measurement uncertainty for thermocouple type J:



## Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.458 mV … +1372 °C ≈ 54.886 mV |
| Measuring range, end value (full scale value) | | +1372 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.0 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

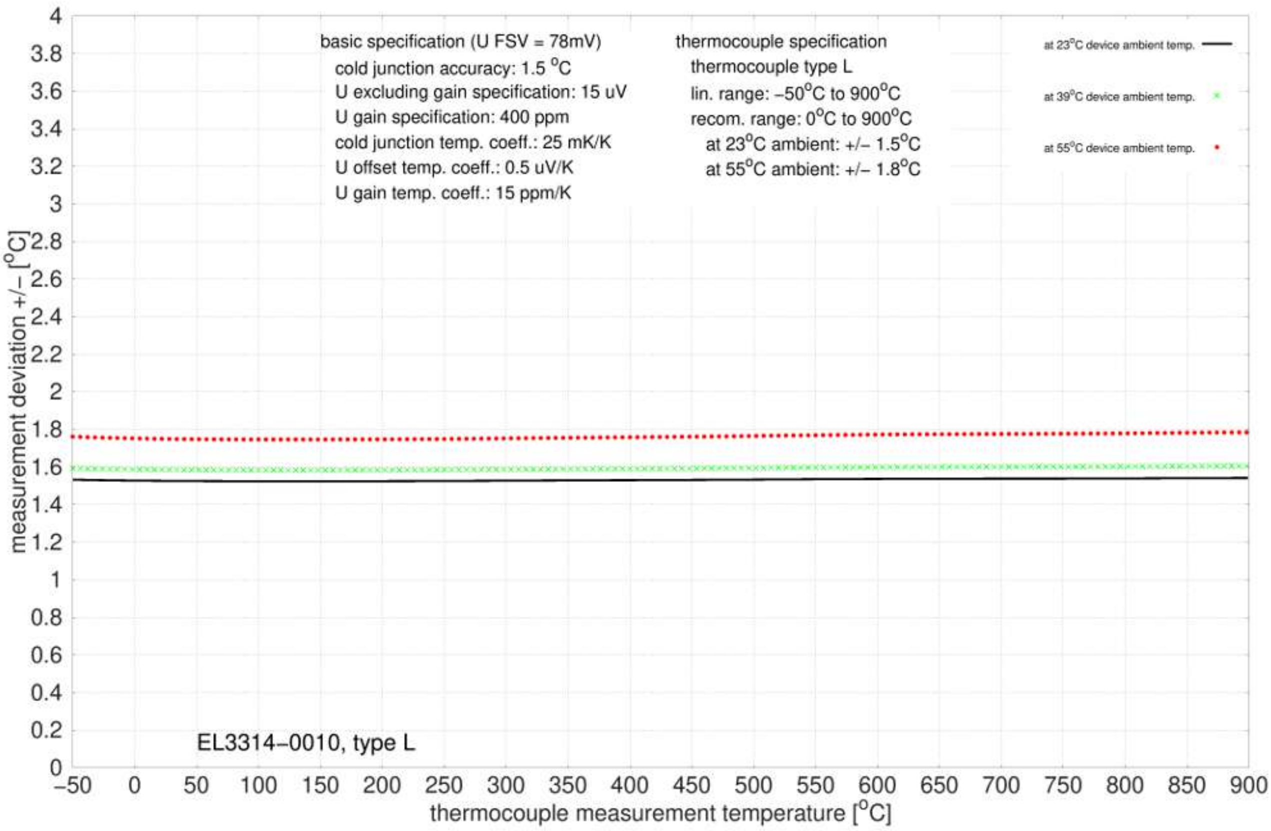
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -2.510 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.17 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.20 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

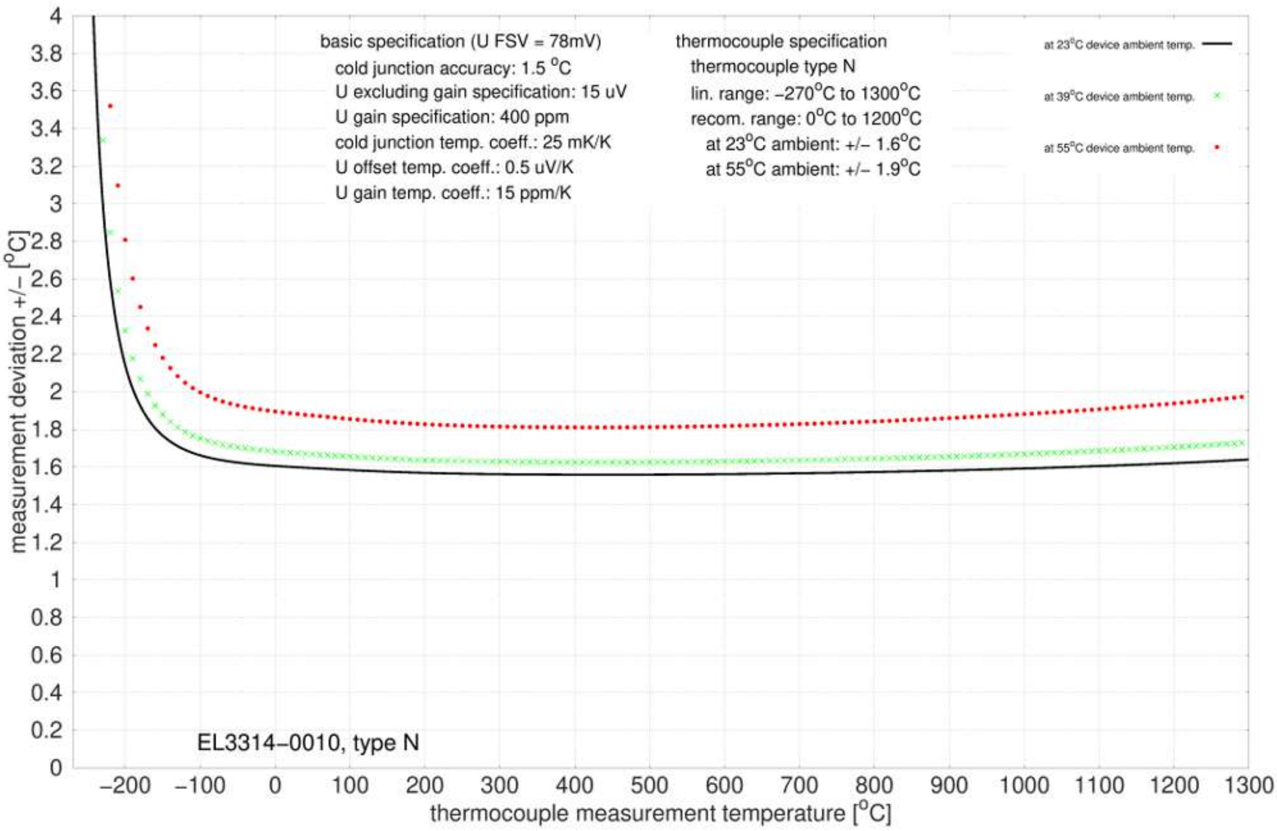
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -4.346 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.12 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.15 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

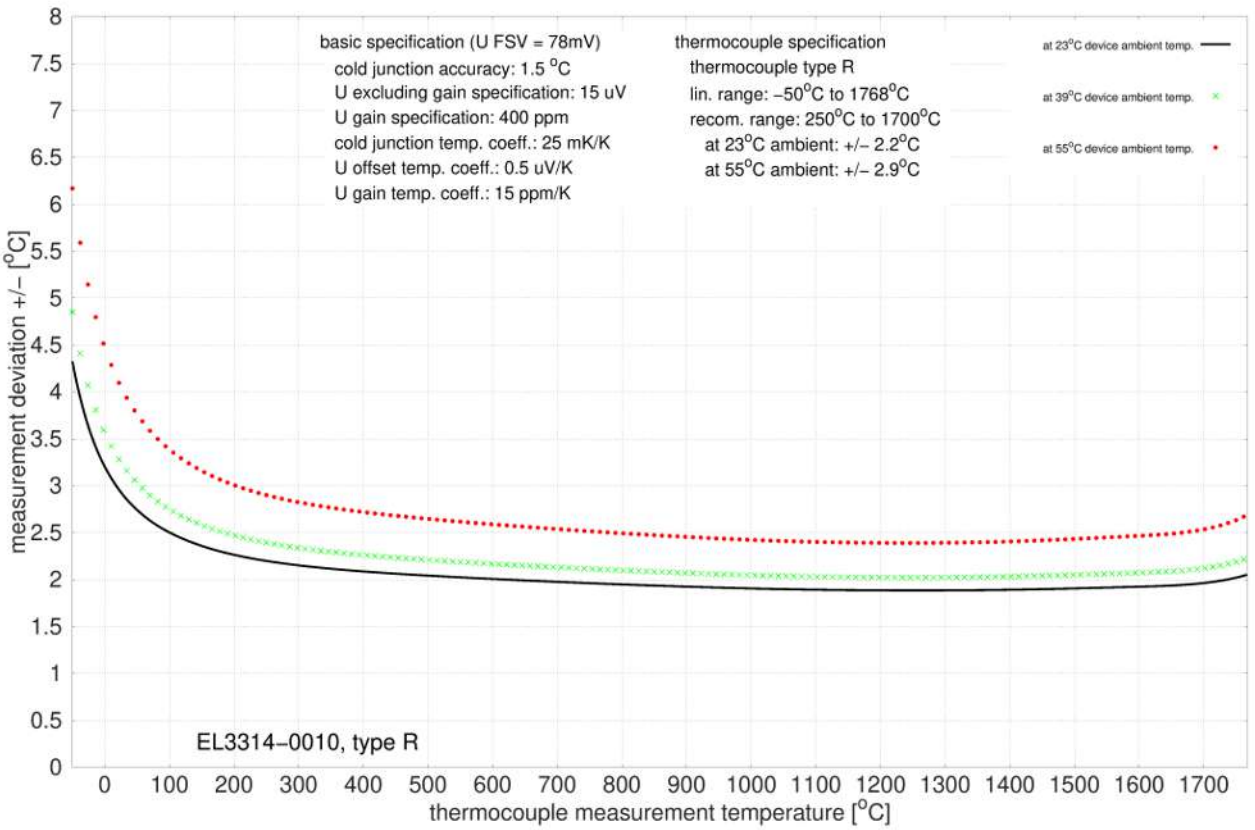
Measurement uncertainty for thermocouple type N:



## Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.226 mV … +1768 °C ≈ 21.101 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.2 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

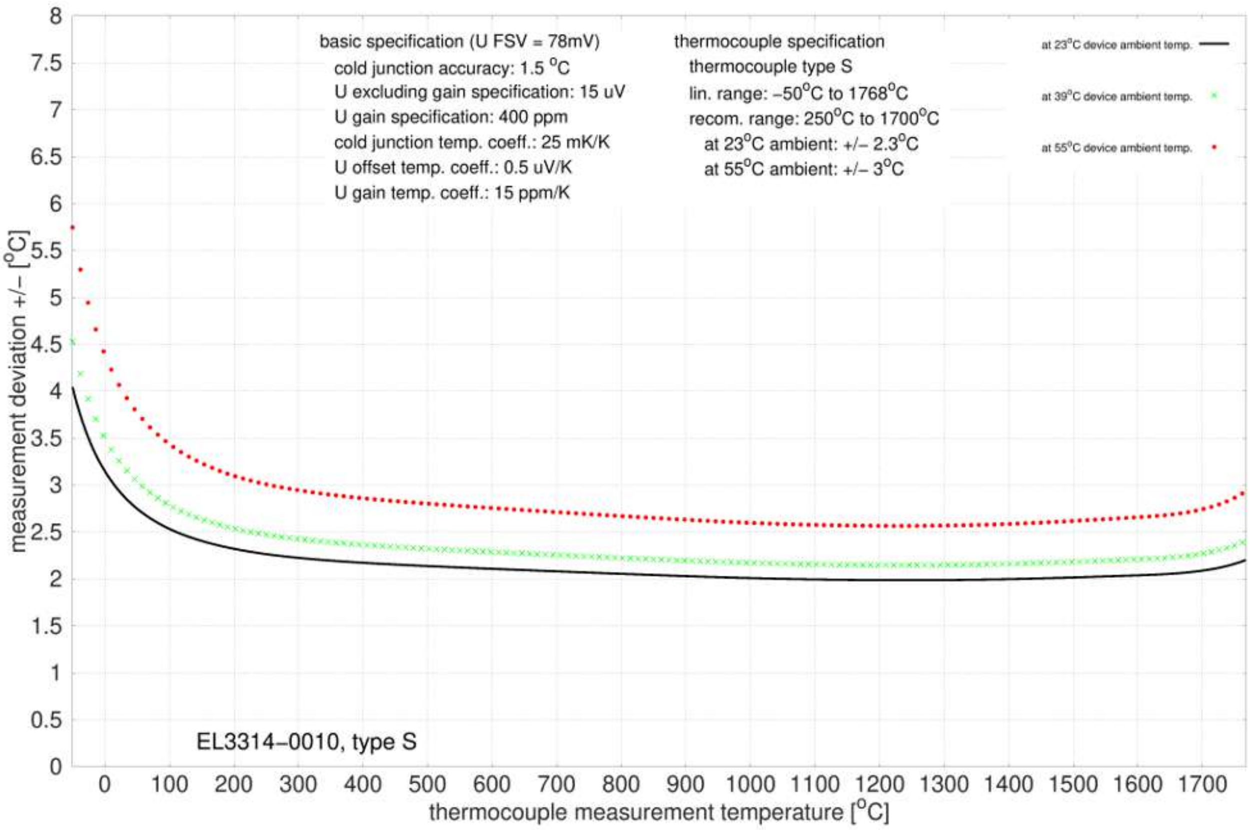
Measurement uncertainty for thermocouple type R:



### Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -0.236 mV … +1768 °C ≈ 18.693 mV |
| Measuring range, end value (full scale value) | | +1768 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.13 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.17 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

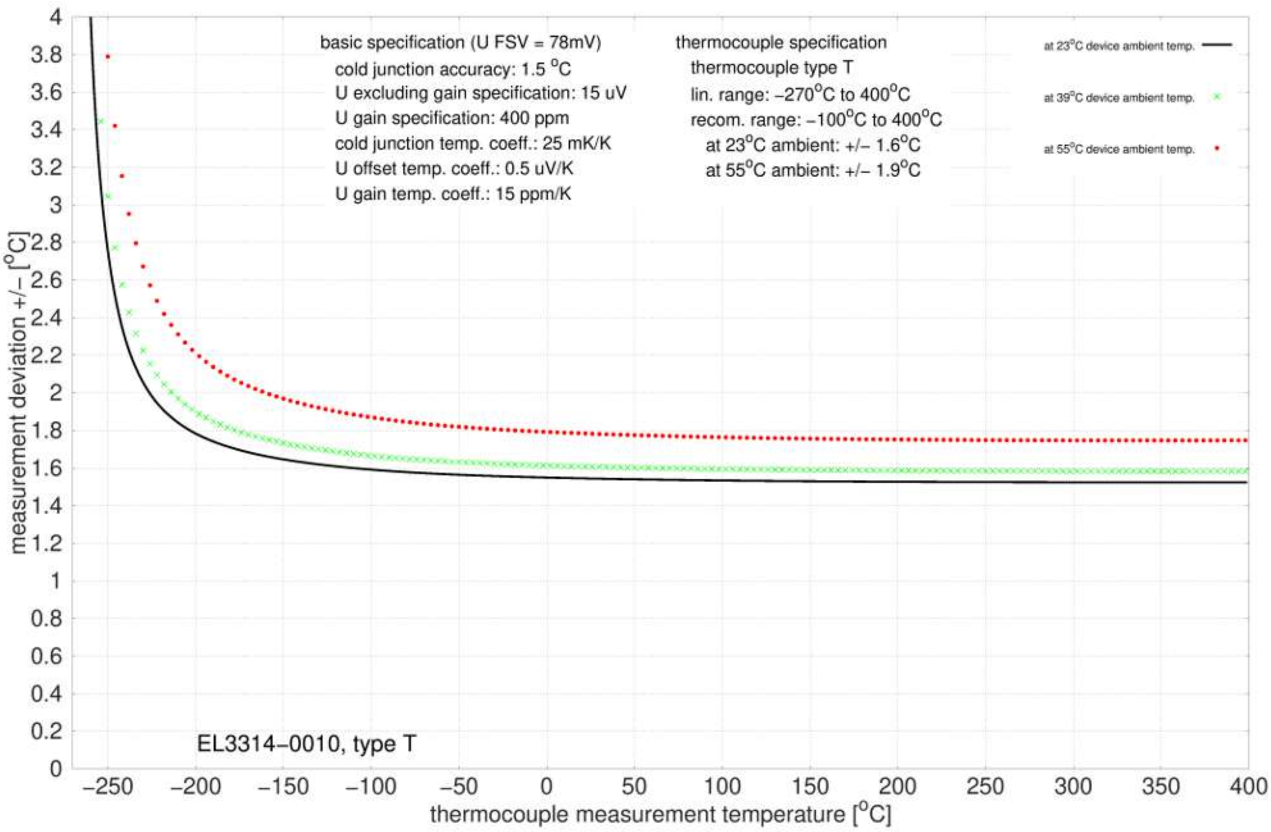
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -270 °C ≈ -6.258 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.6 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

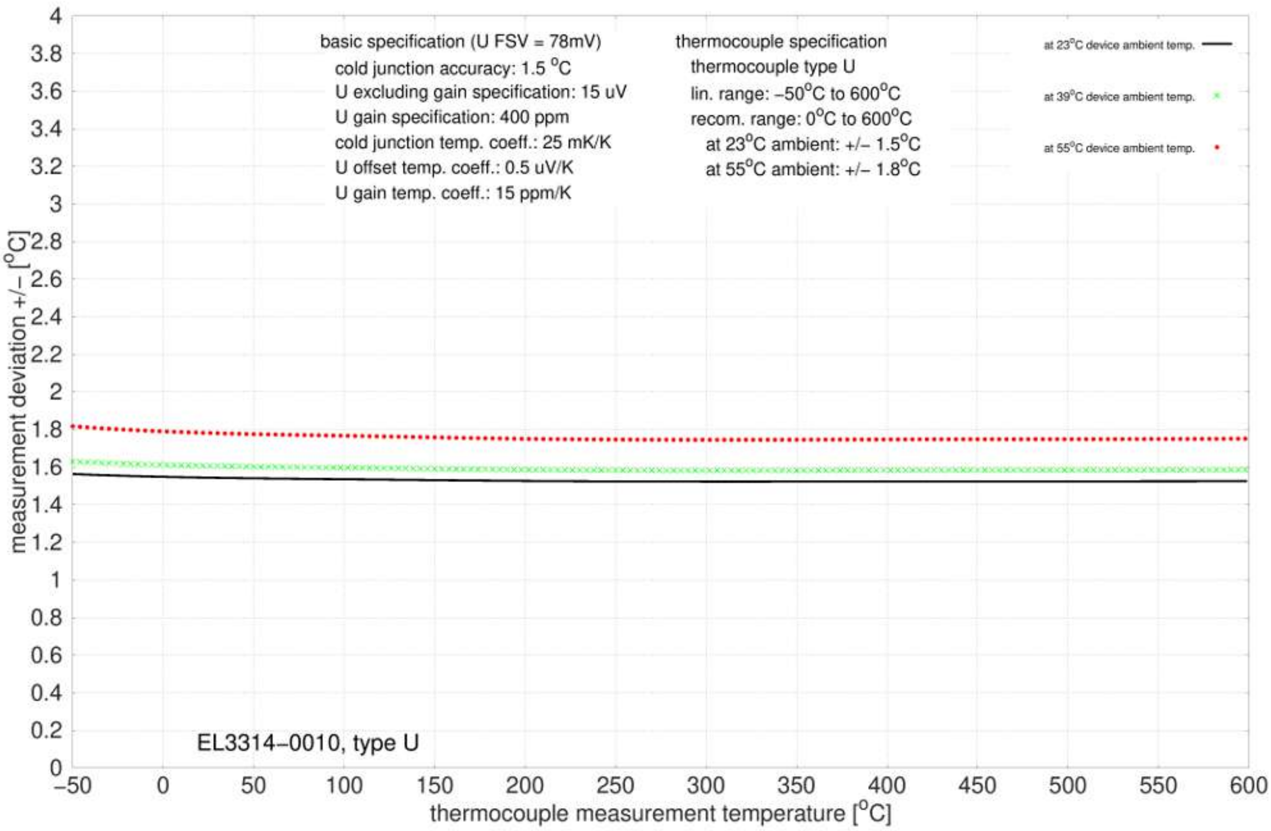
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 78 mV |
| Measuring range, technically usable | | -50 °C ≈ -1.850 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01/0.001 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 1.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 1.8 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.7.3 Connection

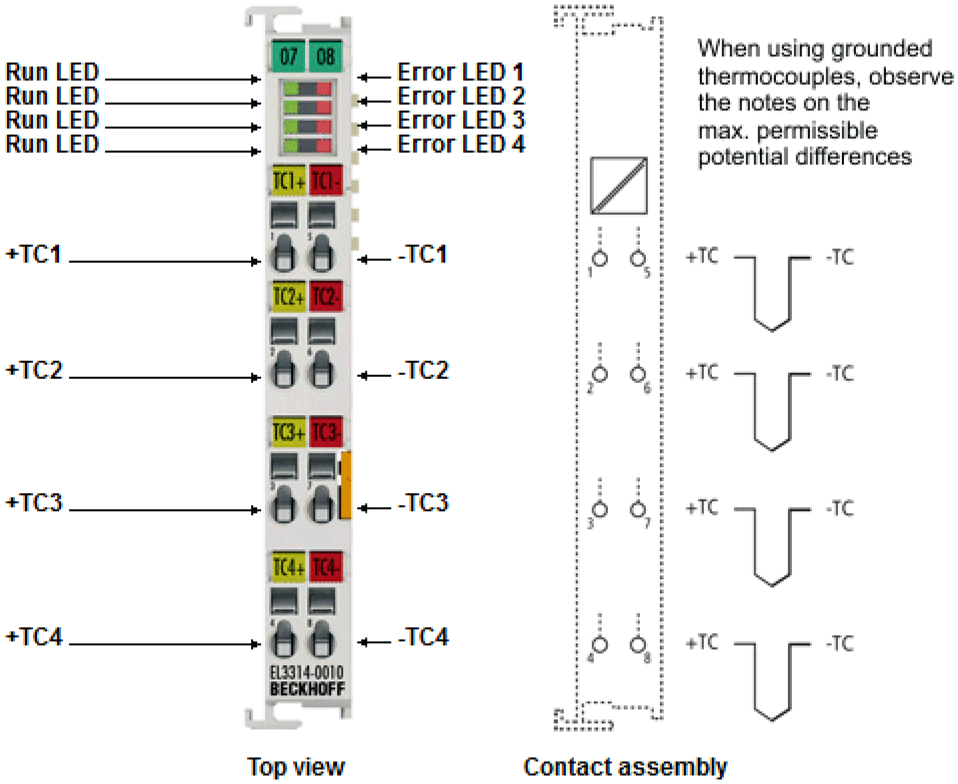



Fig. 17: EL3314-0030 (EL3314-0010)

**EL3314-0030 – Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.7.4 Display, diagnostics

**EL3314-0030 - LEDs**

<table>
<tr><th>LED</th><th>Color</th><th colspan="2">Meaning</th></tr>
<tr><td rowspan="6">RUN</td><td rowspan="6">green</td><td colspan="2">This LED indicates the terminal's operating state:</td></tr>
<tr><td>off</td><td>State of the EtherCAT State Machine: INIT = initialization of the terminal</td></tr>
<tr><td>flashing uniformly</td><td>State of the EtherCAT State Machine: PREOP = function for mailbox communication and different default settings set</td></tr>
<tr><td>flashing slowly</td><td>State of the EtherCAT State Machine: SAFEOP = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state</td></tr>
<tr><td>on</td><td>State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible</td></tr>
<tr><td>flashing rapidly</td><td>State of the EtherCAT State Machine: BOOTSTRAP = function for terminal firmware updates</td></tr>
<tr><td>ERROR1-4</td><td>red</td><td colspan="2">Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve.</td></tr>
</table>

# 2.8 EL3314-0090

## 2.8.1 Introduction

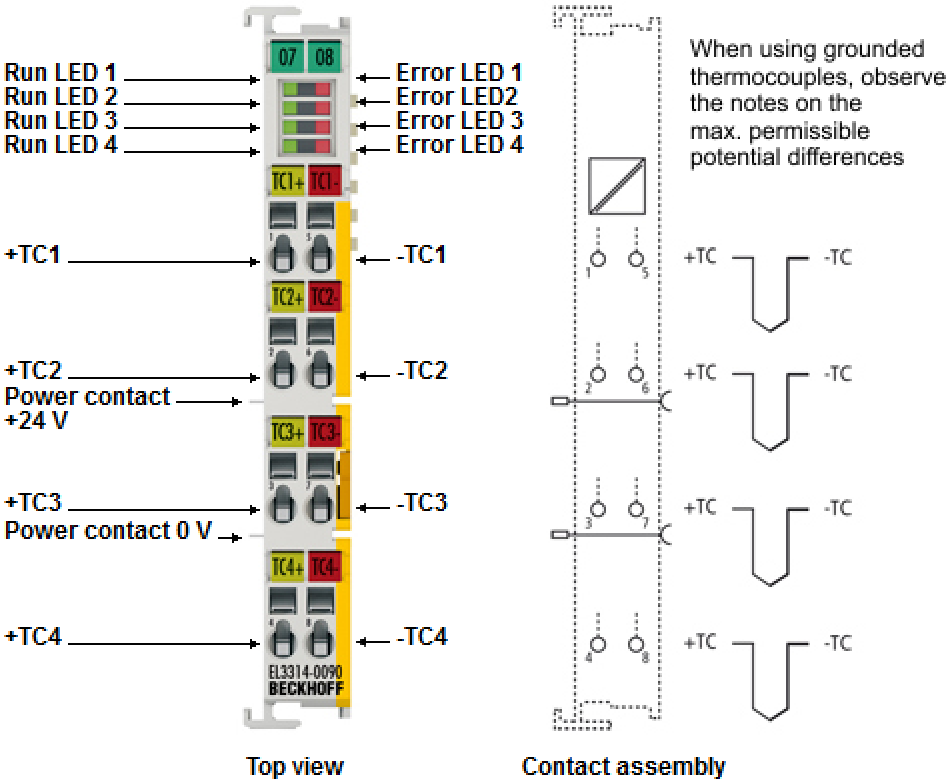



Fig. 18: EL3314-0090

**4-channel thermocouple input terminal with open-circuit recognition, TwinSAFE Single Channel**

The EL3314-0090 analog input terminal allows four thermocouples to be connected directly. The EtherCAT Terminal circuit can operate thermocouple sensors using the 2-wire technique. A microprocessor handles linearisation across the whole temperature range, which is freely selectable. Compensation for the cold junction is made through an internal temperature measurement at the terminal. The EL3314-0090 can also be used for mV measurement.

With the aid of the TwinSAFE SC technology [▸ 309] (TwinSAFE Single Channel) it is possible to make use of standard signals for safety tasks in any network or fieldbus. The standard functions and features of the I/Os remain available. The data from these TwinSAFE SC I/Os is fed to the TwinSAFE Logic, where they undergo safety-related multi-channel processing. In the Safety Logic the data originating from different sources is analysed, checked for plausibility and submitted to a “voting”. This is done by certified function blocks such as Scale, Compare/Voting (1oo2, 2oo3, 3oo5), Limit, etc. For safety reasons, however, at least one of the data sources must be a TwinSAFE SC component. The remainder of the data can originate from other standard Bus Terminals, drive controllers or measuring transducers.

With the aid of the TwinSAFE SC technology it is typically possible to achieve a safety level equivalent to PL d/Cat. 3 in accordance with EN ISO 13849-1 or SIL 2 in accordance with EN 62061

**Quick links**

- EtherCAT basics
- Technology EL33xx [▸ 188]
- Process data and operation modes [▸ 313]

- CoE object description and parameterization [▶ 367]

## 2.8.2 Technical data

### 2.8.2.1 General technical data

| **Analog inputs** | **EL3314-0090** |
|---|---|
| Number of inputs | 4 |
| Thermocouple sensor types, measured variables | Types B, C, E, J, K, L, N, R, S, T, U (default setting type K), mV measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 16-bit |
| Conversion time | approx. 2.5 s to 20 ms,<br>depending on the configuration and filter setting; default: approx. 250 ms |
| Input filter cut-off frequency | 1 kHz typ. |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▸ 218] function | tbd |
| Special features | TwinSAFE SC |

| **Voltage measurement** | **EL3314-0090** |
|---|---|
| Measuring range, technically usable | approx. ± 78 mV |
| Measuring ranges (nominal) and resolution | ± 30 mV (1 µV per digit, thus max. 32.768 mV can be displayed)<br>± 60 mV (2 µV per digit, thus max. 65.536 mV can be displayed)<br>± 75 mV (4 µV per digit, thus max. 131 mV can be displayed, observe technical measuring range)<br>The measuring ranges 30 and 60 mV are executed in software to increase the resolution and always use the same electrical measuring range of ± 75 mV. |
| Measurement uncertainty | See Measurement ±30 mV...±75 mV [▸ 153] |

| **Temperature measurement** | **EL3314-0090** |
|---|---|
| Electrical measuring range used | ± 75 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -100...+1000°C<br>Type J: -100...+1200 °C<br>Type K: -270…+1370 °C (preset)<br>Type L: 0...+900 °C<br>Type N: -100…+1300 °C<br>Type R: -50...+1767 °C<br>Type S: -50...+1760 °C<br>Type T: -200…+400 °C<br>Type U: 0...+600 °C |
| Resolution | Temperature display 0.1/0.01 °C per digit, preset 0.1 °C<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 154] |

| Supply and potentials | EL3314-0090 | Supply and potentials |
|---|---|---|
| Power supply for the electronics | via the E-bus | Power supply for the electronics |
| Current consumption via E-bus | typ. 200 mA | Current consumption via E-bus |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br><br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3314-0090 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 16 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3314-0090 |
|---|---|
| Permissible ambient temperature range during operation | --25 °C...+60 °C (extended temperature range), from firmware 06 |
| Permissible ambient temperature range during storage | -40°C … +85°C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3314-0090 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | variable |
| MTBF (55 °C) | > 1,010,000 h |

| Standards and approvals | EL3314-0090 |
|---|---|
| Protection class | IP20 |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also Installation instructions for enhanced mechanical load capacity [▶ 226] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▶ 205]<br>cULus [▶ 203] |

## Ex marking

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |

| Extended features | EL3314-0090 |
|---|---|
| Pluggable connection level | - |
| Electrical isolation | - |
| TwinSAFE SC | yes |
| Calibration certificate | - |

## 2.8.2.2 Measurement ±30 mV...±75 mV

### Specification ±30 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±30 mV |
|---|---|---|
| Measuring range, nominal | | -30…+30 mV |
| Measuring range, end value (full scale value) | | 30 mV |
| PDO resolution | | 1 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.24%$_{FSV}$ typ. ≈ < ± 0.070 mV |
| | @ 55 °C ambient temperature | < ±026%$_{FSV}$ typ. ≈ < ± 0.077 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±60 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±60 mV |
|---|---|---|
| Measuring range, nominal | | -60…+60 mV |
| Measuring range, end value (full scale value) | | 60 mV |
| PDO resolution | | 2 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.16%$_{FSV}$ typ. ≈ < ± 0.094 mV |
| | @ 55 °C ambient temperature | < ±0.17%$_{FSV}$ typ. ≈ < ± 0.10 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±75 mV

| Measurement mode | | ±75 mV |
|---|---|---|
| Measuring range, nominal | | -75…+75 mV |
| Measuring range, end value (full scale value) | | 75 mV |
| PDO resolution | | 4 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature[1] | < ±0.14%$_{FSV}$ typ. ≈ < ± 0.11 mV |
| | @ 55 °C ambient temperature | < ±0.15%$_{FSV}$ typ. ≈ < ± 0.12 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±60 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 1200 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.8.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

#### Specification of the internal cold junction measurement

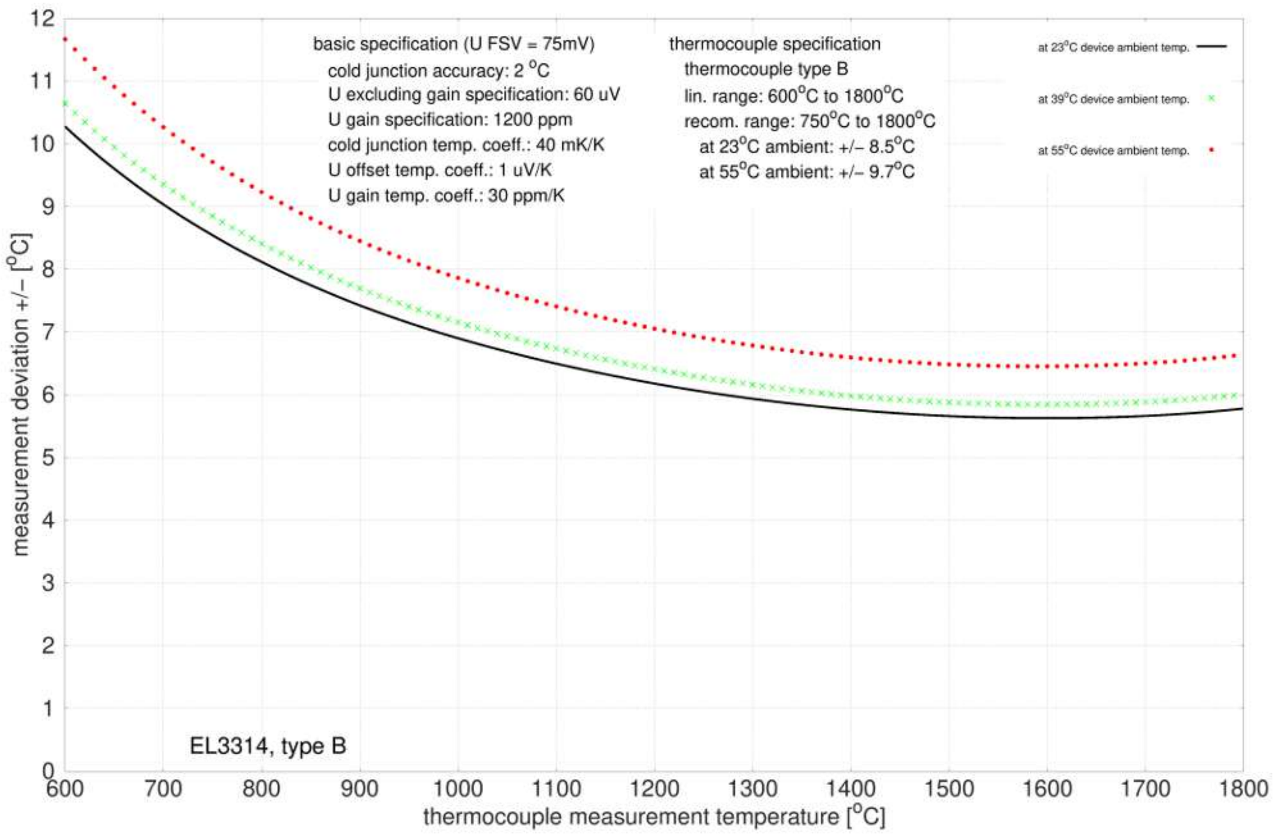
In the EL3314 and EL3314-0090, each channel has its own cold junction sensor.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±2.0 °C |
| Temperature coefficient | Tk | < 40 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | +600 °C ≈ 1.792 mV … +1800 °C ≈ 13.591 mV |
| Measuring range, end value (full scale value) | | +1800 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type B: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 8.5 K ≈ ± 0.47 $\%_{FSV}$ |
| | *@ 55 °C ambient temperature* | ± 9.7 K ≈ ± 0.54 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

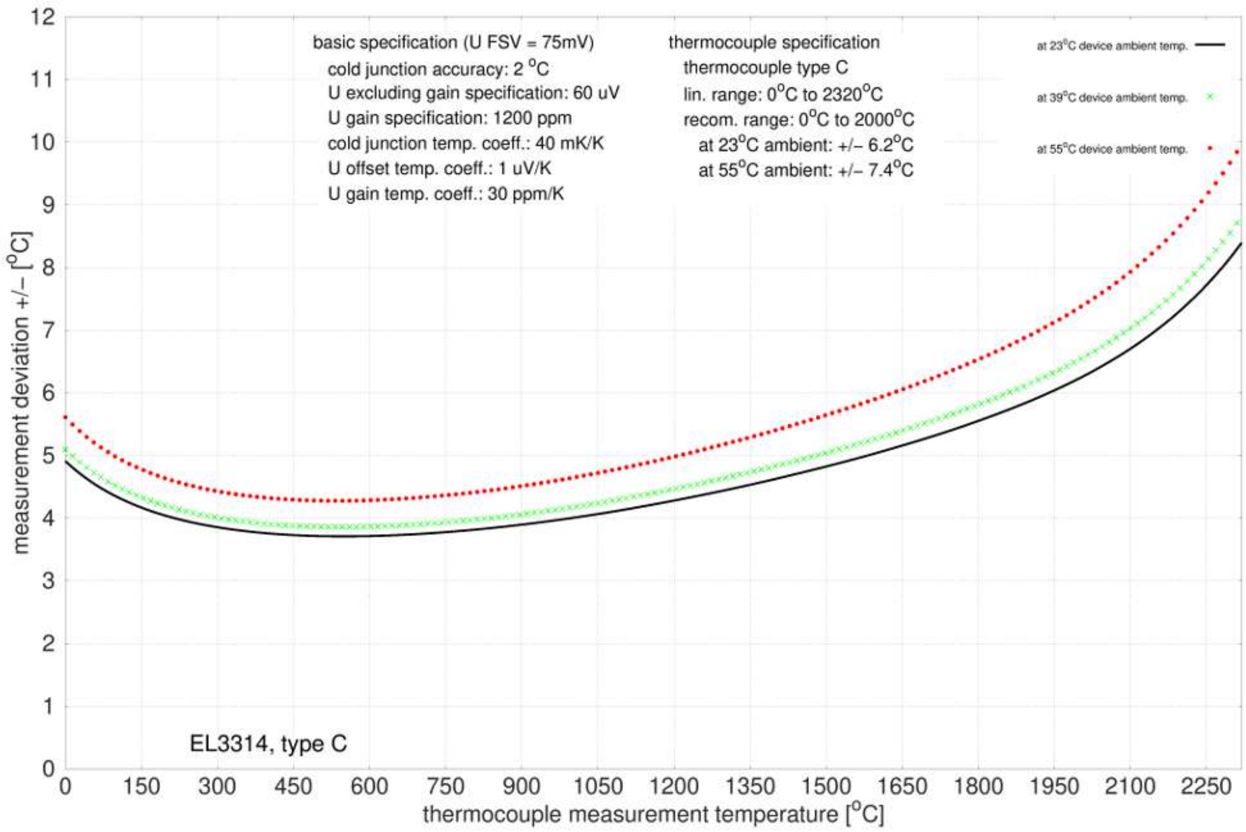
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type C: approx. 0.07 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.2 K ≈ ± 0.27 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.4 K ≈ ± 0.32 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

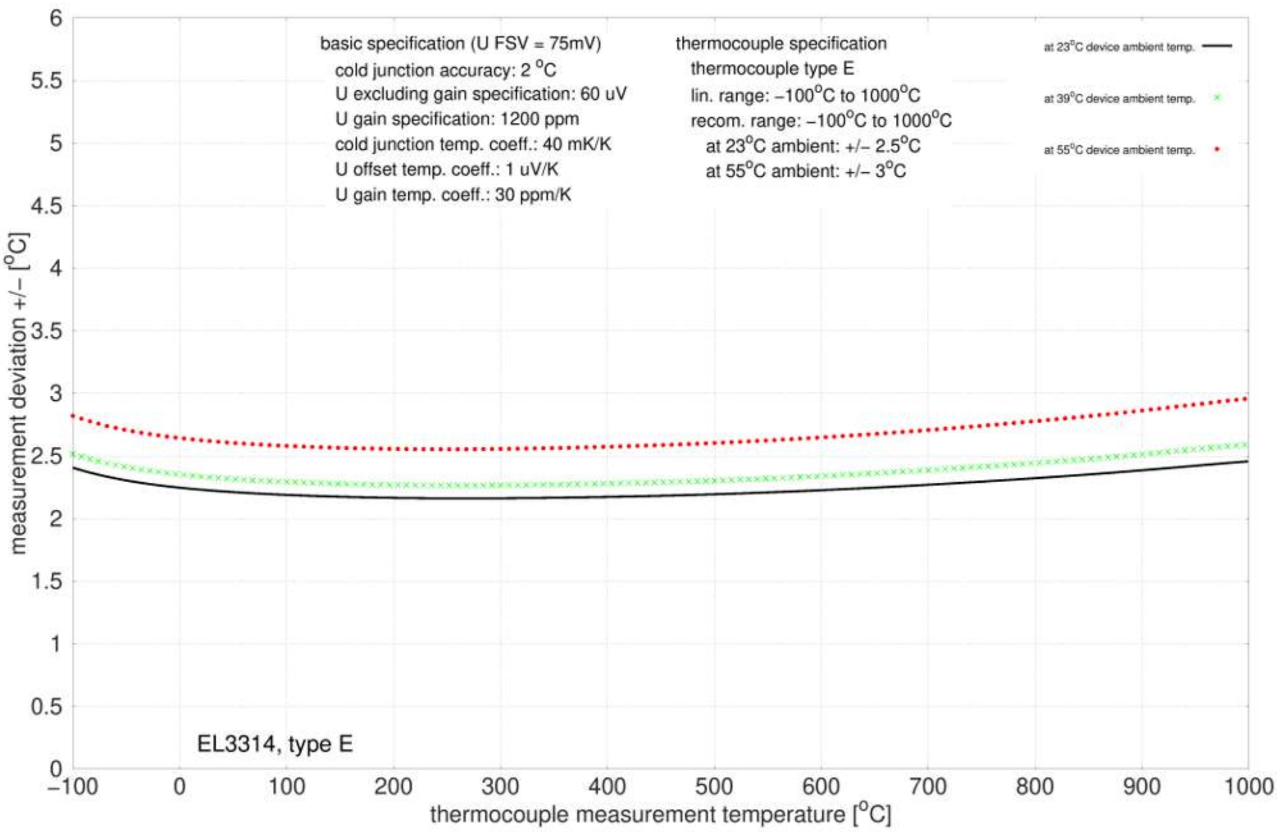
Measurement uncertainty for thermocouple type C:



### Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -5.237 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type E: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.25 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.0 K ≈ ± 0.30 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

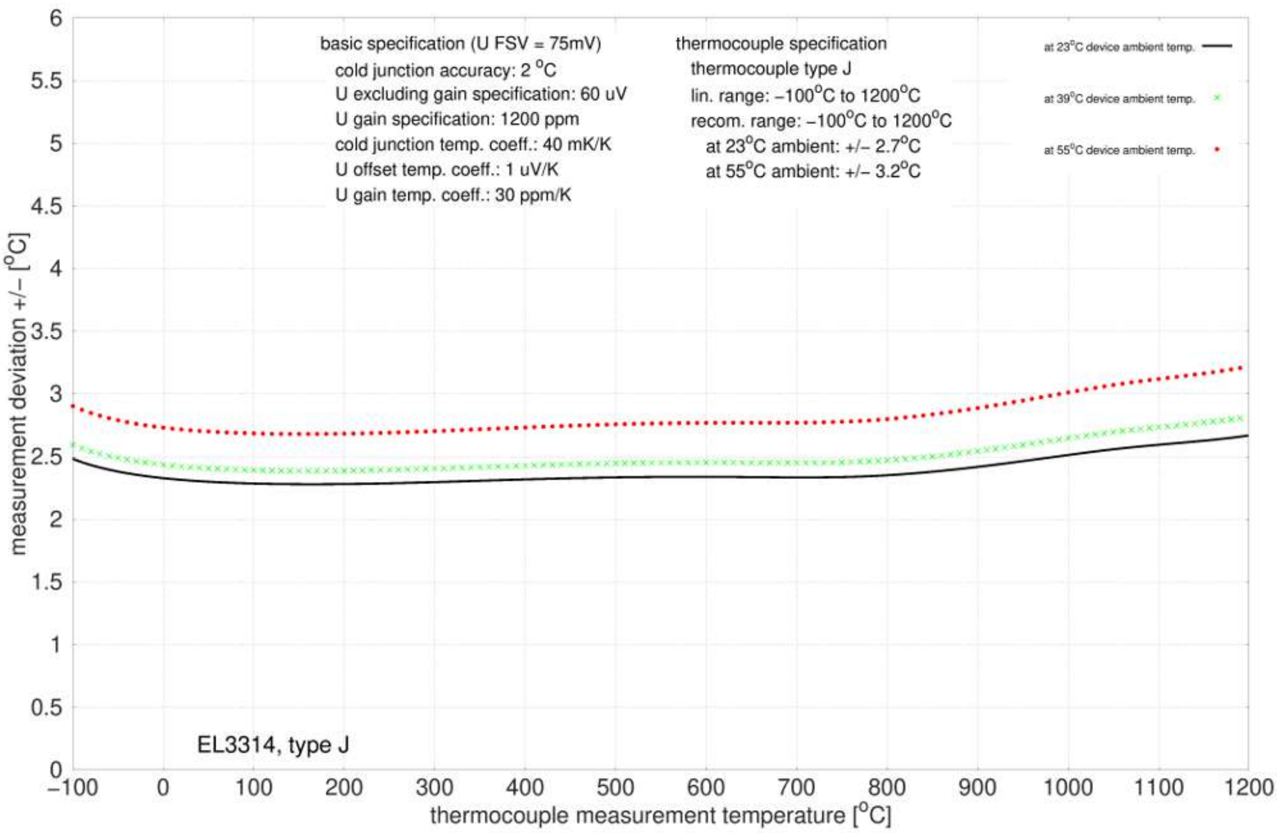
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -4.632 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type J: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.7 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.2 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

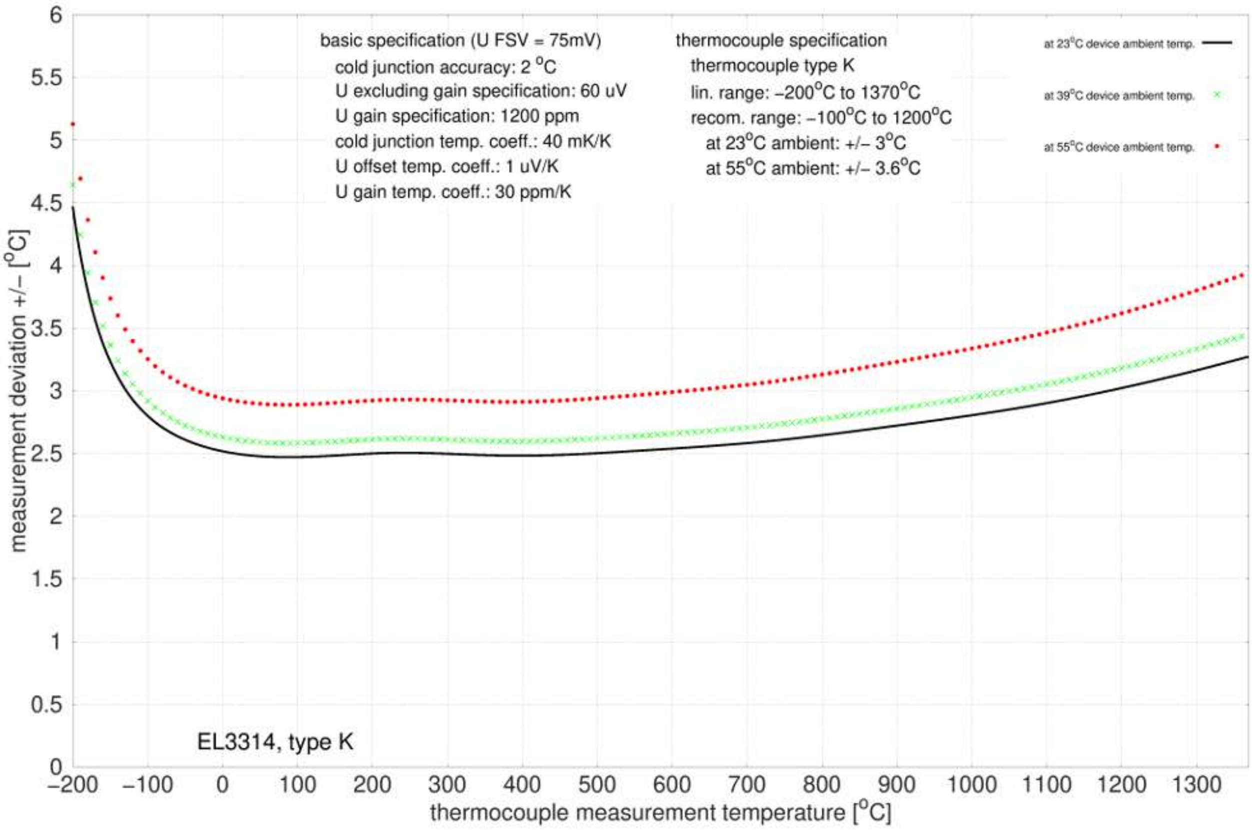
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.891 mV … +1370 °C ≈ 54.818 mV |
| Measuring range, end value (full scale value) | | +1370 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.22 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.26 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

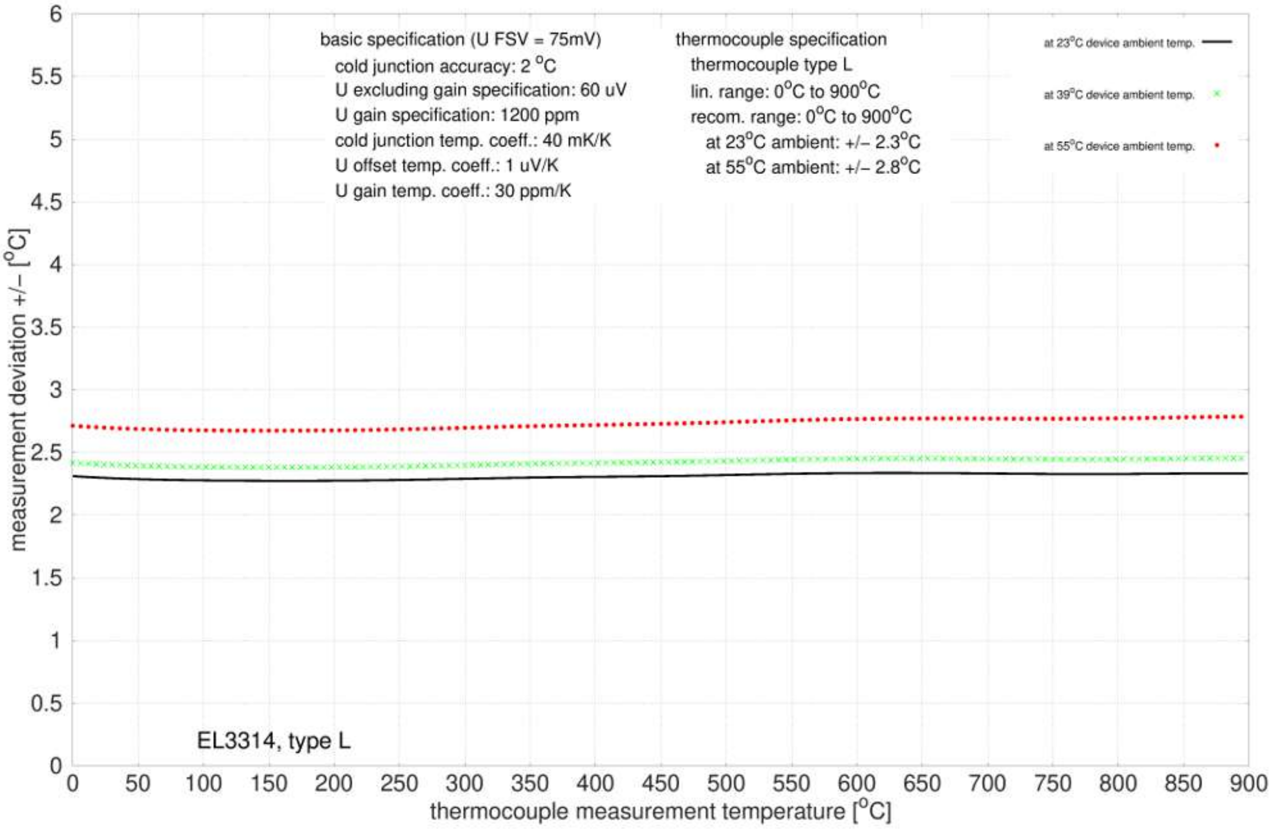
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type L: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.3 K ≈ ± 0.26 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.8 K ≈ ± 0.31 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

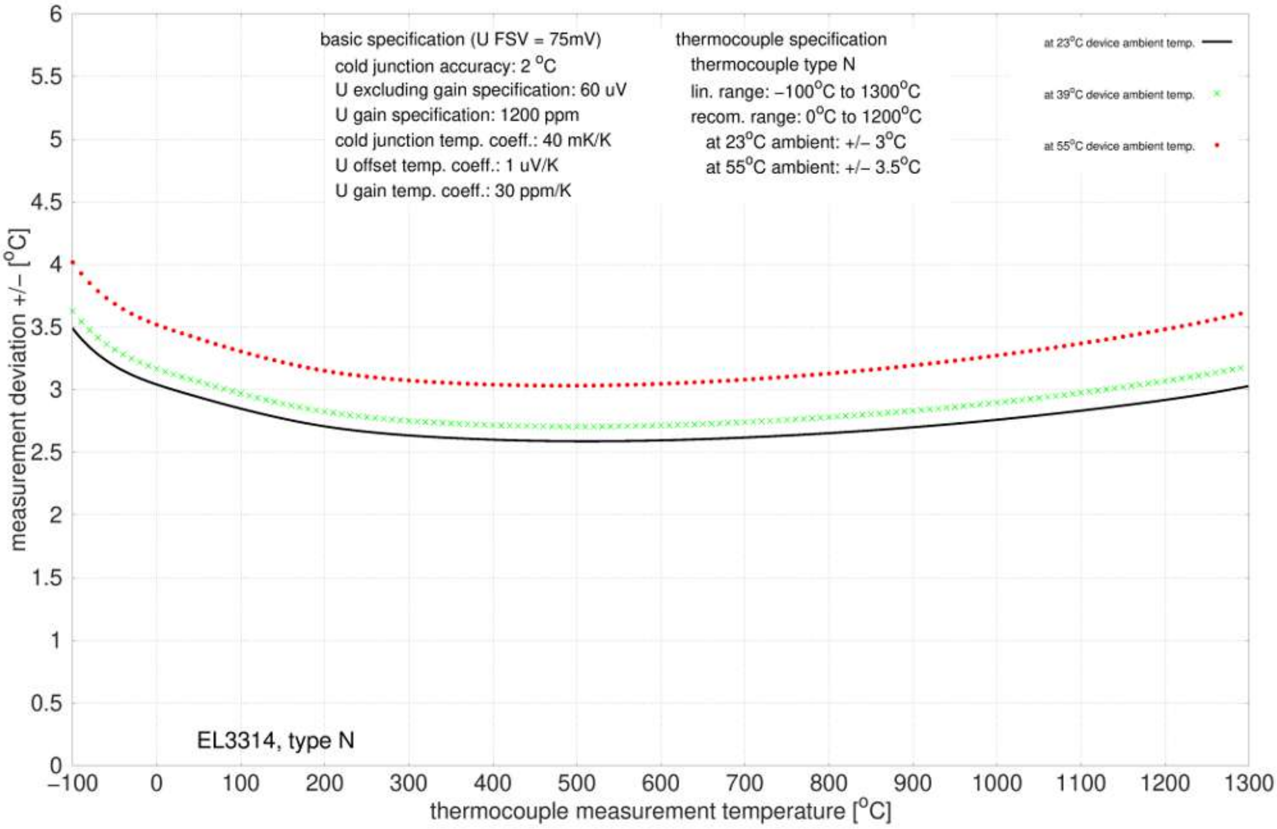
Measurement uncertainty for thermocouple type L:



### Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -2.406 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type N: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.23 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

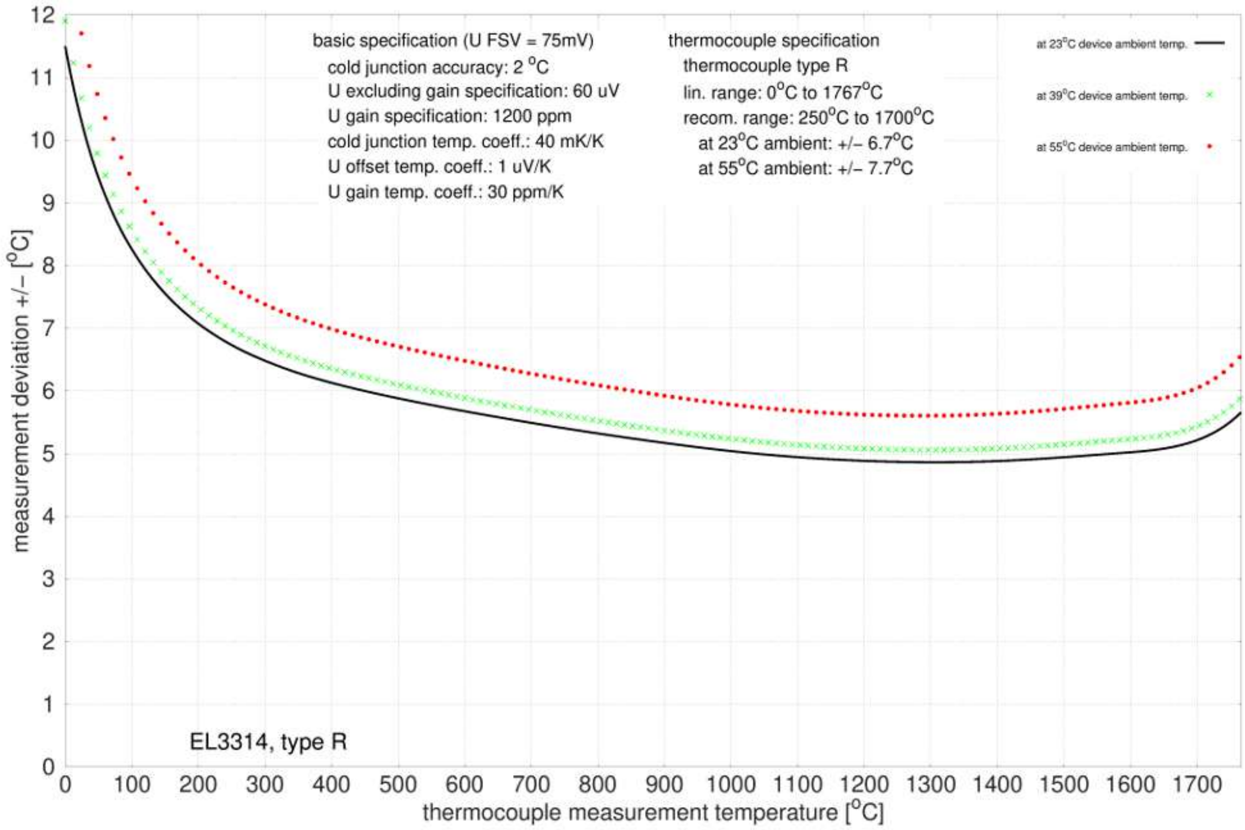
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1767 °C ≈ 21.089 mV |
| Measuring range, end value (full scale value) | | +1767 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type R: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.7 K ≈ ± 0.38 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.7 K ≈ ± 0.44 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

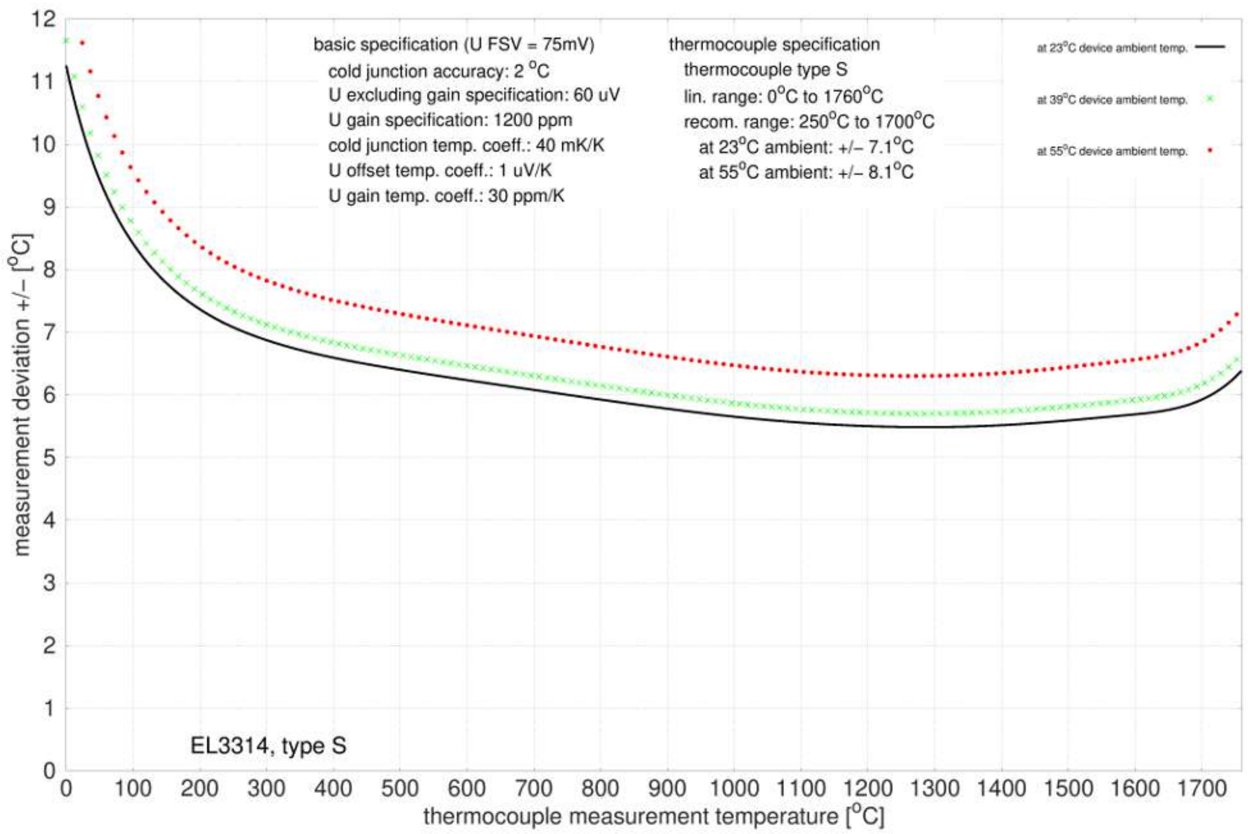
Measurement uncertainty for thermocouple type R:



## Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1760 °C ≈ 17.947 mV |
| Measuring range, end value (full scale value) | | +1760 °C |
| Measuring range, recommended | | +s250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type S: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 7.1 K ≈ ± 0.40 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 8.1 K ≈ ± 0.46 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

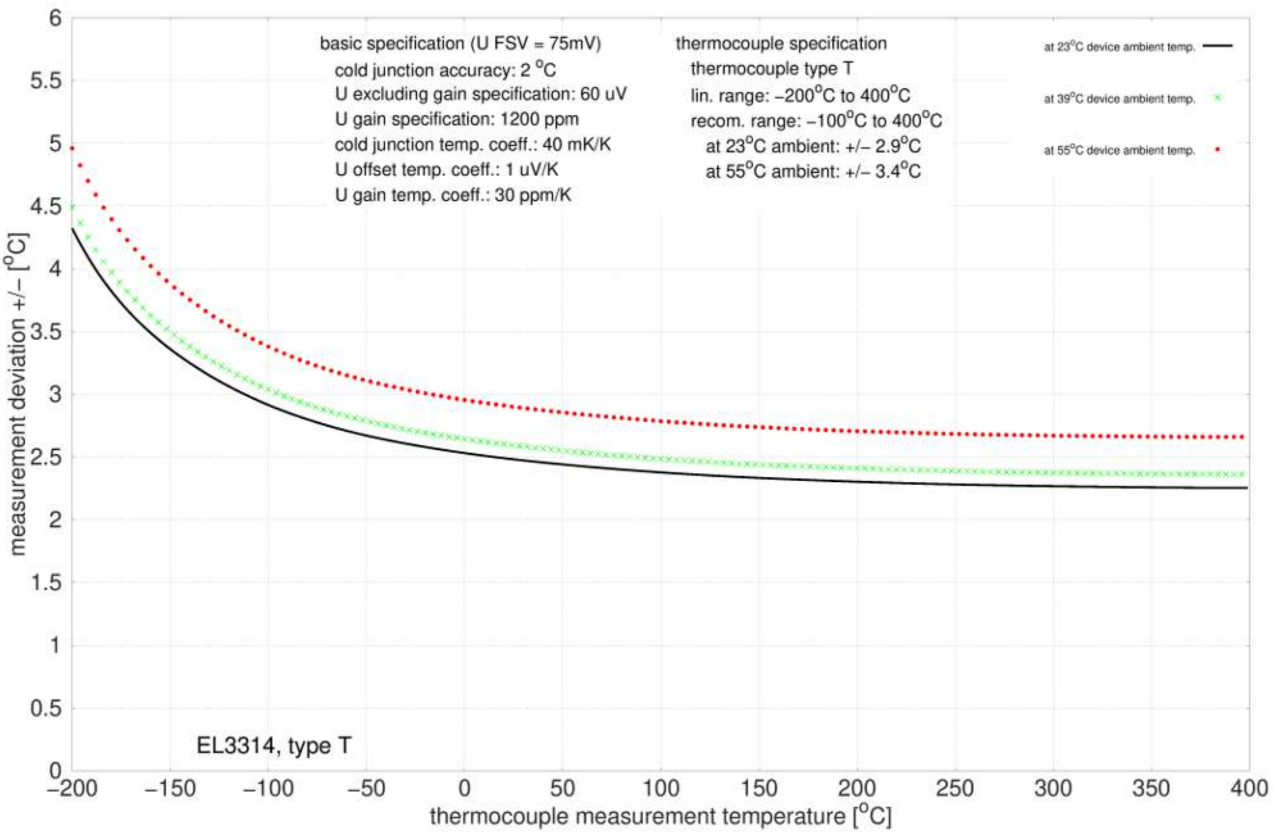
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.603 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.9 K ≈ ± 0.73 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.4 K ≈ ± 0.85 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

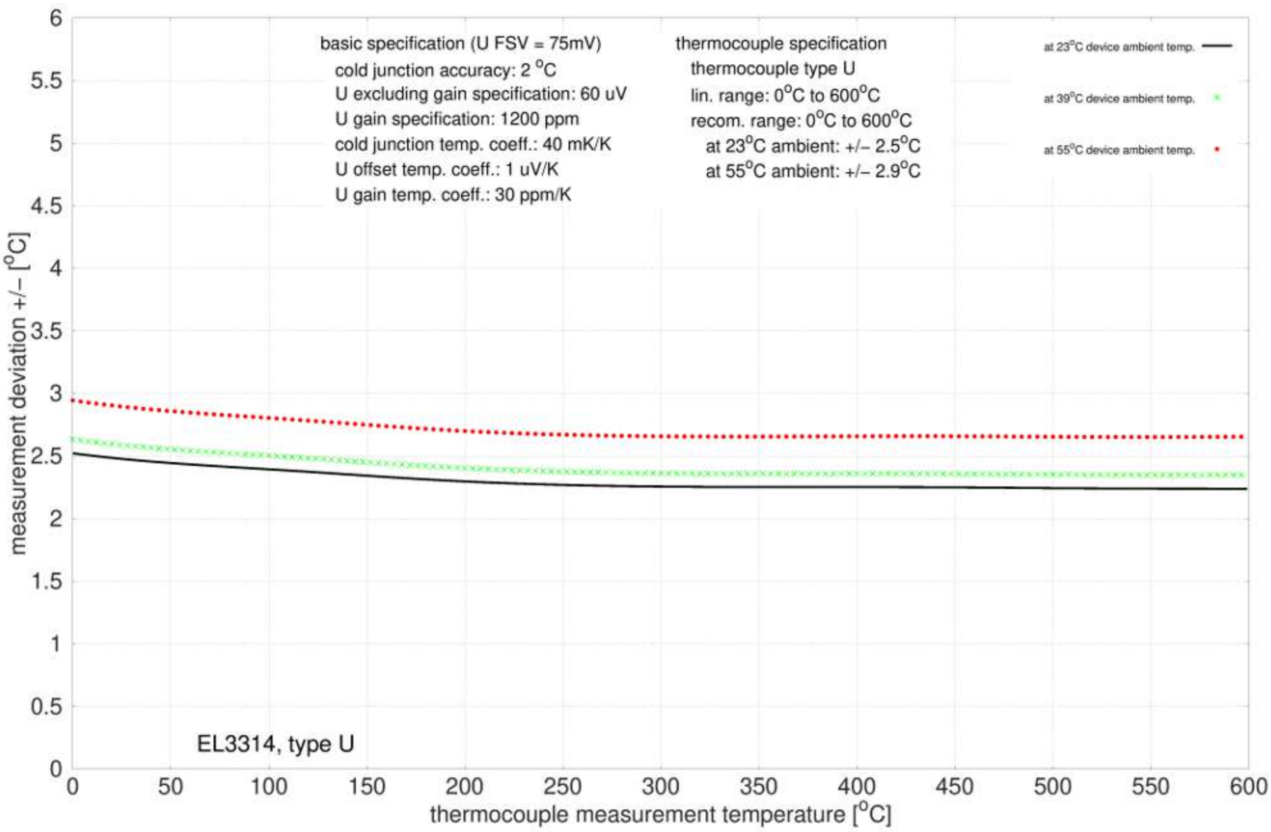
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type U: approx. 0.02 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 2.5 K ≈ ± 0.42 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 2.9 K ≈ ± 0.48 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



## 2.8.3 Connection

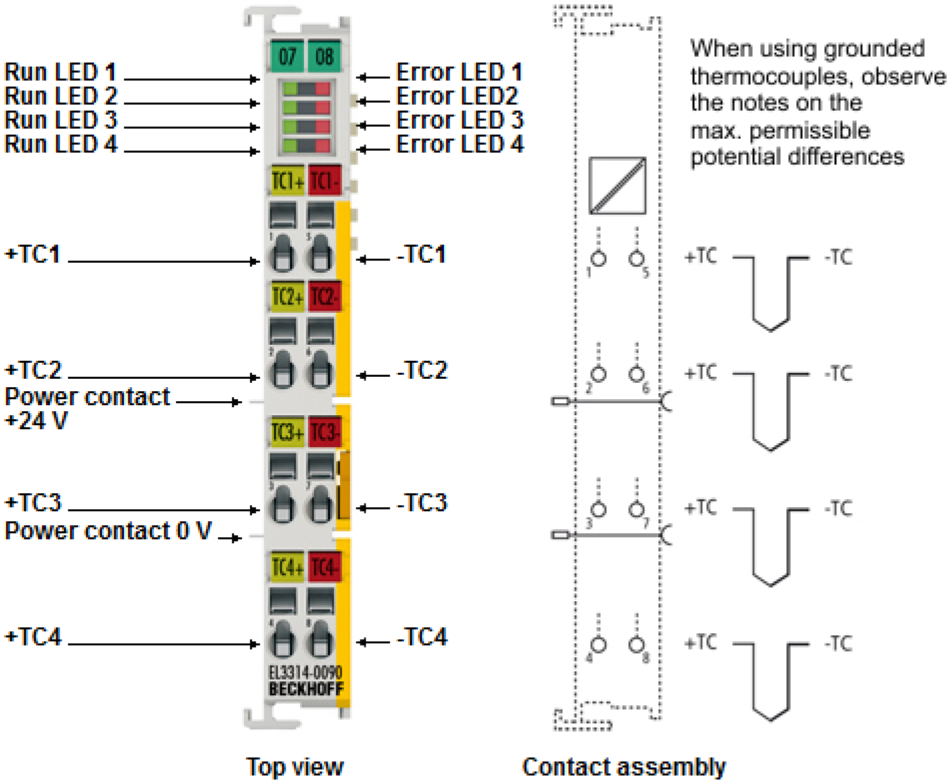



Fig. 19: EL3314-0090

**EL3314-0090 – Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| -TC1 | 5 | Input -TC1 |
| -TC2 | 6 | Input -TC2 |
| -TC3 | 7 | Input -TC3 |
| -TC4 | 8 | Input -TC4 |

**Earthed thermocouples**

Observe for earthed thermocouples: Differential inputs max. ± 2 V to ground!

## 2.8.4 Display, diagnostics

**EL3314-0090 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP =** function for mailbox communication and different default settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP =** normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-4 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

## 2.9 EL3318

### 2.9.1 Introduction

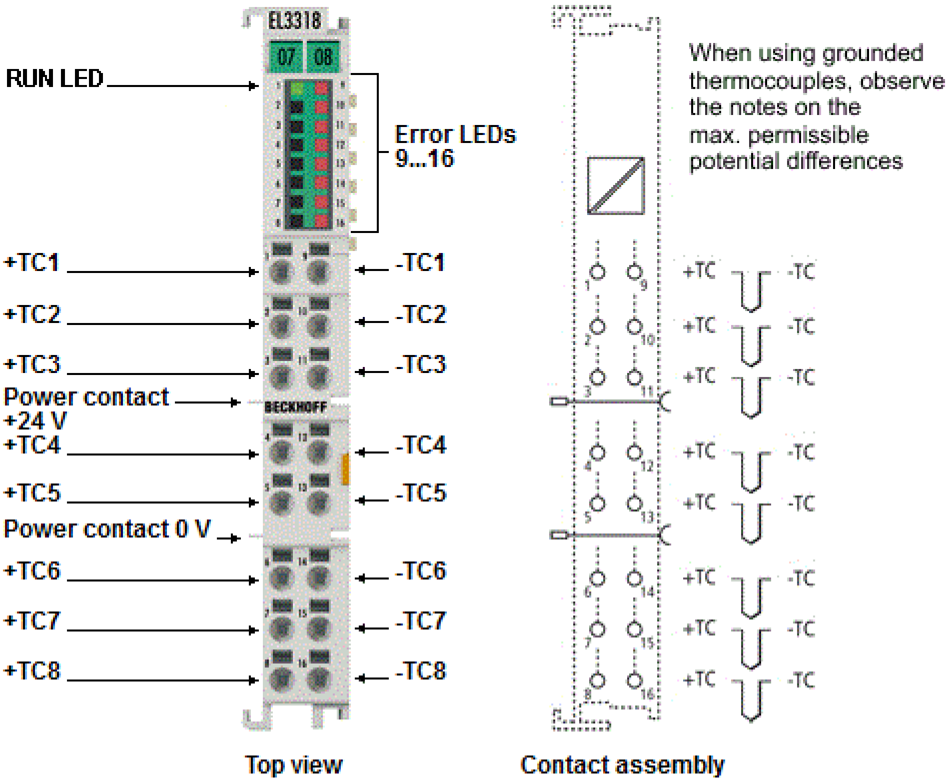



Fig. 20: EL3318

**8 channel HD analog thermocouple input terminal with open-circuit recognition**

The EL3318 analog input terminal allows direct connection of eight thermocouples and is therefore particularly suitable for space-saving use in control cabinets. The EtherCAT Terminal circuit can operate thermocouple sensors using the 2-wire technique. A microprocessor handles linearization across the whole temperature range, which is freely selectable. The error LEDs indicate a broken wire. Compensation for the cold junction is made through an internal temperature measurement at the terminals. The EL3318 also enables measurements in the mV range.

The HD EtherCAT Terminals (High Density) with increased packing density are equipped with 16 connection points in the housing of a 12-mm terminal block.

**Quick links**


- EtherCAT basics
- Technology EL33xx [▸ 188]
- CoE object description and parameterization [▸ 376]
- Process data and operation modes [▸ 313]

## 2.9.2 Technical data

### 2.9.2.1 General technical data

| Analog inputs | EL3318 |
|---|---|
| Number of inputs | 8 |
| Thermocouple sensor types, measured variables | Types B, C, E, J, K, L, N, R, S, T, U (default setting type K), mV measurement |
| Connection technology | 2-wire |
| Maximum cable length to the thermocouple | 30 m (without protective measures), suitable surge protection must be provided for longer cable lengths |
| Resolution | Internal 16-bit |
| Conversion time | approx. 2.5 s to 20 ms,<br>depending on the configuration and filter setting; default: approx. 250 ms |
| Input filter cut-off frequency | 1 kHz typ. |
| Software filter | 5 Hz... 30 kHz, adjustable, notch characteristic; preset: disabled |
| Open-circuit recognition | yes (can be disabled) |
| Supports NoCoEStorage [▸ 218] | yes, from firmware 01 |

| Voltage measurement | EL3318 |
|---|---|
| Measuring range, technically usable | approx. ± 78 mV |
| Measuring ranges (nominal) and resolution | ± 30 mV (1 µV per digit, thus max. 32.768 mV can be displayed)<br>± 60 mV (2 µV per digit, thus max. 65.536 mV can be displayed)<br>± 75 mV (4 µV per digit, thus max. 131 mV can be displayed, observe technical measuring range)<br>The measuring ranges 30 and 60 mV are executed in software to increase the resolution and always use the same electrical measuring range of ± 75 mV. |
| Measurement uncertainty | See Measurement ±30 mV...±75 mV [▸ 172] |

| Temperature measurement | EL3318 |
|---|---|
| Electrical measuring range used | ± 75 mV |
| Measuring ranges | Type B: +200...+1820 °C<br>Type C: 0...+2320 °C<br>Type E: -100...+1000°C<br>Type J: -100...+1200 °C<br>Type K: -270…+1370 °C (preset)<br>Type L: 0...+900 °C<br>Type N: -100…+1300 °C<br>Type R: -50...+1767 °C<br>Type S: -50...+1760 °C<br>Type T: -200…+400 °C<br>Type U: 0...+600 °C |
| Resolution | Temperature display 0.1/0.01 °C per digit, preset 0.1 °C<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Measurement uncertainty | See Thermocouples measurement [▸ 173] |

| Supply and potentials | | EL3318 |
|---|---|---|
| Power supply for the electronics | | via the E-bus |
| Current consumption via E-bus | | typ. 200 mA |
| Differential voltage between +TC and -TC | Recommended area of application | respective measuring range |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential of the twisted TC ends to one another<br>(non-isolated/grounded TC) | Recommended area of application | ±2 V |
| | Destruction limit, short-term/continuous | ±15 V |
| Max. potential $U_{CM}$ (CommonMode voltage) of the twisted TC to GND | Recommended area of application | Not applicable because GND is not accessible |
| | Destruction limit, short-term/continuous | |
| Max. potential of twisted TC or GND to SGND or 0 V power | Recommended area of application | ±30 V |
| | Destruction limit, short-term/continuous | ±50 V |
| Electrical isolation: Max. potential of twisted TC or GND to bus side | Recommended area of application and short-term/continuous destruction limit | 500 V |

| Communication | EL3318 |
|---|---|
| Configuration | via TwinCAT System Manager |
| Width in the process image | max. 16 bytes input,<br>max. 8 bytes output |
| Distributed Clocks | - |

| Environmental conditions | EL3318 |
|---|---|
| Permissible ambient temperature range during operation | --25 °C...+60 °C (extended temperature range), from firmware 06 |
| Permissible ambient temperature range during storage | -40°C … +85°C |
| Permissible relative air humidity | 95%, no condensation |

| General data | EL3318 |
|---|---|
| Dimensions (W x H x D) | approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm) |
| Weight | approx. 60 g |
| Mounting and wiring [▶ 222] | on 35 mm support rail according to EN 60715 |
| Installation position | variable |

| Standards and approvals | EL3318 |
|---|---|
| Protection class | IP20 |
| Vibration / shock resistance | conforms to EN 60068-2-6 / EN 60068-2-27,<br>see also Installation instructions for enhanced mechanical load capacity [▶ 226] |
| EMC immunity / emission | conforms to EN 61000-6-2 / EN 61000-6-4 |
| Marking / Approval | CE, UKCA, EAC<br>ATEX [▶ 205]<br>cULus [▶ 203]<br>cFMus [▶ 208]<br>IECEx [▶ 207] |

## Ex markings

| Standard | Marking |
|---|---|
| ATEX | II 3 G Ex nA IIC T4 Gc |
| IECEx | Ex nA IIC T4 Gc |
| cFMus | Class I, Division 2, Groups A, B, C, D<br>Class I, Zone 2, AEx/Ex ec IIC T4 Gc |

| Extended features | EL3318 |
|---|---|
| *Pluggable* connection level | - |
| Electrical isolation | - |
| TwinSAFE SC | - |
| Calibration certificate | - |

## 2.9.2.2 Measurement ±30 mV...±75 mV

### Specification ±30 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±30 mV |
|---|---|---|
| Measuring range, nominal | | -30…+30 mV |
| Measuring range, end value (full scale value) | | 30 mV |
| PDO resolution | | 1 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.155%$_{FSV}$ typ. ≈ < ± 0.047 mV |
| | @ 55 °C ambient temperature[1] | < ±0.189%$_{FSV}$ typ. ≈ < ± 0.057 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±40 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 800 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±60 mV

Note: this measuring range is not a separate electrical measuring range but a digital section of the 75 mV measuring range

| Measurement mode | | ±60 mV |
|---|---|---|
| Measuring range, nominal | | -60…+60 mV |
| Measuring range, end value (full scale value) | | 60 mV |
| PDO resolution | | 2 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.104%$_{FSV}$ typ. ≈ < ± 0.062 mV |
| | @ 55 °C ambient temperature[1] | < ±0.117%$_{FSV}$ typ. ≈ < ± 0.070 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±40 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 800 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

### Specification ±75 mV

| Measurement mode | | ±75 mV |
|---|---|---|
| Measuring range, nominal | | -75…+75 mV |
| Measuring range, end value (full scale value) | | 75 mV |
| PDO resolution | | 4 µV / digit |
| Basic accuracy: Measurement deviation, with averaging | @ 23 °C ambient temperature | < ±0.096%$_{FSV}$ typ. ≈ < ± 0.072 mV |
| | @ 55 °C ambient temperature[1] | < ±0.105%$_{FSV}$ typ. ≈ < ± 0.079 mV |
| Offset/zero point deviation (at 23 °C)[2] | $F_{Offset}$ | < ±40 µV |
| Gain/scale/amplification deviation (at 23 °C)[2] | $F_{Gain}$ | < 800 ppm |
| Temperature coefficient | $Tk_{Gain}$ | < 1 µV/K |
| | $Tk_{Offset}$ | < 30 ppm/K |

[1] This specification value includes the temperature coefficient for gain ($Tk_{Gain}$) and offset ($Tk_{Offset}$).

[2] These specifications are already included in the basic accuracy. They are listed here for a detailed, individual uncertainty consideration.

### 2.9.2.3 Thermocouples measurement

In the measuring range of a specified thermocouple type, a measured voltage is converted internally into a temperature according to the set transformation. Since the channel measures a voltage internally, the corresponding measuring error in the voltage measuring range must be used.

The following tables with the specification of the thermocouple measurement apply only when using the internal cold junction.

The EL331x-00xx can also be used with an external cold junction if required. The uncertainties must then be determined for the external cold junction on the application side. The temperature value of the external cold junction must then be communicated to the EL331x-00xx via the process data for its own calculation. The effect on the measurement of the thermocouples must then be calculated on the system side.

The specifications for the internal cold junction and the measuring range given here apply only if the following times are adhered to for thermal stabilization at constant ambient temperature:

- after switching on: 60 min
- after changing wiring/connectors: 15 min

#### Specification of the internal cold junction measurement

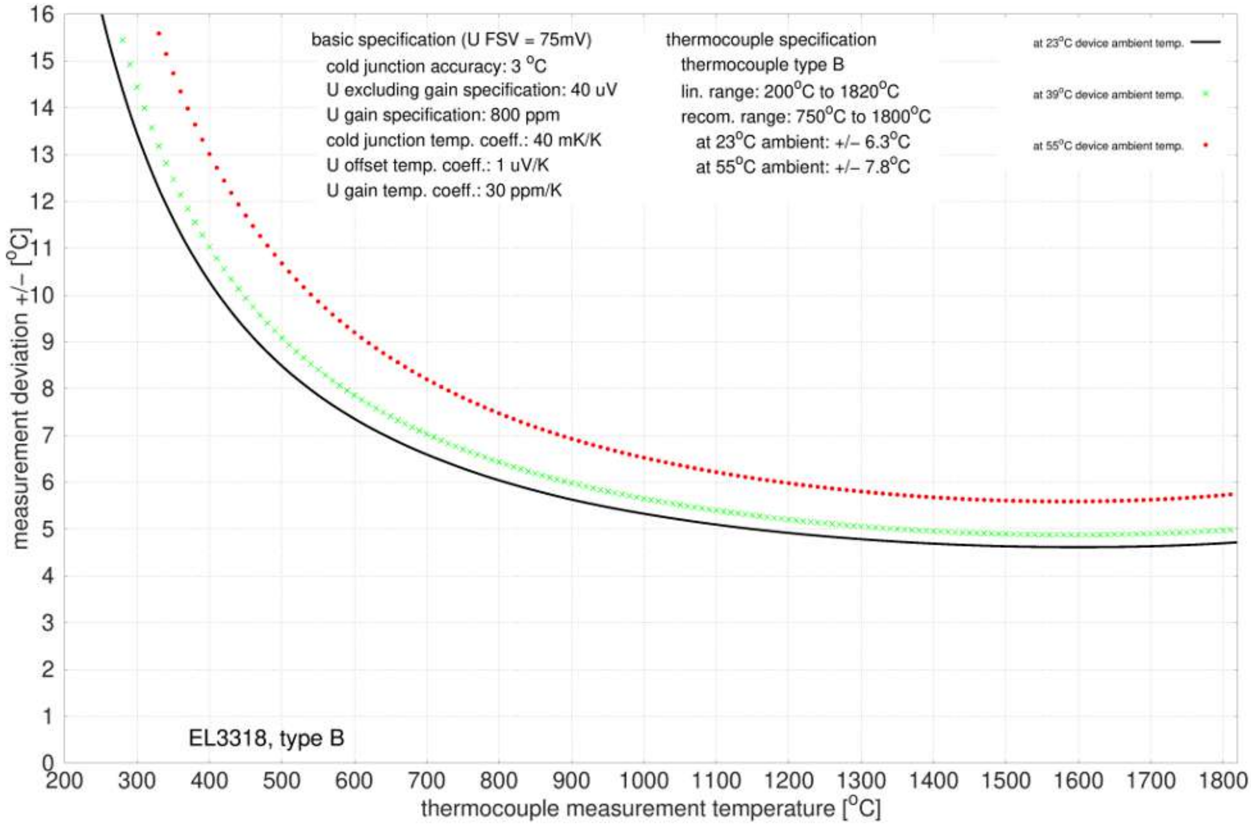
The EL3318 has an internal cold junction measurement.

| Measurement mode | | Cold junction |
|---|---|---|
| Basic accuracy: Measurement deviation at 23 °C, with averaging | | < ±3.0 °C |
| Temperature coefficient | Tk | < 40 mK/K |

### Specification - thermocouple type B

| Temperature measurement thermocouple | | Type B |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | +600 °C ≈ 1.792 mV … +1820 °C ≈ 13.820 mV |
| Measuring range, end value (full scale value) | | +1820 °C |
| Measuring range, recommended | | +750 °C … +1800 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type B: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 6.3 K ≈ ± 0.35 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 7.8 K ≈ ± 0.29 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

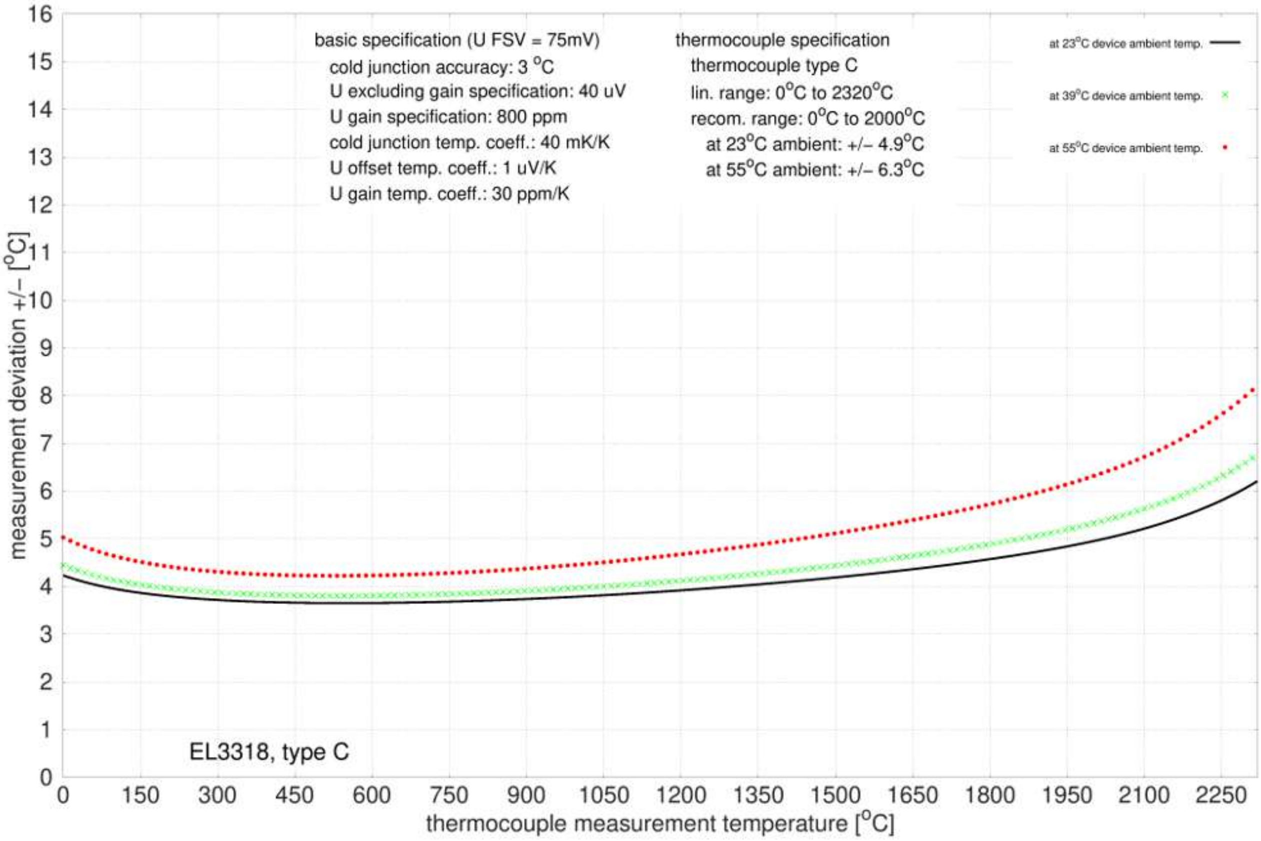
Measurement uncertainty for thermocouple type B:



### Specification - thermocouple type C

| Temperature measurement thermocouple | | Type C |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +2320 °C ≈ 37.107 mV |
| Measuring range, end value (full scale value) | | +2320 °C |
| Measuring range, recommended | | 0 °C … +2000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type C: approx. 0.07 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 4.9 K ≈ ± 0.21 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 6.3 K ≈ ± 0.27 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

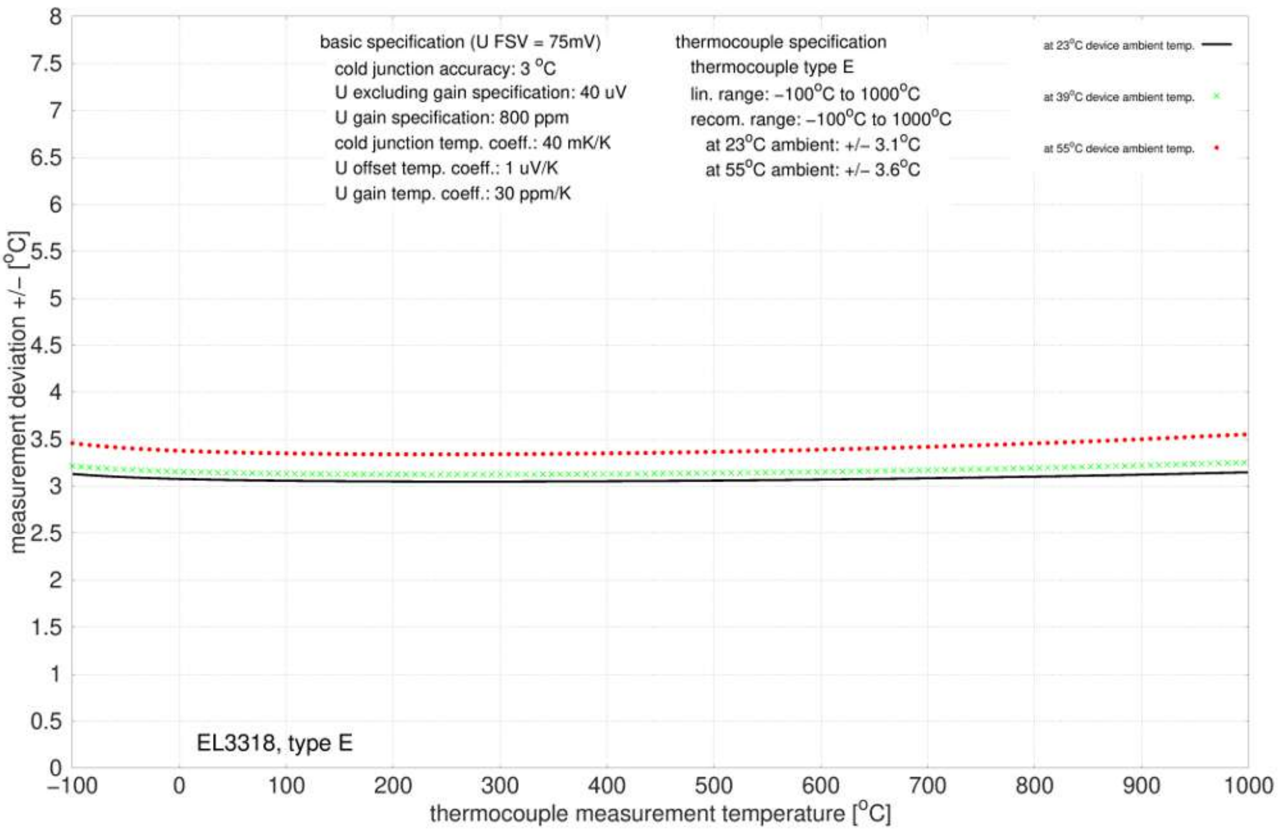
Measurement uncertainty for thermocouple type C:



## Specification - thermocouple type E

| Temperature measurement thermocouple | | Type E |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -5.237 mV … +1000 °C ≈ 76.372 mV |
| Measuring range, end value (full scale value) | | +1000 °C |
| Measuring range, recommended | | -100 °C … +1000 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type E: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.1 K ≈ ± 0.31 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.36 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

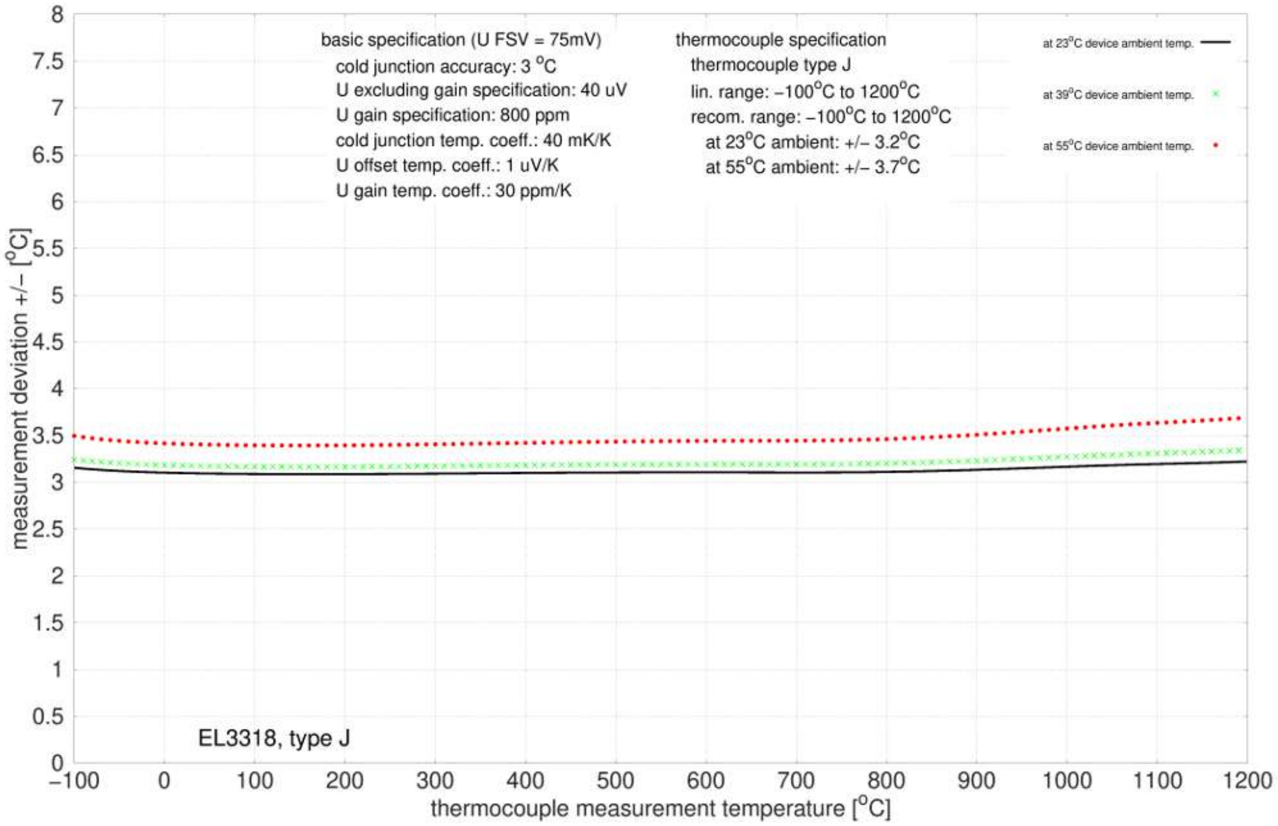
Measurement uncertainty for thermocouple type E:



### Specification - thermocouple type J

| Temperature measurement thermocouple | | Type J |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -4.632 mV … +1200 °C ≈ 69.553 mV |
| Measuring range, end value (full scale value) | | +1200 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type J: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.2 K ≈ ± 0.27 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.7 K ≈ ± 0.31 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

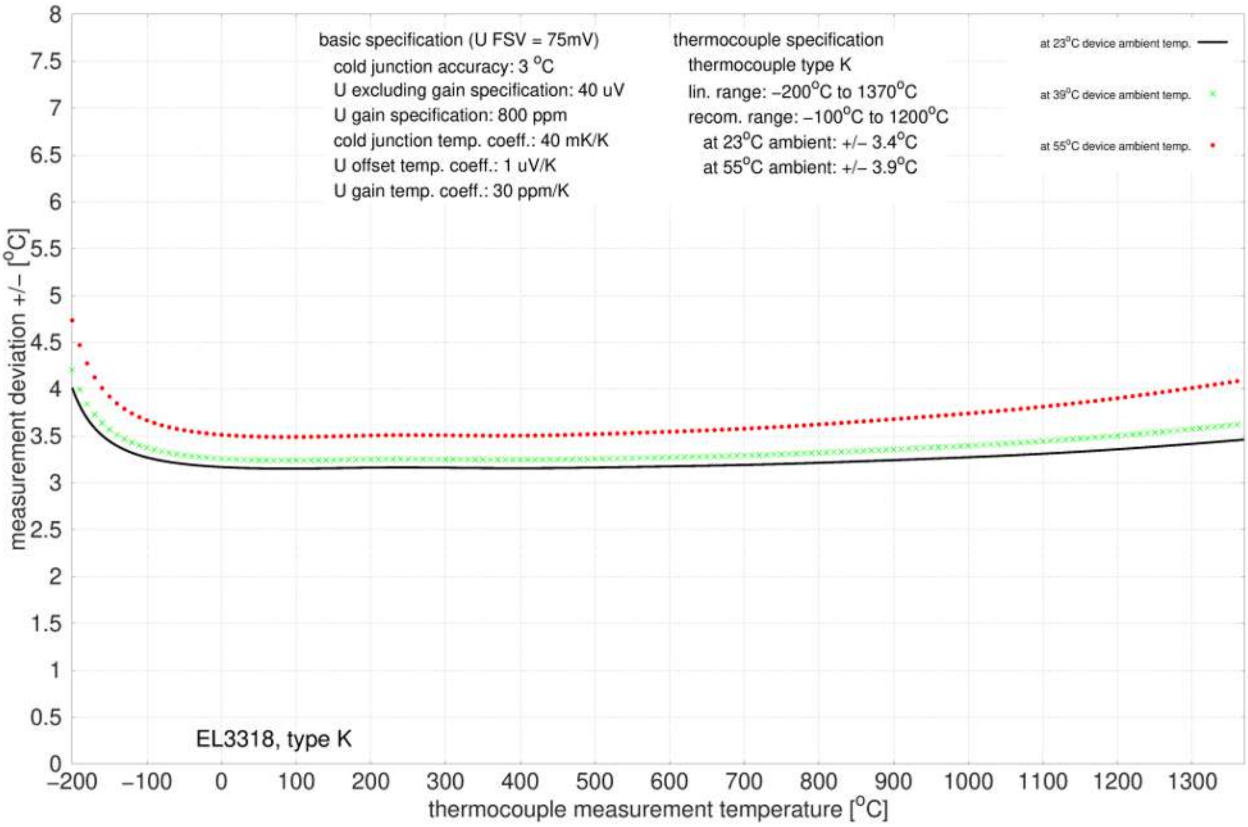
Measurement uncertainty for thermocouple type J:



### Specification - thermocouple type K

| Temperature measurement thermocouple | | Type K |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.891 mV … +1370 °C ≈ 54.818 mV |
| Measuring range, end value (full scale value) | | +1370 °C |
| Measuring range, recommended | | -100 °C … +1200 °C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type K: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.0 K ≈ ± 0.22 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.6 K ≈ ± 0.26 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

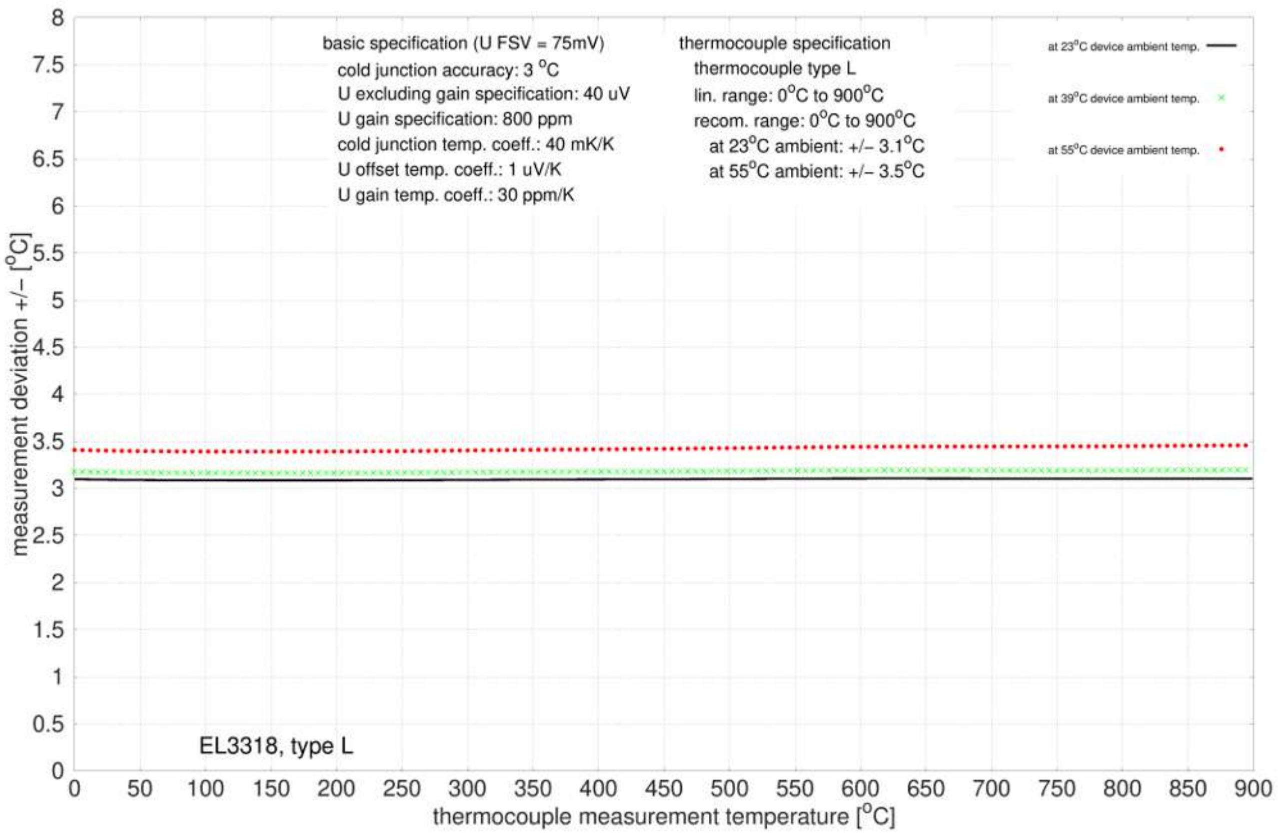
Measurement uncertainty for thermocouple type K:



### Specification - thermocouple type L

| Temperature measurement thermocouple | | Type L |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +900 °C ≈ 52.430 mV |
| Measuring range, end value (full scale value) | | +900 °C |
| Measuring range, recommended | | 0°C … +900°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type L: approx. 0.03 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.1 K ≈ ± 0.34 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.39 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

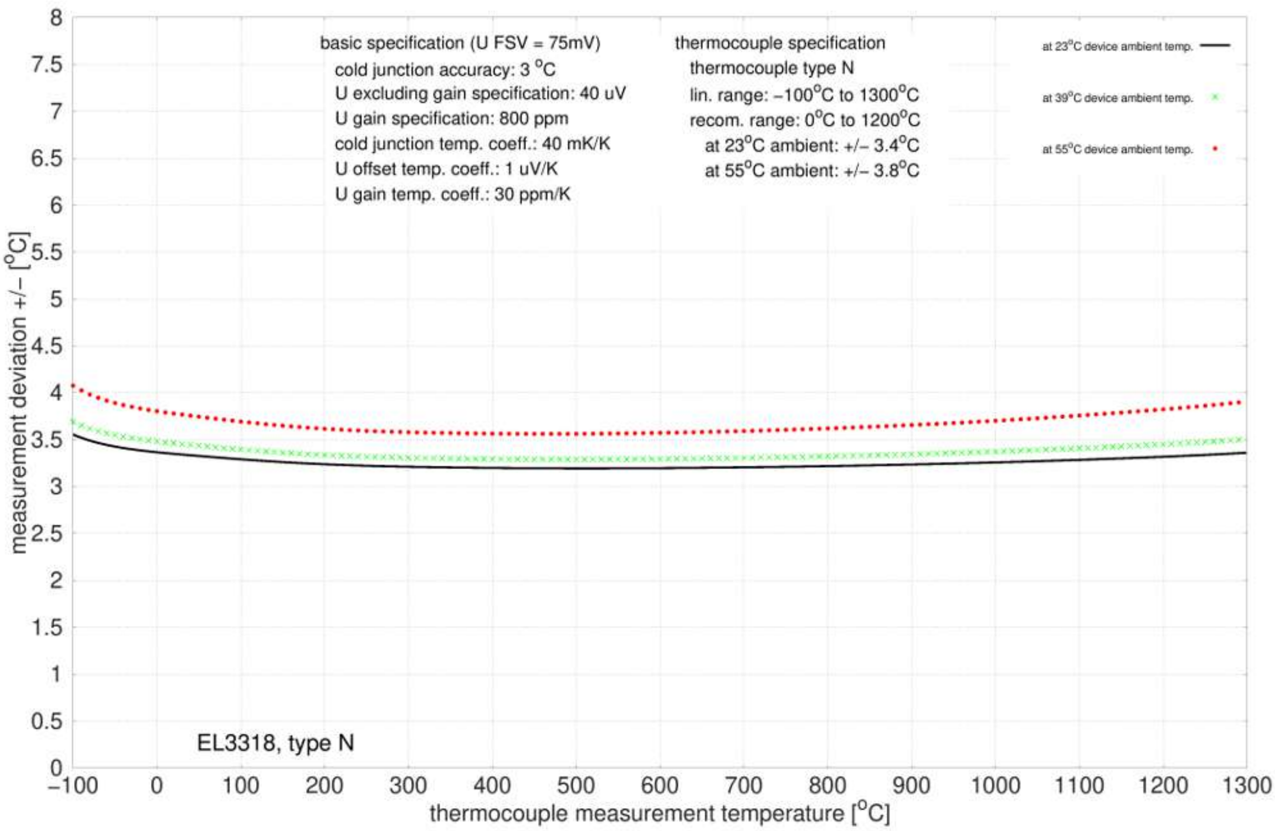
Measurement uncertainty for thermocouple type L:



## Specification - thermocouple type N

| Temperature measurement thermocouple | | Type N |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -100 °C ≈ -2.406 mV … +1300 °C ≈ 47.513 mV |
| Measuring range, end value (full scale value) | | +1300 °C |
| Measuring range, recommended | | 0°C … +1300°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type N: approx. 0.04 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.4 K ≈ ± 0.26 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.8 K ≈ ± 0.29 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

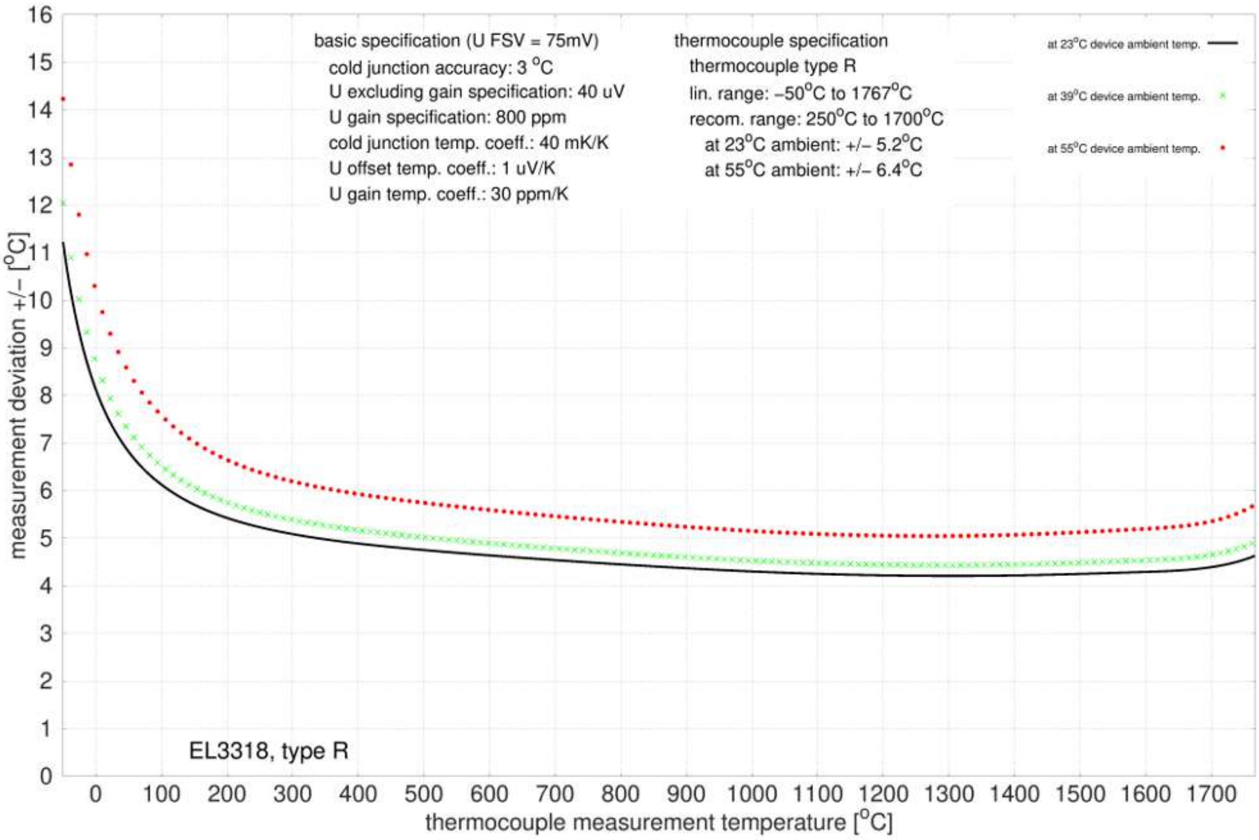
Measurement uncertainty for thermocouple type N:



### Specification - thermocouple type R

| Temperature measurement thermocouple | | Type R |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1767 °C ≈ 21.089 mV |
| Measuring range, end value (full scale value) | | +1767 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type R: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 5.2 K ≈ ± 0.29 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 6.4 K ≈ ± 0.36 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

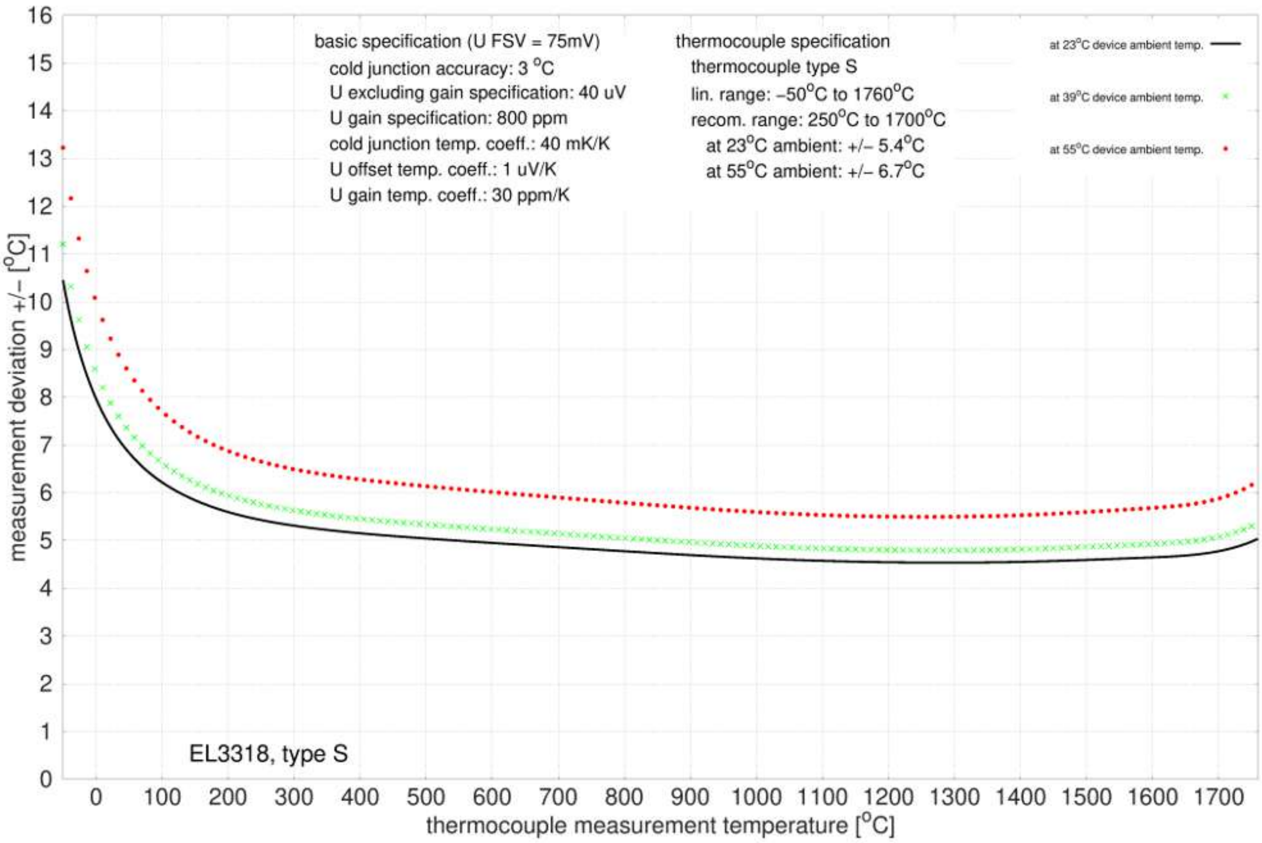
Measurement uncertainty for thermocouple type R:



### Specification - thermocouple type S

| Temperature measurement thermocouple | | Type S |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +1760 °C ≈ 17.947 mV |
| Measuring range, end value (full scale value) | | +1760 °C |
| Measuring range, recommended | | +250°C … +1700°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type S: approx. 0.05 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 5.4 K ≈ ± 0.31 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 6.7 K ≈ ± 0.38 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

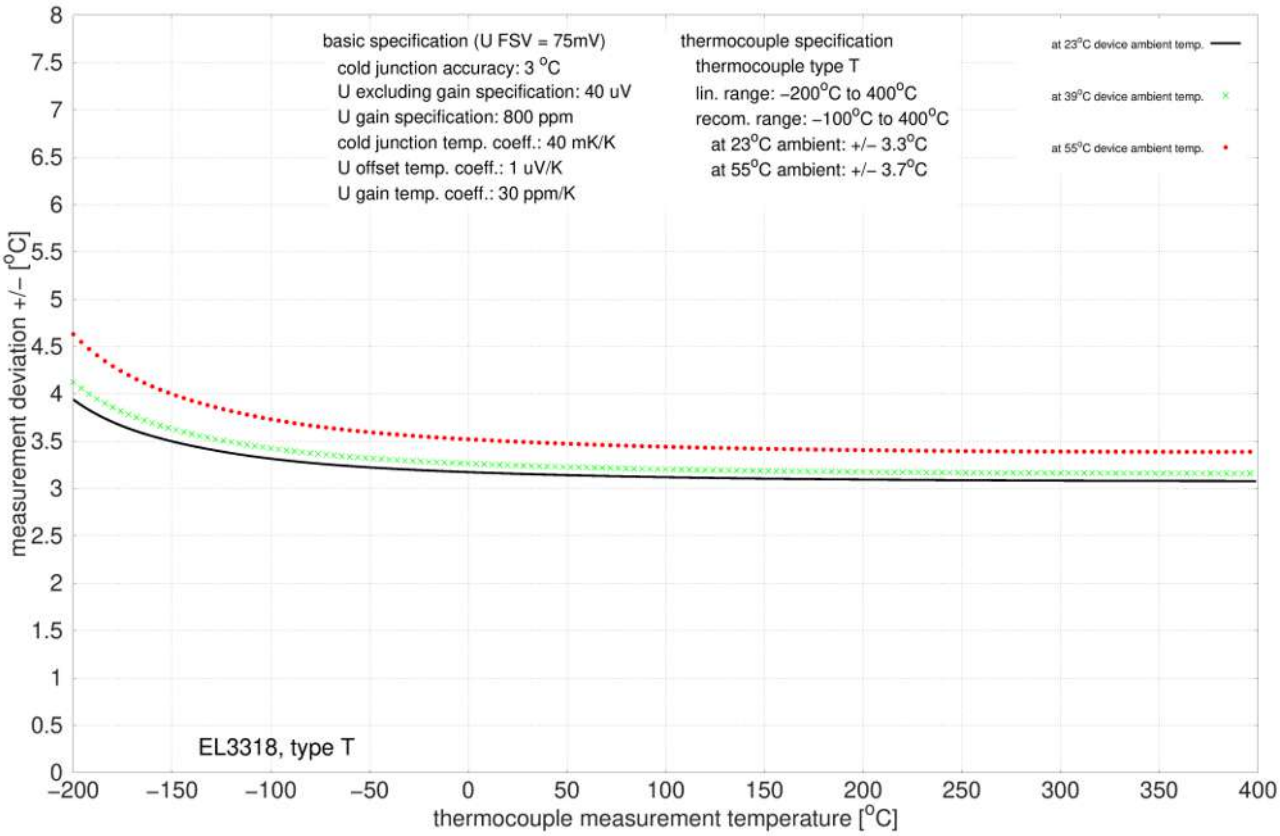
Measurement uncertainty for thermocouple type S:



### Specification - thermocouple type T

| Temperature measurement thermocouple | | Type T |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | -200 °C ≈ -5.603 mV … +400 °C ≈ 20.872 mV |
| Measuring range, end value (full scale value) | | +400 °C |
| Measuring range, recommended | | -100°C … +400°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.3 K ≈ ± 0.83 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.7 K ≈ ± 0.93 $\%_{FSV}$ |
| Temperature coefficient (Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

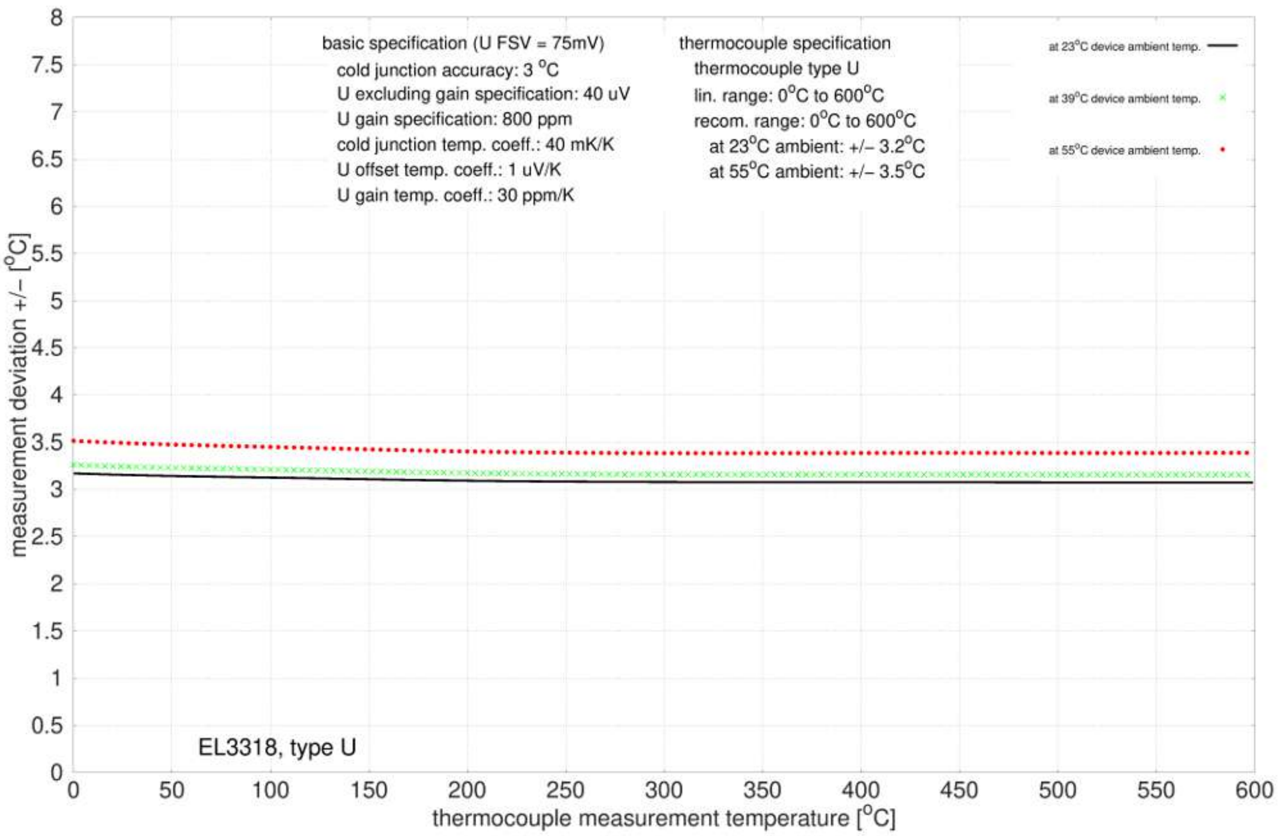
Measurement uncertainty for thermocouple type T:



### Specification - thermocouple type U

| Temperature measurement thermocouple | | Type U |
|---|---|---|
| Electrical measuring range used | | ± 75 mV |
| Measuring range, technically usable | | 0 °C ≈ 0 mV … +600 °C ≈ 33.600 mV |
| Measuring range, end value (full scale value) | | +600 °C |
| Measuring range, recommended | | 0°C … +600°C |
| PDO LSB | | 0.1/0.01 °C/digit, depending on PDO setting<br>Note: internally, 16 bits are used for the calculation up to the FSV; depending on the set thermocouple, therefore, jumps in value >0.01 °C occur with "resolution 0.01 °C"; e.g. type U: approx. 0.02 °C |
| Uncertainty in the recommended measuring range, with averaging | @ 23 °C ambient temperature | ± 3.2 K ≈ ± 0.53 $\%_{FSV}$ |
| | @ 55 °C ambient temperature | ± 3.5 K ≈ ± 0.58 $\%_{FSV}$ |
| Temperature coefficient<br>(Change in the measured value in relation to the change in the ambient temperature of the terminal) | | *Since the value is highly dependent on the sensor temperature, as can be seen in the specification plot shown below, it must basically be derived from the specification plot. For better approximation, the measurement uncertainty at $T_{amb}$= 39 °C as the middle point between 23 °C and 55 °C is also shown informatively in order to illustrate the non-linear curve.* |

Measurement uncertainty for thermocouple type U:



### 2.9.2.4 Housing data

| Housing data | EL-12-16 pin |
|---|---|
| Design | compact HD (High Density) housing with signal LEDs |
| Material | Polycarbonate |
| Dimensions (W x H x D) | 12 mm x 100 mm x 68 mm |
| Mounting | on 35 mm DIN rail, according to EN 60715 with lock |
| Stackable by | double groove-tongue connection |
| Labelling | Labeling of the BZxxx series |
| Wiring | solid wire conductors (e): direct plug-in technique;<br>stranded wire conductors (f) and wire end sleeve (a): spring actuation by screwdriver |
| Connection cross-section | e*: 0.08 … 1.5 mm²,<br>f*: 0.25 … 1.5 mm²,<br>a*: 0.14 … 0.75 mm² |
| Connection cross section AWG | e*: AWG 28 … 16,<br>f*: AWG 22 … 16,<br>a*: AWG 26 … 19 |
| Strip length | 8 … 9 mm |
| Power contacts current loading | $I_{max}$: 10 A |
| *e: single-wire, solid wire; f: stranded wire; a: with wire end sleeve | |

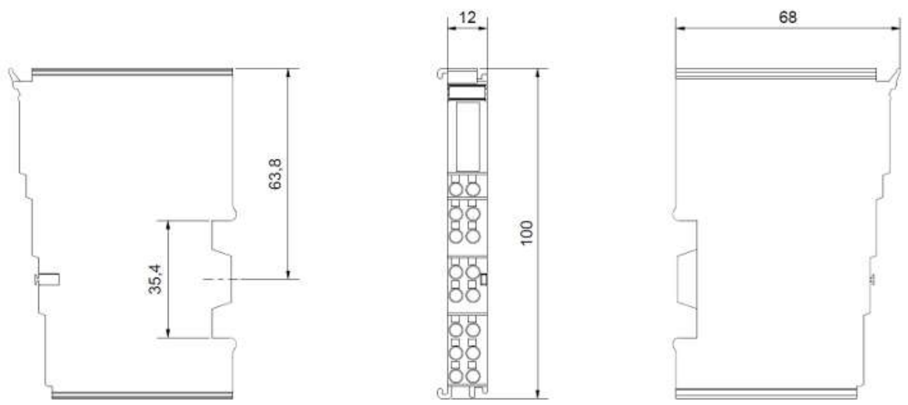



Fig. 21: Technical drawing | housing EL-12-16 pin

## 2.9.3 Connection

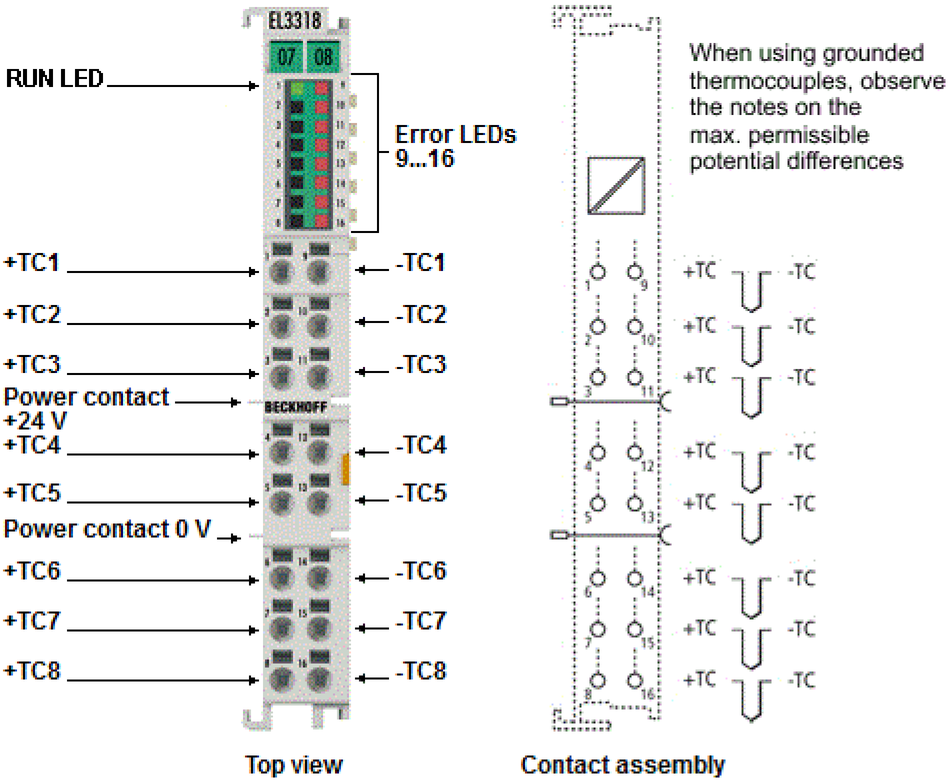



Fig. 22: EL3318

**EL3318 - Connection**

| Terminal point | No. | Comment |
|---|---|---|
| +TC1 | 1 | Input +TC1 |
| +TC2 | 2 | Input +TC2 |
| +TC3 | 3 | Input +TC3 |
| +TC4 | 4 | Input +TC4 |
| +TC5 | 5 | Input +TC5 |
| +TC6 | 6 | Input +TC6 |
| +TC7 | 7 | Input +TC7 |
| +TC8 | 8 | Input +TC8 |
| -TC1 | 9 | Input -TC1 |
| -TC2 | 10 | Input -TC2 |
| -TC3 | 11 | Input -TC3 |
| -TC4 | 12 | Input -TC4 |
| -TC5 | 13 | Input -TC5 |
| -TC6 | 14 | Input -TC6 |
| -TC7 | 15 | Input -TC7 |
| -TC8 | 16 | Input -TC8 |

## 2.9.4 Display, diagnostics

**EL3318 - LEDs**

| LED | Color | Meaning | |
|---|---|---|---|
| RUN | green | This LED indicates the terminal's operating state: | |
| | | off | State of the EtherCAT State Machine: **INIT** = initialization of the terminal |
| | | flashing uniformly | State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different standard-settings set |
| | | flashing slowly | State of the EtherCAT State Machine: **SAFEOP** = verification of the sync manager channels and the distributed clocks.<br>Outputs remain in safe state |
| | | on | State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible |
| | | flashing rapidly | State of the EtherCAT State Machine: **BOOTSTRAP** = function for terminal firmware updates |
| ERROR1-8 | red | Short circuit or wire breakage. The voltage is in the invalid range of the characteristic curve. | |

## 2.10 Technology "Temperature measurement with thermocouples

### 2.10.1 Basics of thermocouple technology

**General term: "device"**

This chapter is used in the documentation of several Beckhoff products. It is therefore written in general terms and uses the generic term "device" for the different device types such as terminal (EL/ELM/KL/ES series...), box (IP/EP/EPP series...), module (EJ/FM series…).

Thermocouples are temperature sensors. The application areas of thermocouples are very diverse due to their low cost, fast detection of temperature differences, wide temperature ranges, high temperature limits and availability in a wide range of types and sizes.

#### Measuring principle and configuration

Temperature measurement with a thermocouple is based on the Seebeck effect, which was discovered in the 1820s by the German physicist Thomas Johann Seebeck. The Seebeck effect, also known as thermoelectric effect, describes a charge shift in a conductive material due to a temperature gradient along the conductor. The magnitude of the charge shift depends on the magnitude of the temperature difference and the respective conductor material.

In thermocouples this charge shift is used to generate a voltage. Two different conductor materials are connected at one end. This is the measuring point at which the temperature is to be determined. At the other end the conductors are not connected. This open end, where the transition to the measuring electronics is located, is the cold junction. A temperature difference occurs between the cold junction and the measuring point, which can be measured via the voltage between the conductors at the open end. The voltage depends on the conductor materials used and the temperature difference. It is in the range of a few mV.

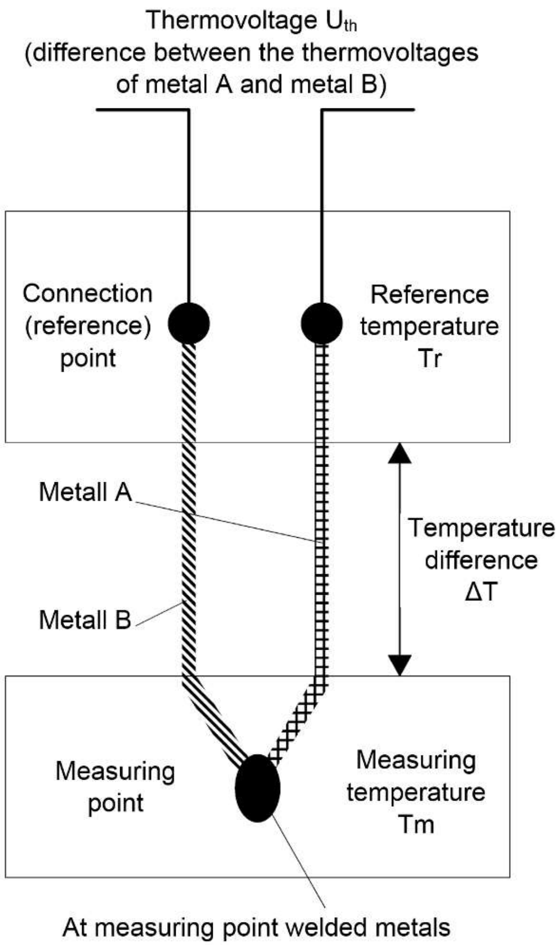



Fig. 23: Structure and principle of a thermocouple

If only one material were used for a thermocouple, the charge shift in both conductors would be identical, so that no potential difference between the two conductors at the open end could be measured.

The temperature measurement with thermocouples is therefore actually a voltage measurement, based on which a temperature can be determined from the known characteristic curve. In addition, the measuring procedure is not absolute but differential, since no absolute temperature (with the reference point 0 °C) is determined, but the temperature difference between the measuring point and the cold junction.

For the evaluation of thermocouples, measuring electronics are required that can evaluate small voltages in the mV range with sufficiently high resolution and accuracy. Thermocouples are active sensors, which means that no sensor supply is required to measure the temperature.

### Thermocouple types

There are different types of thermocouples, which consist of different combinations of conductor materials. Each material combination has specific properties and is suitable for certain applications. The different thermocouple types are distinguished by letters.

Due to the different material combinations, the different thermocouple types have different characteristic values. They differ in the temperature limits and the characteristic voltage/temperature curve. In order to be able to differentiate between the thermocouple types, the color codes for the sheath, the positive pole and the negative pole are defined in various standards.

The following table shows common thermocouple types with the specification of the materials used, the defined temperature ranges and the color coding.

| Type (conforms to EN60584-1) | Element | Measuring range * | | Average temperature coefficient | Voltage at FSV | Color coding (sheath - positive pole - negative pole) |
|---|---|---|---|---|---|---|
| | | min | max | | | |
| B | Pt30%Rh-Pt6Rh | 600 °C | 1820 °C | 6 µV/K | 13.820 mV | grey - grey - white |
| C ** | W5%Re-W25%Re | -18 °C | 2316 °C | 15 µV/K | 37.070 mV | n.d. |
| E | NiCr-CuNi | -270 °C | 1000 °C | 65 µV/K | 76.373 mV | violet - violet - white |
| J | Fe-CuNi | -210 °C | 1200 °C | 54 µV/K | 69.553 mV | black - black - white |
| K | NiCr-Ni | -270 °C | 1372 °C | 42 µV/K | 54.886 mV | green - green - white |
| L *** | Fe-CuNi | -200 °C | 900 °C | 54 µV/K | 53.140 mV | blue - red - blue |
| N | NiCrSi-NiSi | -270 °C | 1300 °C | 27 µV/K | 47.513 mV | pink - pink - white |
| R | Pt13%Rh-Pt | -50 °C | 1768 °C | 10 µV/K | 21.101 mV | orange - orange - white |
| S | Pt10%Rh-Pt | -50 °C | 1768 °C | 10 µV/K | 18.693 mV | orange - orange - white |
| T | Cu-CuNi | -270 °C | 400 °C | 40 µV/K | 20.872 mV | brown - brown - white |
| U *** | Cu-CuNi | -200 °C | 600 °C | 40 µV/K | 34.310 mV | brown - red - brown |

*The specified measuring range refers to the maximum possible measuring range of the specified thermocouple type. The possible measuring ranges of the thermocouple measuring devices may be limited. The possible measuring ranges of the thermocouple measuring devices are specified in the technical data in the documentation.

**not standardized according to EN60584-1

***conforms to DIN 43710

The thermocouple must be selected according to the operating conditions. Therefore, not only the uncertainty must be taken into account, but also the other properties of the different thermocouple types. For an application with small temperature fluctuations, it is advantageous to select a thermocouple type with a high thermovoltage per temperature change. In an application where the temperature to be measured is very high, it is important to observe the maximum operating temperature.

**Characteristic curve**

Type-specific reference tables are available for determining the temperature difference to a measured thermovoltage. A simple conversion of the voltage into a temperature with a temperature coefficient, as is often approximated in resistance thermometers, is not possible because the relationship between voltage and temperature is clearly non-linear over the entire measuring range. The changing temperature coefficient results in a non-linear characteristic voltage/temperature curve. This characteristic curve is in turn dependent on the thermocouple type, so that each type has its own non-linear characteristic voltage/temperature curve. As an example, the characteristic curves for typical thermocouple types are shown in the following diagram. The non-linearity is particularly evident in the temperature range below 0 °C.

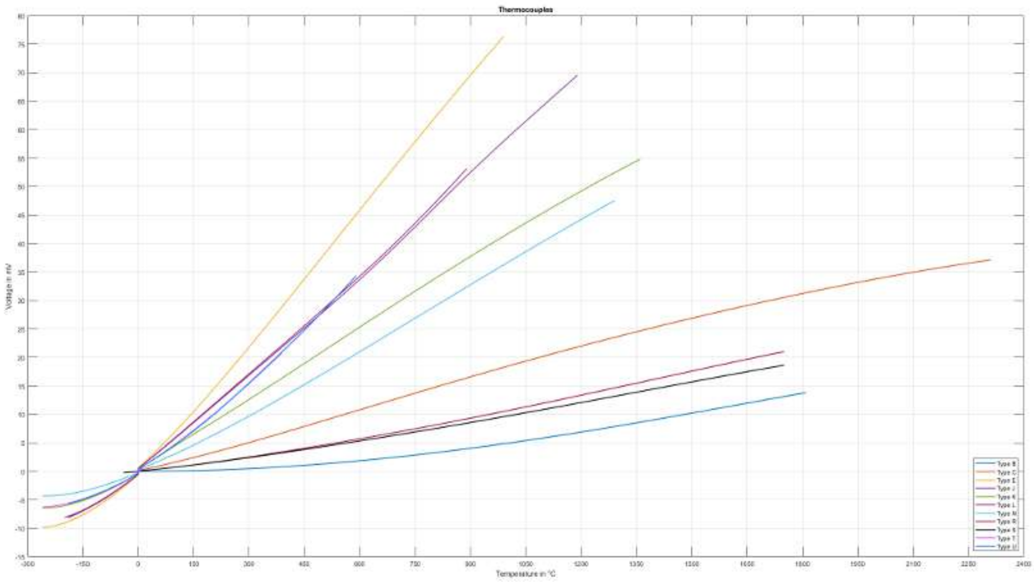


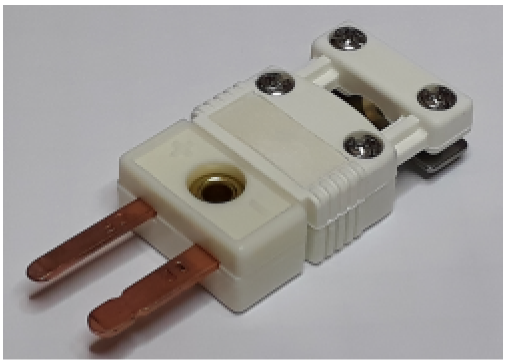

Fig. 24: Characteristic voltage/temperature curves of different thermocouple types

Thermocouples are subject to unavoidable and irreversible changes during practical application, which leads to ever-increasing measurement uncertainties over time. In other words: the measurement becomes more and more incorrect over time. These changes are also referred to as aging and depend on various influencing factors. Examples of these influences are mechanical and chemical stresses on the thermocouples. Mechanical stresses are deformations of the conductors, which change the crystal structure of the metals. This leads to incorrect thermovoltages. Chemical stresses are also changes in the crystal structure of the metals or oxidation, which change the thermal properties of the conductors, resulting in a change in the characteristic curve. This influence can be reduced by installation in gas-tight protection tubes.

**Pluggable connections**

Open wire ends or suitable thermocouple connectors can be used to connect thermocouples to measuring devices and evaluation electronics or to connect a thermocouple to thermo or compensating cables.

Ideally, the contacts of such a thermocouple connector are made of the material of the respective thermocouple. This results in a thermovoltage-free transition at the connection points. The plugs are color-coded depending on the type, e.g. type K is green. Labelling on the housing and different contact shapes are intended to avoid polarity reversal.



There are several common sizes: standard, mini, micro.

A special feature is the white connector, which is designed with normal copper contacts, almost like a normal non-thermocouple connector. This makes it universally applicable for all thermocouple types, although it has the disadvantage that it does not create a thermovoltage-free transition. Far more common than the white plug is the white "universal" socket on the measuring device. This allows any thermocouple plug to be plugged into the device. In the measuring device, the cold junction temperature must then be determined at this plug transition.

**Extensions and connection of thermocouples**

In some cases it is useful to extend the thermocouple and thus to move the cold junction to a particular location, where the temperature can be kept constant or measured by simple means. For this purpose the thermocouple must be extended. This can be done with a thermo or compensation wire. Thermo cables are made of the same material as the thermocouple itself. Compensating cables, on the other hand, are usually made of cheaper materials with similar thermal properties. Both types are therefore suitable for extending a thermocouple to a remote cold junction. The wires for thermo and compensating cables are standardized by DIN 43713.

With compensating cables, care must be taken to ensure that the material used has similar thermal properties but not identical properties. The thermal properties only apply in a narrowly limited temperature range. At the transition from thermocouple to compensation wire, another thermocouple is created. This results in small thermovoltage distortions, which influence the measurement result. If the compensating cables are used outside the specified temperature range, the accuracy of the temperature measurement will be further affected and the measurement result will deteriorate.

For both thermal and compensation wires, there are two accuracy classes that indicate the limit deviations. These are defined in DIN 43722. When selecting the thermocouple extension, the resulting uncertainty should be considered and evaluated.

**Sensor circuit**

Changing the sensor circuit through additional elements such as selector switches or multiplexers can affect the measuring accuracy. In such switches, small local thermovoltages can be generated which distort the measurement. If such components cannot be avoided in the application, their influence should be carefully examined.

**Maximum cable length to the thermocouple**

Without additional protective measures, the maximum cable length from the measuring device to the thermocouple is 30 m. For longer cable lengths, suitable surge protection should be provided.

**Cold junction compensation / CJC**

The correction of the thermovoltage value to determine the absolute temperature value is referred to as cold junction compensation. In order to determine an absolute temperature value that is as accurate as possible, the temperature at the cold junction must either be kept constant at a known value or measured continuously during the measurement with the smallest possible uncertainty. In some applications, the cold junction may be in an ice bath (0 °C), for example. In this case the temperature determined via the thermovoltage corresponds to both the temperature difference and the absolute temperature. In many applications, however, this option cannot be implemented, so that cold junction compensation is necessary.

As a cold junction for thermocouple evaluation with EtherCAT and Bus Terminals in an IP20 housing, the cold junction temperature is measured at the transition from the thermocouple to the copper contacts. During operation this value is continuously measured within the terminal via a sensor in order to correct the measured values. This continuous measurement can optionally be disabled in cases where external cold junction compensation is used, for example.

With the EJ plug-in modules for the PCB, the cold junction measurement is not integrated in the module. In this case, the cold junction must be measured externally. This temperature can then be transferred to the terminal for cold junction compensation and calculation of the absolute temperature.

For IP67 modules and for EJ plug-in modules, the cold junction is located outside the module. For cold junction compensation, Pt1000 measuring resistors must be connected externally.
For IP67 modules Beckhoff offers the ZS2000-3712 connector with integrated Pt1000 measuring resistor for this purpose.

**Determination of the absolute temperature**

Temperature measurement with a thermocouple is a differential temperature measurement, in which the temperature difference between the measuring point and the reference junction, also known as cold junction, is determined. To determine the absolute temperature at the measuring point, the measured thermovoltage must therefore be corrected by the thermovoltage at the cold junction. With the corrected thermovoltage, the temperature at the measuring point can then be determined from suitable tables or characteristic curves. Due to the non-linearity of the characteristic curve, it is imperative that this calculation is carried out with the voltages and not with the temperature. Otherwise, there would be a significant error in the measurement.

**Difficulties in measuring temperature with thermocouples**

- Linearization

- Cold junction compensation

In general, the absolute temperature is calculated using the following relationship:

$U_{measuring\ point} = U_{thermo} + U_{cold\ junction}$

$T_{measuring\ point} = f(U_{measuring\ point})$

In the following section, the absolute temperature is determined as an example based on correction of the thermovoltages and the temperature. The example calculation can be used to illustrate the error resulting from incorrect correction.

Sought: $T_{measuring\ point}$

Known: Thermocouple type K, $U_{thermo}$ = 24.255 mV, $T_{cold\ junction}$ = 22 °C

**Option 1: Correction of thermovoltages – CORRECT**

The thermovoltage at the cold junction $U_{cold\ junction}$ must be determined based on the known temperature $T_{cold\ junction}$ from the characteristic voltage/temperature curve or table for thermocouple type K:

$U_{cold\ junction}$ = U(22 °C) = 0.879 mV

The thermovoltage at the measuring point can then be determined with reference to 0 °C:

$U_{measuring\ point} = U_{thermo} + U_{cold\ junction}$ = 24.255 mV + 0.879 mV = 25.134 mV

The corresponding temperature value can then be determined for thermocouple type K based on the determined thermovoltage from the characteristic voltage/temperature curve or table:

$T_{measuring\ point}$ = T(25.134 mV) ≈ 605.5 °C

**Option 2: Temperature correction – WRONG**

In principle, the temperature difference between the cold junction and the measuring point $T_{thermo}$ could be determined based on the known thermovoltage $U_{thermo}$ from the characteristic voltage/temperature curve or table for thermocouple type K:

$T_{thermo}$ = T(24.255 mV) = 585 °C

The temperature of the measuring point could then be determined with reference to 0 °C:

$T_{measuring\ point} = T_{thermo} + T_{cold\ junction}$ = 585 °C + 22 °C = 607 °C

Note that there is a temperature difference of 1.5 °C between the value with the proper correction (voltage correction, option 1) and the value with the incorrect correction (temperature correction, option 2).

**Evaluation of thermocouples with thermocouple measuring devices**

Beckhoff thermocouple measuring devices can evaluate thermocouples of different types. Linearization of the characteristic curves and determination of the reference temperature takes place directly in the measuring device. The measuring device can be fully configured via the Bus Coupler or the controller. Different output formats may be selected or own scaling activated. Linearization of the characteristic curve and determination and calculation of the reference temperature (temperature at the connection contacts of the measuring device) can be disabled, so that the device can be used as a [mV] measuring device or with an external cold junction. In addition to the internal evaluation of the measured voltage for conversion into a temperature, the raw voltage value can be transferred from the measuring device to the control system for further processing.

Temperature measurement with thermocouples generally comprises three steps:

- Measuring the electrical voltage
- Optional: Temperature measurement of the cold junction
- Software-based conversion of the voltage into a temperature value according to the set thermocouple type (K, J, …)

All three steps can take place locally in the Beckhoff measuring device. Transformation in the measuring device can be disabled if it is to take place in the higher-level control system. Depending on the measuring device type, several thermocouple conversion options are available, which differ in terms of their software implementation.

**Uncertainties in the evaluation of thermocouples with thermocouple measuring devices**

The thermocouple measurement consists of a chain of measuring and computing elements that affect the attainable measurement deviation:

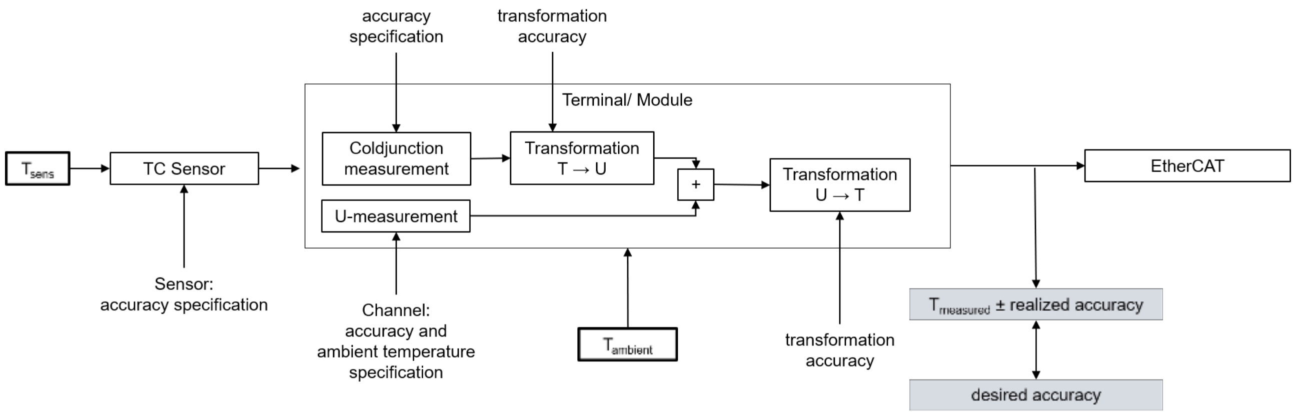



Fig. 25: Concatenation of the uncertainties in temperature measurement with thermocouples

When measuring a temperature, there are various factors influencing the accuracy, from which the total inaccuracy (total uncertainty) is then derived.

**Uncertainty of the voltage measurement**

First and foremost, measuring a temperature with thermocouples is not based on an actual temperature measurement, but a voltage measurement with subsequent conversion into a temperature. The accuracy of the voltage measurement is therefore the basis for the accuracy of the temperature determination. Since a change of 1 °C at the sensor causes a change in the single-digit µV range, depending on the thermocouple type, even a small uncertainty of the voltage measurement has a large influence on the final result.

**Uncertainty of the temperature conversion**

The conversion of the measured voltage into a temperature is carried out during evaluation either by means of value tables from the characteristic voltage/temperature curve of a thermocouple type or by approximation based on a polynomial. Due to the non-linearity of the characteristic voltage/temperature curve, both options are only approximations of the actual values, so that the conversion results in a further (small) uncertainty component from the transformation.

**Uncertainty of the cold junction evaluation**

Cold junction compensation in thermocouple measuring devices must be carried out at the transition from the thermocouple to the copper contacts of the electronics. However, in many cases the temperature at this point cannot be measured directly for mechanical reasons. In this case the temperature of the cold junction has to be approximated at a distance of a few millimeters or through an average value of the housing temperatures. Since the exact value cannot be determined in this way, this results in further uncertainty.

**Uncertainty of the sensor**

The three factors influencing the uncertainty referred to above relate to the uncertainties in the evaluation of the thermocouples. The accuracy of the thermocouple itself is another factor and must also be taken into account.

Since temperature measurement with thermocouples is actually a voltage measurement and the thermocouples have a non-linear characteristic voltage/temperature curve, it is not possible to simply add up the individual temperature uncertainties to obtain the total uncertainty. To calculate the total uncertainty, all temperature values must be converted into the corresponding voltage value of the respective thermocouple type. When the temperatures are added together an error occurs, as described in the example in the chapter on "Determination of the absolute temperature".

The following diagram shows an example of an analysis of the uncertainties associated with the evaluation of a thermocouple for an EL331x thermocouple terminal with internal cold junction compensation and conversion of the voltage into a temperature via a second degree polynomial. The diagram does not take into account the uncertainty of the thermocouple itself, which is an additional factor!

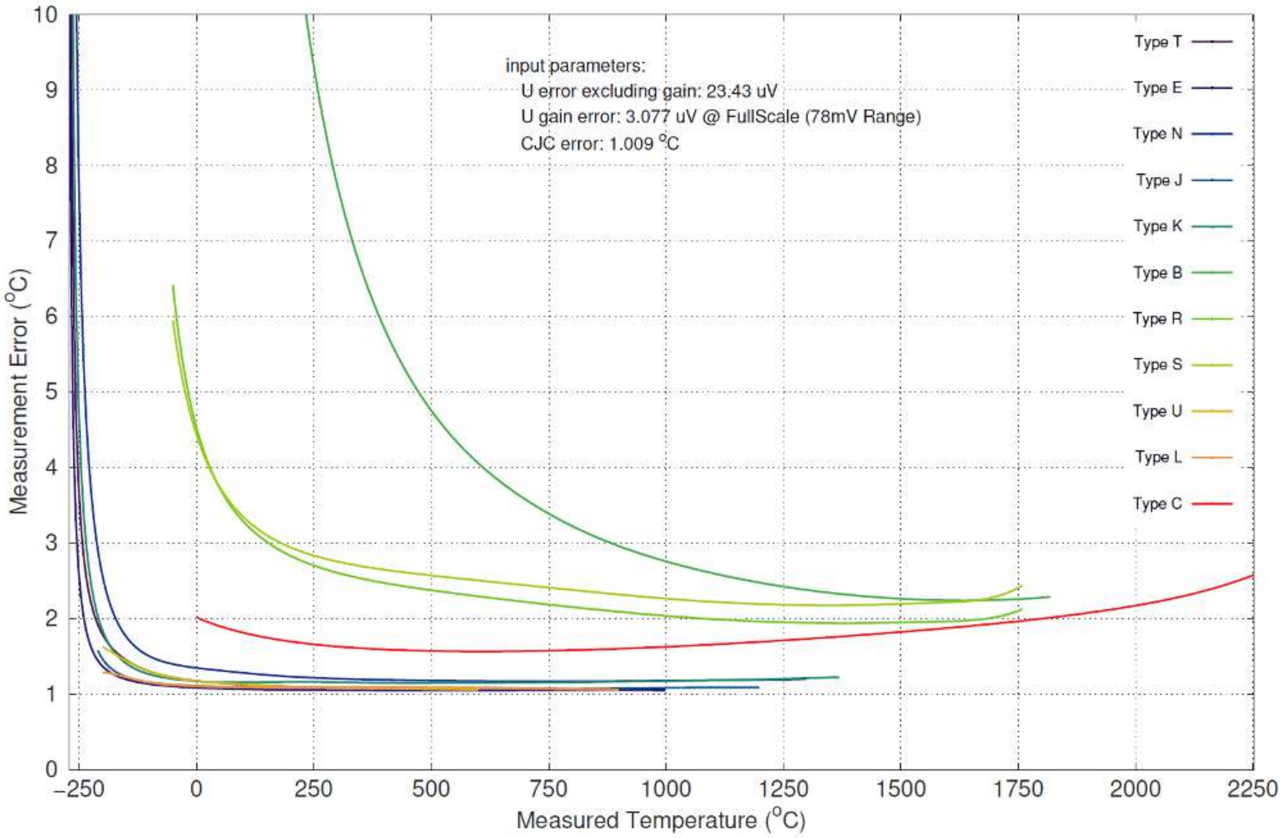



Fig. 26: Example of a thermocouple evaluation uncertainty analysis with an EL331x thermocouple terminal

It is clear from the diagram that the uncertainty of the measured temperature depends on the temperature to be measured. Especially in the lower temperature range, where there is a strong non-linearity of voltage and temperature, the uncertainty of the temperature measurement increases significantly.

Beckhoff offers several products for the evaluation of thermocouples, including

- EL331x-0000: EtherCAT terminal, 1/2/4/8 channel analog input, temperature, thermocouple, 16 bit
- EL3314-0002: EtherCAT terminal, 4 channel analog input, temperature, thermocouple, 24 bit, electrically isolated
- EL3314-0010: EtherCAT terminal, 4 channel analog input, temperature, thermocouple, 24 bit, high-precision
- EL3314-0030: EtherCAT terminal, 4 channel analog input, temperature, thermocouple, 24 bit, high-precision, external calibrated
- EL3314-0090: EtherCAT terminal, 4 channel analog input, temperature, thermocouple, 16 bit, TwinSAFE SC
- ELM370x-xxxx: EtherCAT terminal, 2/4 channel analog input, multi-functional, 24 bit, 10 ksps

- ELM334x-xxxx: EtherCAT measurement technology series, thermocouple input, mini thermocouple connector
- EP3314-0002: EtherCAT Box, 4 channel analog input, temperature, thermocouple, 16 bit, M12
- EPP3314-0002: EtherCAT P Box, 4 channel analog input, temperature, thermocouple, 16 bit, M12
- KL331x: bus terminal, 1/2/4 channel analog input, temperature, thermocouple, 16 bit
- EJ3318: EtherCAT plug-in module, 8 channel analog input, temperature, thermocouple, 16 bit

The current overview can be found at www.beckhoff.com

## 2.10.2 Thermocouple measurement with Beckhoff

**Thermocouple specification and conversion**

Temperature measurement with thermocouples generally comprises three steps:

- Measuring the electrical voltage,
- optional: Temperature measurement of the internal cold junction,
- optional: Software-based conversion of the voltage into a temperature value according to the set thermocouple type (K, J, …).

All three steps can take place locally in the Beckhoff measuring device. Device-based transformation can be disabled if the conversion is to take place in the higher-level control system. Depending on the device type, several thermocouple conversions are available, which differ in terms of their software implementation.

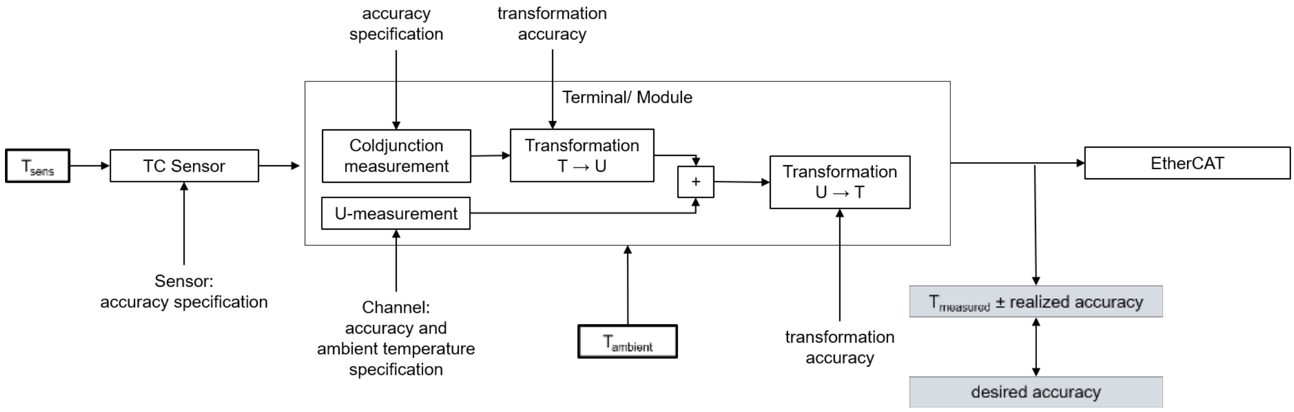
For Beckhoff thermocouple measuring devices this means that

- a specification of the electrical voltage measurement is provided and
- based on this, the effect on temperature measurement is specified depending on the supported thermocouple type. Note that thermocouple characteristic curves are always realized as higher-order equations or by a sampling points table in the software, therefore a direct, linear U → T transfer only makes sense in a narrow range.

**Data for the sensor types in the following table**

The values for the sensor types listed in the following table are shown here merely for informative purposes as an orientation aid. All data are given without guarantee and must be cross-checked against the data sheet for the respective sensor employed.

The thermocouple measurement consists of a chain of measuring and computing elements that affect the attainable measurement deviation:




The given voltage specification is decisive for the achievable temperature measuring accuracy. It is applied to the possible thermocouple types in the following.

On account of

- the strong non-linearity that exists with thermocouple, which suggests a meaningful use of a thermocouple in a limited temperature range (if possible)
- influence of the possibly used internal cold junction
- the possible use of an external cold junction, the specification of which is not known at this point, and
- the influence of the ambient temperature on the analog input device used in the voltage and cold junction measurement (leads to a change in $T_{measured}$ due to $\Delta T_{ambient}$)

detailed temperature specification tables are not given below, but rather

- one short table per thermocouple type
    - indicating the electrical measuring range used in the voltage measurement

    - indicating the entire technically usable measuring range supported by the device. This is also the linearization range of the temperature transformation, usually the application range of the respective thermocouple specified in the standards.
      Note: the electrical measuring range is designed to cover the entire linearization range. The entire temperature measuring range can therefore be used
    - with specification of the measuring range recommended by Beckhoff for this type. It is a subset of the technically usable measuring range and covers the measuring range commonly used in industry in which a relatively good measurement uncertainty is achieved.
      Since thermocouples have a non-linear characteristic curve across the entire implemented linearization range as shown in the chapter on thermocouple principles, the specification of measurement uncertainty over this entire range as the so-called basic accuracy would be unrealistic and even misleading. A much better uncertainty is achieved in the temperature range commonly used in industry. Nevertheless, it is of course possible to use the device outside of the "recommended measuring range" (but within the "technically usable measuring range")
    - with the specified measurement uncertainty in the "recommended measuring range" at an ambient temperature of 23 °C and 55 °C, where the measurement uncertainty at 55 °C corresponds to the value for 23 °C ±32 °C.
      Thus, the measurement uncertainty at other ambient temperatures in the recommended measuring range can be approximately interpolated or extrapolated. The values can also be taken from the specification plot.
      Attention when determining the TC [K/Kamb] (temperature coefficient): the specified values do not necessarily have to be available for the same $T_{sens}$! To determine TC, read the measurement uncertainty values from the plot at $T_{sens}$ and calculate TC.
- the "Specification Plot": a comprehensive specification statement as a graphical representation of the measurement uncertainty for $T_{sens}$ at the two aforementioned ambient temperatures and additionally 39 °C in the entire technically usable measuring range. The representation of the measurement uncertainty at 39 °C ambient temperatures (mean temperature between 23 °C and 55 °C) shows the non-linear influence of the temperature on the measurement uncertainty.
  If accuracy values outside of the "recommended measuring range" are required, they can thus be read graphically here.

**Notes on the calculation of detailed specifications**

If further specifications are of interest, they can or must be calculated from the values given in the voltage specification.

The sequence:

- General: The conversion is explained here only for one measuring point (a certain input signal); the steps simply have to be repeated in case of several measuring points (up to the entire measuring range).
- The determination of the entire temperature error at a measuring point results from two steps
    - Determination of the temperature error from the error of the voltage measurement
    - Determination of the error by the cold junction measurement at the temperature of the measuring point
    - Note: Due to the non-linearity of the thermocouples, it is not possible to easily add the temperature errors
- If the measured voltage is not known at the measured temperature measuring point, the measured value (MV) must be determined in [mV]:
  $MW = R_{Measuring\ point}\ (T_{Measuring\ point})$ with the help of an U→T table
- The deviation is calculated at this voltage value
    - Via the total equation

$$E_{Total} = \sqrt{(E_{Gain} \cdot \frac{MV}{FSV})^2 + (Tc_{Gain} \cdot \Delta T \cdot \frac{MV}{FSV})^2 + E_{Offset}^2 + E_{Lin}^2 + E_{Rep}^2 + (\frac{1}{2} \cdot E_{Noise,PtP})^2 + (Tc_{Offset} \cdot \Delta T)^2 + (E_{Age} \cdot N_{Years})^2}$$

    - or a single value, e.g. $E_{Single} = 15\ ppm_{FSV}$

- the measurement uncertainty in [mV] must be calculated:
  $E_{voltage}(U_{measuring\ point}) = E_{Total}(U_{measuring\ point}) \cdot FSV$
  or: $E_{voltage}(U_{measuring\ point}) = E_{Single}(U_{measuring\ point}) \cdot FSV$
  or (if already known) e.g.: $E_{voltage}(U_{measuring\ point}) = 0.003$ mV
- Also, for the calculation of the cold junction error required for further calculations, the entire error must be calculated using the above equation.

- The slope at the point used must then be determined:
  $\Delta U_{proK}(T_{measuring\ point}) = [U(T_{measuring\ point} + 1\ °C) - U(T_{measuring\ point})] / 1\ °C$
  with the help of an U→T table
- The cold junction error is given as a temperature in °C. The temperature error must then be converted into a voltage error in [mV] via the slope at the temperature measuring point:
  $E_{CJC,\ U}(T_{measuring\ point}) = E_{CJC,\ T} \cdot \Delta U_{proK}(T_{measuring\ point})$
- The combined error in [mV] must then be calculated using a square addition of the voltage error and the cold junction error:
- $$E_{voltage+CJC} = \sqrt{(E_{voltage})^2 + (E_{CJC,\ U})^2}$$
  - For calibrated thermocouples, the thermocouple error can also be included at this point in order to determine the combined error of the entire system in [mV]. For this purpose, all three error influences in [mV] (voltage, cold junction, thermocouple) must be added squarely.
- The temperature measurement uncertainty can be calculated via the voltage measurement uncertainty and the slope
  $E_{Temp}(U_{measuring\ point}) = (E_{voltage+CJC}(T_{measuring\ point})) / (\Delta U_{proK}(T_{measuring\ point}))$

## 2.11 Use of EL33xx in the TwinCAT System Manager

In the full configuration (all possible PDOs activated, see PDO assignment), the EL3314, for example, offers the following process data for use:

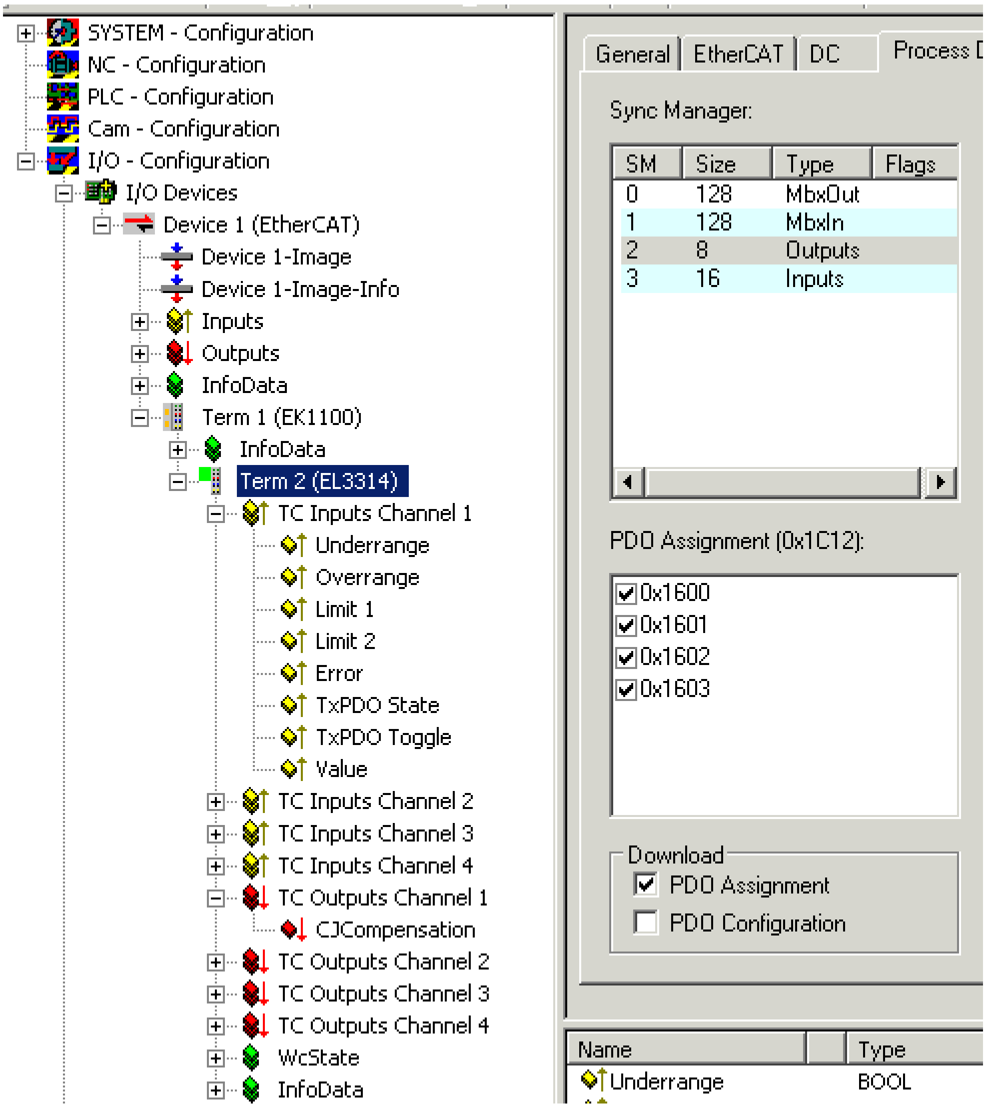



Fig. 27: EL3314 process data

In the case of the EL3314, 4 sets of process data are available, one for each measurement channel.

- **Underrange**: Measurement is below range
- **Overrange**: Range of measurement exceeded ("Cable break" together with "Error")
- **Limit 1***: Limit value monitoring 0: ok, 1: Limit value overshot, 2: Limit value undershot
- **Limit 2***: Limit value monitoring 0: ok, 1: Limit value overshot, 2: Limit value undershot
- **Error**: The error bit is set if the process data is invalid (cable break, over-range, under-range)
- **TxPDO State**: Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).
- **TxPDO Toggle**: The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. This allows the currently required conversion time to be derived.
- **CJCompensation**: Externally measured temperature of the reference measuring point for cold junction compensation

*) not for EL3318

For detailed information on settings and operating modes, please read the chapter "Process data and operating modes [▶ 313]".

# 2.12 Notes on markings, approvals and calibration certificates

## 2.12.1 Note on Beckhoff calibration certificates

Basically every Beckhoff analogue device (input or output) will be justified i.e. will be calibrated during production. This procedure won't be documented unique. This documentation as a calibration certificate is only provided for devices that are expressly delivered with a certificate.

The calibration certificate (or German: "Kalibrierschein") entitles the residual error after compensation/ adjustment to the used standard (reference device). The calibration certificate (as a PDF document) is to be assigned to the device via a unique number. It is therefore not a statement about a device class such as e.g. an approval, but always only applies to a single, named device. It is available for download.

The calibration certificate documents the measurement accuracy at the time the certificate was issued and contains, among other things, information on the ambient conditions and the reference instrument used. It does not contain statement about the behavior or the change of the measuring accuracy in the future. A calibration certificate acts as a backtracking view to the previous time of usage. By reiterated certification procedures over years (without justification) it allows making conclusions about its ageing behavior, so called calibrate history.

**Performance levels of the calibration certificates**

Different "qualities" of a calibration certificate are common:

- Beckhoff calibration certificates
  Such IP20 terminals can be usually identified by the product suffix -0020. The certificate is issued in Beckhoff production as PDF.
  The terminals can be obtained from Beckhoff and recalibrated by the Beckhoff service department.
- ISO17025 calibration certificates
  Such IP20 terminals can be usually identified by the product suffix -0030. The certificate is issued by a service provider on behalf of Beckhoff as part of Beckhoff production and delivered by Beckhoff as a PDF.
  The terminals can be obtained from Beckhoff and recalibrated by the Beckhoff service department.
- DAkkS calibration certificates (German: "Deutsche Akkreditierungsstelle GmbH")
  Such IP20 terminals can be usually identified by the product suffix -0030. The certificate is issued by a accredited service provider on behalf of Beckhoff as a part of Beckhoff production and delivered by Beckhoff as a PDF.
  The terminals can be obtained from Beckhoff and recalibrated by the Beckhoff service department.

**Unique device number**

Depending on the device, the following numbers are used for identification:

- EL/ELM terminals up to year of manufacture 2020: the ID number which is lasered on the side.


Fig. 28: ID number

- From year of manufacture 2021 onwards, the BTN number (Beckhoff Traceability Number) will gradually replace the ID number, this is also lasered on the side.

Beckhoff produces a wide range of analog input/output devices as IP20 terminal or IP67 box. A selection of these is also available with factory/ISO/DAkkS calibration certificates. For specific details and availability, see the technical data of the devices or contact Beckhoff Sales.

**Linguistic note**

In American English, "calibration" or "alignment" is understood to mean compensation/adjustment, thus a modifying effect on the device. "Verification", on the other hand, refers to observational determination and documentation of the residual error, referred in German language use as “*Kalibrierung*”.

## 2.12.2 UL notice

**Application**

Beckhoff EtherCAT modules are intended for use with Beckhoff’s UL Listed EtherCAT System only.

**Examination**

For cULus examination, the Beckhoff I/O System has only been investigated for risk of fire and electrical shock (in accordance with UL508 and CSA C22.2 No. 142).

**For devices with Ethernet connectors**

Not for connection to telecommunication circuits.

### Basic principles

UL certification according to UL508. Devices with this kind of certification are marked by this sign:

## 2.12.3 ATEX - Special conditions (standard temperature range)

⚠ **WARNING**

**Observe the special conditions for the intended use of Beckhoff fieldbus components with standard temperature range in potentially explosive areas (directive 2014/34/EU)!**

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- 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 to 55°C for the use of Beckhoff fieldbus components standard temperature range 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 individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- 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!
- The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted 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 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

### Marking

The Beckhoff fieldbus components with standard temperature range certified according to the ATEX directive for potentially explosive areas bear one of the following markings:

**II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: 0 … +55°C**
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or

**II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: 0 … +55°C**
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

## 2.12.4 ATEX - Special conditions (extended temperature range)

**⚠ WARNING**

**Observe the special conditions for the intended use of Beckhoff fieldbus components with extended temperature range (ET) in potentially explosive areas (directive 2014/34/EU)!**

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- 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 -25 to 60°C for the use of Beckhoff fieldbus components with extended temperature range (ET) 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 individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- 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!
- The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted 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 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

### Marking

The Beckhoff fieldbus components with extended temperature range (ET) certified according to the ATEX directive for potentially explosive areas bear the following marking:

**II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: -25 … +60°C**
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or

**II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: -25 … +60°C**
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

### 2.12.5 Continuative documentation for ATEX and IECEx

**Continuative documentation about explosion protection according to ATEX and IECEx**

Pay also attention to the continuative documentation

**Ex. Protection for Terminal Systems**
Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx

that is available for download on the Beckhoff homepage www.beckhoff.com!

## 2.12.6 IECEx - Special conditions

⚠ **WARNING**

**Observe the special conditions for the intended use of Beckhoff fieldbus components in potentially explosive areas!**

- For gas: The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to IEC 60079-15, taking into account the environmental conditions under which the equipment is used!
- For dust (only the fieldbus components of certificate no. IECEx DEK 16.0078X Issue 3):
  The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1!
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V!
- 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 for the use of Beckhoff fieldbus components in potentially explosive areas!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- 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!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The front hatch of certified units may only be opened if the supply voltage has been switched off or a non-explosive atmosphere is ensured!

### Standards

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

- EN 60079-0:2011
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. IECEx DEK 16.0078X Issue 3)

### Marking

Beckhoff fieldbus components that are certified in accordance with IECEx for use in areas subject to an explosion hazard bear the following markings:

| | |
|---|---|
| Marking for fieldbus components of certificate no. IECEx DEK 16.0078X Issue 3: | **IECEx DEK 16.0078 X**<br>**Ex nA IIC T4 Gc**<br>**Ex tc IIIC T135°C Dc** |
| Marking for fieldbus components of certficates with later issues: | **IECEx DEK 16.0078 X**<br>**Ex nA IIC T4 Gc** |

## 2.12.7 cFMus - Special conditions

⚠ **WARNING**

**Observe the special conditions for the intended use of Beckhoff fieldbus components in potentially explosive areas!**

- The equipment shall be installed within an enclosure that provides a minimum ingress protection of IP54 in accordance with ANSI/UL 60079-0 (US) or CSA C22.2 No. 60079-0 (Canada).
- The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.
- The circuits shall be limited to overvoltage Category II as defined in IEC 60664-1.
- The Fieldbus Components may only be removed or inserted when the system supply and the field supply are switched off, or when the location is known to be non-hazardous.
- The Fieldbus Components may only be disconnected or connected when the system supply is switched off, or when the location is known to be non-hazardous.

### Standards

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

M20US0111X (US):

- FM Class 3600:2018
- FM Class 3611:2018
- FM Class 3810:2018
- ANSI/UL 121201:2019
- ANSI/ISA 61010-1:2012
- ANSI/UL 60079-0:2020
- ANSI/UL 60079-7:2017

FM20CA0053X (Canada):

- CAN/CSA C22.2 No. 213-17:2017
- CSA C22.2 No. 60079-0:2019
- CAN/CSA C22.2 No. 60079-7:2016
- CAN/CSA C22.2 No.61010-1:2012

### Marking

Beckhoff fieldbus components that are certified in accordance with cFMus for use in areas subject to an explosion hazard bear the following markings:

| | |
|---|---|
| FM20US0111X (US): | **Class I, Division 2, Groups A, B, C, D**<br>**Class I, Zone 2, AEx ec IIC T4 Gc** |
| FM20CA0053X (Canada): | **Class I, Division 2, Groups A, B, C, D**<br>**Ex ec T4 Gc** |

### 2.12.8 Continuative documentation for cFMus

**Continuative documentation about explosion protection according to cFMus**

Pay also attention to the continuative documentation

**Control Drawing I/O, CX, CPX**
Connection diagrams and Ex markings

that is available for download on the Beckhoff homepage www.beckhoff.com!

## 2.13 Start

For commissioning:

- mount the EL33xx as described in the chapter Mounting and wiring [▶ 222]
- configure the EL33xx in TwinCAT as described in the chapter Commissioning [▶ 236].

## 2.14 Similar products

### 2.14.1 Thermocouple (TC)

**Comparative overview of Beckhoff thermocouple (TC) devices**

The following table is intended to provide a quick overview of the available Beckhoff EtherCAT devices for the direct connection of thermocouples for temperature and mV measurement. The values may be shortened extracts from the respective documentation, which is decisive and recommended for detailed analysis.

All devices feature:

- transformation of the best-known TC types;
  Note: the measuring ranges implemented can vary slightly in the endpoints,
- wire break detection,
- internal cold junction.

**NOTE**

**Measurement uncertainty in TC measurement**

The measurement uncertainty in the table is only a rough orientating value, since it depends strongly on the TC type and the measuring temperature; details in the respective documentation.

Version: 2020/12. For a possibly more up-to-date overview, please consult www.beckhoff.com.

| | Design | Number of TC channels | Connection technology | Resolution | Maximum sampling rate per channel for control |
|---|---|---|---|---|---|
| **KL3311, KL3312, KL3314** | K-bus terminal IP20 | 1-4 | Cage Clamp | 0.1 °C | 4 sps |
| **EL3311, EL3312, EL3314, EL3318** | EtherCAT terminal IP20 | 1-8 | Cage Clamp | 0.1/0.01 °C | 50 sps |
| **EL3314-0090** | EtherCAT terminal IP20 | 4 | Cage Clamp | 0.1/0.01 °C | 50 sps |
| **EL3314-0010** | EtherCAT terminal IP20 | 4 | Cage Clamp | 0.1/0.01/0.001 °C | 50 sps |
| **EL3314-0002** | EtherCAT terminal IP20 | 4 | Cage Clamp | 0.1/0.01/0.001 °C | 200 sps |
| **ELM3344, ELM3348** | EtherCAT terminal IP20 | 2/4 | Push-In | 0.1/0.01/0.001 °C | 1,000 sps |
| **ELM3344-0003, ELM3348-0003** | EtherCAT terminal IP20 | 2/4 | Mini-TC | 0.1/0.01/0.001 °C | 1,000 sps |
| **ELM3702-xxxx, ELM3704-xxxx** | EtherCAT terminal IP20 | 2/4 | Push-In, LEMO | 0.1/0.01/0.001 °C | 10,000 sps |
| **EP3314-0002** | EtherCAT Box IP67 | 4 | M8 | 0.1/0.01 °C | 50 sps |
| **EPP3314-0002** | EtherCAT P Box IP67 | 4 | M12 | 0.1/0.01 °C | 50 sps |

**Continuation:**

| | Measurement uncertainty of temperature measurement incl. internal cold junction | Measuring ranges - mV measurement | Oversampling | Operation with external cold junction is possible | Distributed Clocks for timestamp operation |
|---|---|---|---|---|---|
| KL3311, KL3312, KL3314 | < ±0.5 % | 30/60/120 mV | - | - | - |
| EL3311, EL3312, EL3314, EL3318 | < ±0.3 % | 30/75 mV | - | X | - |
| EL3314-0090 | < ±0.3 % | 30/75 mV | - | X | - |
| EL3314-0010 | < ±0.2 % | 78 mV | - | X | - |
| EL3314-0002 | < ±0.2 % | 78 mV / 2.5 V | - | X | - |
| ELM3344, ELM3348 | < ±0.1 % | 20 mV to 10 V | X | X | X |
| ELM3344-0003, ELM3348-0003 | < ±0.05 % | 20 mV to 10 V | X | X | X |
| ELM3702-xxxx, ELM3704-xxxx | < ±0.1 % | 20 mV to 10 V | X | X | X |
| EP3314-0002 | < ±0.3 % | 30/60/75 mV | - | X | - |
| EPP3314-0002 | < ±0.3 % | 30/60/75 mV | - | X | - |

**Continuation:**

| | Electrically isolated channels | TwinSAFE SC | Measured value filtering | Extended diagnosis | Special features |
|---|---|---|---|---|---|
| KL3311, KL3312, KL3314 | - | - | - | - | - |
| EL3311, EL3312, EL3314, EL3318 | - | - | Various predefined internal digital filters | - | - |
| EL3314-0090 | - | X | Various predefined internal digital filters | - | TSC variant of the EL3314-0000 |
| EL3314-0010 | - | - | Various predefined internal digital filters | - | Calibrated version EL3314-0030 available |
| EL3314-0002 | Yes, 2500 V functional isolation | - | Various predefined internal digital filters | - | - |
| ELM3344, ELM3348 | - | - | Various predefined internal digital filters<br>Freely parameterizable with TwinCAT Filter Designer | Yes, with CommonMode measurement | - |
| ELM3344-0003, ELM3348-0003 | - | - | Various predefined internal digital filters<br>Freely parameterizable with TwinCAT Filter Designer | Yes, with CommonMode measurement | - |
| ELM3702-xxxx, ELM3704-xxxx | - | - | Various predefined internal digital filters<br>Freely parameterizable with TwinCAT Filter Designer | Yes | Multi-function terminal |
| EP3314-0002 | - | - | Various predefined internal digital filters | - | - |
| EPP3314-0002 | - | - | Various predefined internal digital filters | - | - |

# 3 Basics communication

## 3.1 EtherCAT basics

Please refer to the EtherCAT System Documentation for the EtherCAT fieldbus basics.

## 3.2 EtherCAT cabling – wire-bound

The cable length between two EtherCAT devices must not exceed 100 m. This results from the FastEthernet technology, which, above all for reasons of signal attenuation over the length of the cable, allows a maximum link length of 5 + 90 + 5 m if cables with appropriate properties are used. See also the Design recommendations for the infrastructure for EtherCAT/Ethernet.

### Cables and connectors

For connecting EtherCAT devices only Ethernet connections (cables + plugs) that meet the requirements of at least category 5 (CAt5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT uses 4 wires for signal transfer.

EtherCAT uses RJ45 plug connectors, for example. The pin assignment is compatible with the Ethernet standard (ISO/IEC 8802-3).

| Pin | Color of conductor | Signal | Description |
|---|---|---|---|
| 1 | yellow | TD + | Transmission Data + |
| 2 | orange | TD - | Transmission Data - |
| 3 | white | RD + | Receiver Data + |
| 6 | blue | RD - | Receiver Data - |

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

**Recommended cables**

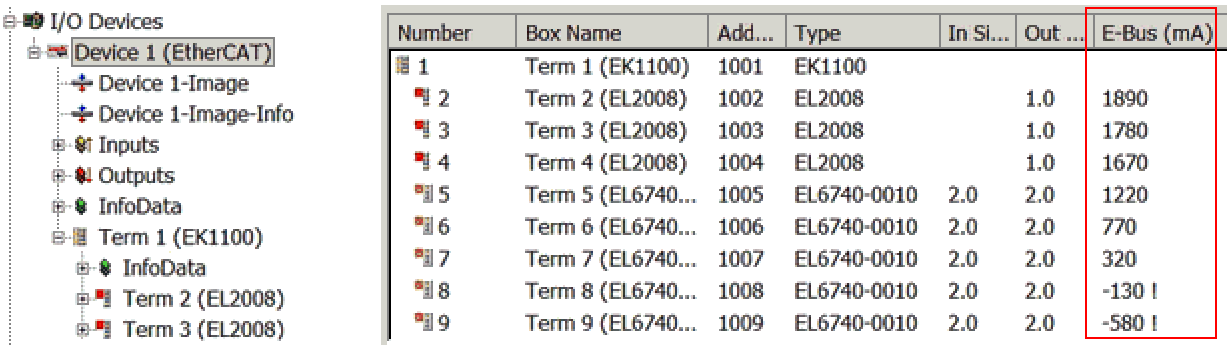
It is recommended to use the appropriate Beckhoff components e.g.
- cable sets ZK1090-9191-xxxx respectively
- RJ45 connector, field assembly ZS1090-0005
- EtherCAT cable, field assembly ZB9010, ZB9020

Suitable cables for the connection of EtherCAT devices can be found on the Beckhoff website!

### E-Bus supply

A bus coupler can supply the EL terminals added to it with the E-bus system voltage of 5 V; a coupler is thereby loadable up to 2 A as a rule (see details in respective device documentation).
Information on how much current each EL terminal requires from the E-bus supply is available online and in the catalogue. If the added terminals require more current than the coupler can supply, then power feed terminals (e.g. EL9410) must be inserted at appropriate places in the terminal strand.

The pre-calculated theoretical maximum E-Bus current is displayed in the TwinCAT System Manager. A shortfall is marked by a negative total amount and an exclamation mark; a power feed terminal is to be placed before such a position.




| Number | Box Name | Add... | Type | In Si... | Out ... | E-Bus (mA) |
|---|---|---|---|---|---|---|
| 1 | Term 1 (EK1100) | 1001 | EK1100 | | | |
| 2 | Term 2 (EL2008) | 1002 | EL2008 | | 1.0 | 1890 |
| 3 | Term 3 (EL2008) | 1003 | EL2008 | | 1.0 | 1780 |
| 4 | Term 4 (EL2008) | 1004 | EL2008 | | 1.0 | 1670 |
| 5 | Term 5 (EL6740... | 1005 | EL6740-0010 | 2.0 | 2.0 | 1220 |
| 6 | Term 6 (EL6740... | 1006 | EL6740-0010 | 2.0 | 2.0 | 770 |
| 7 | Term 7 (EL6740... | 1007 | EL6740-0010 | 2.0 | 2.0 | 320 |
| 8 | Term 8 (EL6740... | 1008 | EL6740-0010 | 2.0 | 2.0 | -130 ! |
| 9 | Term 9 (EL6740... | 1009 | EL6740-0010 | 2.0 | 2.0 | -580 ! |

Fig. 29: System manager current calculation

**NOTE**

**Malfunction possible!**

The same ground potential must be used for the E-Bus supply of all EtherCAT terminals in a terminal block!

## 3.3 General notes for setting the watchdog

ELxxxx terminals are equipped with a safety feature (watchdog) that switches off the outputs after a specifiable time e.g. in the event of an interruption of the process data traffic, depending on the device and settings, e.g. in OFF state.

The EtherCAT slave controller (ESC) in the EL2xxx terminals features two watchdogs:

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

### SM watchdog (SyncManager Watchdog)

The SyncManager watchdog is reset after each successful EtherCAT process data communication with the terminal. If no EtherCAT process data communication takes place with the terminal 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 state of the terminal is unaffected. The watchdog is only reset after a successful EtherCAT process data access. Set the monitoring time as described 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 from the application side.

The settings of the SM- and PDI-watchdog must be done for each slave separately in the TwinCAT System Manager.

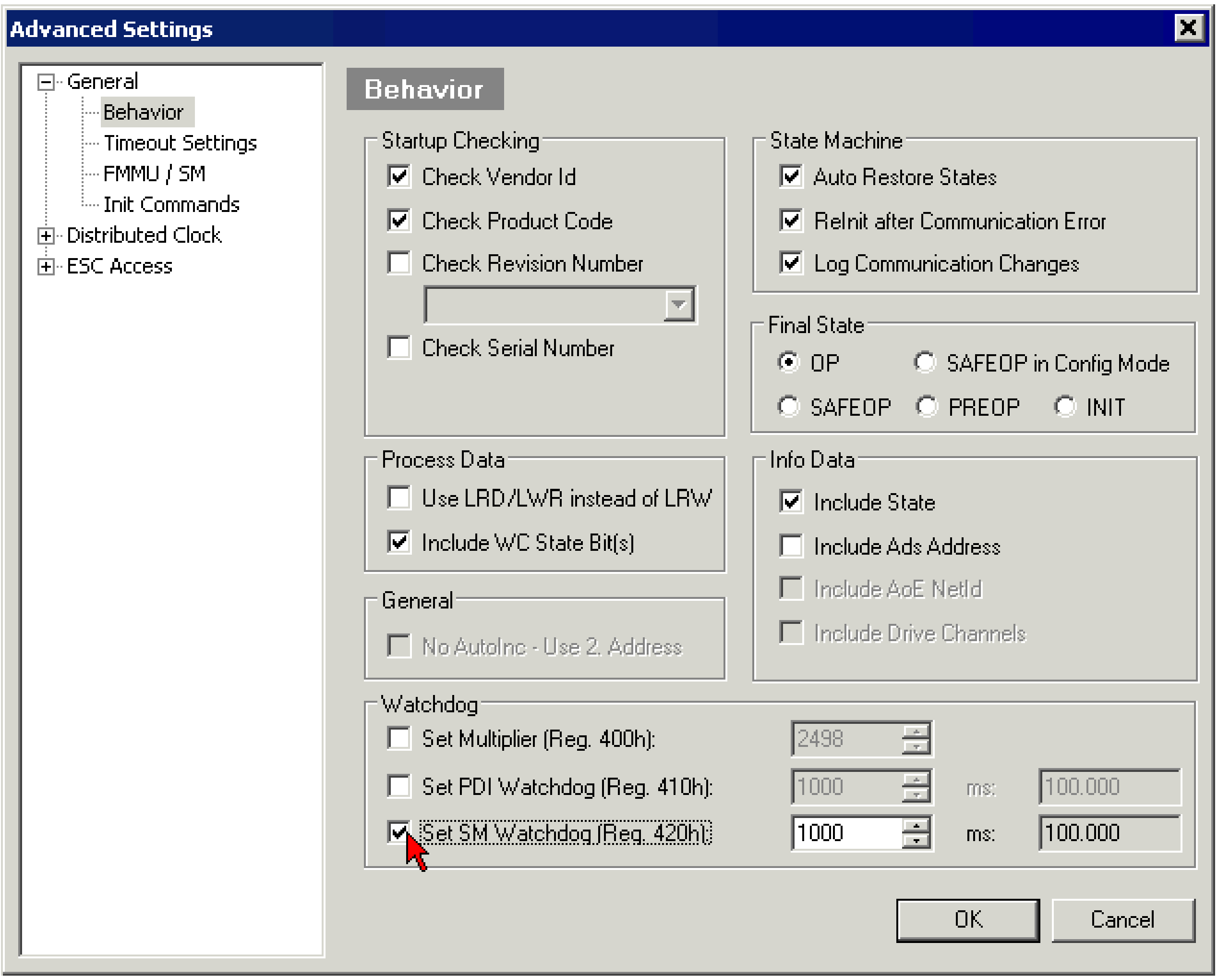



Fig. 30: EtherCAT tab -> Advanced Settings -> Behavior -> Watchdog

Notes:

- the multiplier is valid for both watchdogs.
- each watchdog has its own timer setting, the outcome of this in summary with the multiplier is a resulting time.
- Important: the multiplier/timer setting is only loaded into the slave at the start up, if the checkbox is activated.
  If the checkbox is not activated, nothing is downloaded and the ESC settings remain unchanged.

**Multiplier**

Both watchdogs receive their pulses from the local terminal cycle, divided by the watchdog multiplier:

1/25 MHz * (watchdog multiplier + 2) = 100 µs (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 erased. 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 0...65535. Together with a multiplier with a range of 1...65535 this covers a watchdog period between 0...~170 seconds.

**Calculation**

Multiplier = 2498 → watchdog base time = 1 / 25 MHz * (2498 + 2) = 0.0001 seconds = 100 µs
SM watchdog = 10000 → 10000 * 100 µs = 1 second watchdog monitoring time

⚠ **CAUTION**

**Undefined state 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**

**Damage of devices and undefined state possible!**

If the SM watchdog is activated and a value of 0 is entered the watchdog switches off completely. This is the deactivation of the watchdog! Set outputs are NOT set in a safe state, if the communication is interrupted.

## 3.4 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.

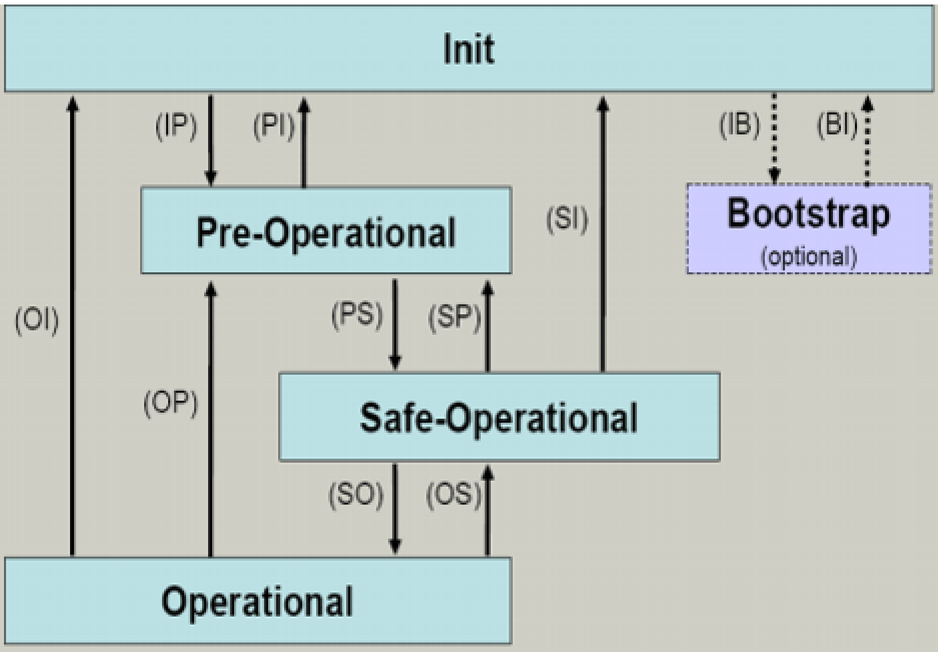



Fig. 31: States of the EtherCAT State Machine

### 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).

In *Safe-Op* state mailbox and process data communication is possible, although the slave keeps its outputs in a safe state, while the input data are updated cyclically.

**Outputs in SAFEOP state**

The default set watchdog [▸ 213] monitoring sets the outputs of the module in a safe state - depending on the settings in SAFEOP and OP - e.g. in OFF state. If this is prevented by deactivation of the watchdog monitoring in the module, the outputs can be switched or set also in the SAFEOP state.

### 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.

## 3.5 CoE Interface

### General description

The CoE interface (CAN application protocol 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 attributes.

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.

The order is specified in two levels via hexadecimal numbering: (main)index, followed by subindex. The value ranges are

- Index: 0x0000 …0xFFFF (0...65535$_{dez}$)
- SubIndex: 0x00…0xFF (0...255$_{dez}$)

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: here are the channel parameters for some EtherCAT devices. Historically, this was the first parameter area before the 0x8000 area was introduced. EtherCAT devices that were previously equipped with parameters in 0x4000 and changed to 0x8000 support both ranges for compatibility reasons and mirror internally.
- 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:

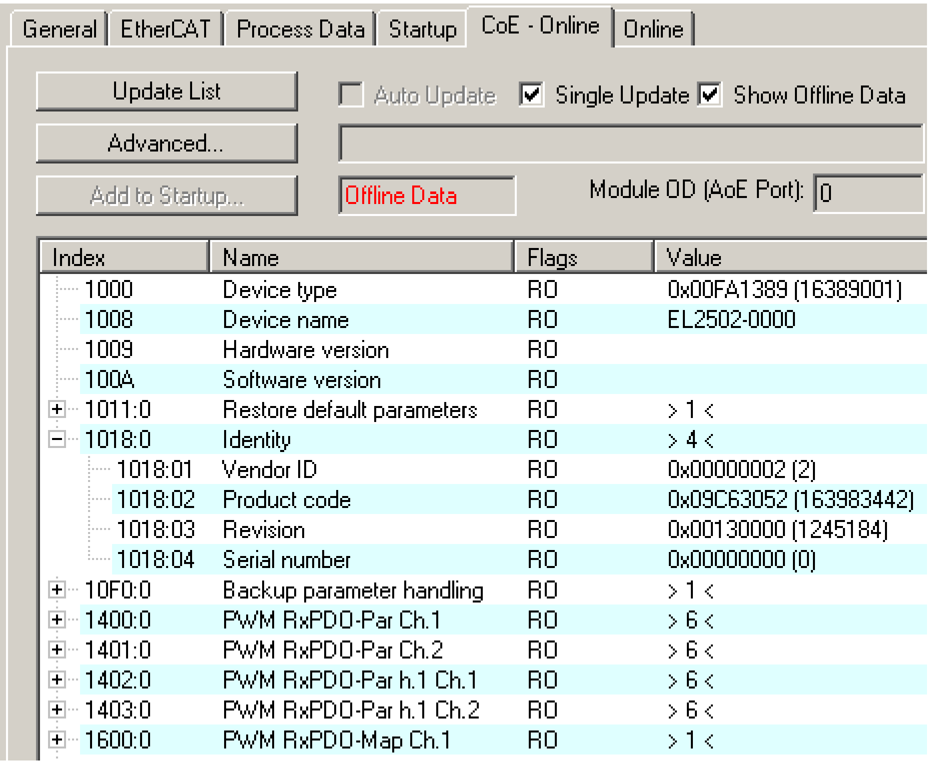



Fig. 32: “CoE Online” tab

The figure above shows the CoE objects available in device “EL2502”, ranging from 0x1000 to 0x1600. The subindices for 0x1018 are expanded.

### Data management and function “NoCoeStorage”

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 (Fig. “CoE Online” tab) 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 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.

#### Data management

If slave CoE parameters are modified online, Beckhoff devices store any changes in a fail-safe manner in the EEPROM, i.e. the modified CoE parameters are still available after a restart.
The situation may be different with other manufacturers.

An EEPROM is subject to a limited lifetime with respect to write operations. From typically 100,000 write operations onwards it can no longer be guaranteed that new (changed) data are reliably saved or are still readable. This is irrelevant for normal commissioning. However, if CoE parameters are continuously changed via ADS at machine runtime, it is quite possible for the lifetime limit to be reached. Support for the NoCoeStorage function, which suppresses the saving of changed CoE values, depends on the firmware version.
Please refer to the technical data in this documentation as to whether this applies to the respective device.

- If the function is supported: the function is activated by entering the code word 0x12345678 once in CoE 0xF008 and remains active as long as the code word is not changed. After switching the device on it is then inactive. Changed CoE values are not saved in the EEPROM and can thus be changed any number of times.
- Function is not supported: continuous changing of CoE values is not permissible in view of the lifetime limit.

#### 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 default 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.

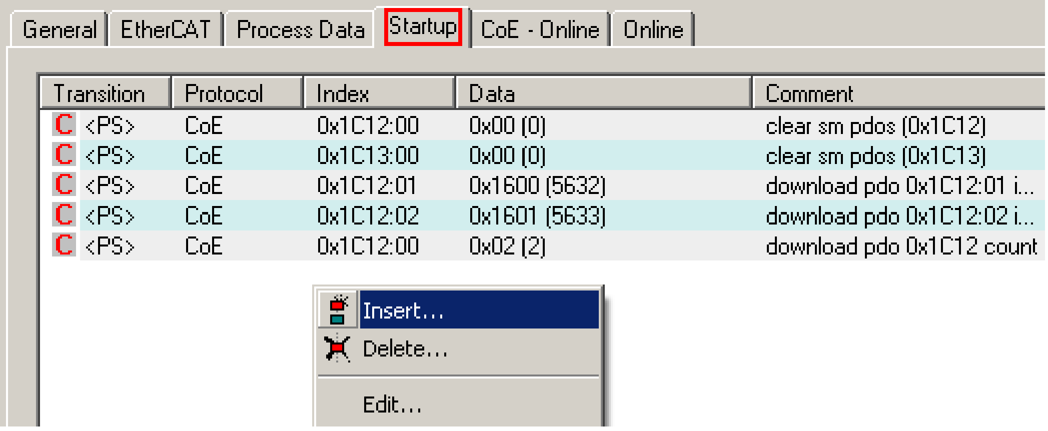



Fig. 33: Startup list in the TwinCAT System Manager

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 list**

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 list as shown in Fig. “CoE online tab” is displayed. The connectivity is shown 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.

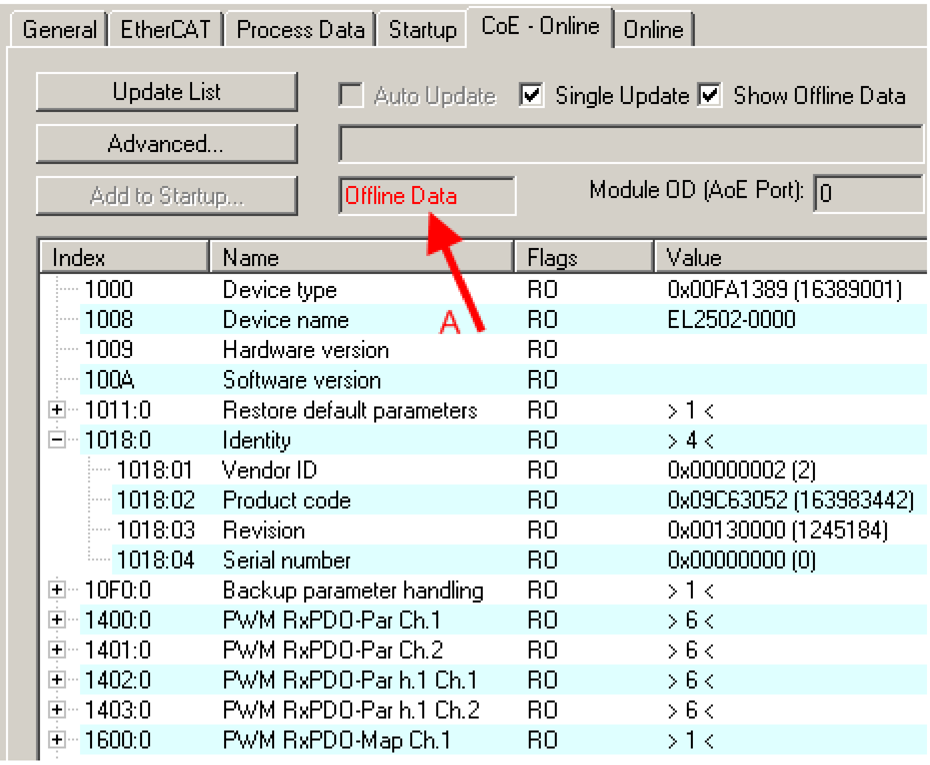



Fig. 34: Offline list

- If the slave is online
  - The actual current slave list 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.

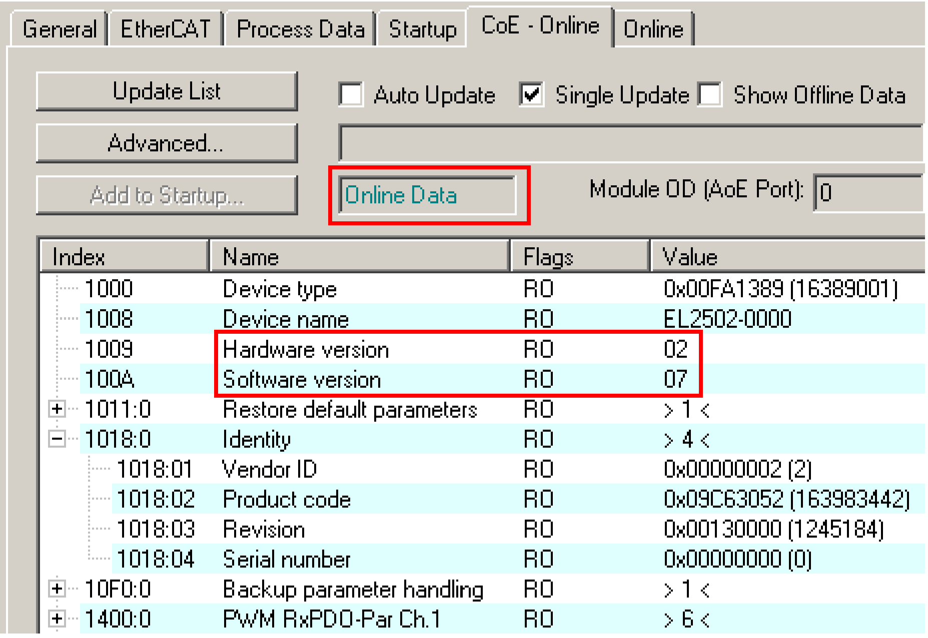



Fig. 35: Online list

### Channel-based order

The CoE list is available in EtherCAT devices that usually feature several functionally equivalent channels. For example, a 4-channel analog 0...10 V input terminal also has four logical channels and therefore four 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 $16_{dec}/10_{hex}$ 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.

## 3.6 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 wiring

## 4.1 Safety instructions

Before installing and commissioning the TwinSAFE components please read the safety instructions in the foreword of this documentation.

## 4.2 Environmental conditions

Please ensure that the TwinSAFE components are only transported, stored and operated under the specified conditions (see technical data)!

⚠ **WARNING**

**Risk of injury!**

The TwinSAFE components must not be used under the following operating conditions.

- under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation)
- in corrosive environments
- in an environment that leads to unacceptable soiling of the TwinSAFE component

***NOTE***

**Electromagnetic compatibility**

The TwinSAFE components comply with the current standards on electromagnetic compatibility with regard to spurious radiation and immunity to interference in particular.
However, in cases where devices such as mobile phones, radio equipment, transmitters or high-frequency systems that exceed the interference emissions limits specified in the standards are operated near TwinSAFE components, the function of the TwinSAFE components may be impaired.

## 4.3 Transport / storage

Use the original packaging in which the components were delivered for transporting and storing the TwinSAFE components.

⚠ **CAUTION**

**Note the specified environmental conditions**

Please ensure that the digital TwinSAFE components are only transported and stored under the specified environmental conditions (see technical data).

## 4.4 Control cabinet / terminal box

The TwinSAFE terminals must be installed in a control cabinet or terminal box with IP54 protection class according to IEC 60529 as a minimum.

## 4.5 Instructions for ESD protection

**NOTE**

**Destruction of the devices by electrostatic discharge possible!**

The devices contain components at risk from electrostatic discharge caused by improper handling.

- Please ensure you are electrostatically discharged and avoid touching the contacts of the device directly.
- Avoid contact with highly insulating materials (synthetic fibers, plastic film etc.).
- Surroundings (working place, packaging and personnel) should by grounded probably, when handling with the devices.
- Each assembly must be terminated at the right hand end with an EL9011 or EL9012 bus end cap, to ensure the protection class and ESD protection.

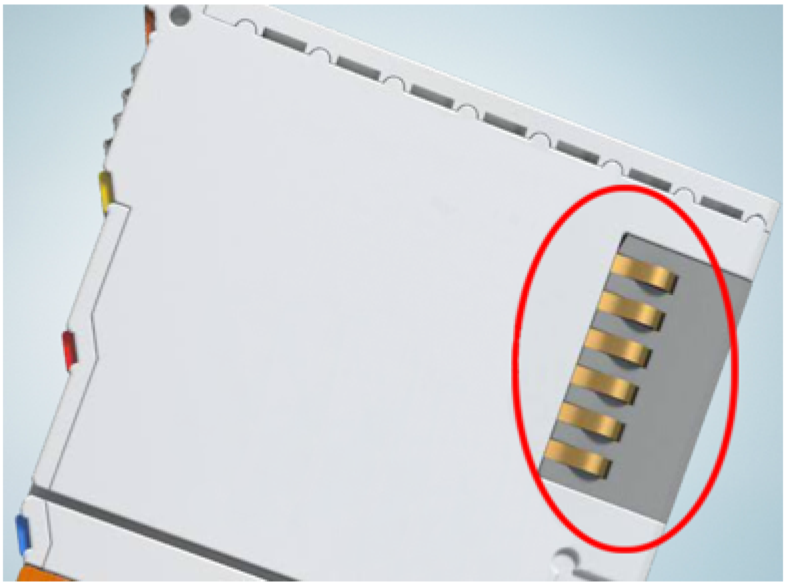


Fig. 36: Spring contacts of the Beckhoff I/O components

## 4.6 Installation on mounting rails

**⚠ WARNING**

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

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

**Assembly**

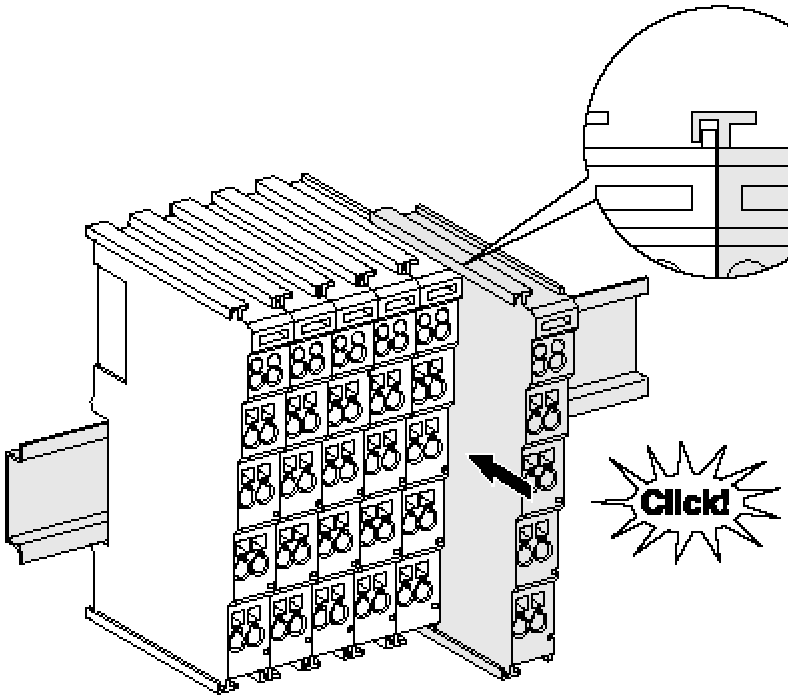



Fig. 37: Attaching on mounting rail

The bus coupler and bus terminals are attached to commercially available 35 mm mounting rails (DIN rails according to EN 60715) by applying slight pressure:

1. First attach the fieldbus coupler to the mounting rail.
2. The bus terminals are now attached on the right-hand side of the fieldbus coupler. Join the components with tongue and groove and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.
   If the terminals are clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

**Fixing of mounting rails**

The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

**Disassembly**

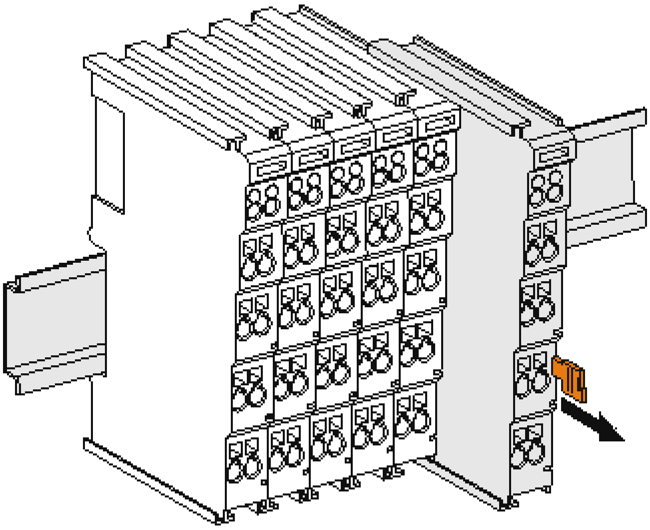


Fig. 38: Disassembling of terminal

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull the terminal by its orange-colored lugs approximately 1 cm away from the mounting rail. In doing so for this terminal the mounting rail lock is released automatically and you can pull the terminal out of the bus terminal block easily without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal out of the bus terminal block.

**Connections within a bus terminal block**

The electric connections between the Bus Coupler and the Bus Terminals are automatically realized by joining the components:

- The six spring contacts of the K-Bus/E-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the bus terminal block. The power contacts are supplied via terminals on the Bus Coupler (up to 24 V) or for higher voltages via power feed terminals.

**Power Contacts**

During the design of a bus terminal block, the pin assignment of the individual Bus Terminals must be taken account of, since some types (e.g. analog Bus Terminals or digital 4-channel Bus Terminals) do not or not fully loop through the power contacts. Power Feed Terminals (KL91xx, KL92xx or EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

**PE power contact**

The power contact labeled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

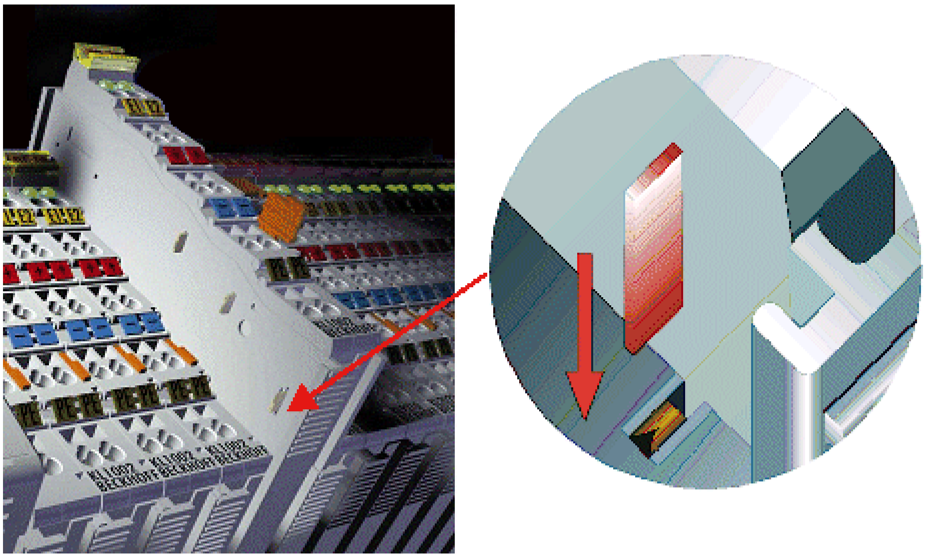


Fig. 39: Power contact on left side

**NOTE**

**Possible damage of the device**

Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V). For insulation testing, disconnect the PE supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

**⚠ WARNING**

**Risk of electric shock!**

The PE power contact must not be used for other potentials!

## 4.7 Installation instructions for enhanced mechanical load capacity

**⚠ WARNING**

**Risk of injury through electric shock and damage to the device!**

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals!

### Additional checks

The terminals have undergone the following additional tests:

| Verification | Explanation |
|---|---|
| Vibration | 10 frequency runs in 3 axes |
| | 6 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 |
| | 25 *g*, 6 ms |

**Additional installation instructions**

For terminals with enhanced mechanical load capacity, the following additional installation instructions apply:

- The enhanced mechanical load capacity is valid for all permissible installation positions
- Use a mounting rail according to EN 60715 TH35-15
- Fix the terminal segment on both sides of the mounting rail with a mechanical fixture, e.g. an earth terminal or reinforced end clamp
- The maximum total extension of the terminal segment (without coupler) is:
  64 terminals (12 mm mounting with) or 32 terminals (24 mm mounting with)
- Avoid deformation, twisting, crushing and bending of the mounting rail during edging and installation of the rail
- The mounting points of the mounting rail must be set at 5 cm intervals
- Use countersunk head screws to fasten the mounting rail
- The free length between the strain relief and the wire connection should be kept as short as possible. A distance of approx. 10 cm should be maintained to the cable duct.

# 4.8 Connection

## 4.8.1 Connection system

**⚠ WARNING**

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

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

**Overview**

The bus terminal system offers different connection options for optimum adaptation to the respective application:

- The terminals of ELxxxx and KLxxxx series with standard wiring include electronics and connection level in a single enclosure.
- The terminals of ESxxxx and KSxxxx series feature a pluggable connection level and enable steady wiring while replacing.
- The High Density Terminals (HD Terminals) include electronics and connection level in a single enclosure and have advanced packaging density.

**Standard wiring (ELxxxx / KLxxxx)**

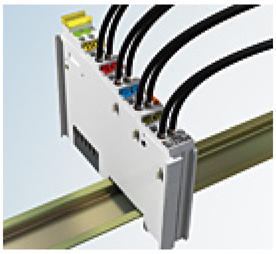


Fig. 40: Standard wiring

The terminals of ELxxxx and KLxxxx series have been tried and tested for years.
They feature integrated screwless spring force technology for fast and simple assembly.

### Pluggable wiring (ESxxxx / KSxxxx)

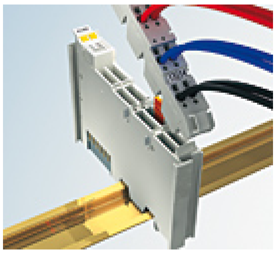


Fig. 41: Pluggable wiring

The terminals of ESxxxx and KSxxxx series feature a pluggable connection level.
The assembly and wiring procedure is the same as for the ELxxxx and KLxxxx series.
The pluggable connection level enables the complete wiring to be removed as a plug connector from the top of the housing for servicing.
The lower section can be removed from the terminal block by pulling the unlocking tab.
Insert the new component and plug in the connector with the wiring. This reduces the installation time and eliminates the risk of wires being mixed up.

The familiar dimensions of the terminal only had to be changed slightly. The new connector adds about 3 mm. The maximum height of the terminal remains unchanged.

A tab for strain relief of the cable simplifies assembly in many applications and prevents tangling of individual connection wires when the connector is removed.

Conductor cross sections between 0.08 $mm^2$ and 2.5 $mm^2$ can continue to be used with the proven spring force technology.

The overview and nomenclature of the product names for ESxxxx and KSxxxx series has been retained as known from ELxxxx and KLxxxx series.

### High Density Terminals (HD Terminals)

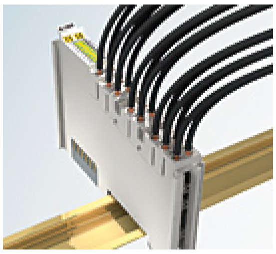


Fig. 42: High Density Terminals

The terminals from these series with 16 terminal points are distinguished by a particularly compact design, as the packaging density is twice as large as that of the standard 12 mm bus terminals. Massive conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.

**Wiring HD Terminals**

The High Density Terminals of the ELx8xx and KLx8xx series doesn't support pluggable wiring.

### Ultrasonically “bonded” (ultrasonically welded) conductors

**Ultrasonically “bonded” conductors**

It is also possible to connect the Standard and High Density Terminals with ultrasonically “bonded” (ultrasonically welded) conductors. In this case, please note the tables concerning the wire-size width!

## 4.8.2 Wiring

**⚠ WARNING**

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

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

**Terminals for standard wiring ELxxxx/KLxxxx and for pluggable wiring ESxxxx/KSxxxx**

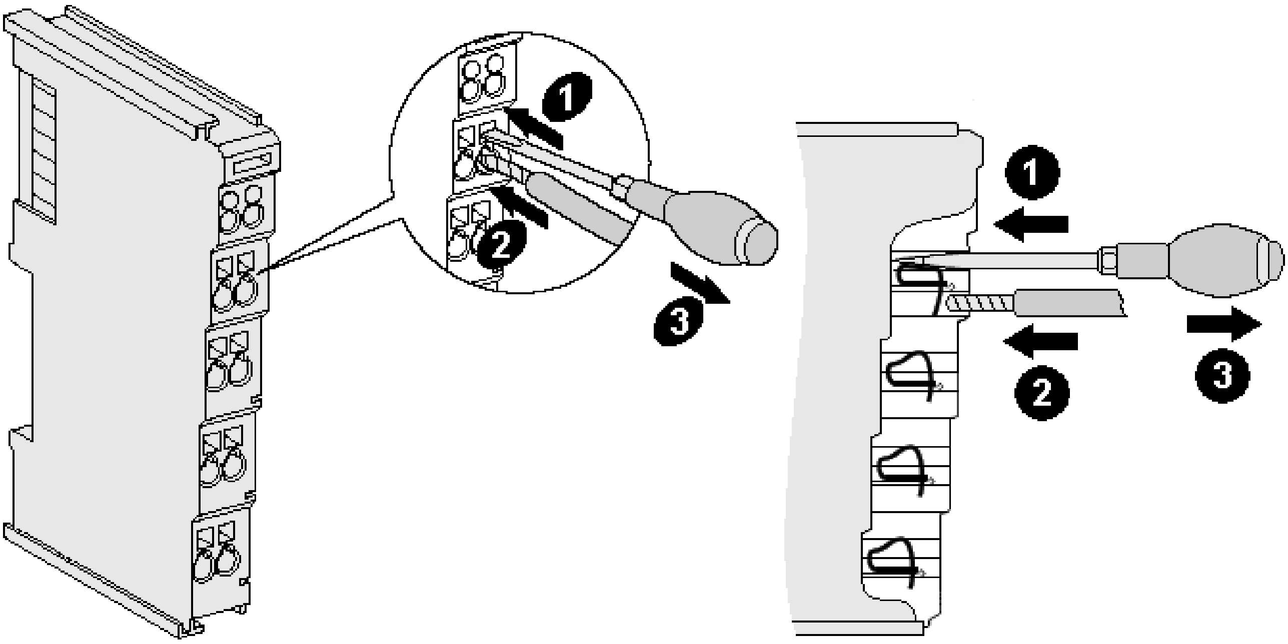



Fig. 43: Connecting a cable on a terminal point

Up to eight terminal points enable the connection of solid or finely stranded cables to the bus terminal. The terminal points are implemented in spring force technology. Connect the cables as follows:

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal point closes automatically when the pressure is released, holding the wire securely and permanently.

See the following table for the suitable wire size width.

| Terminal housing | ELxxxx, KLxxxx | ESxxxx, KSxxxx |
|---|---|---|
| Wire size width (single core wires) | 0.08 ... 2.5 mm$^2$ | 0.08 ... 2.5 mm$^2$ |
| Wire size width (fine-wire conductors) | 0.08 ... 2.5 mm$^2$ | 0,08 ... 2.5 mm$^2$ |
| Wire size width (conductors with a wire end sleeve) | 0.14 ... 1.5 mm$^2$ | 0.14 ... 1.5 mm$^2$ |
| Wire stripping length | 8 ... 9 mm | 9 ... 10 mm |

**High Density Terminals (HD Terminals [▸ 228]) with 16 terminal points**

The conductors of the HD Terminals are connected without tools for single-wire conductors using the direct plug-in technique, i.e. after stripping the wire is simply plugged into the terminal point. The cables are released, as usual, using the contact release with the aid of a screwdriver. See the following table for the suitable wire size width.

| Terminal housing | High Density Housing |
|---|---|
| Wire size width (single core wires) | 0.08 ... 1.5 mm$^2$ |
| Wire size width (fine-wire conductors) | 0.25 ... 1.5 mm$^2$ |
| Wire size width (conductors with a wire end sleeve) | 0.14 ... 0.75 mm$^2$ |
| Wire size width (ultrasonically “bonded" conductors) | only 1.5 mm$^2$ |
| Wire stripping length | 8 ... 9 mm |

### 4.8.3 Shielding

**Shielding**

Encoder, analog sensors and actors should always be connected with shielded, twisted paired wires.

## 4.9 Connection instructions for earthed/potential-free thermocouples

Due to the differential inputs of the terminals, different connection types are recommended depending on the type of thermocouple used. For earthed thermocouples, ground is not connected to the shielding. If the thermocouple does not have an ground connection, the ground and shielding contacts can be connected (see Fig. *Connection of earthed and earth-free thermocouples* and Connection instructions for thermocouples).

**Connection instructions for thermocouples**

- *Earthed thermocouple*
  ⇨ Do not connect GND to the shielding
  ⇨ For EL3312: potential difference **max. 2 V**
- *Potential-free / earth-free thermocouple*
  ⇨ GND can be connected to the shielding
  ⇨ or: GND can connected to any potential, **max. 35 V** to 0 V power
- *Non-potential-free thermocouple*
  ⇨ Do not connect GND to the shielding
  ⇨ Do not connect GND to thermocouple potential.
  ⇨ Thermocouple-potential **max. 35 V** to 0 V power
  ⇨ For **different thermocouple potentials** several 1-channel EL3311 units should be used.
- *Unused inputs*
  ⇨ For the multi-channel versions EL3312 and EL3314, unused inputs should be short-circuited (low-resistance connection of +TC, -TC)

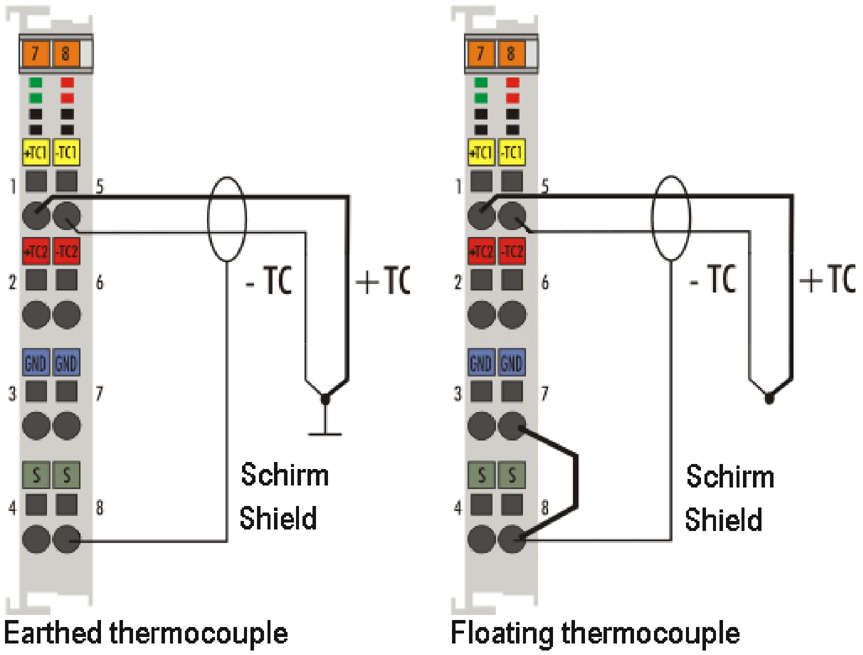



Fig. 44: Connection methods for earthed and earth-free thermocouples

The example shows EL3312. For the EL3314, the shield should be connected to an additional shield terminal (EL9195).

## 4.10 Positioning of passive Terminals

**Hint for positioning of passive terminals in the bus terminal block**

EtherCAT Terminals (ELxxxx / ESxxxx), which do not take an active part in data transfer within the bus terminal block are so called passive terminals. The passive terminals have no current consumption out of the E-Bus.

To ensure an optimal data transfer, you must not directly string together more than two passive terminals!

**Examples for positioning of passive terminals (highlighted)**

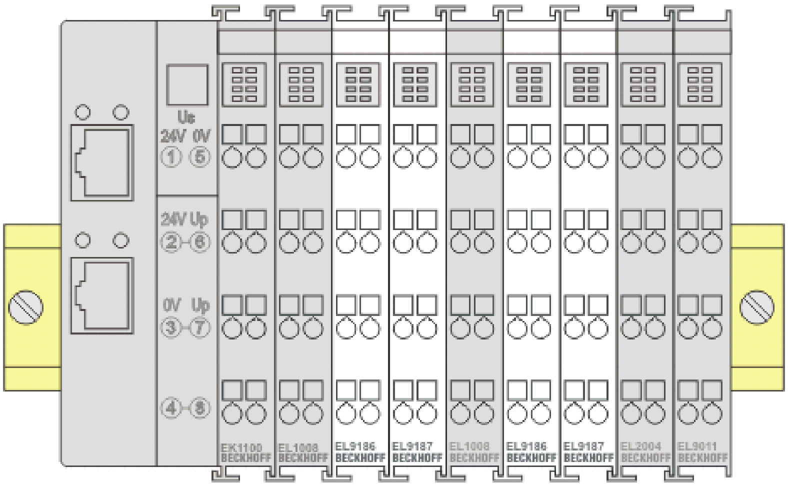


Fig. 45: Correct positioning

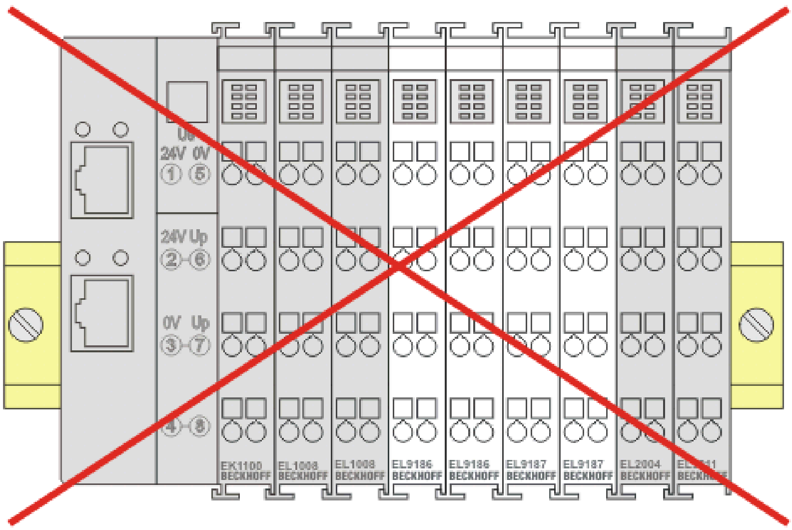


Fig. 46: Incorrect positioning

## 4.11 Installation positions 331x-0000

**NOTE**

**Constraints regarding installation position and operating temperature range**

Please refer to the technical data for a terminal to ascertain whether any restrictions regarding the installation position and/or the operating temperature range have been specified. When installing high power dissipation terminals ensure that an adequate spacing is maintained between other components above and below the terminal in order to guarantee adequate ventilation!

**Optimum installation position (standard)**

The optimum installation position requires the mounting rail to be installed horizontally and the connection surfaces of the EL/KL terminals to face forward (see Fig. *Recommended distances for standard installation position*). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. “From below” is relative to the acceleration of gravity.

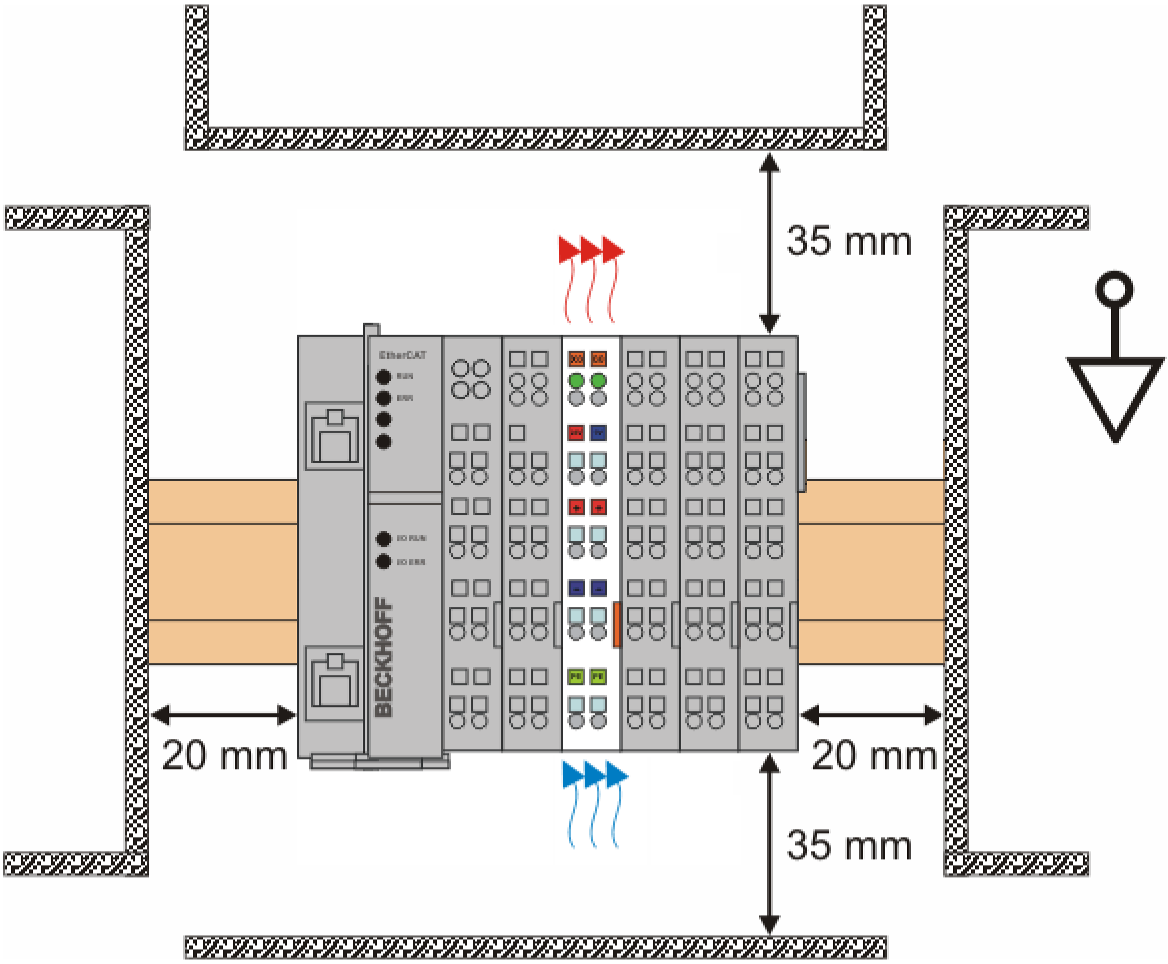



Fig. 47: Recommended distances for standard installation position

Compliance with the distances shown in Fig. *Recommended distances for standard installation position* is recommended.

**Other installation positions**

All other installation positions are characterized by different spatial arrangement of the mounting rail - see Fig *Other installation positions.*

The minimum distances to ambient specified above also apply to these installation positions.

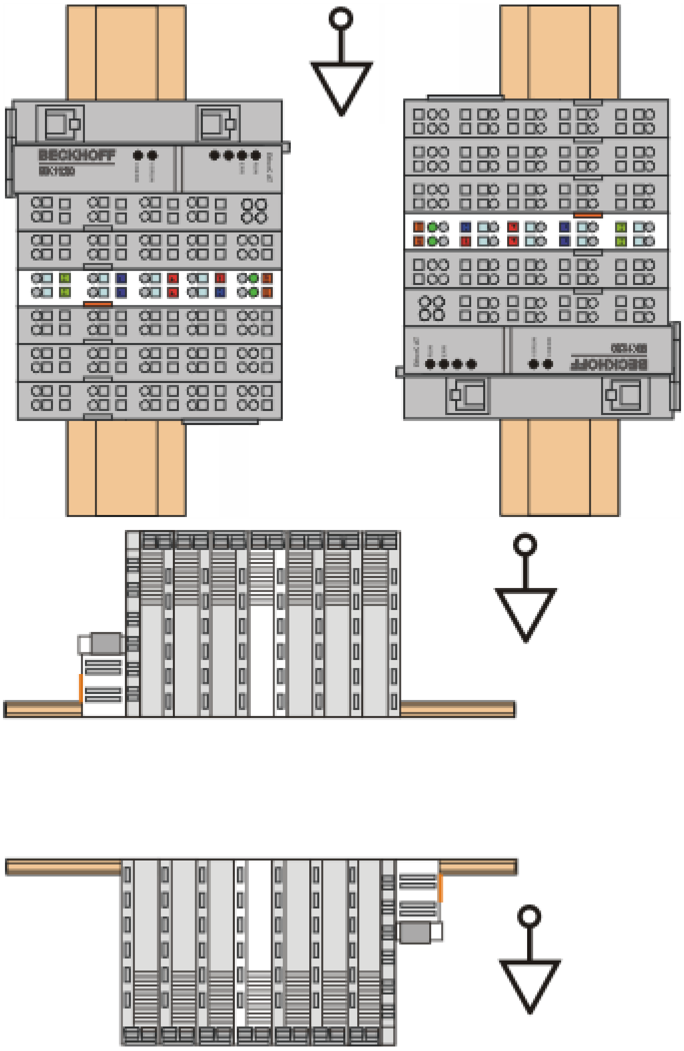


Fig. 48: Other installation positions

## 4.12 Prescribed installation position EL3314-0002/ EL3314-0010

**NOTE**

**Constraints regarding installation position and operating temperature range**

When installing the terminals ensure that an adequate spacing is maintained between other components above and below the terminal in order to guarantee adequate ventilation!

#### Prescribed installation position

The prescribed installation position requires the mounting rail to be installed horizontally and the connection surfaces of the EL/KL terminals to face forward (see Fig. *Recommended distances for standard installation position*).
The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. "From below" is relative to the acceleration of gravity.

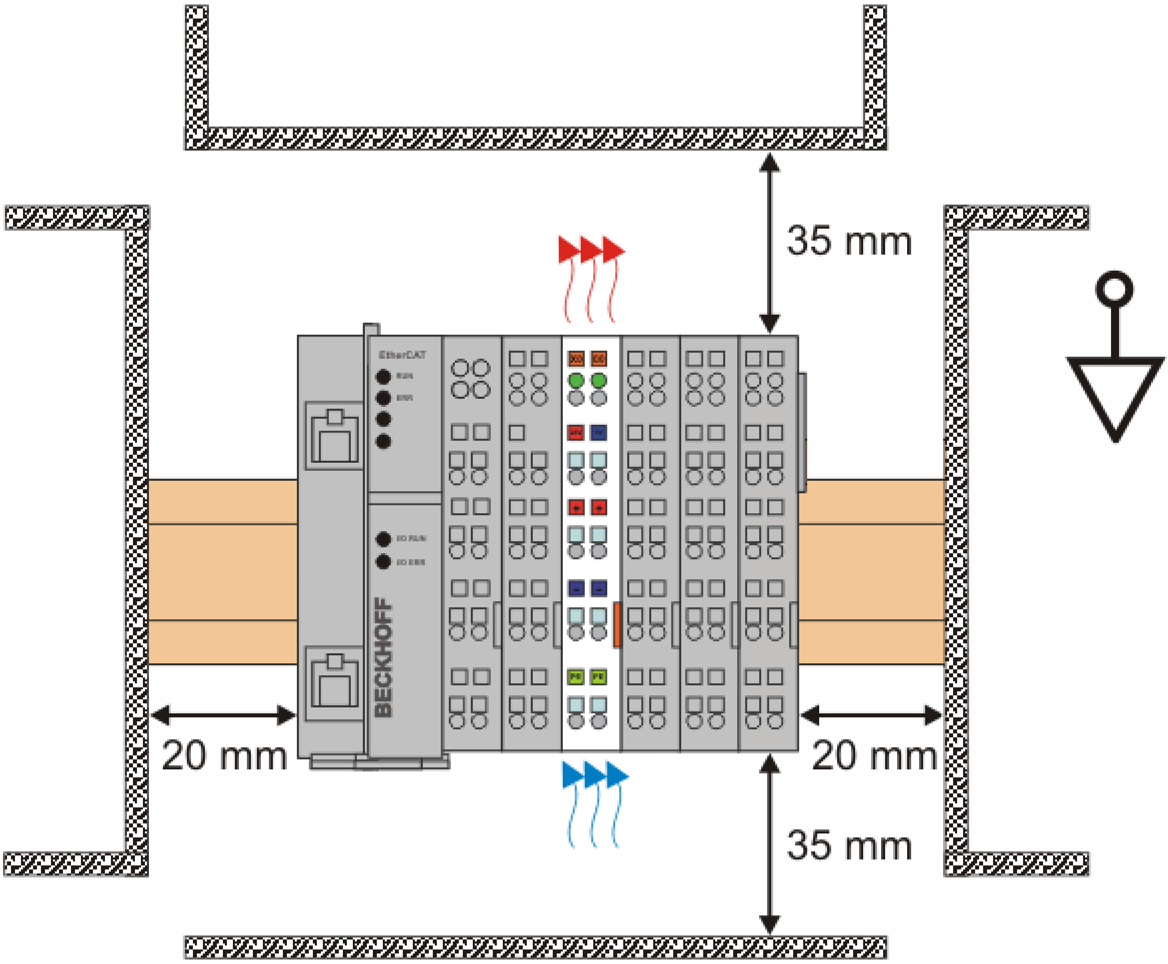



Fig. 49: *Recommended distances for standard installation position*

Compliance with the distances shown in Fig. *Recommended distances for standard installation position* is strongly recommended.

# 5 Commissioning

## 5.1 TwinCAT Quick Start

TwinCAT is a development environment for real-time control including multi-PLC system, NC axis control, programming and operation. The whole system is mapped through this environment and enables access to a programming environment (including compilation) for the controller. Individual digital or analog inputs or outputs can also be read or written directly, in order to verify their functionality, for example.

For further information please refer to http://infosys.beckhoff.com:

- **EtherCAT Systemmanual:**
  Fieldbus Components → EtherCAT Terminals → EtherCAT System Documentation → Setup in the TwinCAT System Manager
- **TwinCAT 2** → TwinCAT System Manager → I/O - Configuration
- In particular, TwinCAT driver installation:
  **Fieldbus components** → Fieldbus Cards and Switches → FC900x – PCI Cards for Ethernet → Installation

Devices contain the terminals for the actual configuration. All configuration data can be entered directly via editor functions (offline) or via the “Scan” function (online):

- **“offline”**: The configuration can be customized by adding and positioning individual components. These can be selected from a directory and configured.
  - The procedure for offline mode can be found under http://infosys.beckhoff.com:
    **TwinCAT 2** → TwinCAT System Manager → IO - Configuration → Adding an I/O Device
- **“online”**: The existing hardware configuration is read
  - See also http://infosys.beckhoff.com:
    **Fieldbus components** → Fieldbus cards and switches → FC900x – PCI Cards for Ethernet → Installation → Searching for devices

The following relationship is envisaged from user PC to the individual control elements:

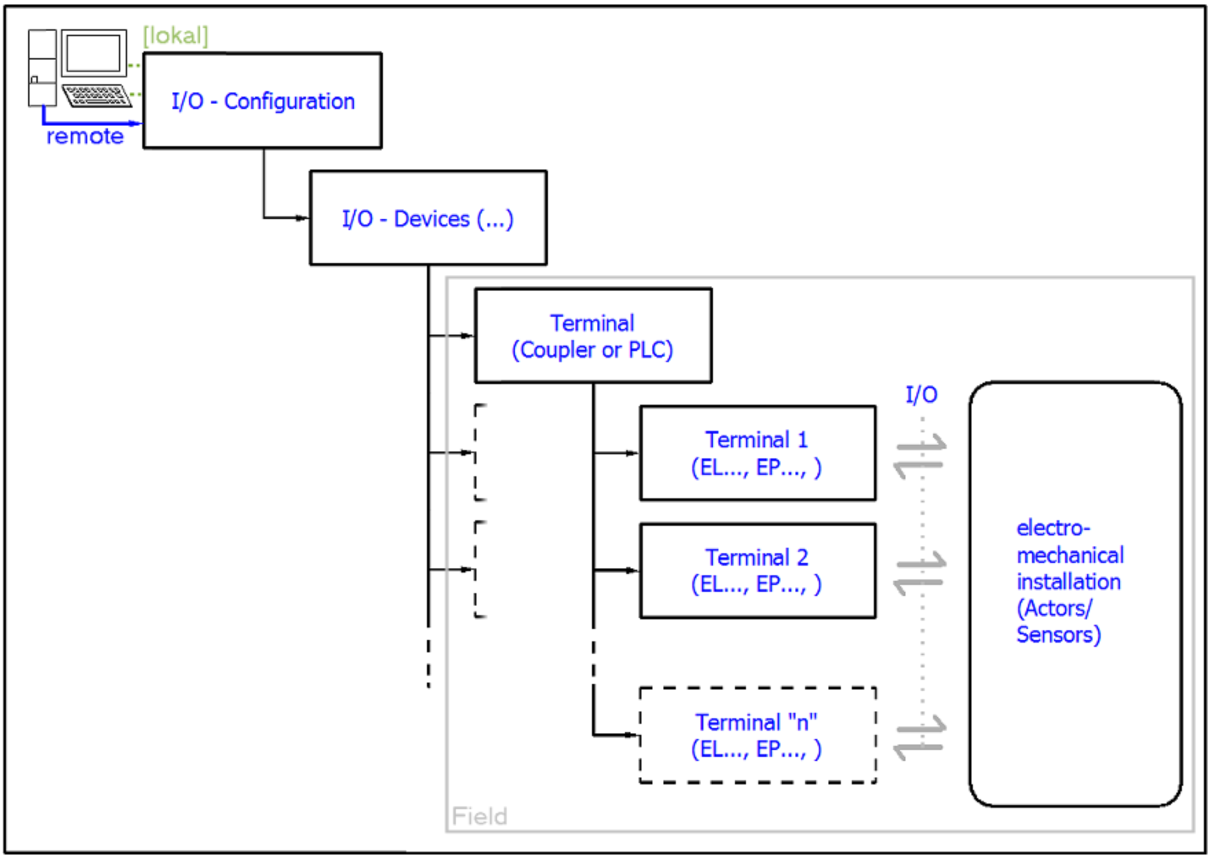



Fig. 50: Relationship between user side (commissioning) and installation

The user inserting of certain components (I/O device, terminal, box...) is the same in TwinCAT 2 and TwinCAT 3. The descriptions below relate to the online procedure.

### Sample configuration (actual configuration)

Based on the following sample configuration, the subsequent subsections describe the procedure for TwinCAT 2 and TwinCAT 3:

- Control system (PLC) **CX2040** including **CX2100-0004** power supply unit
- Connected to the CX2040 on the right (E-bus):
  **EL1004** (4-channel digital input terminal 24 $V_{DC}$)
- Linked via the X001 port (RJ-45): **EK1100** EtherCAT Coupler
- Connected to the EK1100 EtherCAT coupler on the right (E-bus):
  **EL2008** (8-channel digital output terminal 24 $V_{DC}$; 0.5 A)
- (Optional via X000: a link to an external PC for the user interface)

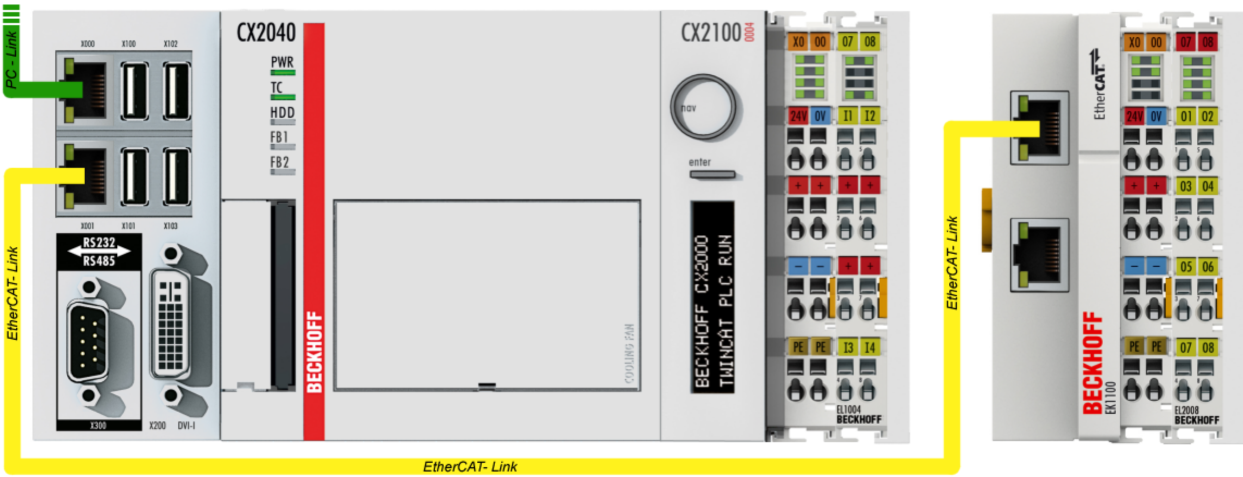



Fig. 51: Control configuration with Embedded PC, input (EL1004) and output (EL2008)

Note that all combinations of a configuration are possible; for example, the EL1004 terminal could also be connected after the coupler, or the EL2008 terminal could additionally be connected to the CX2040 on the right, in which case the EK1100 coupler wouldn't be necessary.

## 5.1.1 TwinCAT 2

### Startup

TwinCAT basically uses two user interfaces: the TwinCAT System Manager for communication with the electromechanical components and TwinCAT PLC Control for the development and compilation of a controller. The starting point is the TwinCAT System Manager.

After successful installation of the TwinCAT system on the PC to be used for development, the TwinCAT 2 System Manager displays the following user interface after startup:

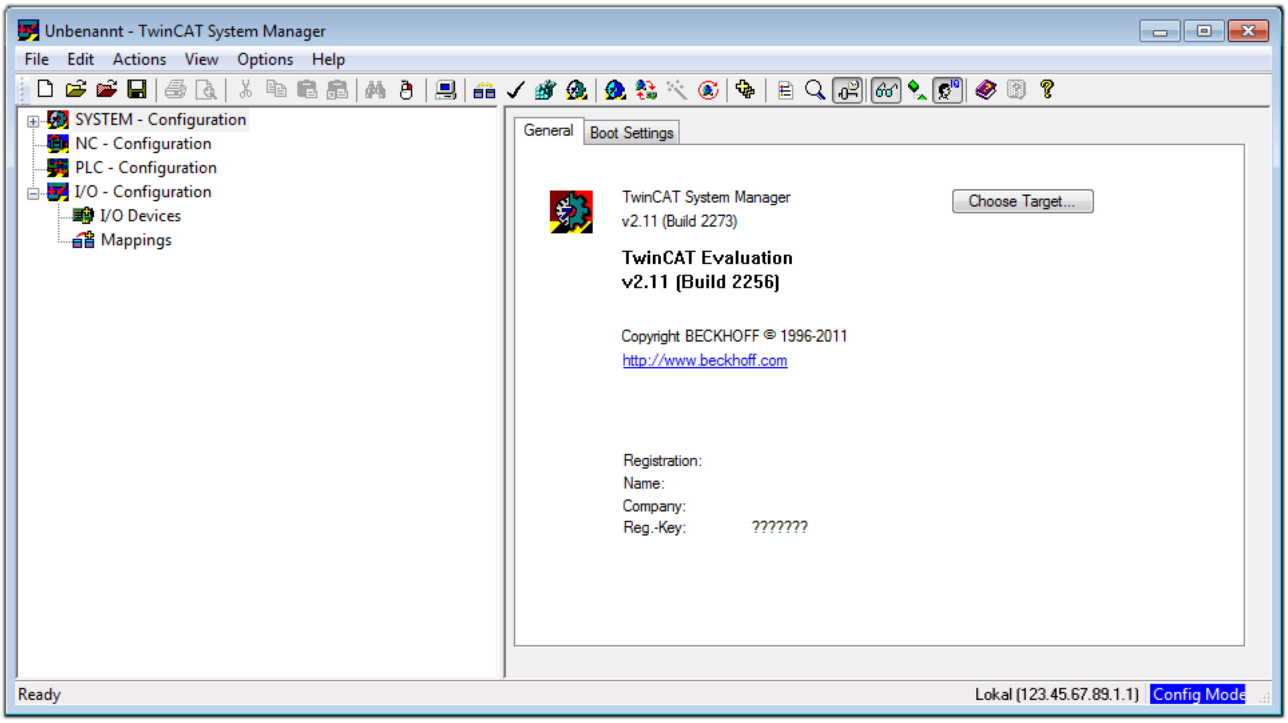



Fig. 52: Initial TwinCAT 2 user interface

Generally, TwinCAT can be used in local or remote mode. Once the TwinCAT system including the user interface (standard) is installed on the respective PLC, TwinCAT can be used in local mode and thereby the next step is "Insert Device [▶ 241]".

If the intention is to address the TwinCAT runtime environment installed on a PLC as development environment remotely from another system, the target system must be made known first. In the menu under "Actions" → "Choose Target System...", via the symbol "  " or the "F8" key, open the following window:

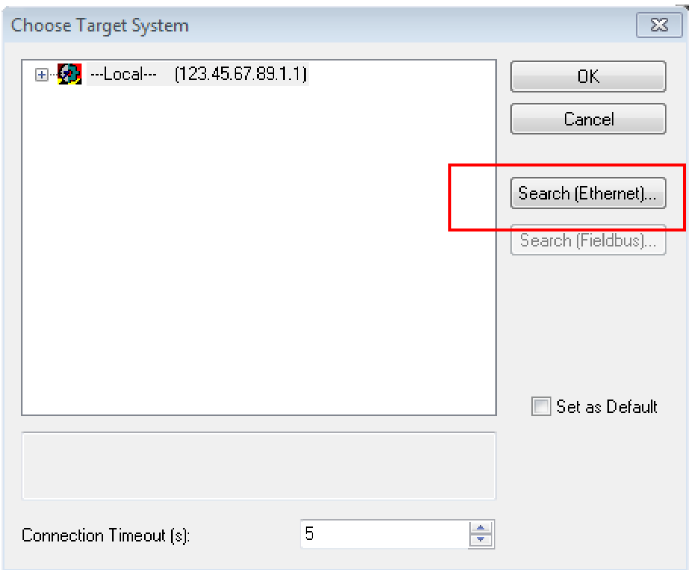



Fig. 53: Selection of the target system

Use “Search (Ethernet)...” to enter the target system. Thus a next dialog opens to either:

- enter the known computer name after “Enter Host Name / IP:” (as shown in red)
- perform a “Broadcast Search” (if the exact computer name is not known)
- enter the known computer IP or AmsNetID.

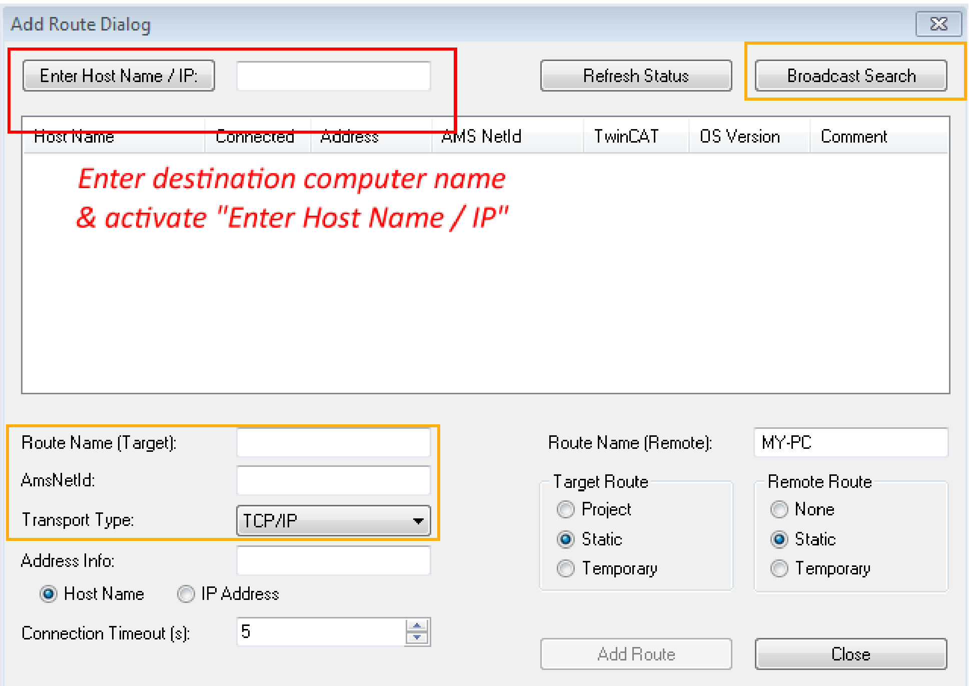
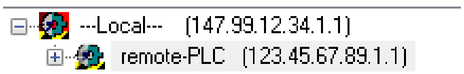



Fig. 54: Specify the PLC for access by the TwinCAT System Manager: selection of the target system

Once the target system has been entered, it is available for selection as follows (a password may have to be entered):




After confirmation with “OK” the target system can be accessed via the System Manager.

**Adding devices**

In the configuration tree of the TwinCAT 2 System Manager user interface on the left, select “I/O Devices” and then right-click to open a context menu and select “Scan Devices…”, or start the action in the menu bar via . The TwinCAT System Manager may first have to be set to “Config mode” via  or via menu “Actions” → “Set/Reset TwinCAT to Config Mode…” (Shift + F4).

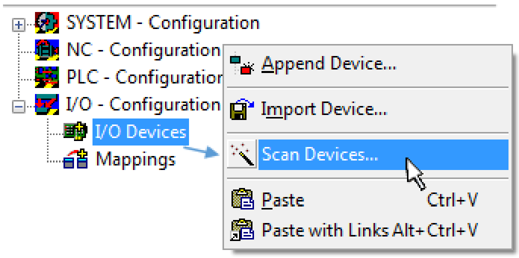



Fig. 55: Select “Scan Devices...”

Confirm the warning message, which follows, and select “EtherCAT” in the dialog:

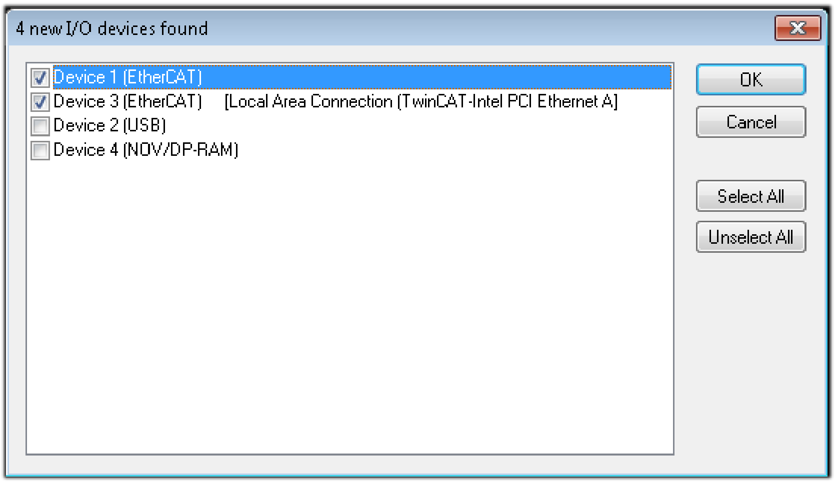



Fig. 56: Automatic detection of I/O devices: selection the devices to be integrated

Confirm the message “Find new boxes”, in order to determine the terminals connected to the devices. “Free Run” enables manipulation of input and output values in “Config mode” and should also be acknowledged.

Based on the sample configuration [▶ 237] described at the beginning of this section, the result is as follows:

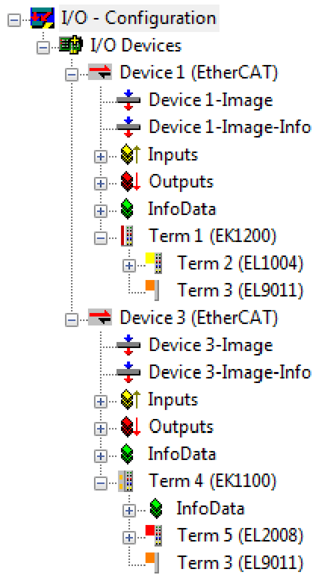



Fig. 57: Mapping of the configuration in the TwinCAT 2 System Manager

The whole process consists of two stages, which may be performed separately (first determine the devices, then determine the connected elements such as boxes, terminals, etc.). A scan can also be initiated by selecting “Device ...” from the context menu, which then reads the elements present in the configuration below:

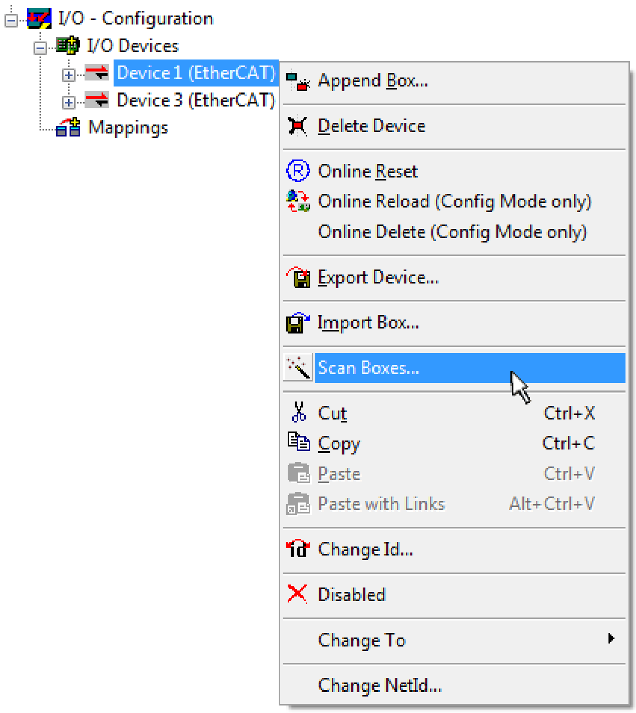



Fig. 58: Reading of individual terminals connected to a device

This functionality is useful if the actual configuration is modified at short notice.

### Programming and integrating the PLC

TwinCAT PLC Control is the development environment for the creation of the controller in different program environments: TwinCAT PLC Control supports all languages described in IEC 61131-3. There are two text-based languages and three graphical languages.

- **Text-based languages**
    - Instruction List (IL)

  - Structured Text (ST)
- **Graphical languages**
  - Function Block Diagram (FBD)
  - Ladder Diagram (LD)
  - The Continuous Function Chart Editor (CFC)
  - Sequential Function Chart (SFC)

The following section refers to Structured Text (ST).

After starting TwinCAT PLC Control, the following user interface is shown for an initial project:

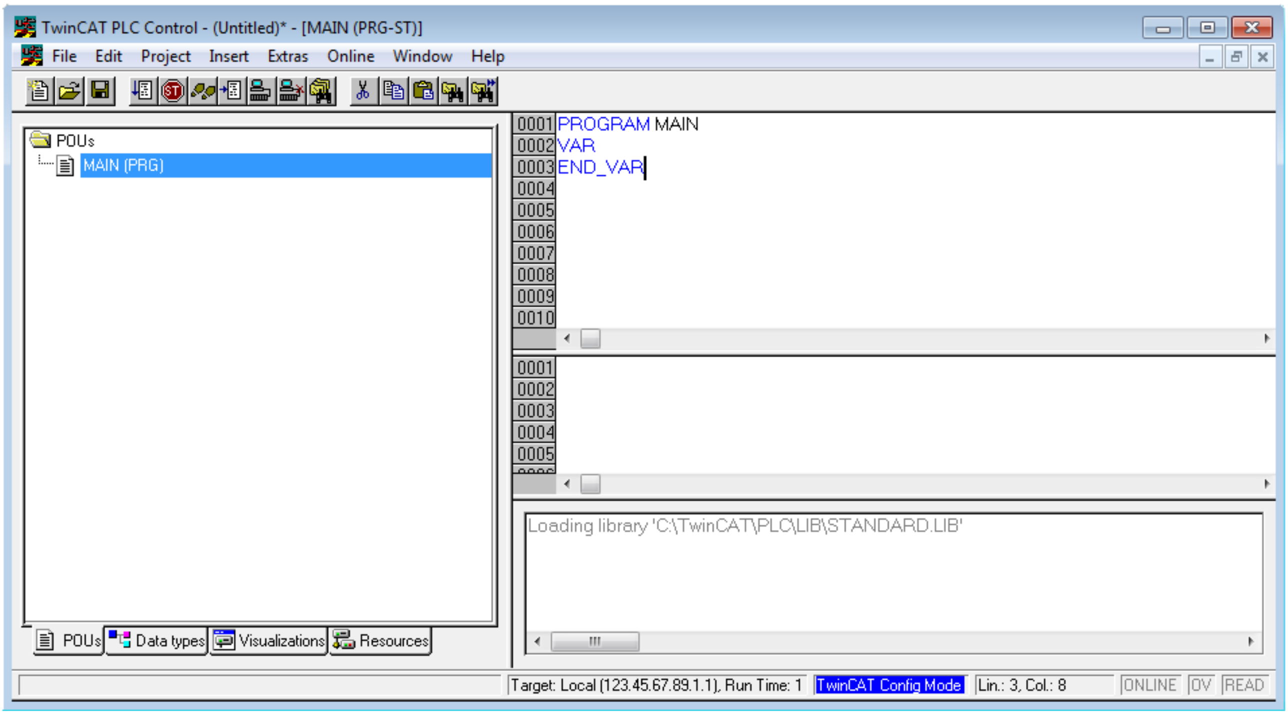



Fig. 59: TwinCAT PLC Control after startup

Sample variables and a sample program have been created and stored under the name “PLC_example.pro”:

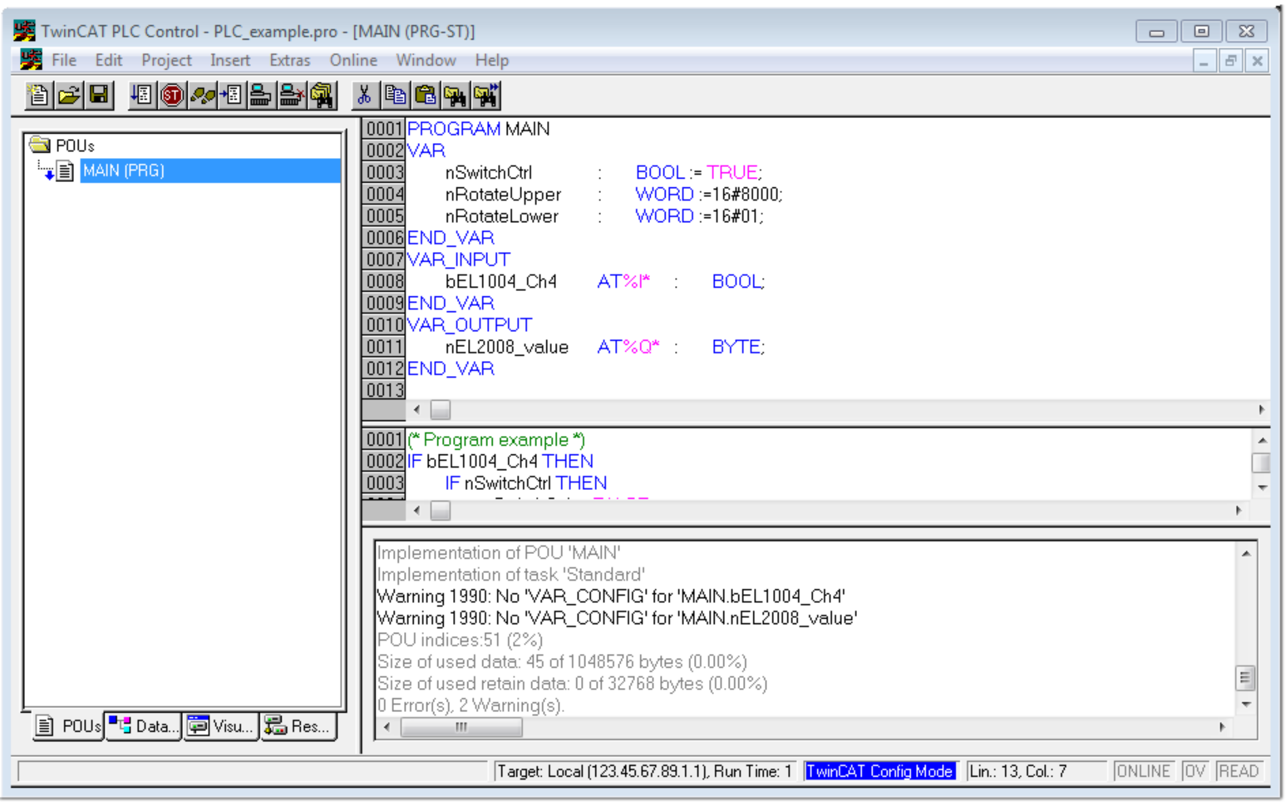



Fig. 60: Sample program with variables after a compile process (without variable integration)

Warning 1990 (missing “VAR_CONFIG”) after a compile process indicates that the variables defined as external (with the ID “AT%I*” or “AT%Q*”) have not been assigned. After successful compilation, TwinCAT PLC Control creates a “*.tpy” file in the directory in which the project was stored. This file (“*.tpy”) contains variable assignments and is not known to the System Manager, hence the warning. Once the System Manager has been notified, the warning no longer appears.

First, integrate the TwinCAT PLC Control project in the **System Manager** via the context menu of the PLC configuration; right-click and select “Append PLC Project…”:

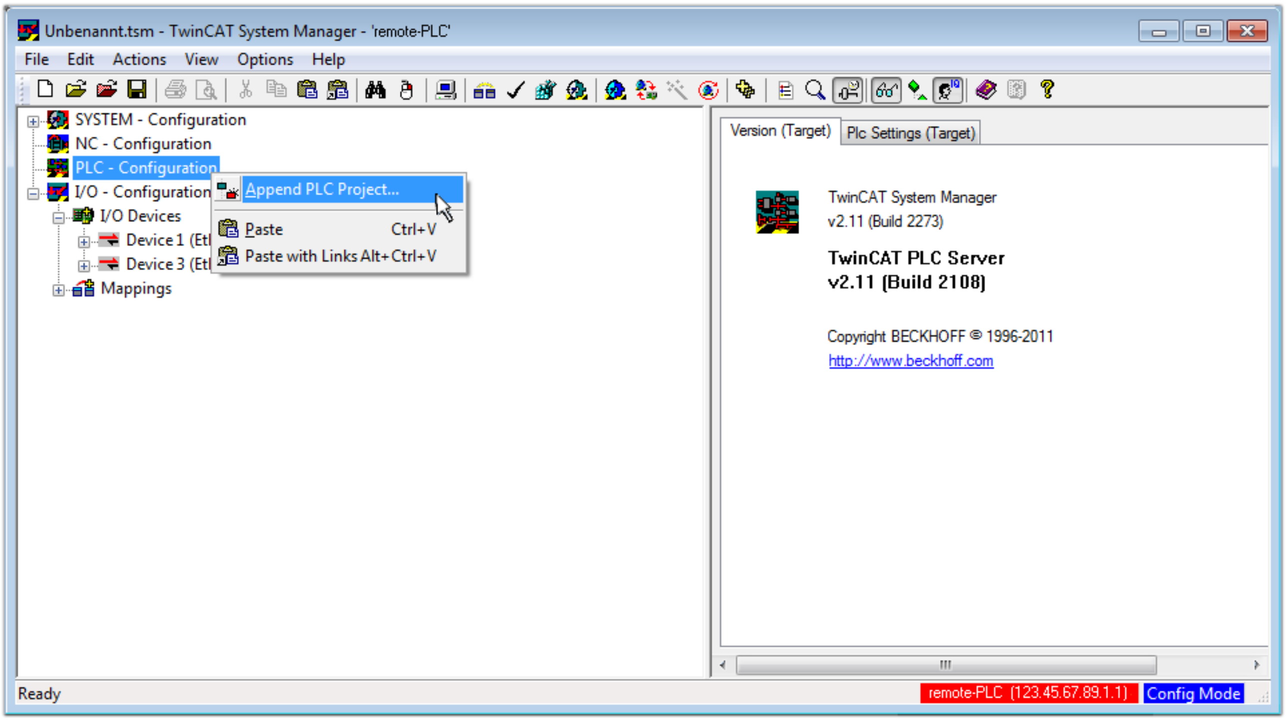



Fig. 61: Appending the TwinCAT PLC Control project

Select the PLC configuration “PLC_example.tpy” in the browser window that opens. The project including the two variables identified with “AT” are then integrated in the configuration tree of the System Manager:

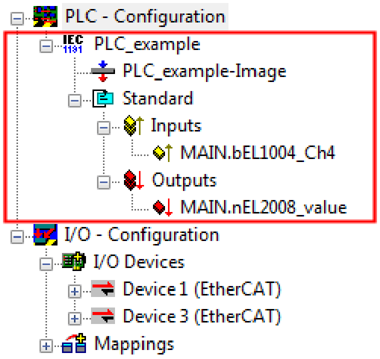



Fig. 62: PLC project integrated in the PLC configuration of the System Manager

The two variables “bEL1004_Ch4” and “nEL2008_value” can now be assigned to certain process objects of the I/O configuration.

## Assigning variables

Open a window for selecting a suitable process object (PDO) via the context menu of a variable of the integrated project “PLC_example” and via “Modify Link...” “Standard”:

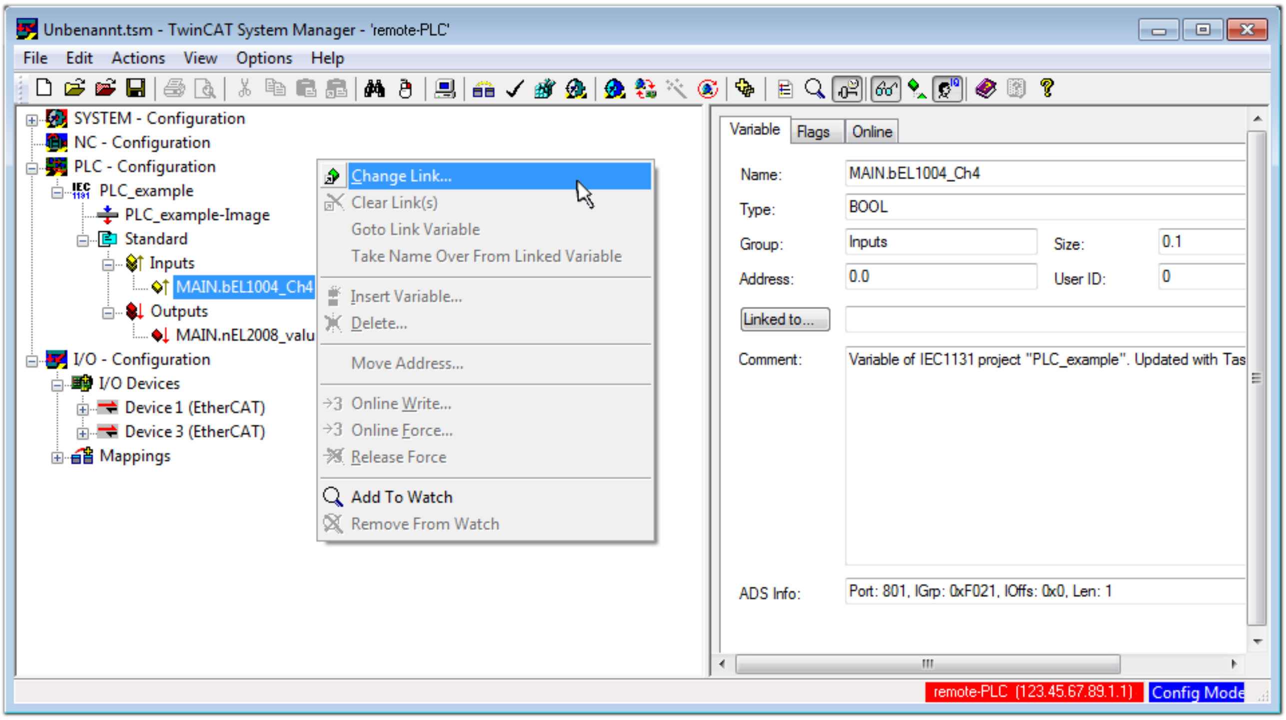



Fig. 63: Creating the links between PLC variables and process objects

In the window that opens, the process object for the variable “bEL1004_Ch4” of type BOOL can be selected from the PLC configuration tree:

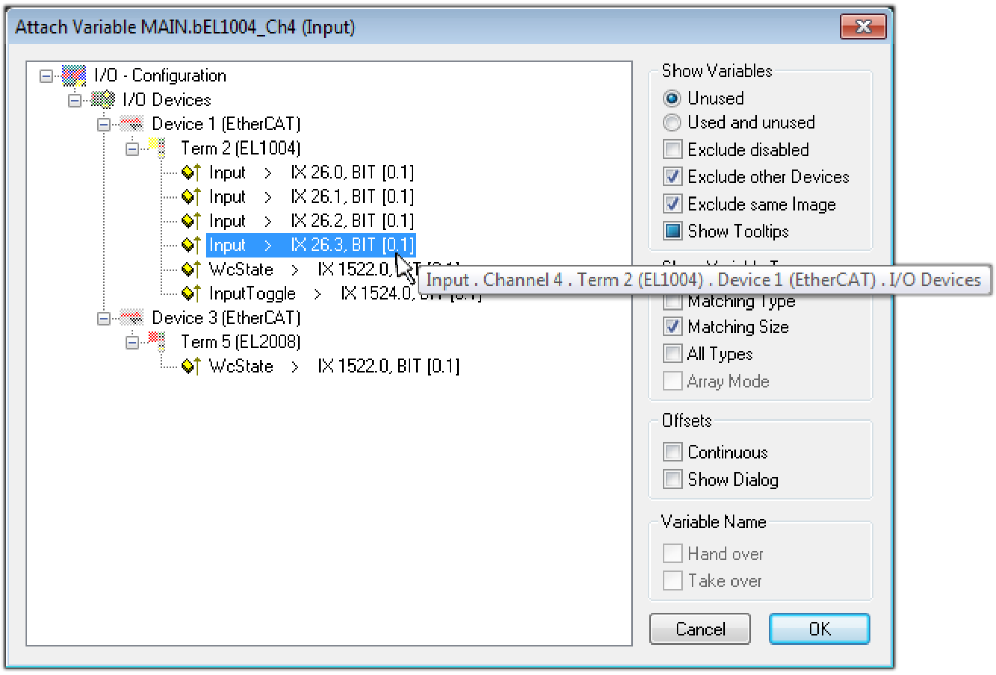



Fig. 64: Selecting PDO of type BOOL

According to the default setting, certain PDO objects are now available for selection. In this sample the input of channel 4 of the EL1004 terminal is selected for linking. In contrast, the checkbox “All types” must be ticked for creating the link for the output variables, in order to allocate a set of eight separate output bits to a byte variable. The following diagram shows the whole process:

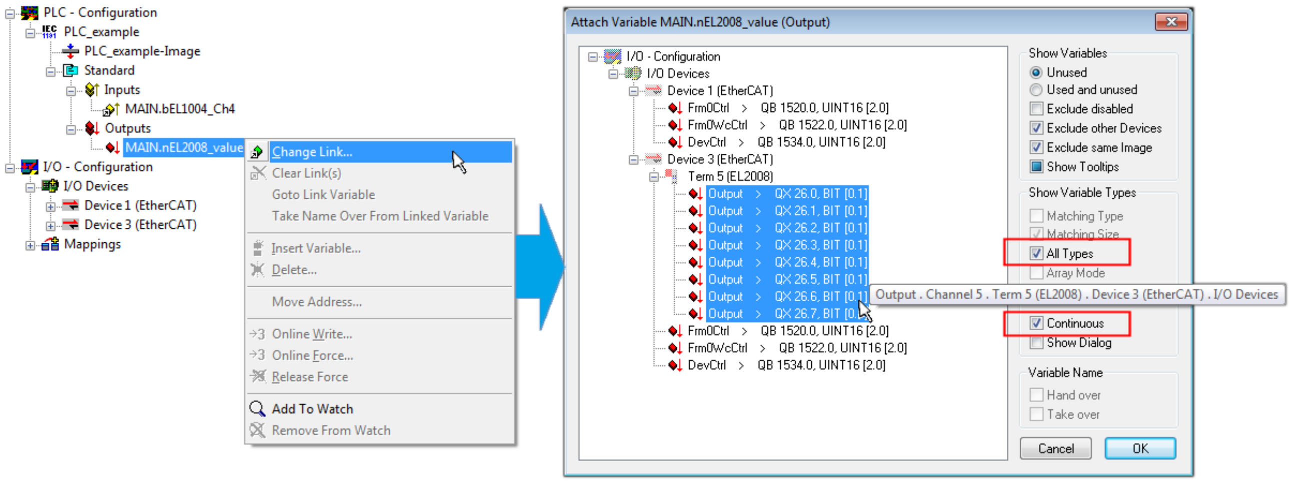



Fig. 65: Selecting several PDOs simultaneously: activate “Continuous” and “All types”

Note that the “Continuous” checkbox was also activated. This is designed to allocate the bits contained in the byte of the variable “nEL2008_value” sequentially to all eight selected output bits of the EL2008 terminal. In this way it is possible to subsequently address all eight outputs of the terminal in the program with a byte corresponding to bit 0 for channel 1 to bit 7 for channel 8 of the PLC. A special symbol ( ) at the yellow or red object of the variable indicates that a link exists. The links can also be checked by selecting a “Goto Link Variable” from the context menu of a variable. The object opposite, in this case the PDO, is automatically selected:

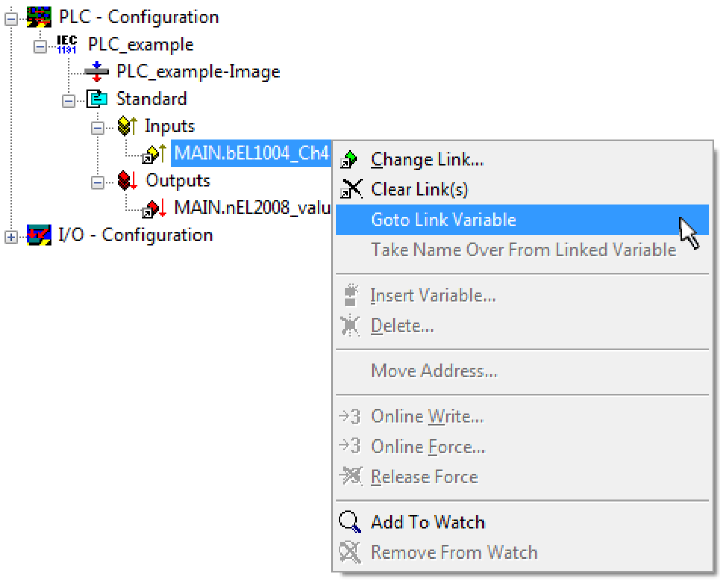
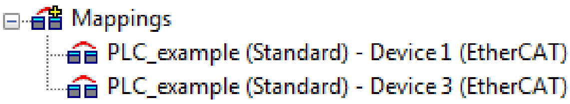



Fig. 66: Application of a “Goto Link” variable, using “MAIN.bEL1004_Ch4” as a sample

The process of assigning variables to the PDO is completed via the menu selection “Actions” → “Generate Mappings”, key Ctrl+M or by clicking on the symbol  in the menu.

This can be visualized in the configuration:




The process of creating links can also take place in the opposite direction, i.e. starting with individual PDOs to variable. However, in this example it would then not be possible to select all output bits for the EL2008, since the terminal only makes individual digital outputs available. If a terminal has a byte, word, integer or similar PDO, it is possible to allocate this a set of bit-standardized variables (type “BOOL”). Here, too, a “Goto Link Variable” from the context menu of a PDO can be executed in the other direction, so that the respective PLC instance can then be selected.

### Activation of the configuration

The allocation of PDO to PLC variables has now established the connection from the controller to the inputs and outputs of the terminals. The configuration can now be activated. First, the configuration can be verified via  (or via “Actions” → “Check Configuration”). If no error is present, the configuration can be activated via  (or via “Actions” → “Activate Configuration…”) to transfer the System Manager settings to the runtime system. Confirm the messages “Old configurations are overwritten!” and “Restart TwinCAT system in Run mode” with “OK”.

A few seconds later the real-time status 

is displayed at the bottom right in the System Manager. The PLC system can then be started as described below.

### Starting the controller

Starting from a remote system, the PLC control has to be linked with the Embedded PC over Ethernet via “Online” → “Choose Run-Time System…”:

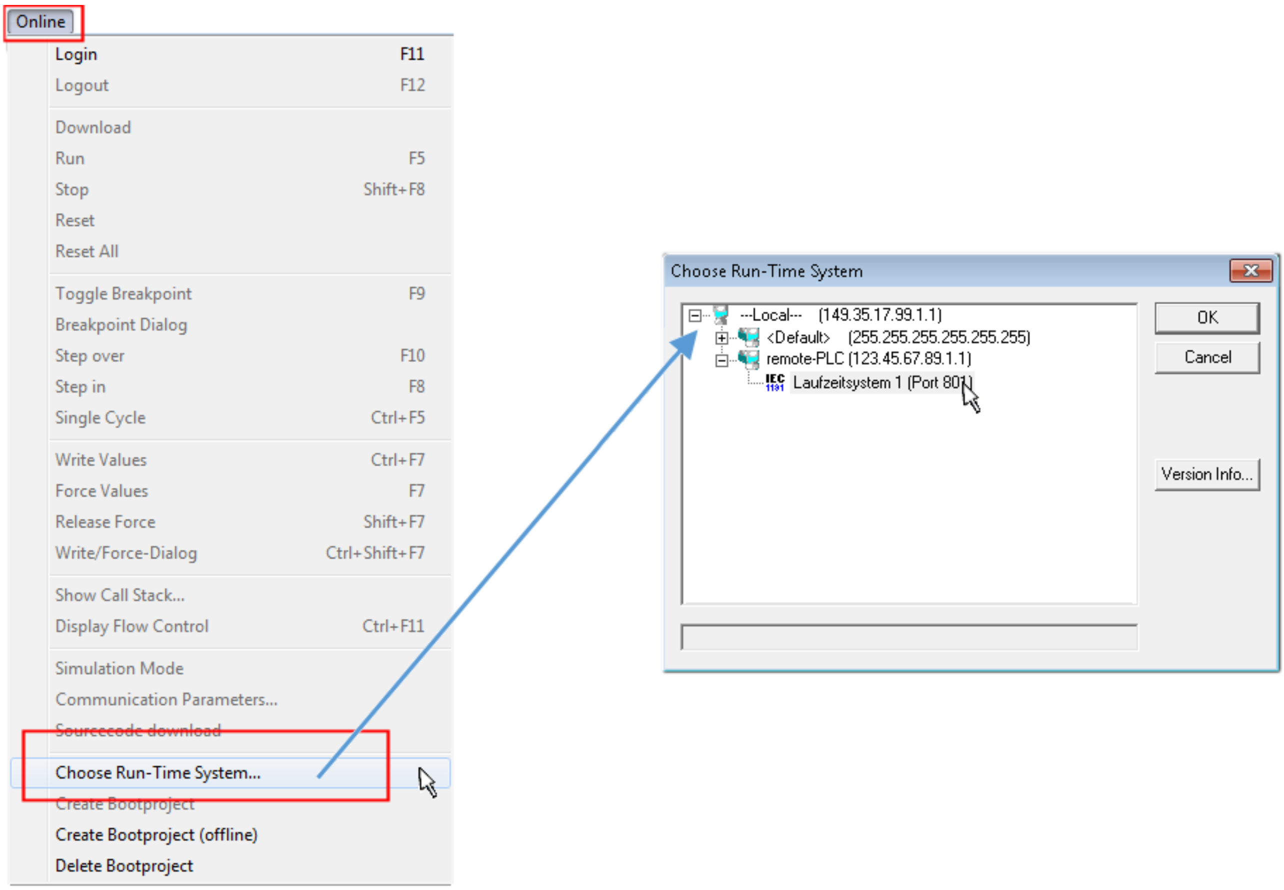
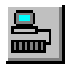



Fig. 67: Choose target system (remote)

In this sample “Runtime system 1 (port 801)” is selected and confirmed. Link the PLC with the real-time system via menu option “Online” → “Login”, the F11 key or by clicking on the symbol . The control program can then be loaded for execution. This results in the message “No program on the controller! Should the new program be loaded?”, which should be acknowledged with “Yes”. The runtime environment is ready for the program start:

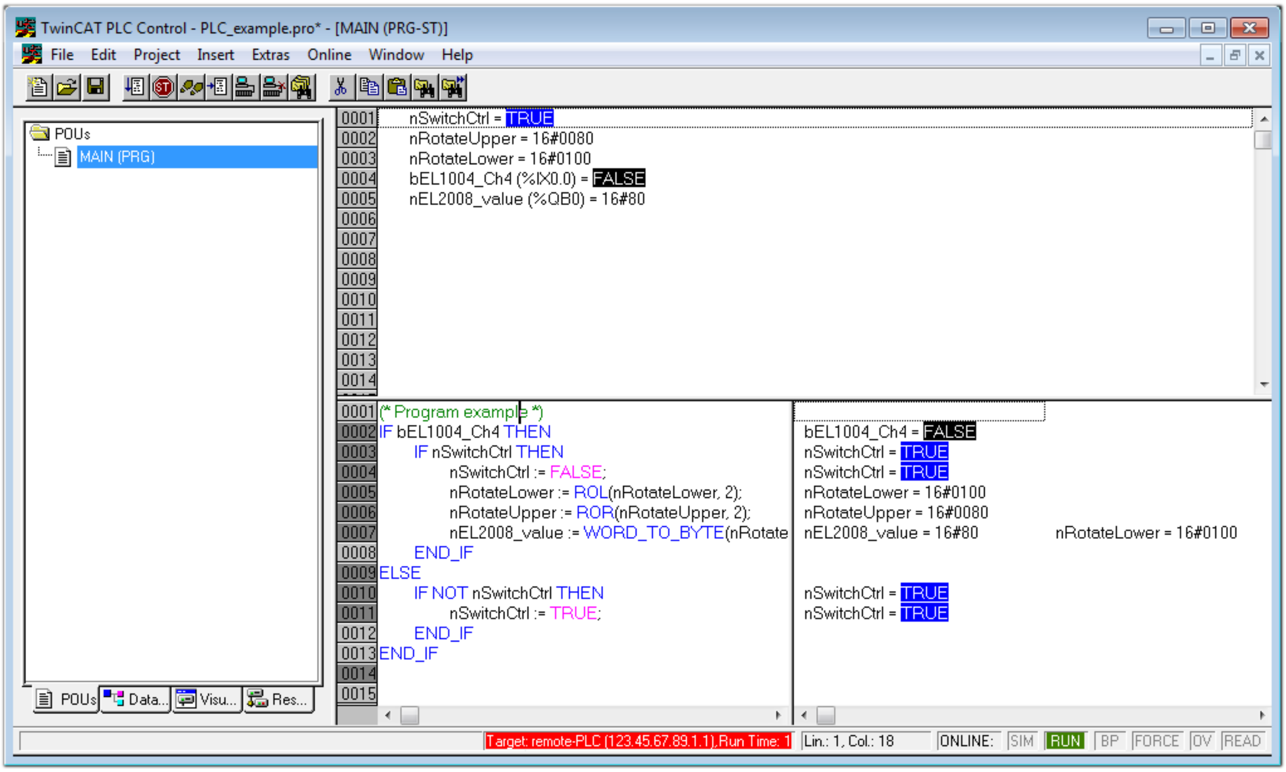


Fig. 68: PLC Control logged in, ready for program startup

The PLC can now be started via “Online” → “Run”, F5 key or  .

## 5.1.2 TwinCAT 3

### Startup

TwinCAT makes the development environment areas available together with Microsoft Visual Studio: after startup, the project folder explorer appears on the left in the general window area (cf. “TwinCAT System Manager” of TwinCAT 2) for communication with the electromechanical components.

After successful installation of the TwinCAT system on the PC to be used for development, TwinCAT 3 (shell) displays the following user interface after startup:

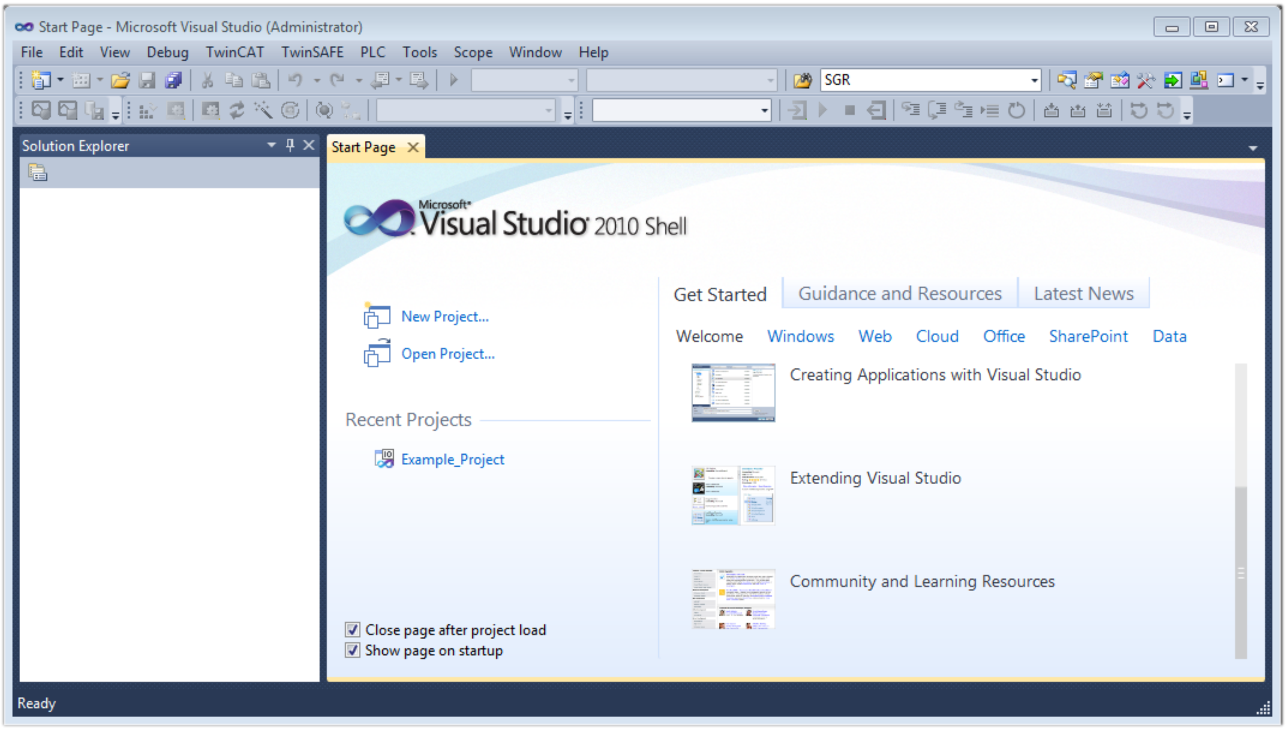



Fig. 69: Initial TwinCAT 3 user interface

First create a new project via 

(or under “File”→“New”→ “Project…”). In the following dialog make the corresponding entries as required (as shown in the diagram):

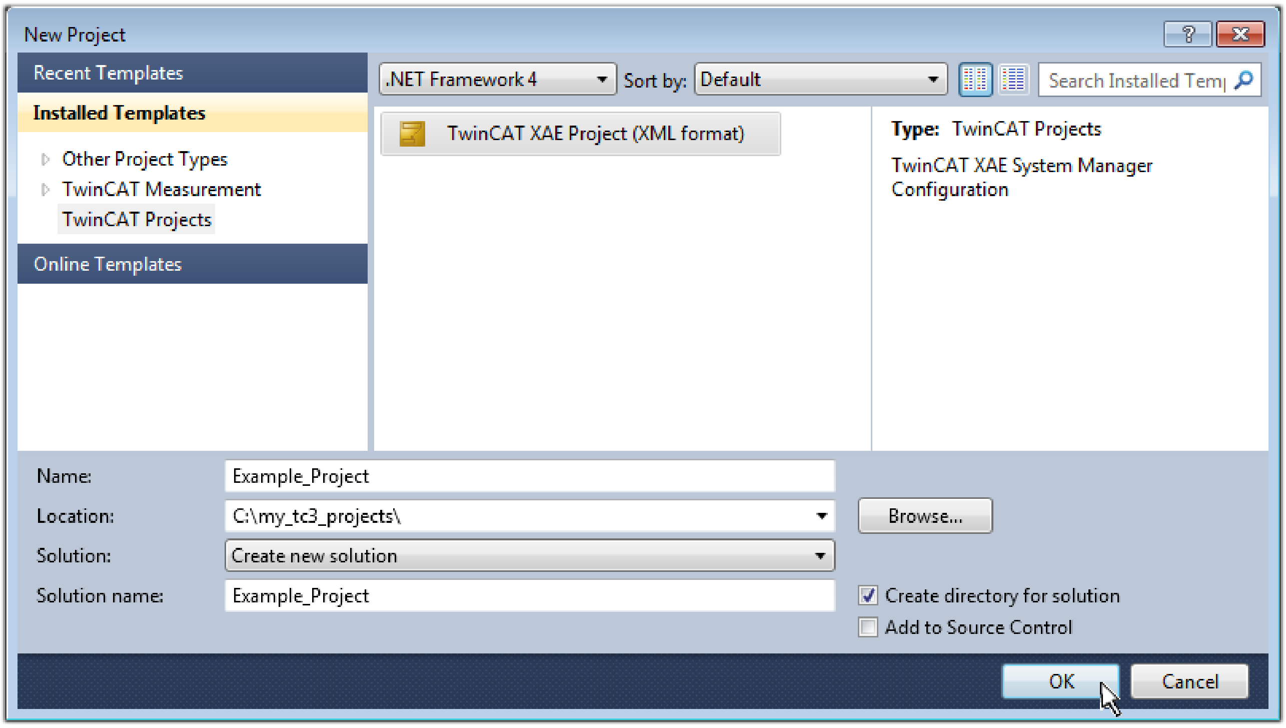



Fig. 70: Create new TwinCAT project

The new project is then available in the project folder explorer:

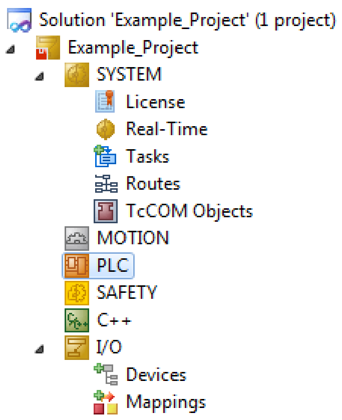
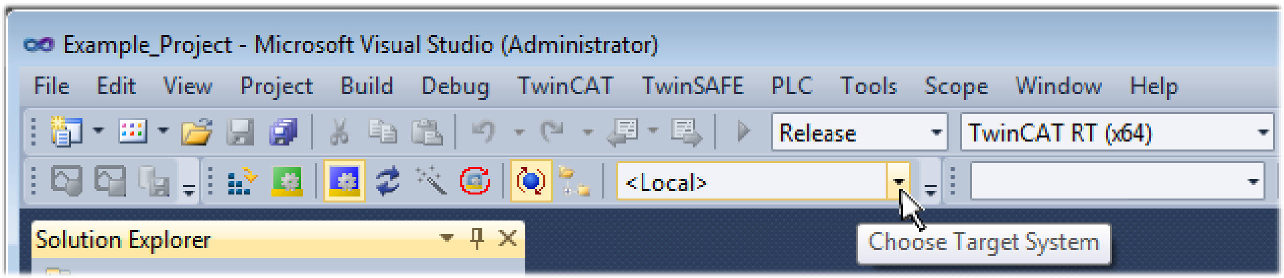


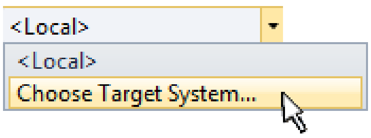

Fig. 71: New TwinCAT3 project in the project folder explorer

Generally, TwinCAT can be used in local or remote mode. Once the TwinCAT system including the user interface (standard) is installed on the respective PLC, TwinCAT can be used in local mode and thereby the next step is "Insert Device [▸ 252]".

If the intention is to address the TwinCAT runtime environment installed on a PLC as development environment remotely from another system, the target system must be made known first. Via the symbol in the menu bar:




expand the pull-down menu:




and open the following window:

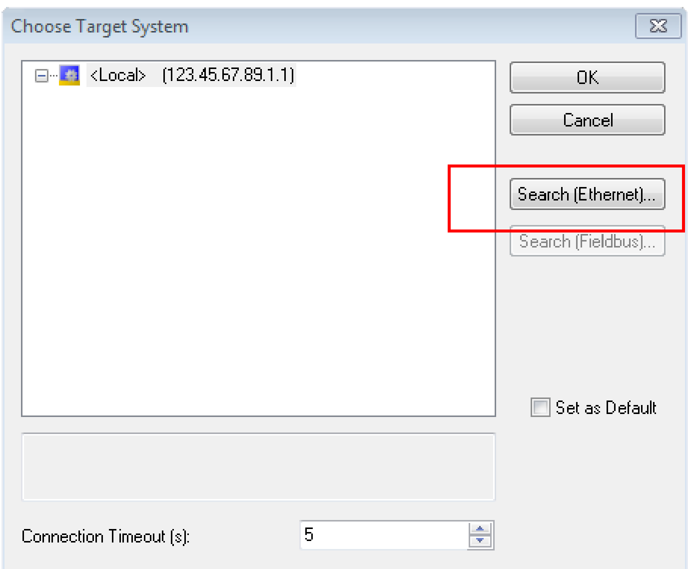



Fig. 72: Selection dialog: Choose the target system

Use “Search (Ethernet)...” to enter the target system. Thus a next dialog opens to either:

- enter the known computer name after “Enter Host Name / IP:” (as shown in red)
- perform a “Broadcast Search” (if the exact computer name is not known)
- enter the known computer IP or AmsNetID.

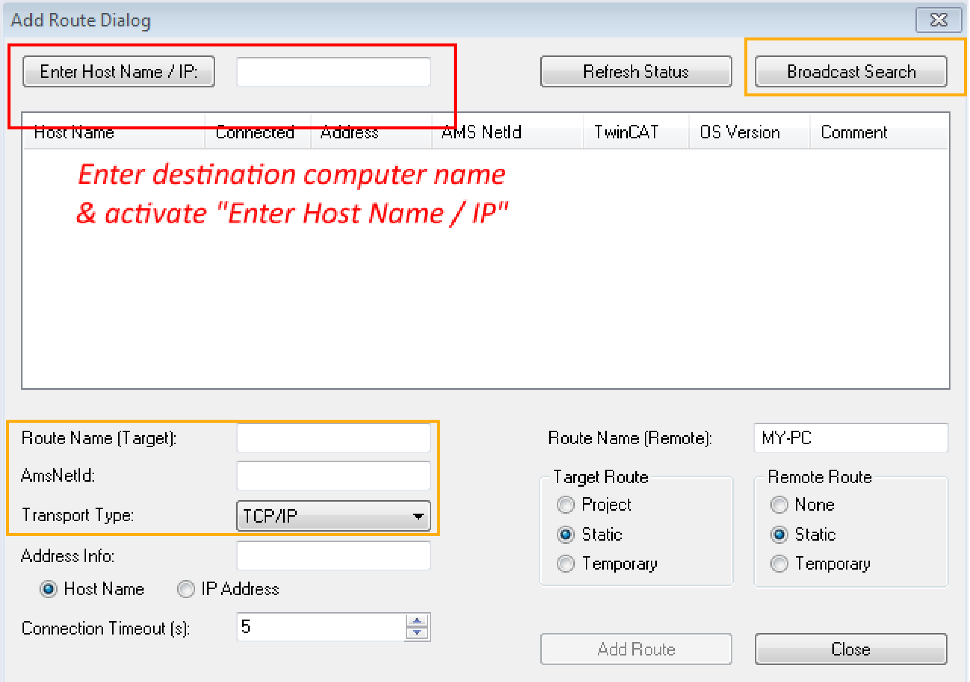
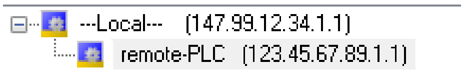


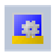

Fig. 73: Specify the PLC for access by the TwinCAT System Manager: selection of the target system

Once the target system has been entered, it is available for selection as follows (a password may have to be entered):




After confirmation with “OK” the target system can be accessed via the Visual Studio shell.

### Adding devices

In the project folder explorer of the Visual Studio shell user interface on the left, select “Devices” within element “I/O”, then right-click to open a context menu and select “Scan” or start the action via  in the menu bar. The TwinCAT System Manager may first have to be set to “Config mode” via  or via the menu “TwinCAT” → “Restart TwinCAT (Config mode)”.

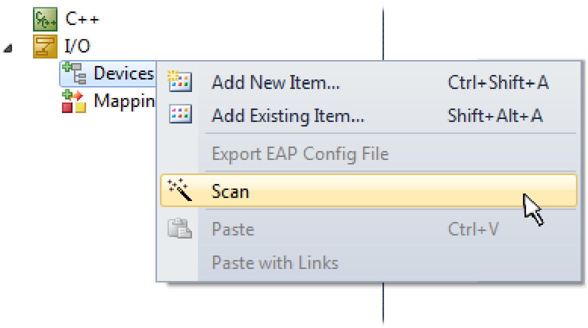



Fig. 74: Select “Scan”

Confirm the warning message, which follows, and select “EtherCAT” in the dialog:

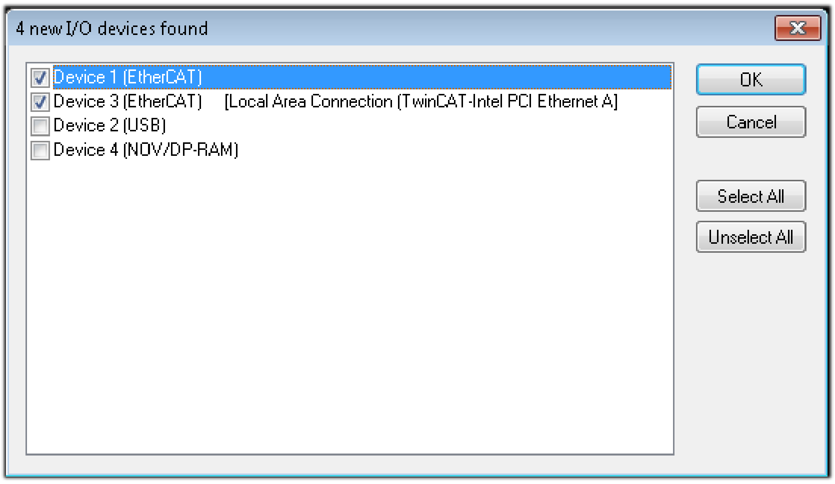



Fig. 75: Automatic detection of I/O devices: selection the devices to be integrated

Confirm the message “Find new boxes”, in order to determine the terminals connected to the devices. “Free Run” enables manipulation of input and output values in “Config mode” and should also be acknowledged.

Based on the sample configuration [▶ 237] described at the beginning of this section, the result is as follows:

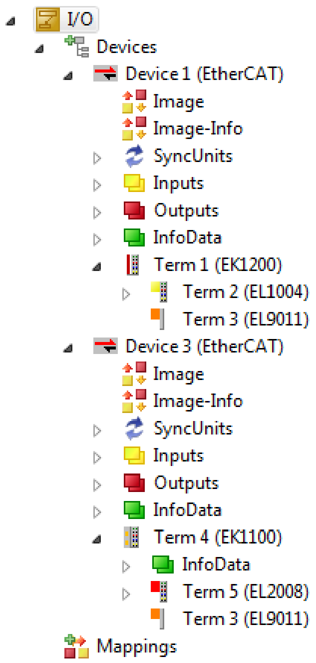



Fig. 76: Mapping of the configuration in VS shell of the TwinCAT3 environment

The whole process consists of two stages, which may be performed separately (first determine the devices, then determine the connected elements such as boxes, terminals, etc.). A scan can also be initiated by selecting “Device ...” from the context menu, which then reads the elements present in the configuration below:

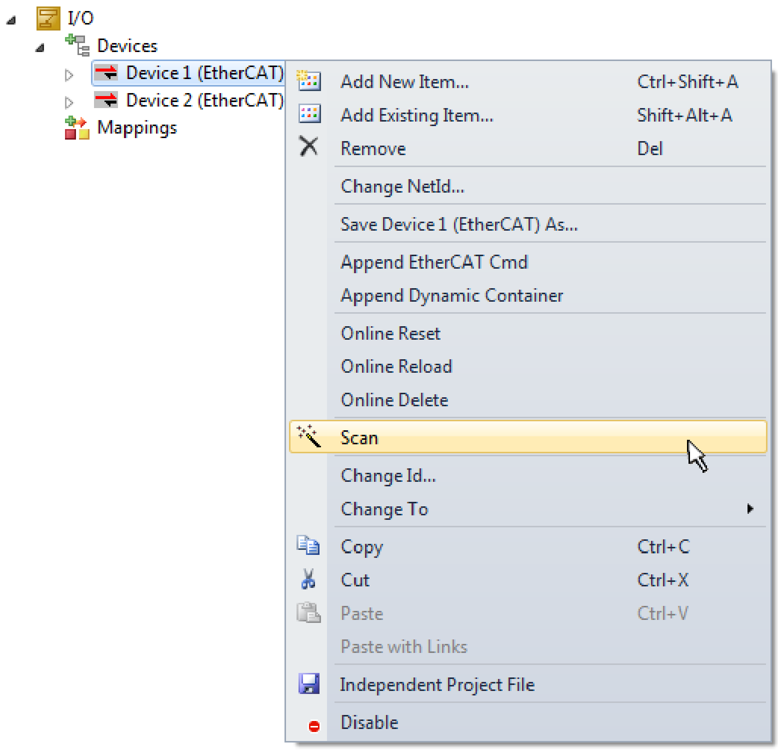



Fig. 77: Reading of individual terminals connected to a device

This functionality is useful if the actual configuration is modified at short notice.

## Programming the PLC

TwinCAT PLC Control is the development environment for the creation of the controller in different program environments: TwinCAT PLC Control supports all languages described in IEC 61131-3. There are two text-based languages and three graphical languages.

- **Text-based languages**
  - Instruction List (IL)
  - Structured Text (ST)
- **Graphical languages**
  - Function Block Diagram (FBD)
  - Ladder Diagram (LD)
  - The Continuous Function Chart Editor (CFC)
  - Sequential Function Chart (SFC)

The following section refers to Structured Text (ST).

In order to create a programming environment, a PLC subproject is added to the project sample via the context menu of “PLC” in the project folder explorer by selecting “Add New Item….”:

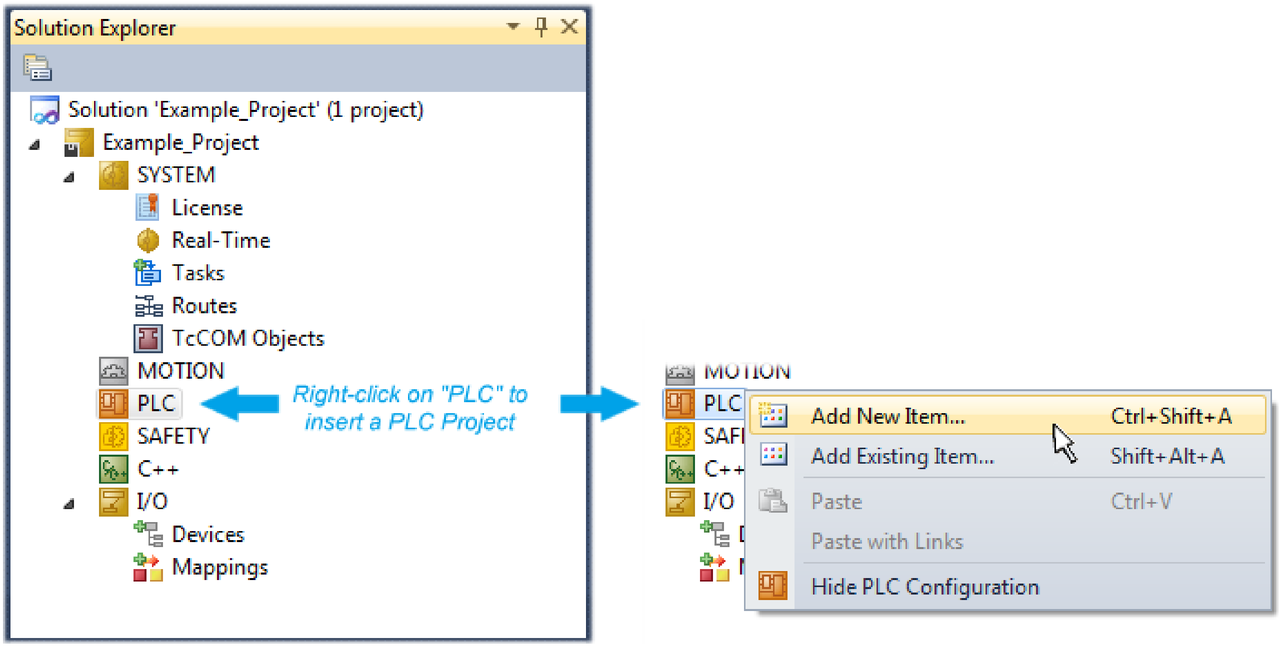



Fig. 78: Adding the programming environment in “PLC”

In the dialog that opens select “Standard PLC project” and enter “PLC_example” as project name, for example, and select a corresponding directory:

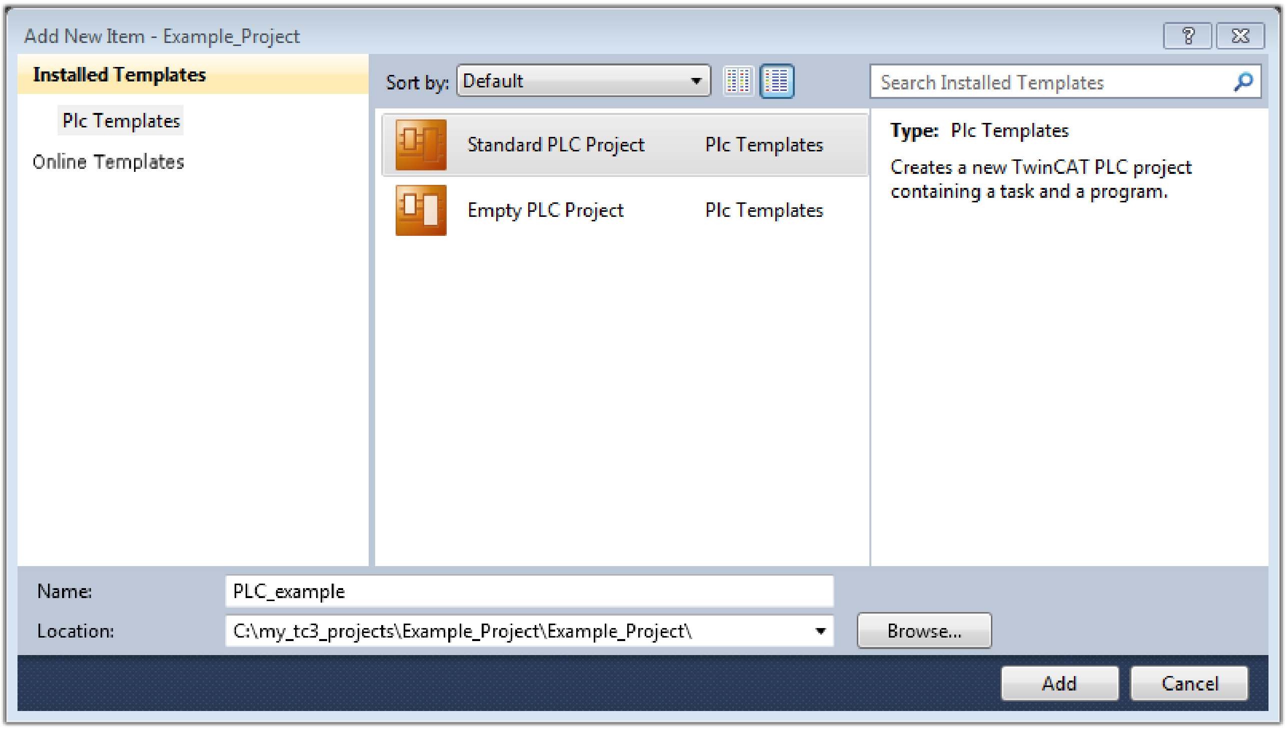



Fig. 79: Specifying the name and directory for the PLC programming environment

The “Main” program, which already exists by selecting “Standard PLC project”, can be opened by double-clicking on “PLC_example_project” in “POUs”. The following user interface is shown for an initial project:

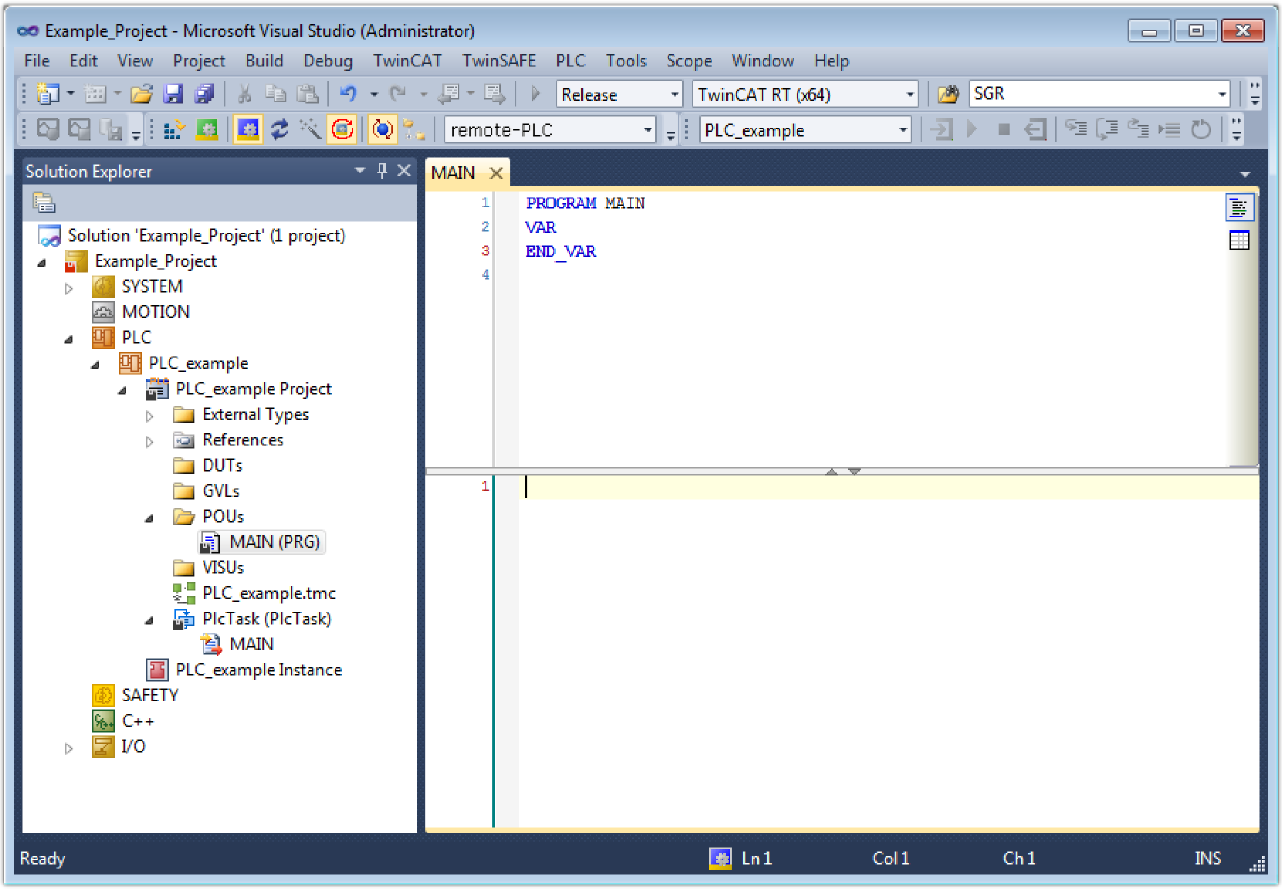



Fig. 80: Initial “Main” program of the standard PLC project

To continue, sample variables and a sample program have now been created:

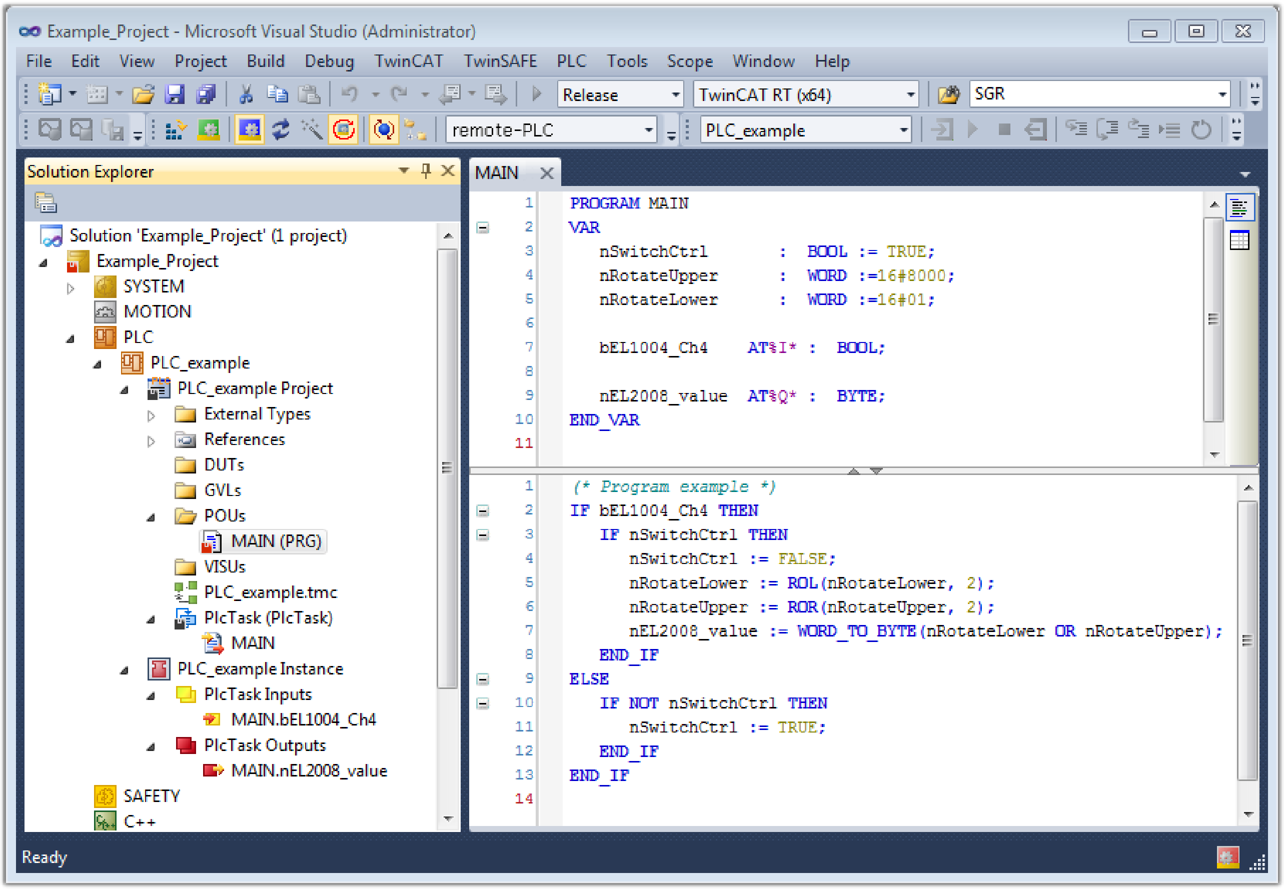


Fig. 81: Sample program with variables after a compile process (without variable integration)

The control program is now created as a project folder, followed by the compile process:

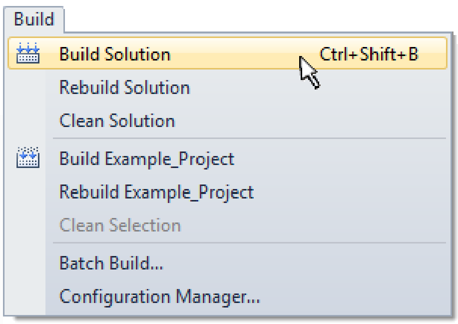
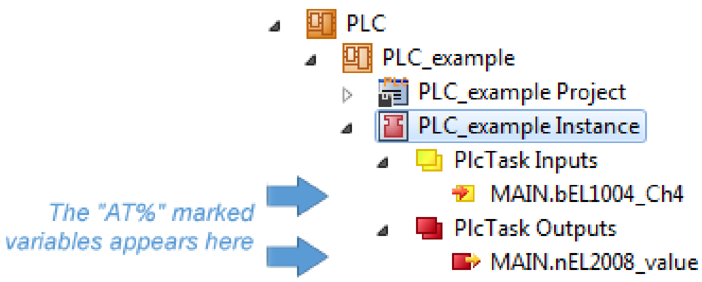


Fig. 82: Start program compilation

The following variables, identified in the ST/ PLC program with “AT%”, are then available in under “Assignments” in the project folder explorer:




## Assigning variables

Via the menu of an instance - variables in the “PLC” context, use the “Modify Link…” option to open a window for selecting a suitable process object (PDO) for linking:

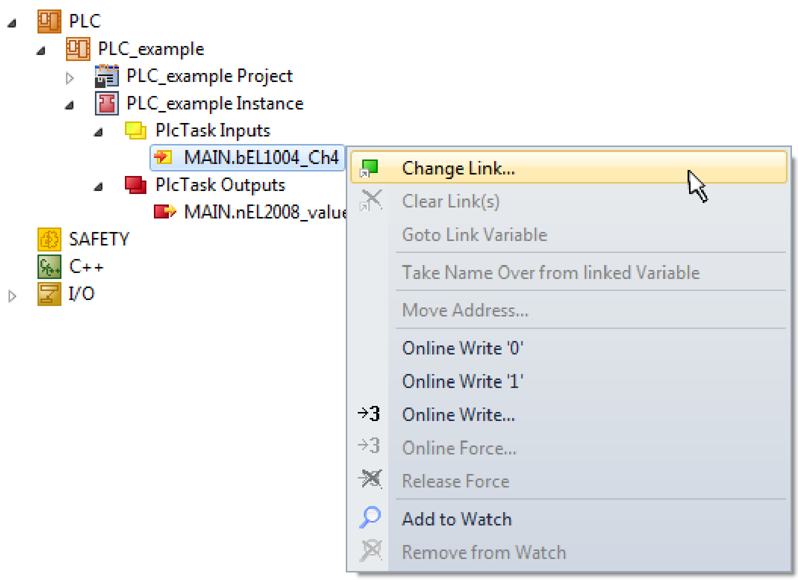



Fig. 83: Creating the links between PLC variables and process objects

In the window that opens, the process object for the variable “bEL1004_Ch4” of type BOOL can be selected from the PLC configuration tree:

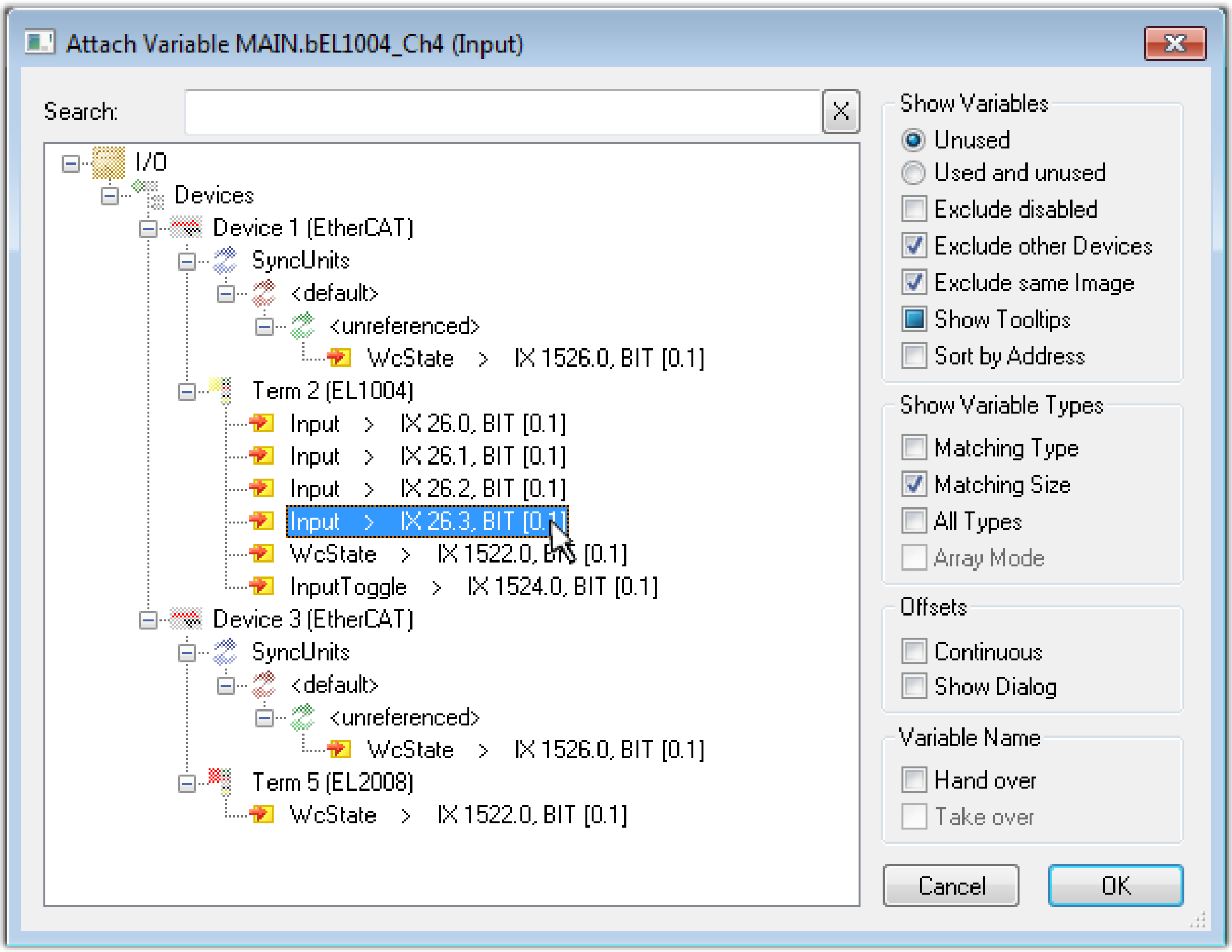



Fig. 84: Selecting PDO of type BOOL

According to the default setting, certain PDO objects are now available for selection. In this sample the input of channel 4 of the EL1004 terminal is selected for linking. In contrast, the checkbox “All types” must be ticked for creating the link for the output variables, in order to allocate a set of eight separate output bits to a byte variable. The following diagram shows the whole process:

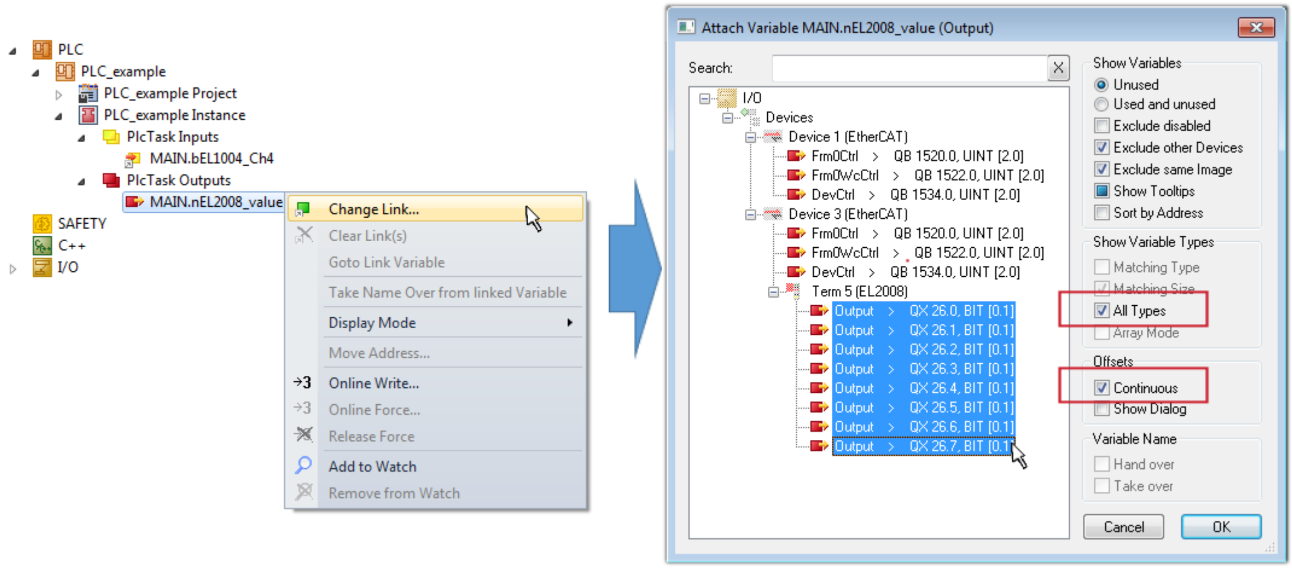



Fig. 85: Selecting several PDOs simultaneously: activate “Continuous” and “All types”

Note that the “Continuous” checkbox was also activated. This is designed to allocate the bits contained in the byte of the variable “nEL2008_value” sequentially to all eight selected output bits of the EL2008 terminal. In this way it is possible to subsequently address all eight outputs of the terminal in the program with a byte corresponding to bit 0 for channel 1 to bit 7 for channel 8 of the PLC. A special symbol ( ) at the yellow or red object of the variable indicates that a link exists. The links can also be checked by selecting a “Goto Link Variable” from the context menu of a variable. The object opposite, in this case the PDO, is automatically selected:

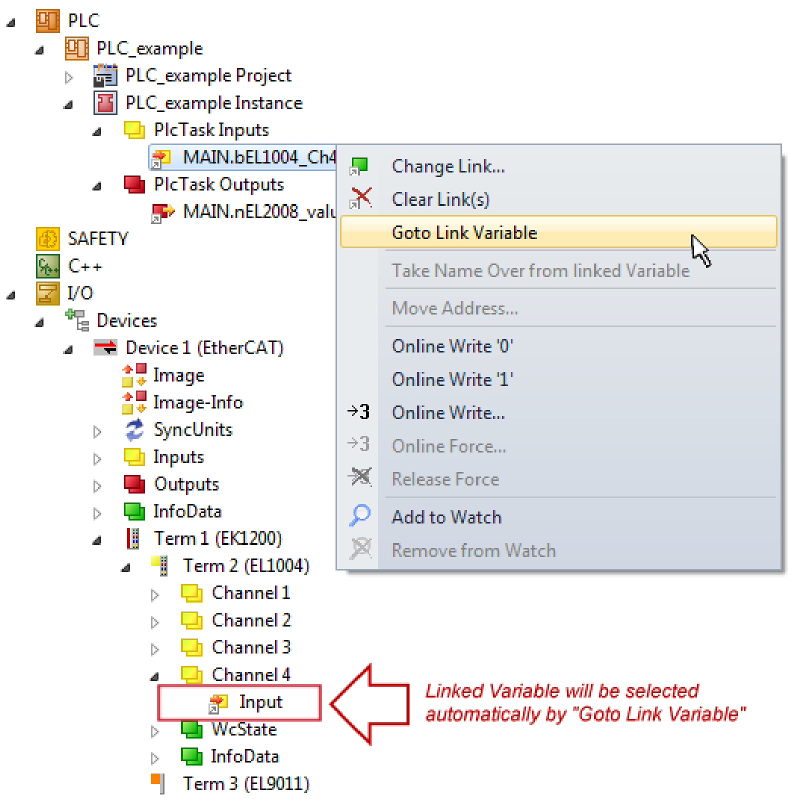



Fig. 86: Application of a “Goto Link” variable, using “MAIN.bEL1004_Ch4” as a sample

The process of creating links can also take place in the opposite direction, i.e. starting with individual PDOs to variable. However, in this example it would then not be possible to select all output bits for the EL2008, since the terminal only makes individual digital outputs available. If a terminal has a byte, word, integer or similar PDO, it is possible to allocate this a set of bit-standardized variables (type “BOOL”). Here, too, a “Goto Link Variable” from the context menu of a PDO can be executed in the other direction, so that the respective PLC instance can then be selected.

**Note on the type of variable assignment**

The following type of variable assignment can only be used from TwinCAT version V3.1.4024.4 onwards and is only available for terminals with a microcontroller.

In TwinCAT it is possible to create a structure from the mapped process data of a terminal. An instance of this structure can then be created in the PLC, so it is possible to access the process data directly from the PLC without having to declare own variables.

The procedure for the EL3001 1-channel analog input terminal -10...+10 V is shown as an example.

1. First the required process data must be selected in the “Process data” tab in TwinCAT.
2. After that, the PLC data type must be generated in the tab “PLC” via the check box.
3. The data type in the “Data Type” field can then be copied using the “Copy” button.

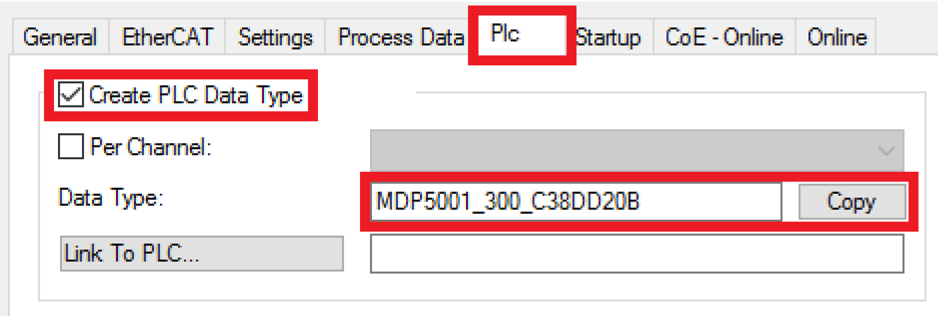



Fig. 87: Creating a PLC data type

4. An instance of the data structure of the copied data type must then be created in the PLC.

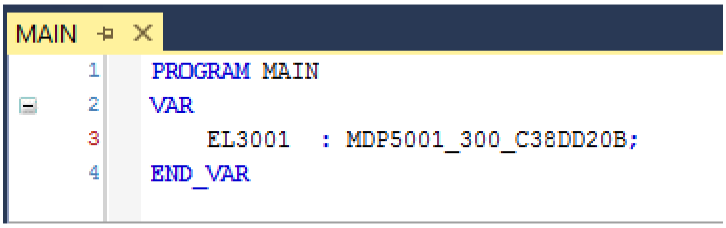



Fig. 88: Instance_of_struct

5. Then the project folder must be created. This can be done either via the key combination “CTRL + Shift + B” or via the “Build” tab in TwinCAT.
6. The structure in the “PLC” tab of the terminal must then be linked to the created instance.

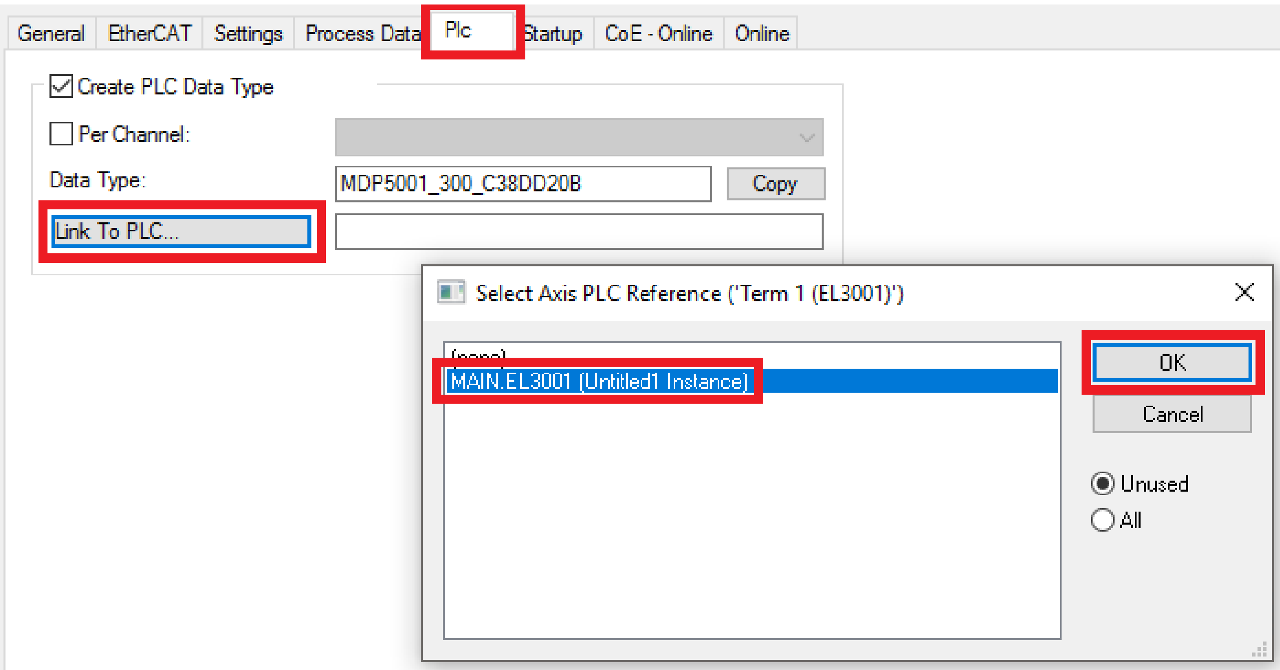



Fig. 89: Linking the structure

7. In the PLC the process data can then be read or written via the structure in the program code.

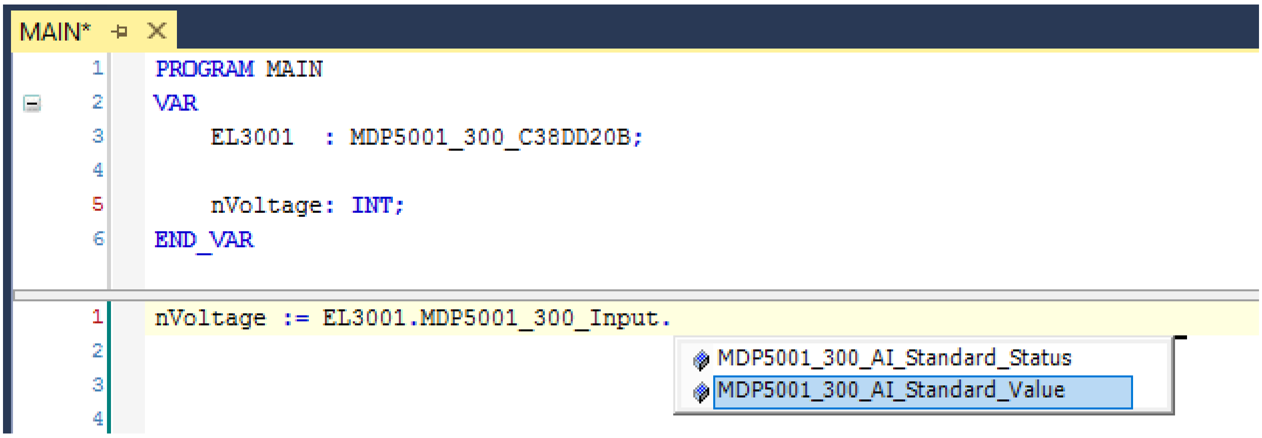
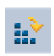
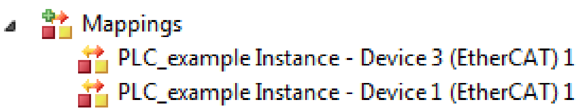



Fig. 90: Reading a variable from the structure of the process data

**Activation of the configuration**

The allocation of PDO to PLC variables has now established the connection from the controller to the inputs and outputs of the terminals. The configuration can now be activated with  or via the menu under "TwinCAT" in order to transfer settings of the development environment to the runtime system. Confirm the messages "Old configurations are overwritten!" and "Restart TwinCAT system in Run mode" with "OK". The corresponding assignments can be seen in the project folder explorer:




A few seconds later the corresponding status of the Run mode is displayed in the form of a rotating symbol  at the bottom right of the VS shell development environment. The PLC system can then be started as described below.

**Starting the controller**

Select the menu option “PLC” → “Login” or click on  to link the PLC with the real-time system and load the control program for execution. This results in the message *No program on the controller! Should the new program be loaded?,* which should be acknowledged with “Yes”. The runtime environment is ready for program start by click on symbol  , the “F5” key or via “PLC” in the menu selecting “Start”. The started programming environment shows the runtime values of individual variables:

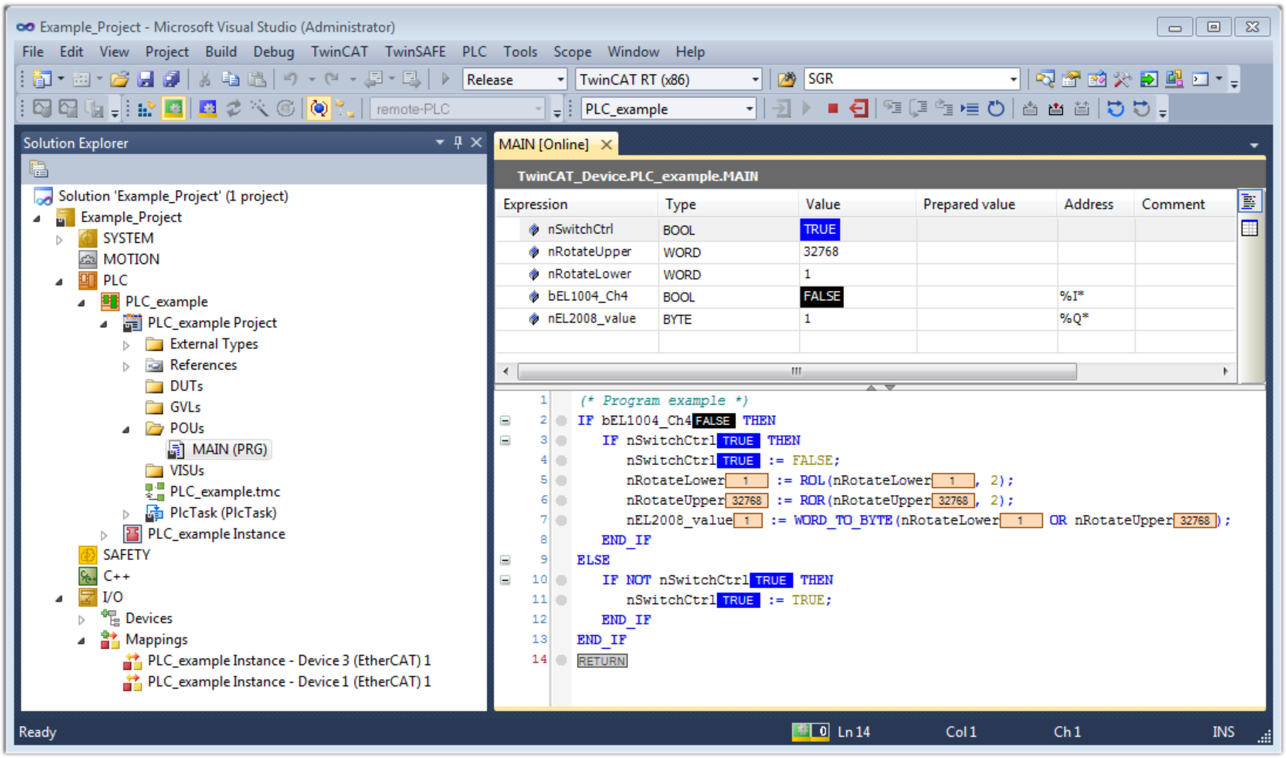



Fig. 91: TwinCAT development environment (VS shell): logged-in, after program startup

The two operator control elements for stopping  and logout  result in the required action (accordingly also for stop “Shift + F5”, or both actions can be selected via the PLC menu).

## 5.2 TwinCAT Development Environment

The Software for automation TwinCAT (The Windows Control and Automation Technology) will be distinguished into:

- TwinCAT 2: System Manager (Configuration) & PLC Control (Programming)
- TwinCAT 3: Enhancement of TwinCAT 2 (Programming and Configuration takes place via a common Development Environment)

**Details:**

- **TwinCAT 2:**
    - Connects I/O devices to tasks in a variable-oriented manner
    - Connects tasks to tasks in a variable-oriented manner
    - Supports units at the bit level
    - Supports synchronous or asynchronous relationships
    - Exchange of consistent data areas and process images
    - Datalink on NT - Programs by open Microsoft Standards (OLE, OCX, ActiveX, DCOM+, etc.)

- Integration of IEC 61131-3-Software-SPS, Software- NC and Software-CNC within Windows NT/2000/XP/Vista, Windows 7, NT/XP Embedded, CE
- Interconnection to all common fieldbusses
- More...

**Additional features:**

- **TwinCAT 3** (eXtended Automation):
  - Visual-Studio®-Integration
  - Choice of the programming language
  - Supports object orientated extension of IEC 61131-3
  - Usage of C/C++ as programming language for real time applications
  - Connection to MATLAB®/Simulink®
  - Open interface for expandability
  - Flexible run-time environment
  - Active support of Multi-Core- und 64-Bit-Operatingsystem
  - Automatic code generation and project creation with the TwinCAT Automation Interface
  - More...

Within the following sections commissioning of the TwinCAT Development Environment on a PC System for the control and also the basically functions of unique control elements will be explained.

Please see further information to TwinCAT 2 and TwinCAT 3 at http://infosys.beckhoff.com.

## 5.2.1 Installation of the TwinCAT real-time driver

In order to assign real-time capability to a standard Ethernet port of an IPC controller, the Beckhoff real-time driver has to be installed on this port under Windows.

This can be done in several ways. One option is described here.

In the System Manager call up the TwinCAT overview of the local network interfaces via Options → Show Real Time Ethernet Compatible Devices.

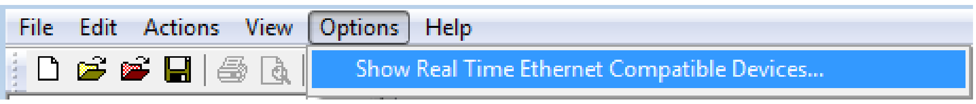



Fig. 92: System Manager “Options” (TwinCAT 2)

This have to be called up by the Menü “TwinCAT” within the TwinCAT 3 environment:

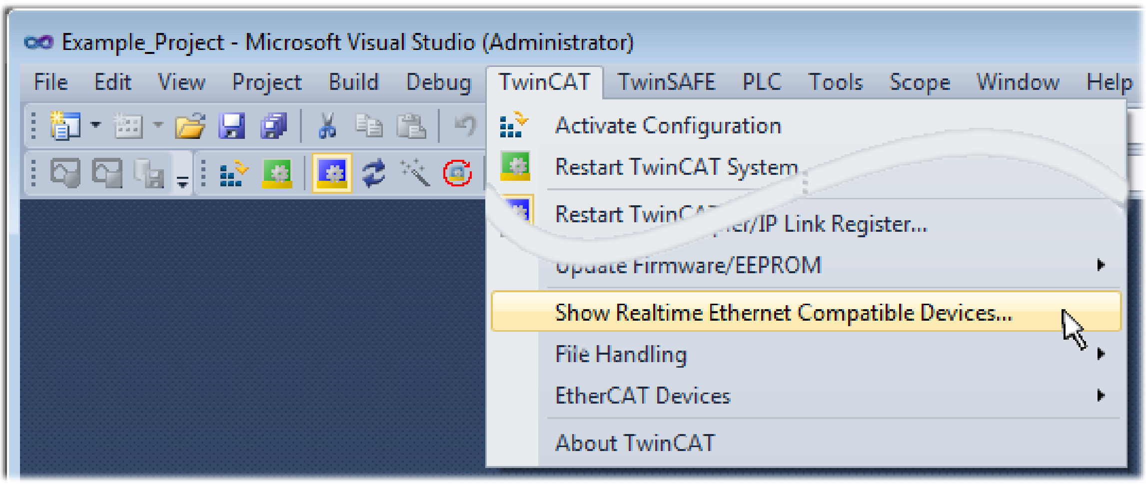



Fig. 93: Call up under VS Shell (TwinCAT 3)

The following dialog appears:

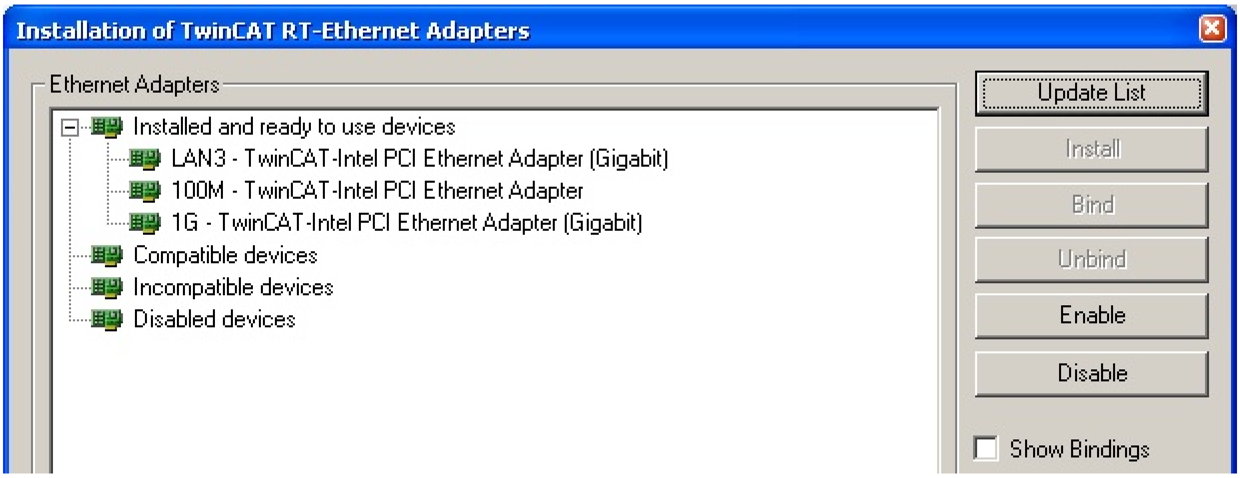



Fig. 94: Overview of network interfaces

Interfaces listed under “Compatible devices” can be assigned a driver via the “Install” button. A driver should only be installed on compatible devices.

A Windows warning regarding the unsigned driver can be ignored.

**Alternatively** an EtherCAT-device can be inserted first of all as described in chapter Offline configuration creation, section “Creating the EtherCAT device” [▶ 273] in order to view the compatible ethernet ports via its EtherCAT properties (tab “Adapter”, button “Compatible Devices…”):

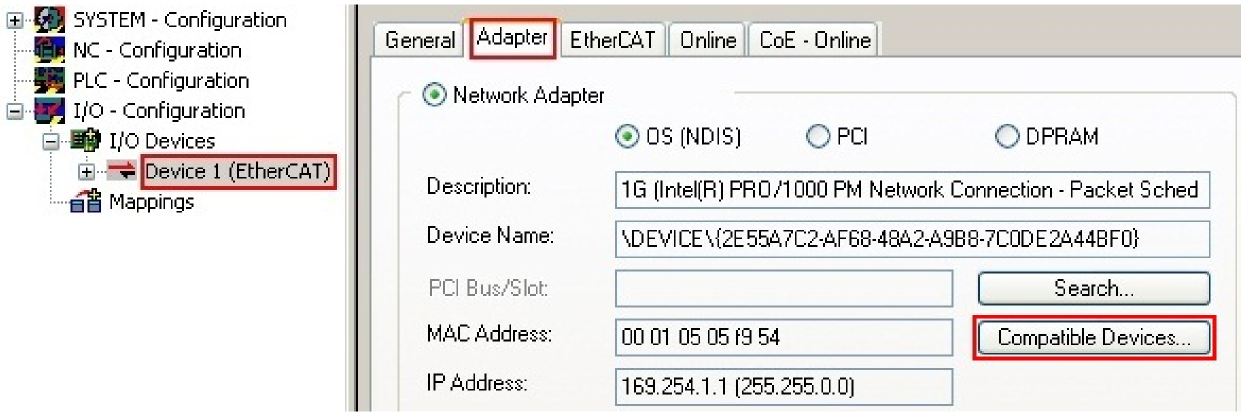
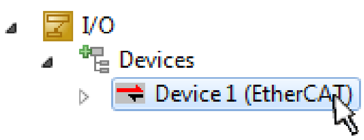



Fig. 95: EtherCAT device properties(TwinCAT 2): click on “Compatible Devices…” of tab “Adapte””

TwinCAT 3: the properties of the EtherCAT device can be opened by double click on “Device .. (EtherCAT)” within the Solution Explorer under “I/O”:




After the installation the driver appears activated in the Windows overview for the network interface (Windows Start → System Properties → Network)

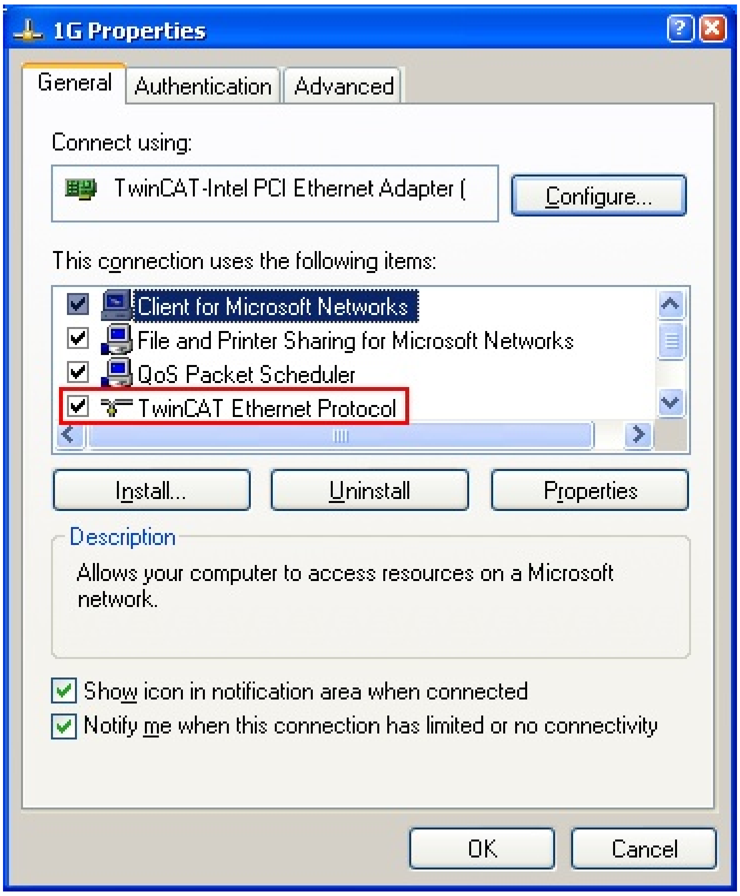



Fig. 96: Windows properties of the network interface

A correct setting of the driver could be:

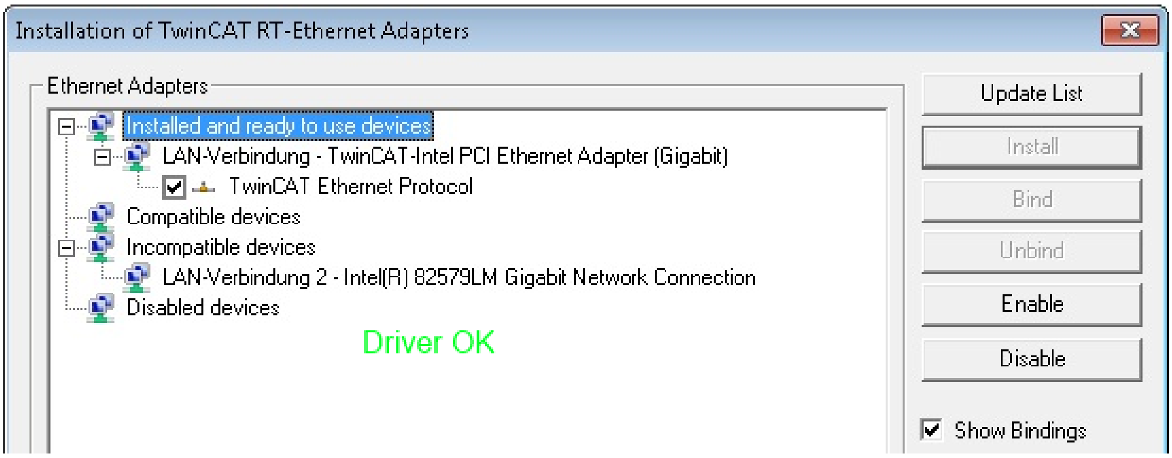



Fig. 97: Exemplary correct driver setting for the Ethernet port

Other possible settings have to be avoided:

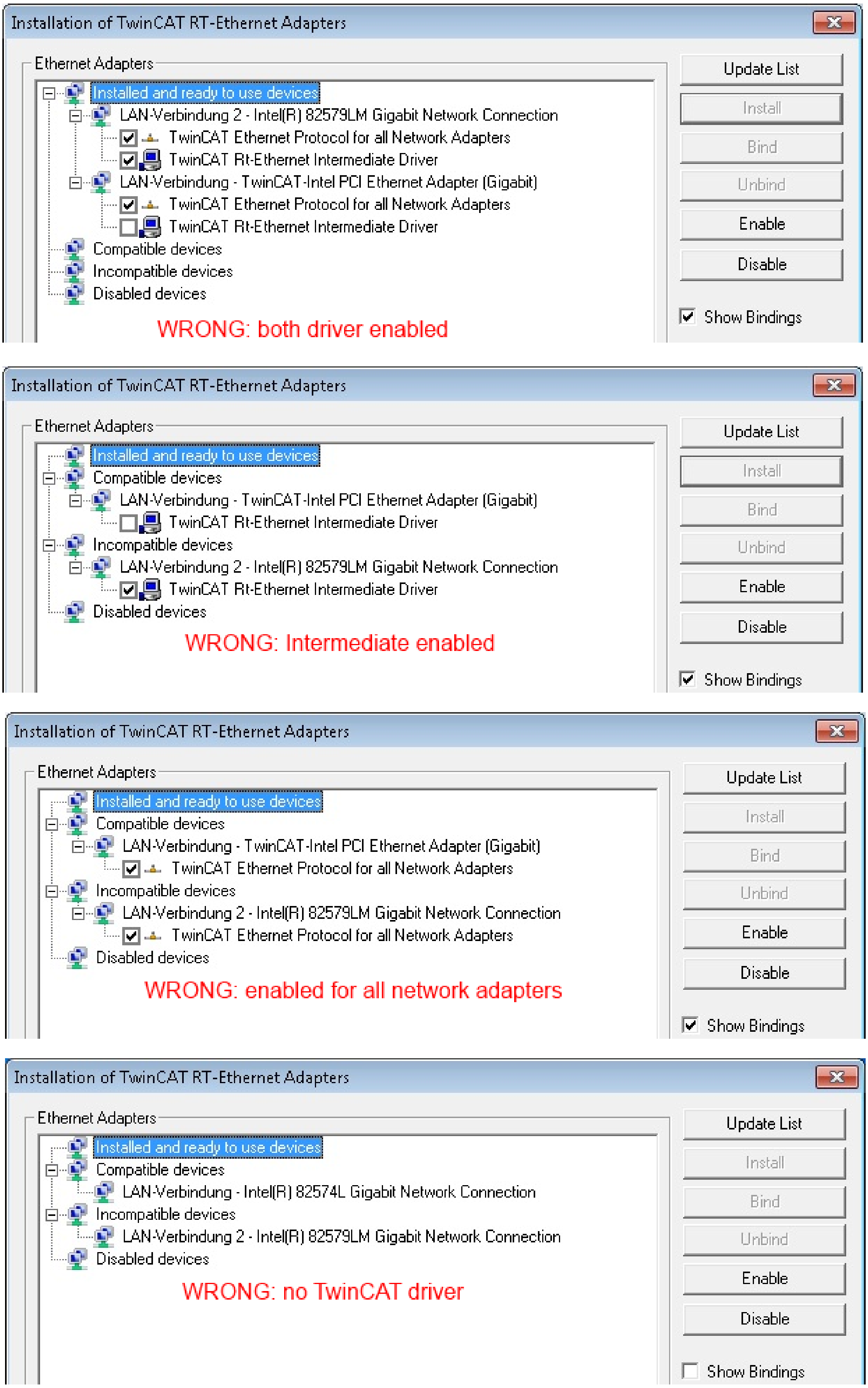



Fig. 98: Incorrect driver settings for the Ethernet port

**IP address of the port used**

### IP address/DHCP

In most cases an Ethernet port that is configured as an EtherCAT device will not transport general IP packets. For this reason and in cases where an EL6601 or similar devices are used it is useful to specify a fixed IP address for this port via the “Internet Protocol TCP/IP” driver setting and to disable DHCP. In this way the delay associated with the DHCP client for the Ethernet port assigning itself a default IP address in the absence of a DHCP server is avoided. A suitable address space is 192.168.x.x, for example.

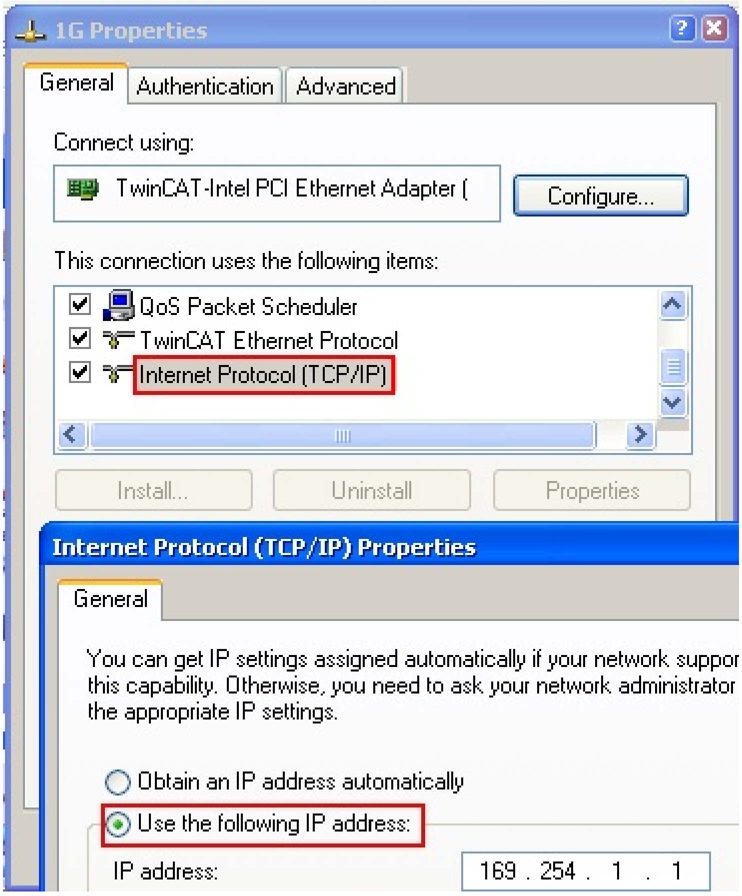



Fig. 99: TCP/IP setting for the Ethernet port

## 5.2.2 Notes regarding ESI device description

**Installation of the latest ESI device description**

The TwinCAT EtherCAT master/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. An *.xml file may contain several device descriptions.

The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website.

The ESI files should be stored in the TwinCAT installation directory.

Default settings:

- **TwinCAT 2**: C:\TwinCAT\IO\EtherCAT
- **TwinCAT 3**: C:\TwinCAT\3.1\Config\Io\EtherCAT

The files are read (once) when a new System Manager window is opened, if they have changed since the last time the System Manager window was opened.

A TwinCAT installation includes the set of Beckhoff ESI files that was current at the time when the TwinCAT build was created.

For TwinCAT 2.11/TwinCAT 3 and higher, the ESI directory can be updated from the System Manager, if the programming PC is connected to the Internet; by

- **TwinCAT 2**: Option → “Update EtherCAT Device Descriptions”
- **TwinCAT 3**: TwinCAT → EtherCAT Devices → “Update Device Descriptions (via ETG Website)…”

The TwinCAT ESI Updater [▶ 272] is available for this purpose.

**ESI**

The *.xml files are associated with *.xsd files, which describe the structure of the ESI XML files. To update the ESI device descriptions, both file types should therefore be updated.

**Device differentiation**

EtherCAT devices/slaves are distinguished by four properties, which determine the full device identifier. For example, the device identifier EL2521-0025-1018 consists of:

- family key “EL”
- name “2521”
- type “0025”
- and revision “1018”

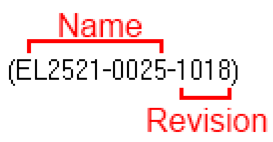



Fig. 100: Identifier structure

The order identifier consisting of name + type (here: EL2521-0010) describes the device function. The revision indicates the technical progress and is managed by Beckhoff. In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation. Each revision has its own ESI description. See further notes [▶ 12].

**Online description**

If the EtherCAT configuration is created online through scanning of real devices (see section Online setup) and no ESI descriptions are available for a slave (specified by name and revision) that was found, the System Manager asks whether the description stored in the device should be used. In any case, the System Manager needs this information for setting up the cyclic and acyclic communication with the slave correctly.

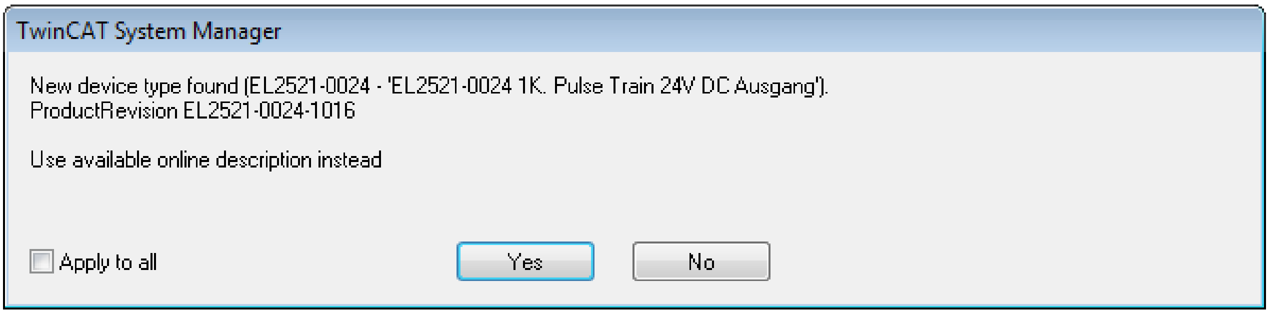



Fig. 101: OnlineDescription information window (TwinCAT 2)

In TwinCAT 3 a similar window appears, which also offers the Web update:

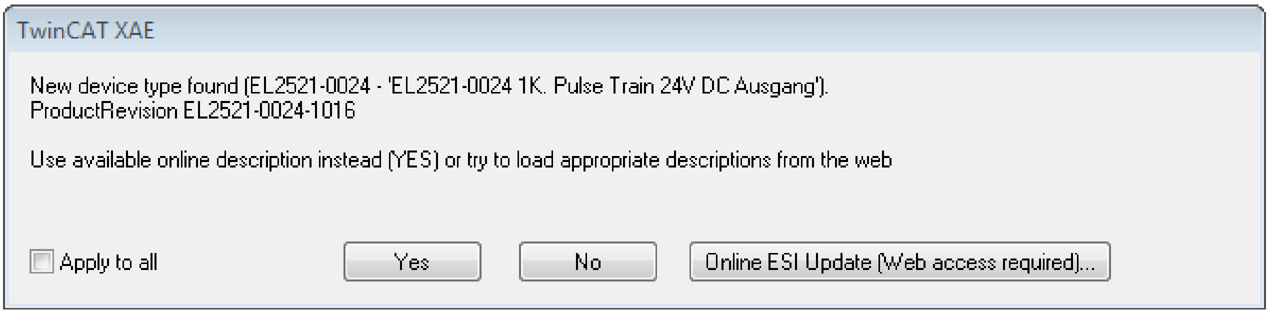



Fig. 102: Information window OnlineDescription (TwinCAT 3)

If possible, the *Yes* is to be rejected and the required ESI is to be requested from the device manufacturer. After installation of the XML/XSD file the configuration process should be repeated.

**NOTE**

**Changing the "usual" configuration through a scan**

✓ If a scan discovers a device that is not yet known to TwinCAT, distinction has to be made between two cases. Taking the example here of the EL2521-0000 in the revision 1019

a) no ESI is present for the EL2521-0000 device at all, either for the revision 1019 or for an older revision. The ESI must then be requested from the manufacturer (in this case Beckhoff).

b) an ESI is present for the EL2521-0000 device, but only in an older revision, e.g. 1018 or 1017. In this case an in-house check should first be performed to determine whether the spare parts stock allows the integration of the increased revision into the configuration at all. A new/higher revision usually also brings along new features. If these are not to be used, work can continue without reservations with the previous revision 1018 in the configuration. This is also stated by the Beckhoff compatibility rule.

Refer in particular to the chapter "General notes on the use of Beckhoff EtherCAT IO components" and for manual configuration to the chapter "Offline configuration creation [▸ 273]".

If the OnlineDescription is used regardless, the System Manager reads a copy of the device description from the EEPROM in the EtherCAT slave. In complex slaves the size of the EEPROM may not be sufficient for the complete ESI, in which case the ESI would be *incomplete* in the configurator. Therefore it's recommended using an offline ESI file with priority in such a case.

The System Manager creates for online recorded device descriptions a new file "OnlineDescription0000...xml" in its ESI directory, which contains all ESI descriptions that were read online.


Fig. 103: File OnlineDescription.xml created by the System Manager

Is a slave desired to be added manually to the configuration at a later stage, online created slaves are indicated by a prepended symbol “>” in the selection list (see Figure *Indication of an online recorded ESI of EL2521 as an example)*.

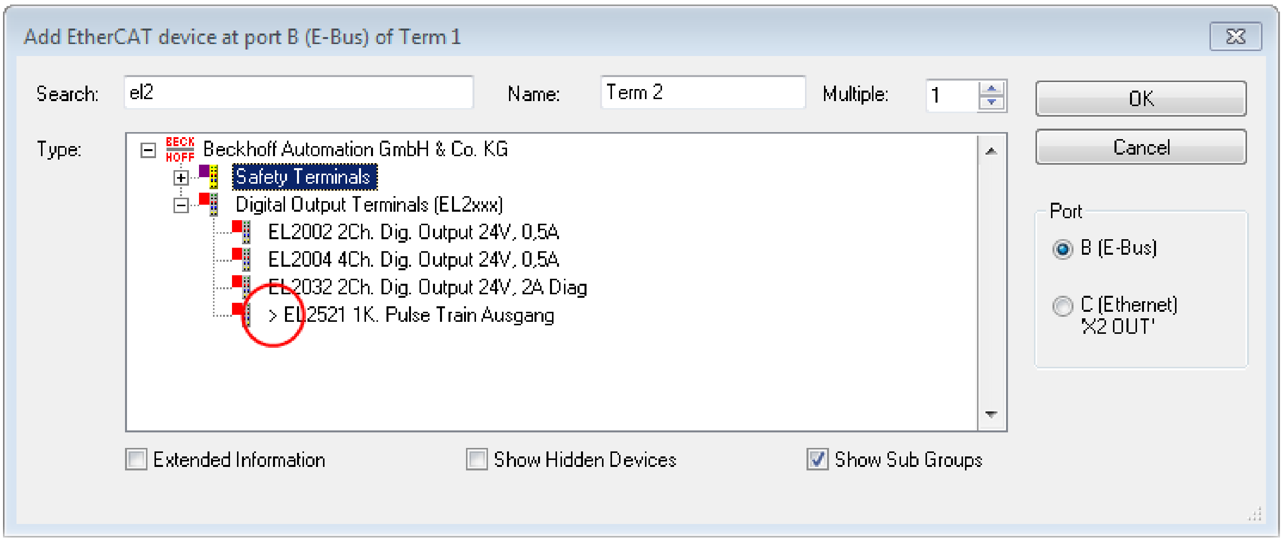



Fig. 104: Indication of an online recorded ESI of EL2521 as an example

If such ESI files are used and the manufacturer's files become available later, the file OnlineDescription.xml should be deleted as follows:

- close all System Manager windows
- restart TwinCAT in Config mode
- delete “OnlineDescription0000...xml”
- restart TwinCAT System Manager

This file should not be visible after this procedure, if necessary press <F5> to update

**OnlineDescription for TwinCAT 3.x**

In addition to the file described above “OnlineDescription0000...xml”, a so called EtherCAT cache with new discovered devices is created by TwinCAT 3.x, e.g. under Windows 7:

*C:\User\[USERNAME]\AppData\Roaming\Beckhoff\TwinCAT3\Components\Base\EtherCATCache.xml*

(Please note the language settings of the OS!)
You have to delete this file, too.

### Faulty ESI file

If an ESI file is faulty and the System Manager is unable to read it, the System Manager brings up an information window.

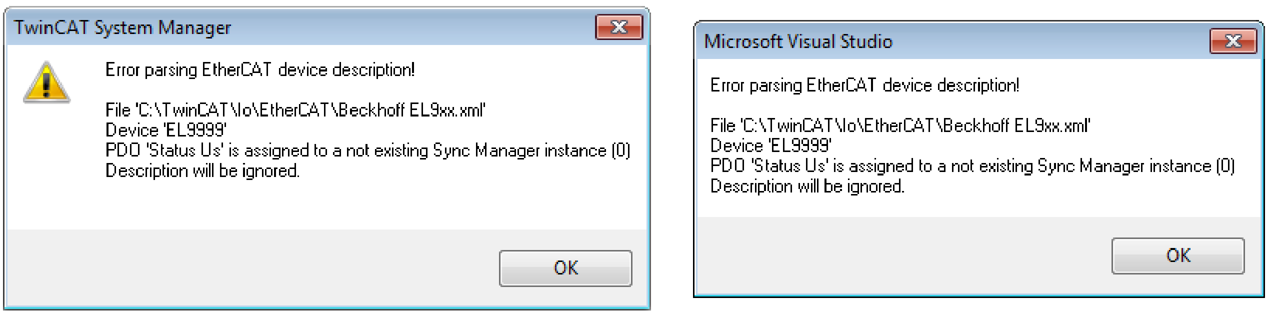



Fig. 105: Information window for faulty ESI file (left: TwinCAT 2; right: TwinCAT 3)

Reasons may include:

- Structure of the *.xml does not correspond to the associated *.xsd file → check your schematics
- Contents cannot be translated into a device description → contact the file manufacturer

## 5.2.3 TwinCAT ESI Updater

For TwinCAT 2.11 and higher, the System Manager can search for current Beckhoff ESI files automatically, if an online connection is available:

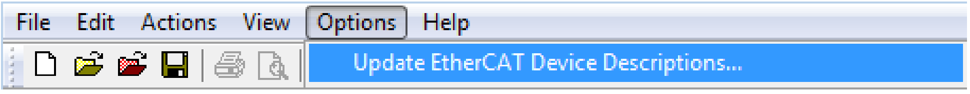



Fig. 106: Using the ESI Updater (>= TwinCAT 2.11)

The call up takes place under:
“Options” → “Update EtherCAT Device Descriptions”

Selection under TwinCAT 3:

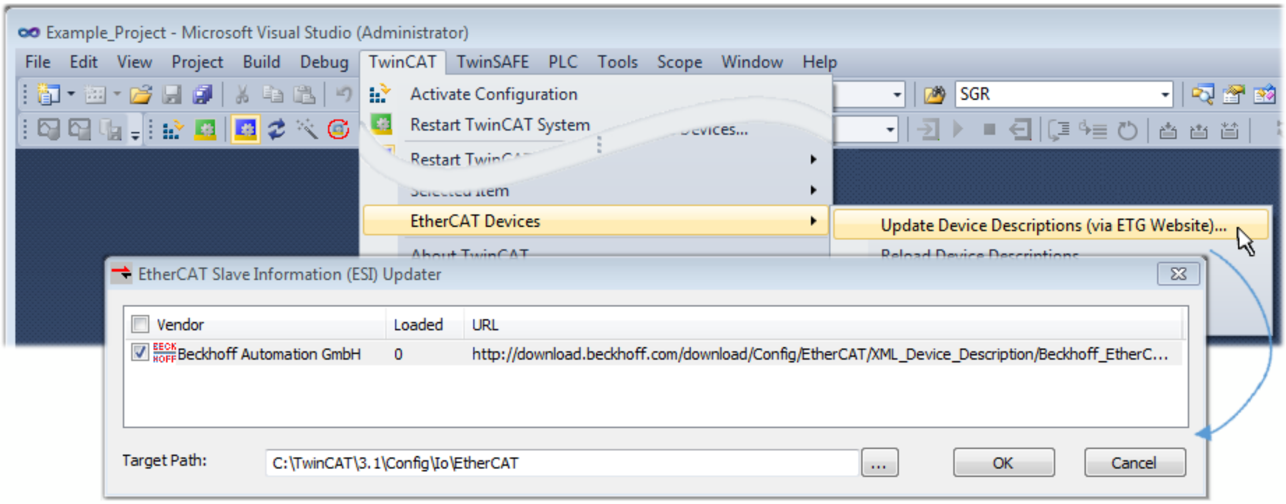



Fig. 107: Using the ESI Updater (TwinCAT 3)

The ESI Updater (TwinCAT 3) is a convenient option for automatic downloading of ESI data provided by EtherCAT manufacturers via the Internet into the TwinCAT directory (ESI = EtherCAT slave information). TwinCAT accesses the central ESI ULR directory list stored at ETG; the entries can then be viewed in the Updater dialog, although they cannot be changed there.

The call up takes place under:
“TwinCAT” → “EtherCAT Devices” → “Update Device Description (via ETG Website)…”.

## 5.2.4 Distinction between Online and Offline

The distinction between online and offline refers to the presence of the actual I/O environment (drives, terminals, EJ-modules). 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.

If the designed control system is already connected to the EtherCAT system and all components are energised 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 slaves it finds match the configuration. This test can be parameterised in the extended slave settings. Refer to note “Installation of the latest ESI-XML device description” [▸ 268].

**For preparation of a configuration:**

- the real EtherCAT hardware (devices, couplers, drives) must be present and installed
- the devices/modules must be connected via EtherCAT cables or in the terminal/ module strand in the same way as they are intended to be used later

- the devices/modules 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 [▶ 278] (Ethernet port at the IPC)
- detecting the connected EtherCAT devices [▶ 279]. This step can be carried out independent of the preceding step
- troubleshooting [▶ 282]

The scan with existing configuration [▶ 283] can also be carried out for comparison.

## 5.2.5 OFFLINE configuration creation

### Creating the EtherCAT device

Create an EtherCAT device in an empty System Manager window.

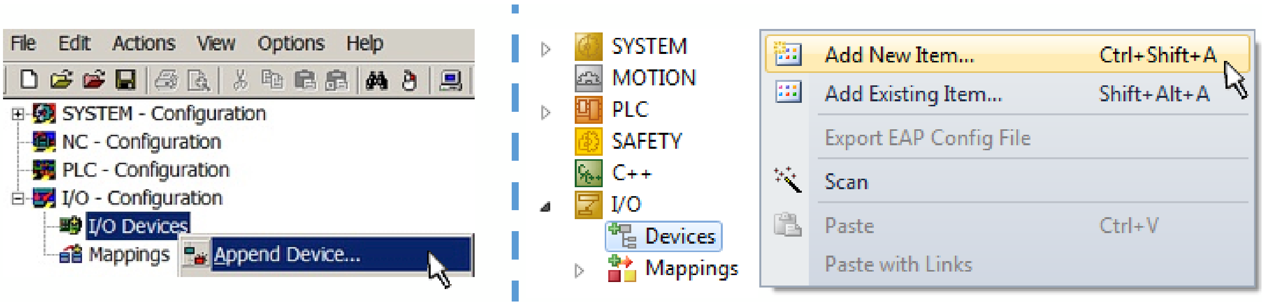



Fig. 108: Append EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

Select type “EtherCAT” for an EtherCAT I/O application with EtherCAT slaves. For the present publisher/subscriber service in combination with an EL6601/EL6614 terminal select “EtherCAT Automation Protocol via EL6601”.

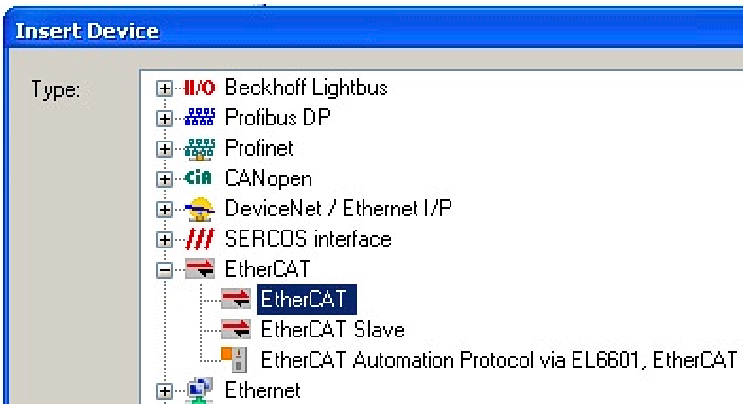



Fig. 109: Selecting the EtherCAT connection (TwinCAT 2.11, TwinCAT 3)

Then assign a real Ethernet port to this virtual device in the runtime system.

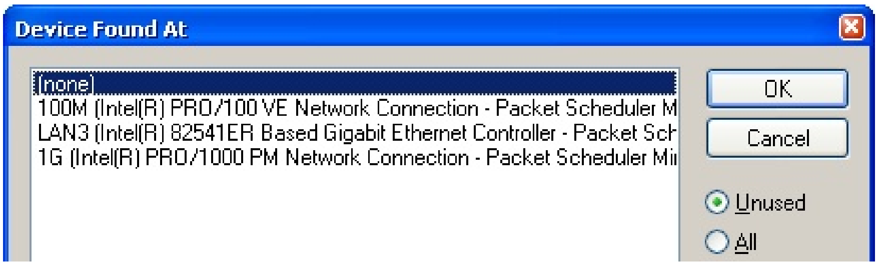



Fig. 110: Selecting the Ethernet port

This query may appear automatically when the EtherCAT device is created, or the assignment can be set/modified later in the properties dialog; see Fig. “EtherCAT device properties (TwinCAT 2)”.

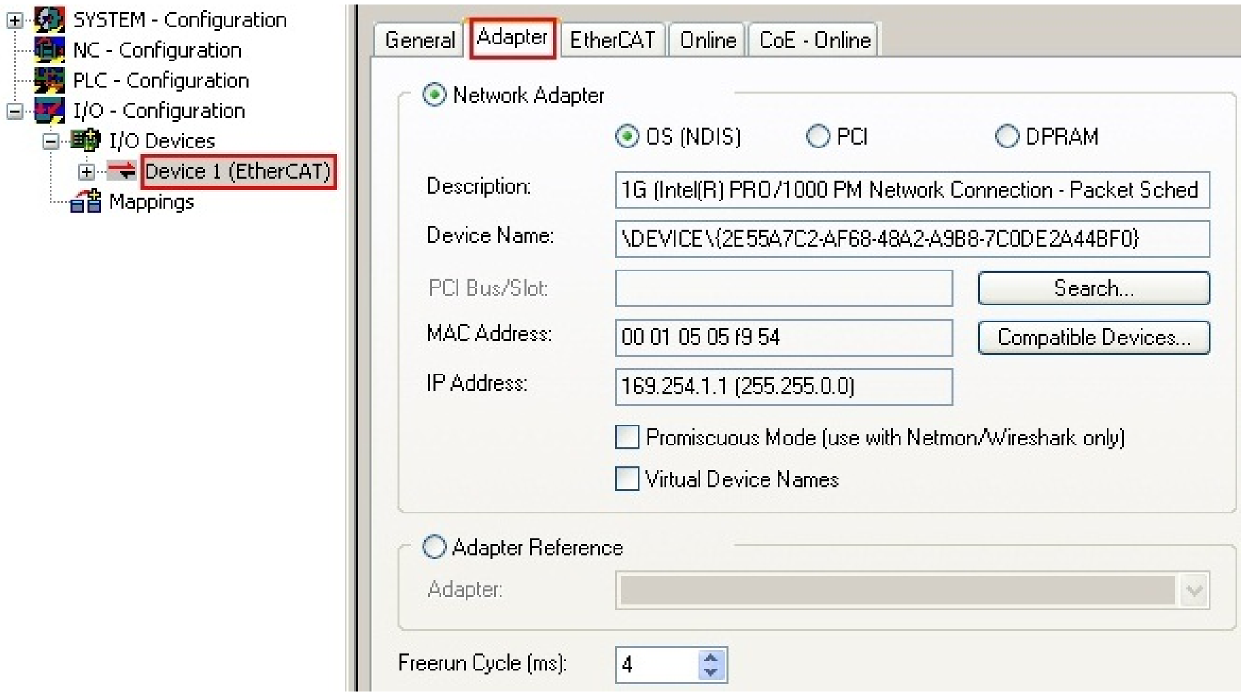
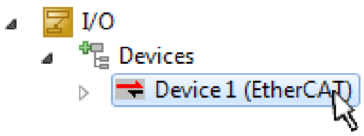



Fig. 111: EtherCAT device properties (TwinCAT 2)

TwinCAT 3: the properties of the EtherCAT device can be opened by double click on “Device .. (EtherCAT)” within the Solution Explorer under “I/O”:




**Selecting the Ethernet port**

Ethernet ports can only be selected for EtherCAT devices for which the TwinCAT real-time driver is installed. This has to be done separately for each port. Please refer to the respective installation page [▶ 263].

### Defining EtherCAT slaves

Further devices can be appended by right-clicking on a device in the configuration tree.

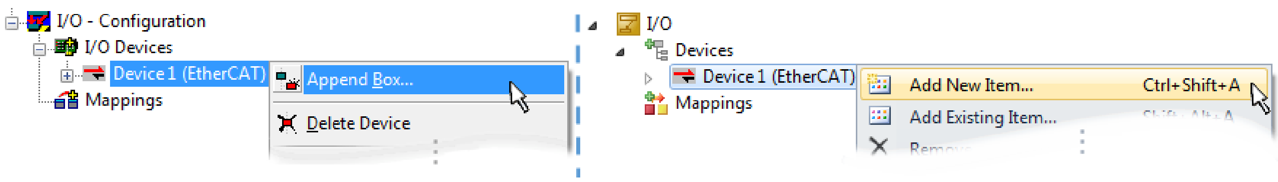



Fig. 112: Appending EtherCAT devices (left: TwinCAT 2; right: TwinCAT 3)

The dialog for selecting a new device opens. Only devices for which ESI files are available are displayed.

Only devices are offered for selection that can be appended to the previously selected device. Therefore the physical layer available for this port is also displayed (Fig. “Selection dialog for new EtherCAT device”, A). In the case of cable-based Fast-Ethernet physical layer with PHY transfer, then also only cable-based devices are available, as shown in Fig. “Selection dialog for new EtherCAT device”. If the preceding device has several free ports (e.g. EK1122 or EK1100), the required port can be selected on the right-hand side (A).

Overview of physical layer

- “Ethernet”: cable-based 100BASE-TX: EK couplers, EP boxes, devices with RJ45/M8/M12 connector

- “E-Bus”: LVDS “terminal bus”, “EJ-module”: EL/ES terminals, various modular modules

The search field facilitates finding specific devices (since TwinCAT 2.11 or TwinCAT 3).

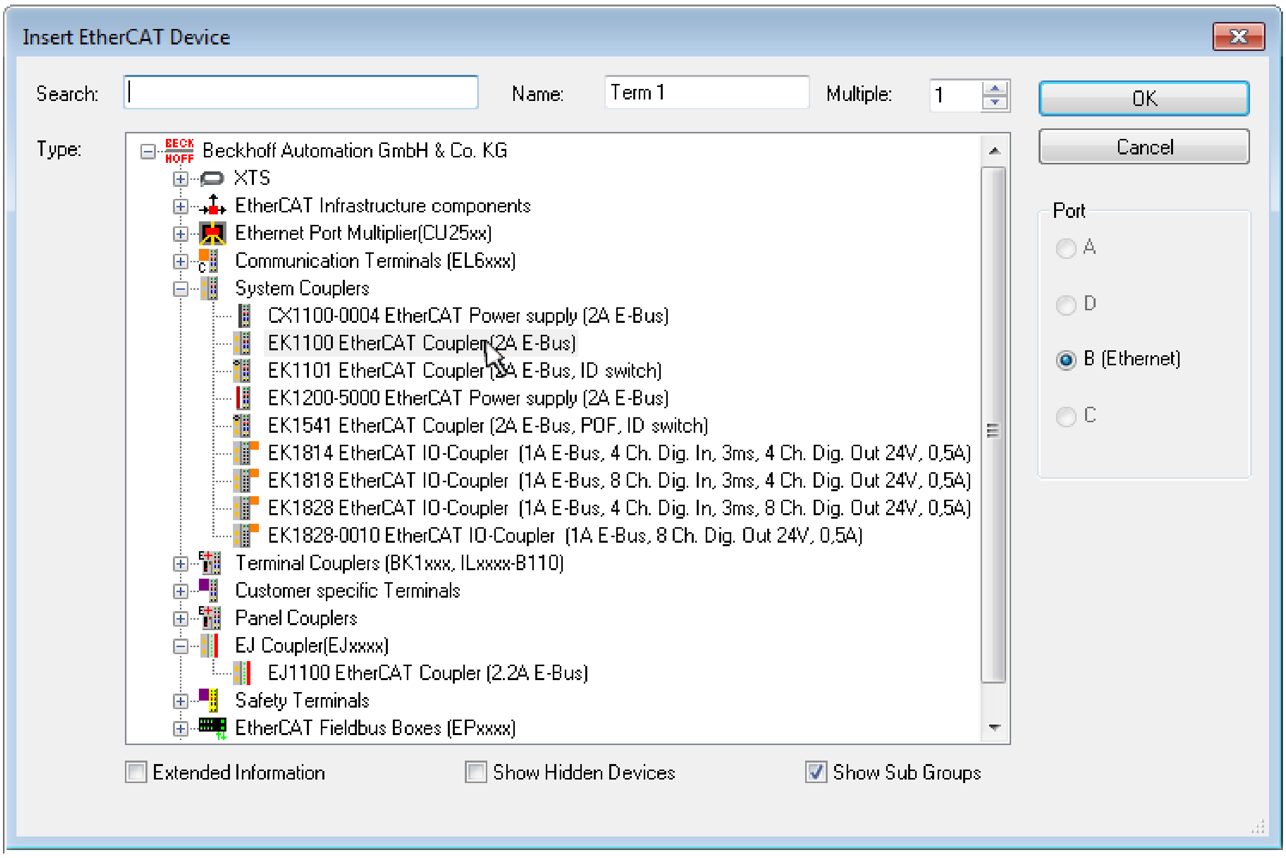



Fig. 113: Selection dialog for new EtherCAT device

By default only the name/device type is used as selection criterion. For selecting a specific revision of the device the revision can be displayed as “Extended Information”.

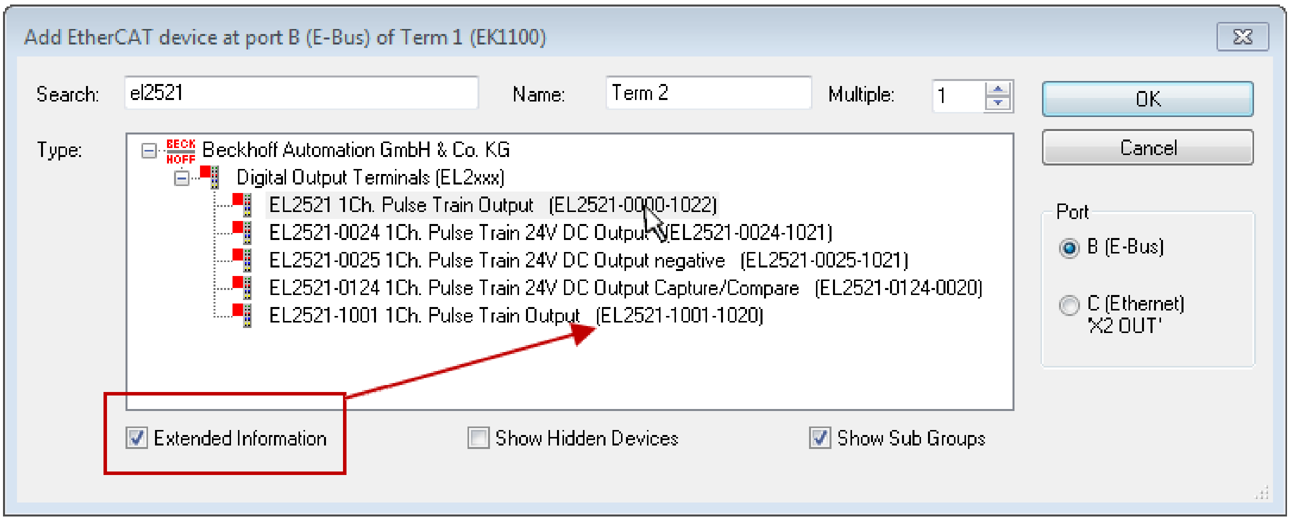



Fig. 114: Display of device revision

In many cases several device revisions were created for historic or functional reasons, e.g. through technological advancement. For simplification purposes (see Fig. “Selection dialog for new EtherCAT device”) only the last (i.e. highest) revision and therefore the latest state of production is displayed in the selection dialog for Beckhoff devices. To show all device revisions available in the system as ESI descriptions tick the “Show Hidden Devices” check box, see Fig. “Display of previous revisions”.

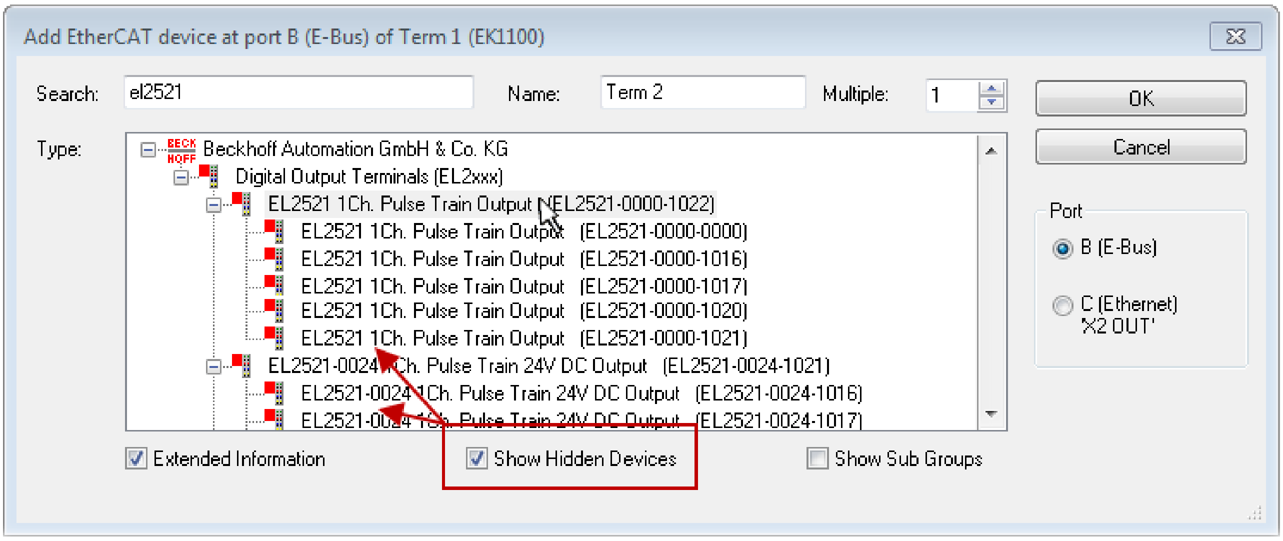



Fig. 115: Display of previous revisions

**Device selection based on revision, compatibility**

The ESI description also defines the process image, the communication type between master and slave/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/ EJ-modules:

**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-**1018** or higher (-**1019**, -**1020**) can be used in practice.

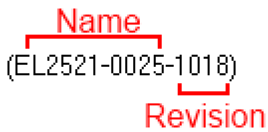



Fig. 116: Name/revision of the terminal

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.

In this case the process image of the device is shown in the configuration tree and can be parameterized as follows: linking with the task, CoE/DC settings, plug-in definition, startup settings, ...

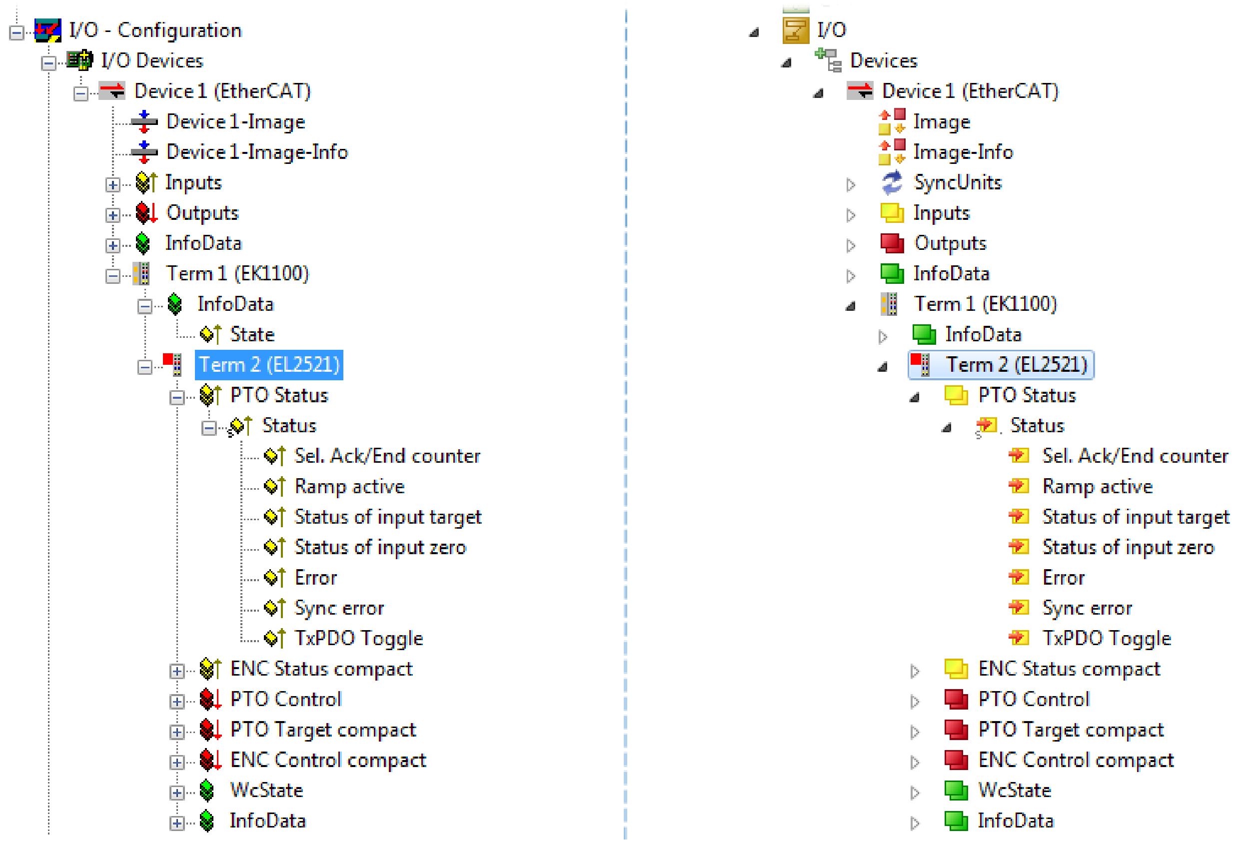



Fig. 117: EtherCAT terminal in the TwinCAT tree (left: TwinCAT 2; right: TwinCAT 3)

## 5.2.6 ONLINE configuration creation

### Detecting/scanning of the EtherCAT device

The online device search can be used if the TwinCAT system is in CONFIG mode. This can be indicated by a symbol right below in the information bar:

- on TwinCAT 2 by a blue display “Config Mode” within the System Manager window: Config Mode .
- on TwinCAT 3 within the user interface of the development environment by a symbol .

TwinCAT can be set into this mode:

- TwinCAT 2: by selection of in the Menubar or by “Actions” → “Set/Reset TwinCAT to Config Mode…”
- TwinCAT 3: by selection of in the Menubar or by “TwinCAT” → “Restart TwinCAT (Config Mode)”

**Online scanning in Config mode**

The online search is not available in RUN mode (production operation). Note the differentiation between TwinCAT programming system and TwinCAT target system.

The TwinCAT 2 icon ( ) or TwinCAT 3 icon ( ) within the Windows-Taskbar always shows the TwinCAT mode of the local IPC. Compared to that, the System Manager window of TwinCAT 2 or the user interface of TwinCAT 3 indicates the state of the target system.

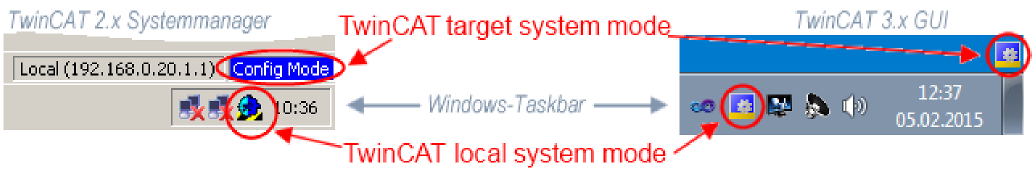



Fig. 118: Differentiation local/target system (left: TwinCAT 2; right: TwinCAT 3)

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

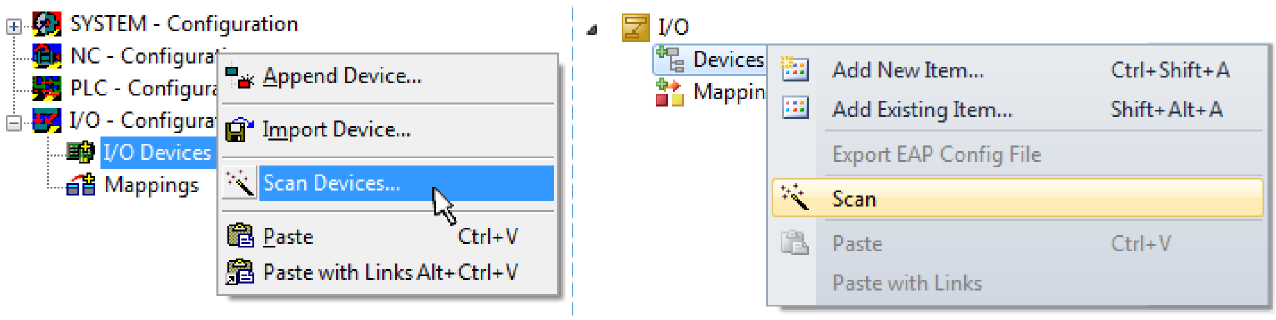



Fig. 119: Scan Devices (left: TwinCAT 2; right: TwinCAT 3)

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

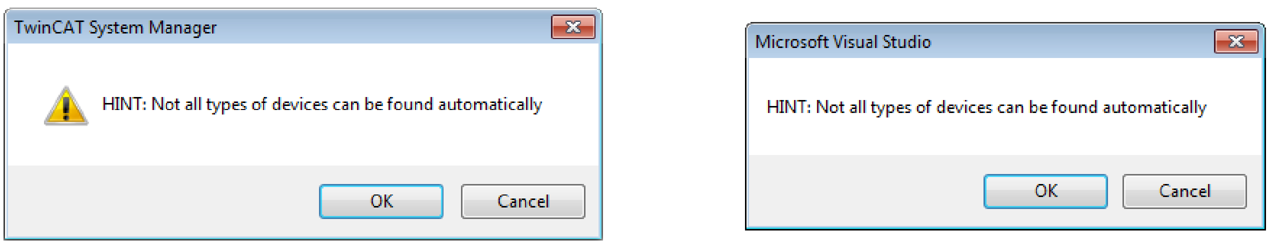



Fig. 120: Note for automatic device scan (left: TwinCAT 2; right: TwinCAT 3)

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 slave is connected, the port is immediately shown as an “EtherCAT Device” .

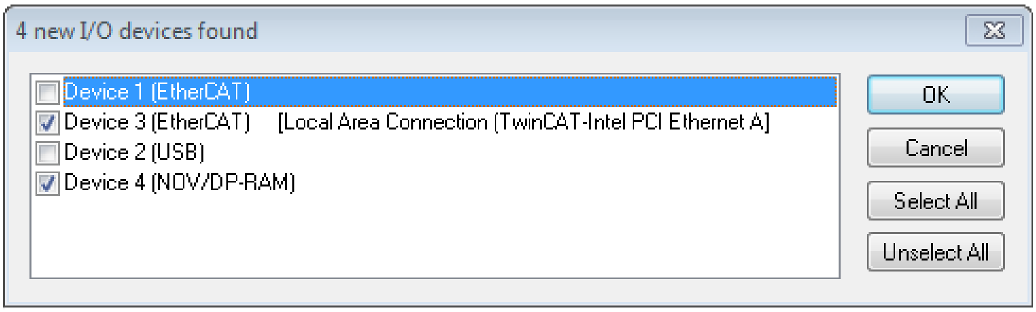



Fig. 121: Detected Ethernet devices

Via respective checkboxes devices can be selected (as illustrated in Fig. “Detected Ethernet devices” e.g. Device 3 and Device 4 were chosen). After confirmation with “OK” a device scan is suggested for all selected devices, see Fig.: “Scan query after automatic creation of an EtherCAT device”.

**Selecting the Ethernet port**

Ethernet ports can only be selected for EtherCAT devices for which the TwinCAT real-time driver is installed. This has to be done separately for each port. Please refer to the respective installation page [▸ 263].

### Detecting/Scanning the EtherCAT devices

**Online scan functionality**

During a scan the master queries the identity information of the EtherCAT slaves from the slave 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.

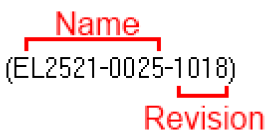



Fig. 122: Example default state

**NOTE**

**Slave scanning in practice in series machine production**

The scanning function should be used with care. It is a practical and fast tool for creating an initial configuration as a basis for commissioning. In series machine production or reproduction of the plant, however, the function should no longer be used for the creation of the configuration, but if necessary for comparison [▸ 283] with the defined initial configuration.Background: since Beckhoff occasionally increases the revision version of the delivered products for product maintenance reasons, a configuration can be created by such a scan which (with an identical machine construction) is identical according to the device list; however, the respective device revision may differ from the initial configuration.

**Example:**

Company A builds the prototype of a machine B, which is to be produced in series later on. To do this the prototype is built, a scan of the IO devices is performed in TwinCAT and the initial configuration “B.tsm” is created. The EL2521-0025 EtherCAT terminal with the revision 1018 is located somewhere. It is thus built into the TwinCAT configuration in this way:

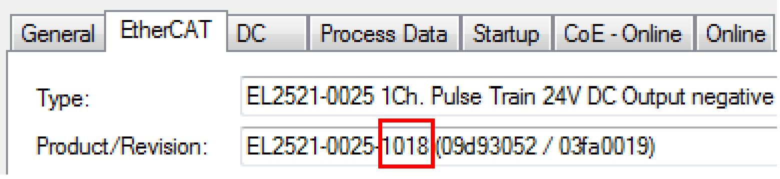



Fig. 123: Installing EthetCAT terminal with revision -1018

Likewise, during the prototype test phase, the functions and properties of this terminal are tested by the programmers/commissioning engineers and used if necessary, i.e. addressed from the PLC "B.pro" or the NC. (the same applies correspondingly to the TwinCAT 3 solution files).

The prototype development is now completed and series production of machine B starts, for which Beckhoff continues to supply the EL2521-0025-0018. If the commissioning engineers of the series machine production department always carry out a scan, a B configuration with the identical contents results again for each machine. Likewise, A might create spare parts stores worldwide for the coming series-produced machines with EL2521-0025-1018 terminals.

After some time Beckhoff extends the EL2521-0025 by a new feature C. Therefore the FW is changed, outwardly recognizable by a higher FW version and **a new revision -1019**. Nevertheless the new device naturally supports functions and interfaces of the predecessor version(s); an adaptation of "B.tsm" or even "B.pro" is therefore unnecessary. The series-produced machines can continue to be built with "B.tsm" and "B.pro"; it makes sense to perform a comparative scan [▶ 283] against the initial configuration "B.tsm" in order to check the built machine.

However, if the series machine production department now doesn't use "B.tsm", but instead carries out a scan to create the productive configuration, the revision **-1019** is automatically detected and built into the configuration:

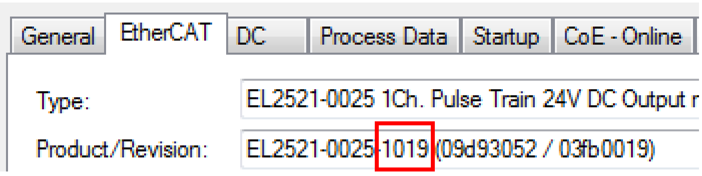



Fig. 124: Detection of EtherCAT terminal with revision -1019

This is usually not noticed by the commissioning engineers. TwinCAT cannot signal anything either, since virtually a new configuration is created. According to the compatibility rule, however, this means that no EL2521-0025-**1018** should be built into this machine as a spare part (even if this nevertheless works in the vast majority of cases).

In addition, it could be the case that, due to the development accompanying production in company A, the new feature C of the EL2521-0025-1019 (for example, an improved analog filter or an additional process data for the diagnosis) is discovered and used without in-house consultation. The previous stock of spare part devices are then no longer to be used for the new configuration "B2.tsm" created in this way. Þ if series machine production is established, the scan should only be performed for informative purposes for comparison with a defined initial configuration. Changes are to be made with care!

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. 125: Scan query after automatic creation of an EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

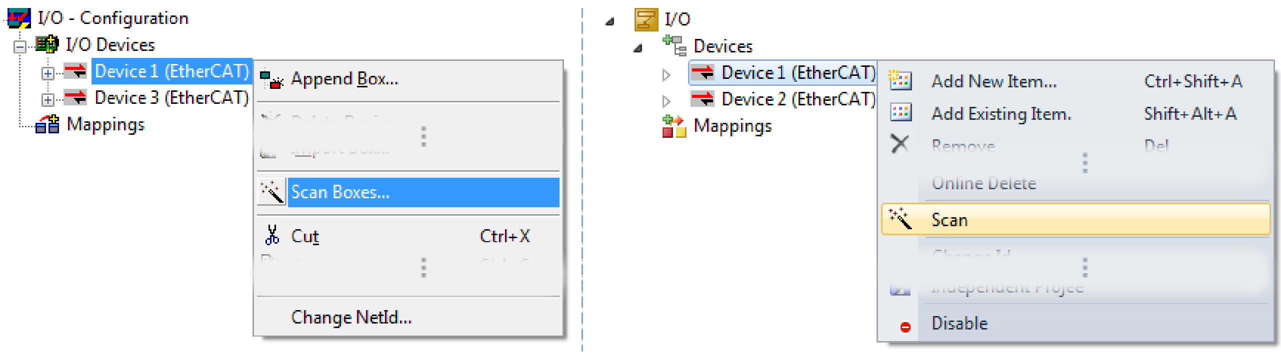



Fig. 126: Manual triggering of a device scan on a specified EtherCAT device (left: TwinCAT 2; right: TwinCAT 3)

In the System Manager (TwinCAT 2) or the User Interface (TwinCAT 3) the scan process can be monitored via the progress bar at the bottom in the status bar.


Fig. 127: *Scan progressexemplary by TwinCAT 2*

The configuration is established and can then be switched to online state (OPERATIONAL).


Fig. 128: Config/FreeRun query (left: TwinCAT 2; right: TwinCAT 3)

In Config/FreeRun mode the System Manager display alternates between blue and red, and the EtherCAT device continues to operate with the idling cycle time of 4 ms (default setting), even without active task (NC, PLC).

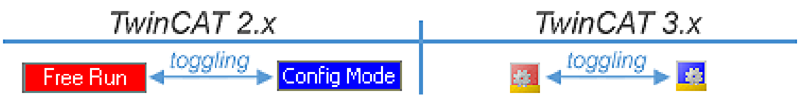



Fig. 129: Displaying of “Free Run” and “Config Mode” toggling right below in the status bar

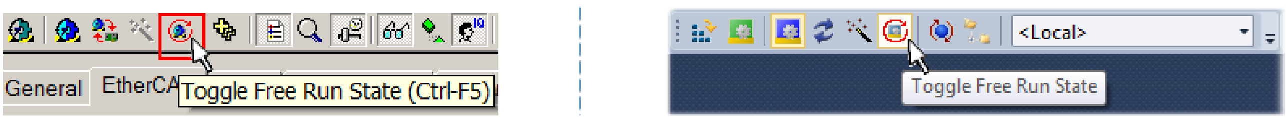



Fig. 130: TwinCAT can also be switched to this state by using a button (left: TwinCAT 2; right: TwinCAT 3)

The EtherCAT system should then be in a functional cyclic state, as shown in Fig. *Online display example*.

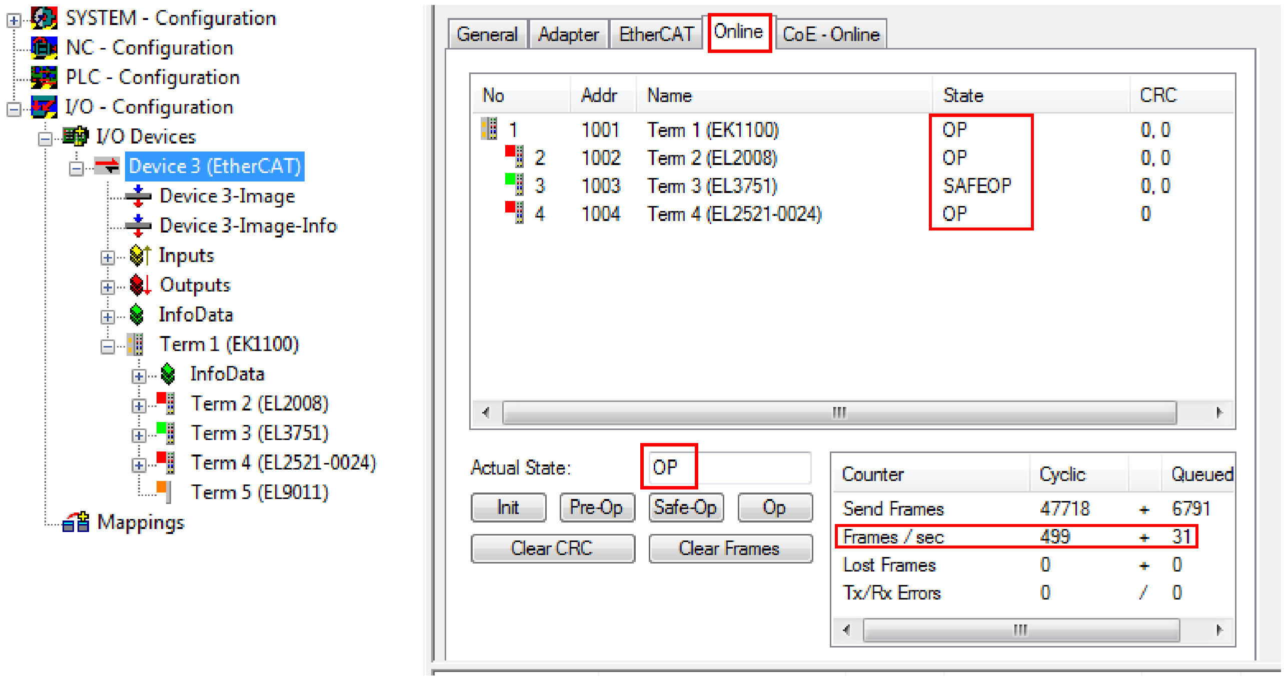



Fig. 131: Online display example

Please note:

- all slaves should be in OP state
- the EtherCAT master should be in "Actual State" OP
- "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 [▸ 273].

## Troubleshooting

Various effects may occur during scanning.

- An **unknown device** is detected, i.e. an EtherCAT slave 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. This case is described in the chapter "Notes regarding ESI device description".
- **Device are not detected properly**
  Possible reasons include:
  - faulty data links, resulting in data loss during the scan
  - slave has 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.

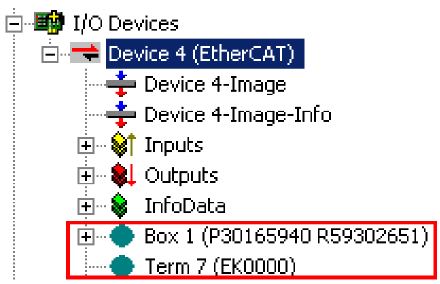



Fig. 132: Faulty identification

In the System Manager such devices may be set up as EK0000 or unknown devices. Operation is not possible or meaningful.

### Scan over existing Configuration

**NOTE**

**Change of the configuration after comparison**

With this scan (TwinCAT 2.11 or 3.1) only the device properties vendor (manufacturer), device name and revision are compared at present! A “ChangeTo” or “Copy” should only be carried out with care, taking into consideration the Beckhoff IO compatibility rule (see above). The device configuration is then replaced by the revision found; this can affect the supported process data and functions.

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. 133: Identical configuration (left: TwinCAT 2; right: TwinCAT 3)

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

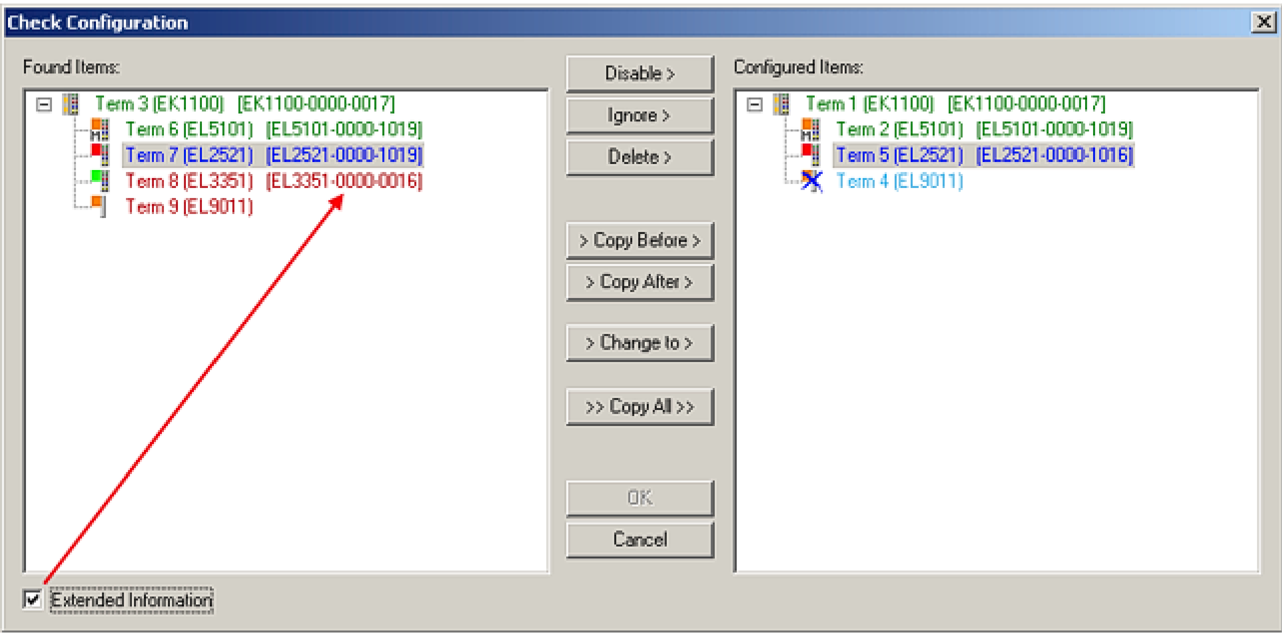



Fig. 134: Correction dialog

It is advisable to tick the “Extended Information” check box to reveal differences in the revision.

| Color | Explanation |
|---|---|
| green | This EtherCAT slave matches the entry on the other side. Both type and revision match. |
| blue | This EtherCAT slave is present on the other side, but in a different revision. This other revision can have other default values for the process data as well as other/additional functions.<br>If the found revision is higher than the configured revision, the slave may be used provided compatibility issues are taken into account.<br>If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found device may not support all functions that the master expects based on the higher revision number. |
| light blue | This EtherCAT slave is ignored ("Ignore" button) |
| red | • This EtherCAT slave is not present on the other side.<br>• It is present, but in a different revision, which also differs in its properties from the one specified. The compatibility principle then also applies here: if the found revision is higher than the configured revision, use is possible provided compatibility issues are taken into account, since the successor devices should support the functions of the predecessor devices. If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found device may not support all functions that the master expects based on the higher revision number. |

### Device selection based on revision, compatibility

The ESI description also defines the process image, the communication type between master and slave/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/ EJ-modules:

**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-**1018** or higher (-**1019**, -**1020**) can be used in practice.

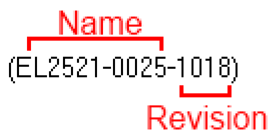



Fig. 135: Name/revision of the terminal

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.

In this case the process image of the device is shown in the configuration tree and can be parameterized as follows: linking with the task, CoE/DC settings, plug-in definition, startup settings, ...

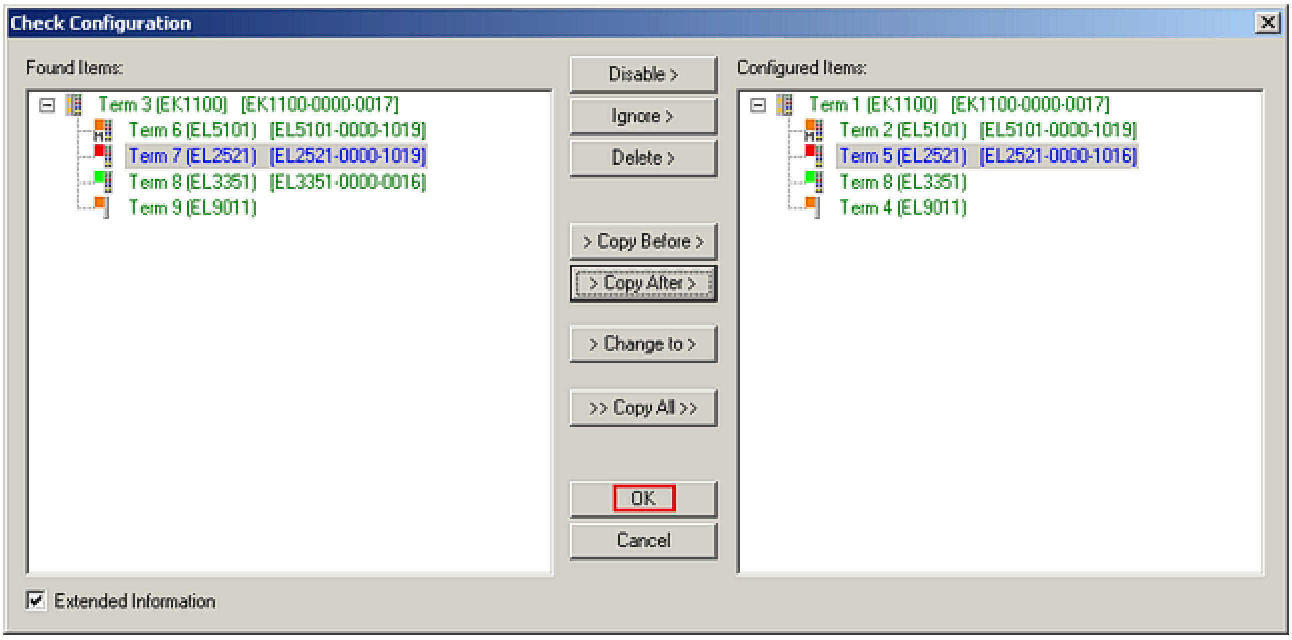



Fig. 136: Correction dialog with modifications

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

## Change to Compatible Type

TwinCAT offers a function *Change to Compatible Type…* for the exchange of a device whilst retaining the links in the task.

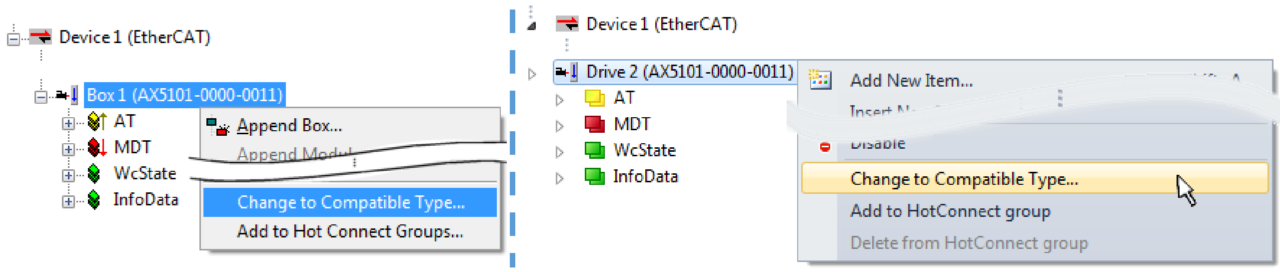



Fig. 137: Dialog “Change to Compatible Type…” (left: TwinCAT 2; right: TwinCAT 3)

The following elements in the ESI of an EtherCAT device are compared by TwinCAT and assumed to be the same in order to decide whether a device is indicated as "compatible":

- Physics (e.g. RJ45, Ebus...)

- FMMU (additional ones are allowed)

- SyncManager (SM, additional ones are allowed)

- EoE (attributes MAC, IP)

- CoE (attributes SdoInfo, PdoAssign, PdoConfig, PdoUpload, CompleteAccess)

- FoE

- PDO (process data: Sequence, SyncUnit SU, SyncManager SM, EntryCount, Ent-ry.Datatype)

This function is preferably to be used on AX5000 devices.

## Change to Alternative Type

The TwinCAT System Manager offers a function for the exchange of a device: Change to Alternative Type

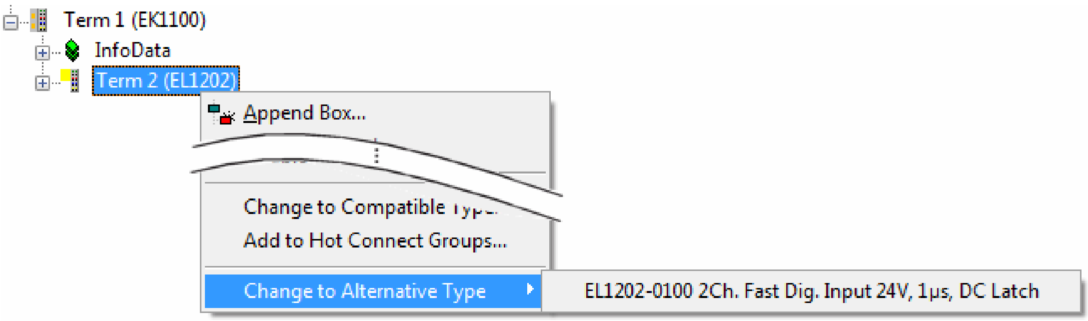



Fig. 138: TwinCAT 2 Dialog Change to Alternative Type

If called, the System Manager searches in the procured device ESI (in this example: EL1202-0000) for details of compatible devices contained there. The configuration is changed and the ESI-EEPROM is overwritten at the same time – therefore this process is possible only in the online state (ConfigMode).

## 5.2.7 EtherCAT subscriber configuration

In the left-hand window of the TwinCAT 2 System Manager or the Solution Explorer of the TwinCAT 3 Development Environment respectively, click on the element of the terminal within the tree you wish to configure (in the example: EL3751 Terminal 3).

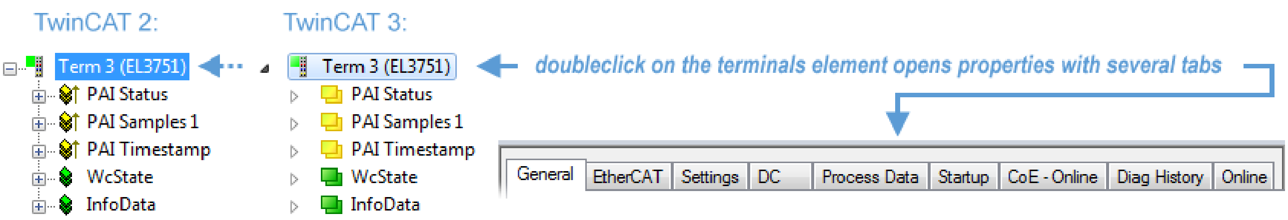



Fig. 139: Branch element as terminal EL3751

In the right-hand window of the TwinCAT System Manager (TwinCAT 2) or the Development Environment (TwinCAT 3), various tabs are now available for configuring the terminal. And yet the dimension of complexity of a subscriber determines which tabs are provided. Thus as illustrated in the example above the terminal EL3751 provides many setup options and also a respective number of tabs are available. On the contrary by the terminal EL1004 for example the tabs “General”, “EtherCAT”, “Process Data” and “Online“ are available only. Several terminals, as for instance the EL6695 provide special functions by a tab with its own terminal name, so “EL6695” in this case. A specific tab “Settings” by terminals with a wide range of setup options will be provided also (e.g. EL3751).

**“General” tab**

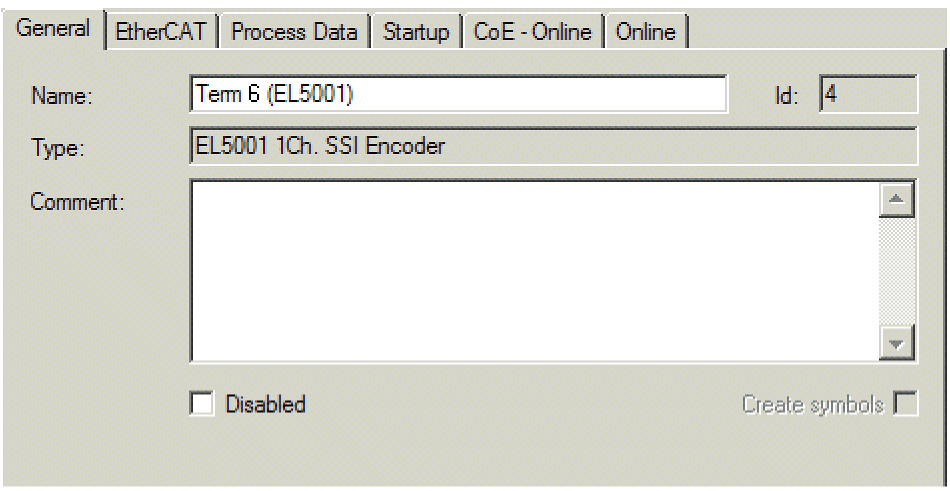



Fig. 140: “General” tab

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

### "EtherCAT" tab

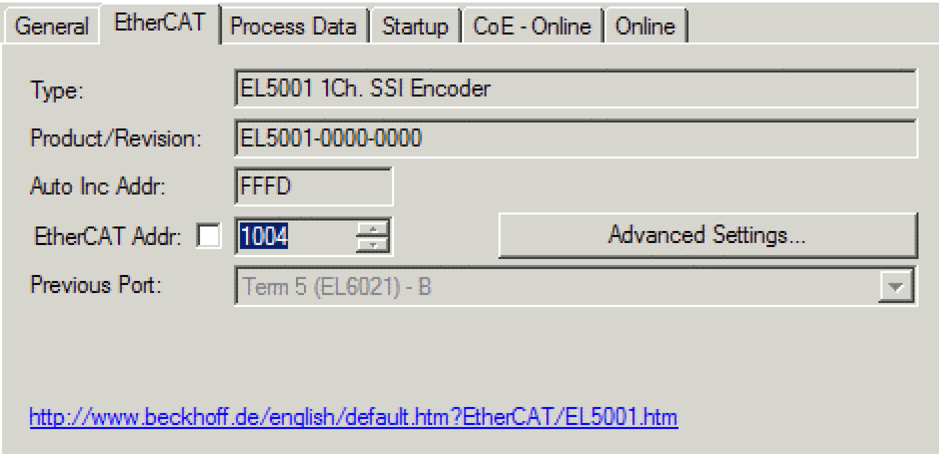



Fig. 141: "EtherCAT" tab

| | |
|---|---|
| **Type** | EtherCAT device type |
| **Product/Revision** | Product and revision number of the EtherCAT device |
| **Auto Inc Addr.** | 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 $0000_{hex}$. For each further slave the address is decremented by 1 ($FFFF_{hex}$, $FFFE_{hex}$ etc.). |
| **EtherCAT Addr.** | Fixed address of an EtherCAT slave. This address is allocated by the EtherCAT master during the start-up phase. Tick the control box to the left of the input field in order to modify the default value. |
| **Previous Port** | 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 combination field is activated and the EtherCAT device to which this device is to be connected can be selected. |
| **Advanced Settings** | 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 (**P**rocess **D**ata **O**bjects, PDOs). 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.

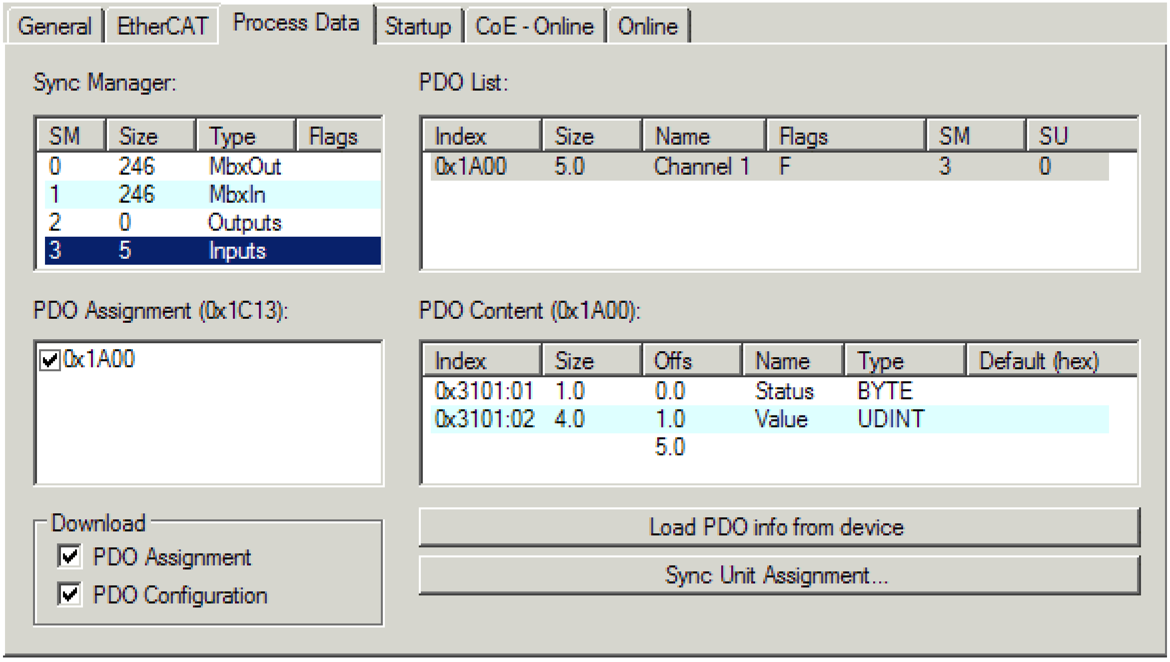



Fig. 142: “Process Data” tab

The process data (PDOs) transferred by an EtherCAT slave during each cycle 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, EM, EJ and 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 allows modification of process data, proceed as follows (see Figure *Configuring the process data*).

- 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”).

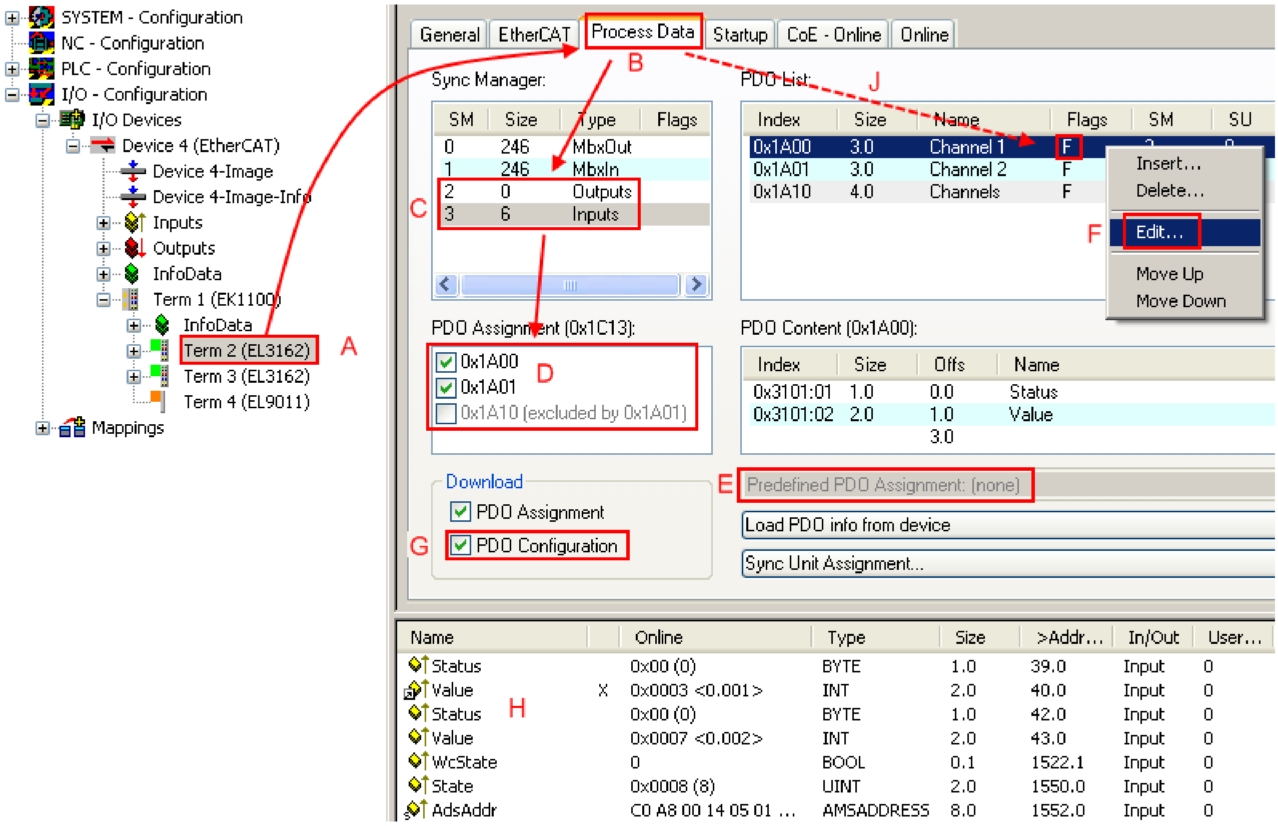



Fig. 143: Configuring the process data

**Manual modification of the process data**

According to the ESI description, a PDO can be identified as “fixed” with the flag “F” in the PDO overview (Fig. *Configuring the process data*, 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: This error message (“invalid SM IN cfg” or “invalid SM OUT cfg”) also indicates the reason for the failed start.

A detailed description [▸ 294] can be found at the end of this section.

### “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.

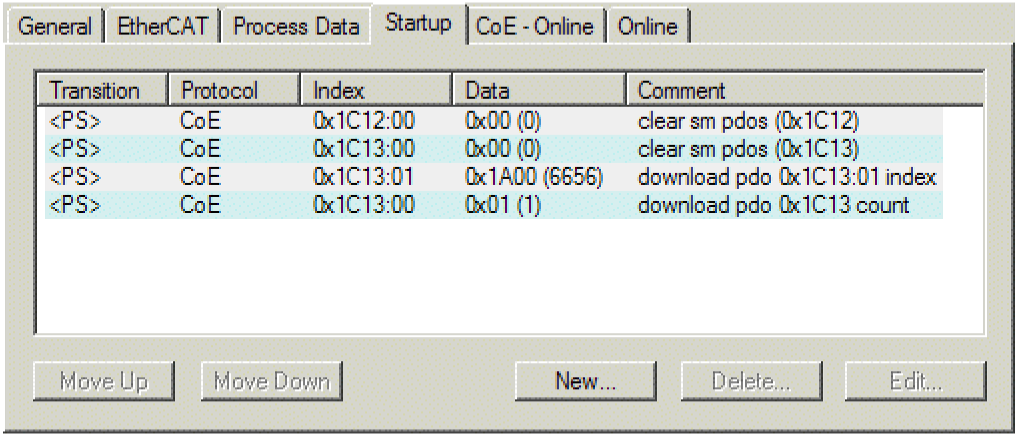



Fig. 144: “Startup” tab

| Column | Description |
|---|---|
| Transition | Transition to which the request is sent. This can either be<br>• the transition from pre-operational to safe-operational (PS), or<br>• the transition from safe-operational to operational (SO).<br>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 list 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.

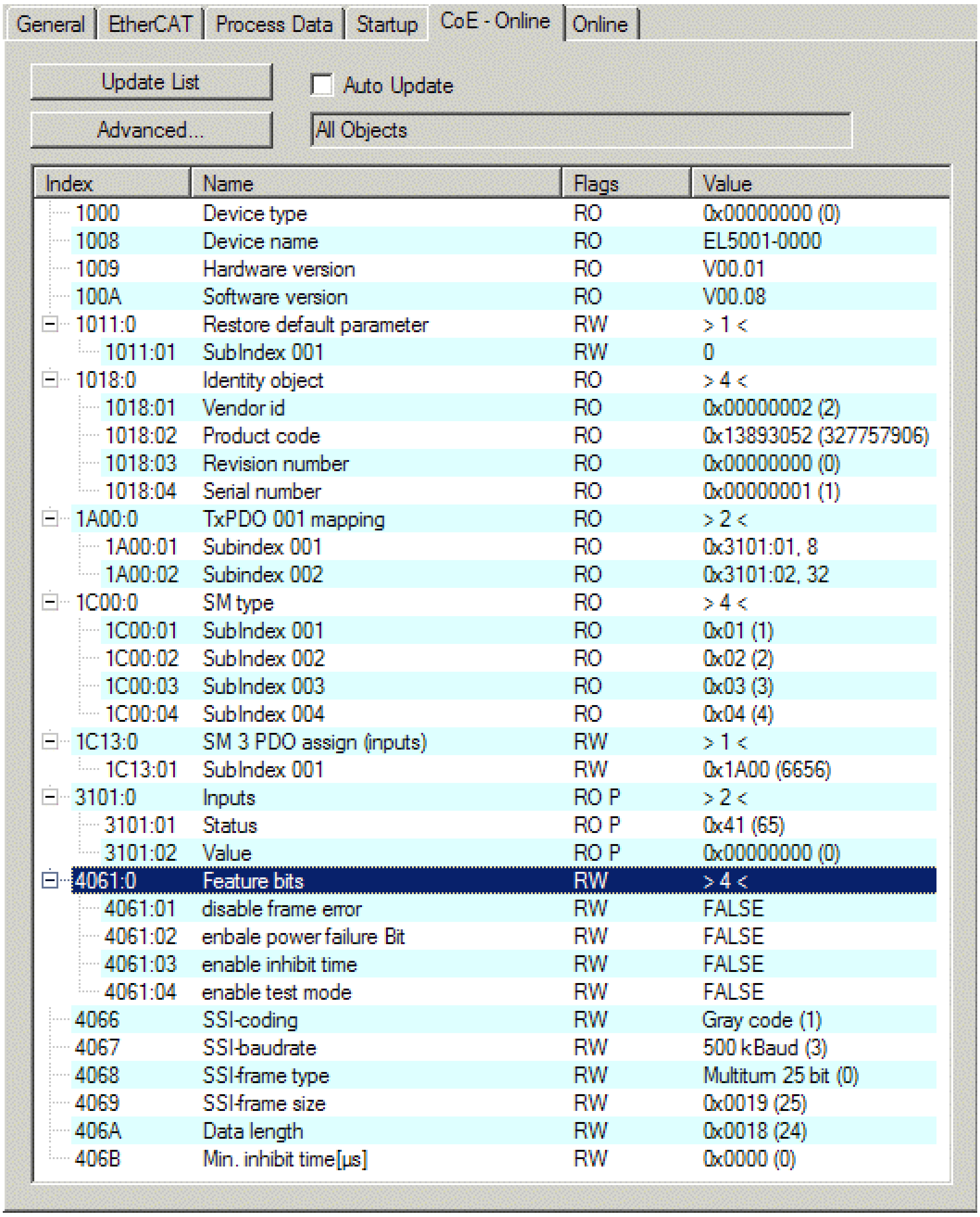



Fig. 145: “CoE - Online” tab

### Object list display

| Column | Description | |
|---|---|---|
| Index | Index and sub-index 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.

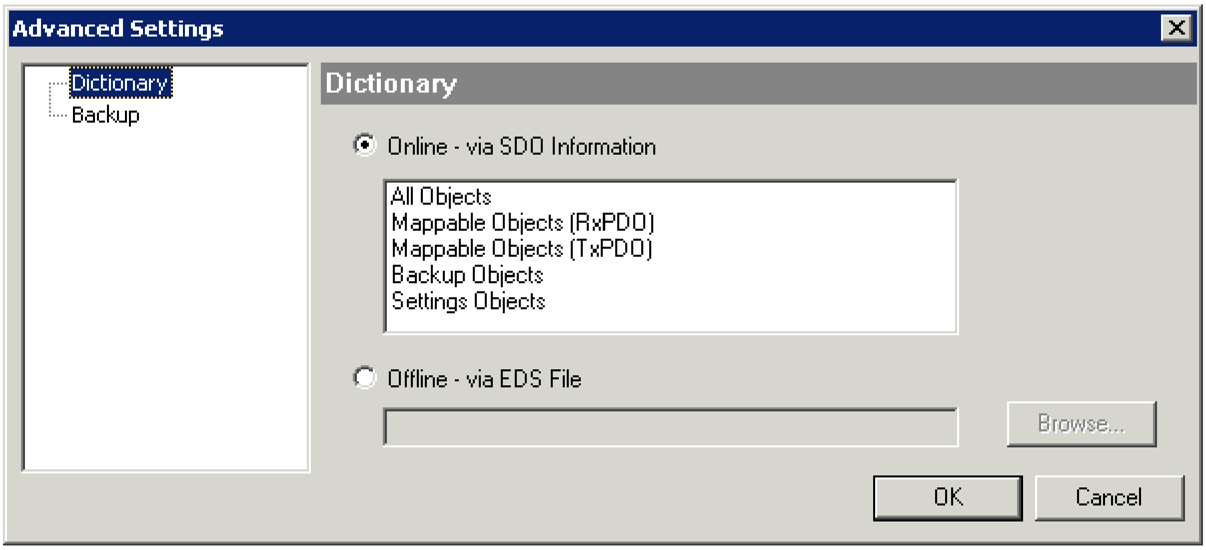



Fig. 146: Dialog “Advanced settings”

| | |
|---|---|
| **Online - via SDO Information** | If this option button is selected, the list of the objects included in the object list 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 list is read from an EDS file provided by the user. |

**“Online” tab**

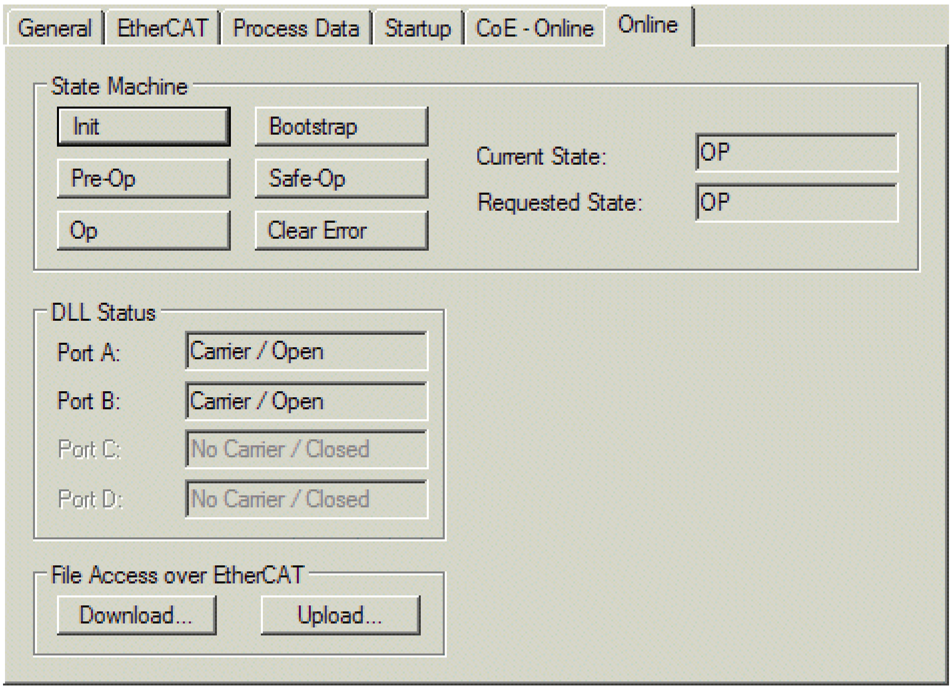



Fig. 147: “Online” tab

### State Machine

| | |
|---|---|
| **Init** | This button attempts to set the EtherCAT device to the *Init* state. |
| **Pre-Op** | This button attempts to set the EtherCAT device to the *pre-operational* state. |
| **Op** | This button attempts to set the EtherCAT device to the *operational* state. |
| **Bootstrap** | This button attempts to set the EtherCAT device to the *Bootstrap* state. |
| **Safe-Op** | This button attempts to set the EtherCAT device to the *safe-operational* state. |
| **Clear Error** | This button attempts to delete the fault display. If an EtherCAT slave fails during change of state it sets an error flag.<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 *Clear Error* button is pressed the error flag is cleared, and the current state is displayed as PREOP again. |
| **Current State** | Indicates the current state of the EtherCAT device. |
| **Requested State** | 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

| | |
|---|---|
| **Download** | With this button a file can be written to the EtherCAT device. |
| **Upload** | With this button a file can be read from the EtherCAT device. |

### "DC" tab (Distributed Clocks)

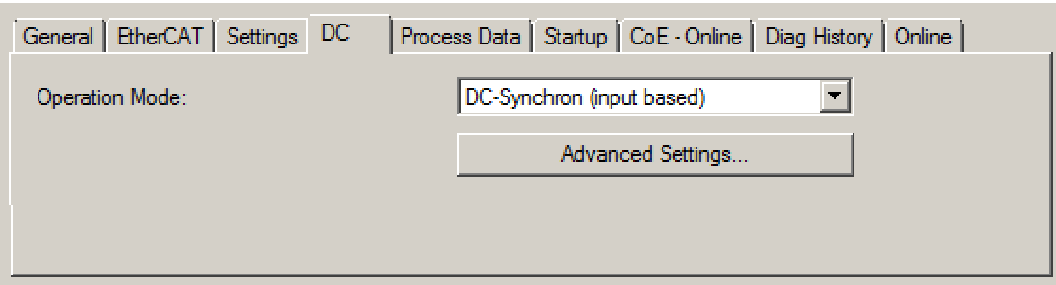



Fig. 148: "DC" tab (Distributed Clocks)

| | |
|---|---|
| **Operation Mode** | Options (optional):<br>• FreeRun<br>• SM-Synchron<br>• DC-Synchron (Input based)<br>• DC-Synchron |
| **Advanced Settings…** | Advanced settings for readjustment of the real time determinant TwinCAT-clock |

Detailed information to Distributed Clocks is specified on http://infosys.beckhoff.com:

**Fieldbus Components** → EtherCAT Terminals → EtherCAT System documentation → EtherCAT basics → Distributed Clocks

### 5.2.7.1 Detailed description of 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 to select a greyed out PDO, the currently selected PDO has to be deselected first.

**Activation of PDO assignment**

✓ If you have changed the PDO assignment, in order to activate the new PDO assignment,

a) the EtherCAT slave has to run through the PS status transition cycle (from pre-operational to safe-operational) once (see Online tab [▶ 292]),

b) and the System Manager has to reload the EtherCAT slaves

(  button for TwinCAT 2 or  button for TwinCAT 3)

**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 *PDO Assignment* 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 [▶ 289] 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.

## 5.2.8 Import/Export of EtherCAT devices with SCI and XTI

**SCI and XTI Export/Import – Handling of user-defined modified EtherCAT slaves**

### 5.2.8.1 Basic principles

An EtherCAT slave is basically parameterized through the following elements:

- Cyclic process data (PDO)
- Synchronization (Distributed Clocks, FreeRun, SM-Synchron)
- CoE parameters (acyclic object dictionary)

Note: Not all three elements may be present, depending on the slave.

For a better understanding of the export/import function, let's consider the usual procedure for IO configuration:

- The user/programmer processes the IO configuration in the TwinCAT system environment. This involves all input/output devices such as drives that are connected to the fieldbuses used.
  Note: In the following sections, only EtherCAT configurations in the TwinCAT system environment are considered.
- For example, the user manually adds devices to a configuration or performs a scan on the online system.
- This results in the IO system configuration.
- On insertion, the slave appears in the system configuration in the default configuration provided by the vendor, consisting of default PDO, default synchronization method and CoE StartUp parameter as defined in the ESI (XML device description).
- If necessary, elements of the slave configuration can be changed, e.g. the PDO configuration or the synchronization method, based on the respective device documentation.

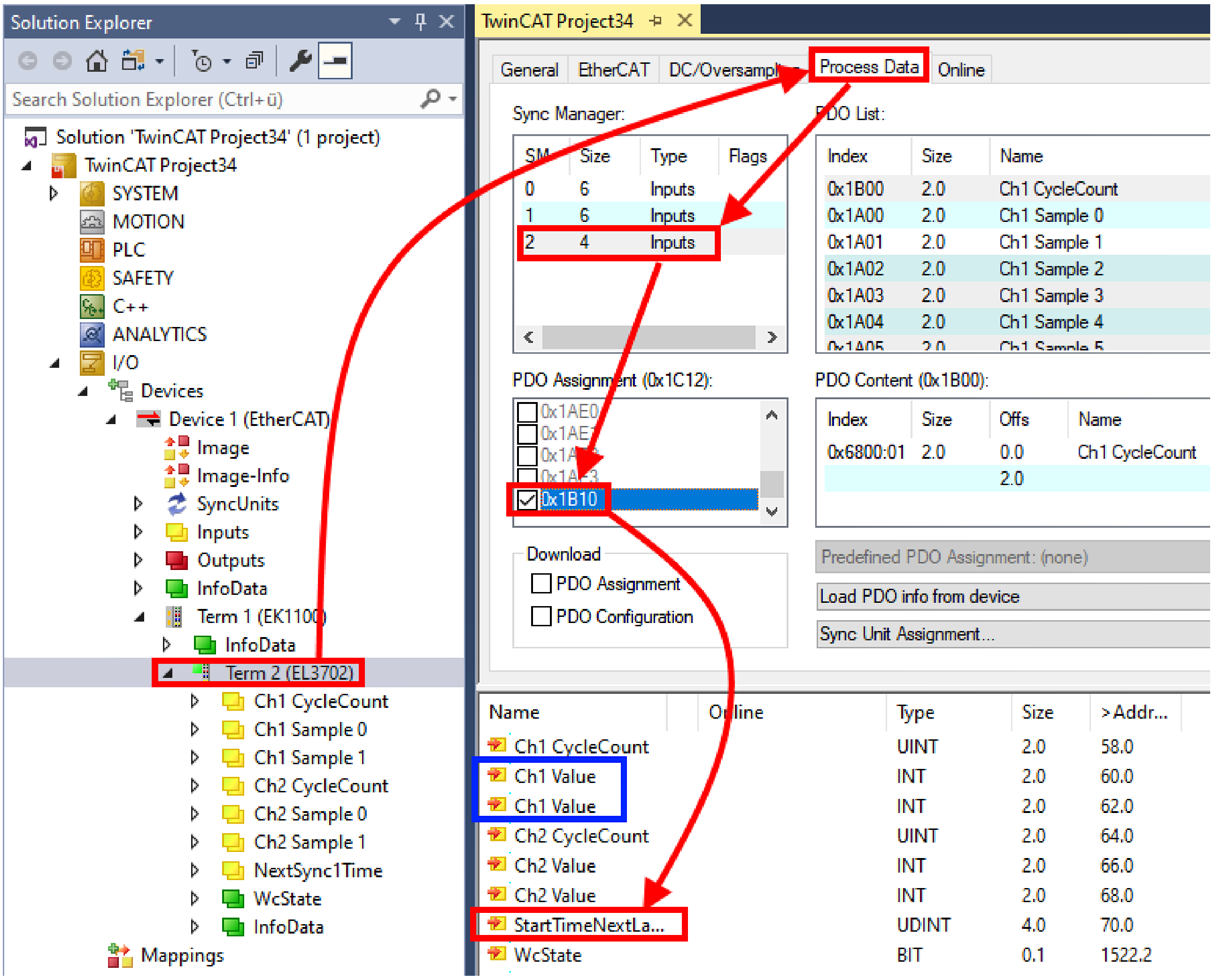
It may become necessary to reuse the modified slave in other projects in this way, without having to make equivalent configuration changes to the slave again. To accomplish this, proceed as follows:

- Export the slave configuration from the project,
- Store and transport as a file,
- Import into another EtherCAT project.

TwinCAT offers two methods for this purpose:

- within the TwinCAT environment: Export/Import as **xti** file or
- outside, i.e. beyond the TwinCAT limits: Export/Import as **sci** file.

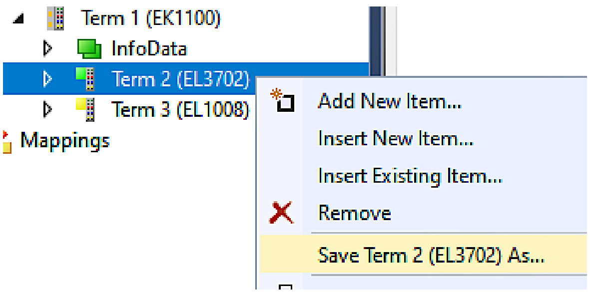
An example is provided below for illustration purposes: an EL3702 terminal with standard setting is switched to 2-fold oversampling (blue) and the optional PDO "StartTimeNextLatch" is added (red):



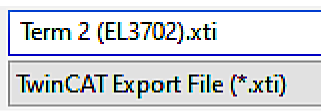

The two methods for exporting and importing the modified terminal referred to above are demonstrated below.

### 5.2.8.2 Procedure within TwinCAT with xti files

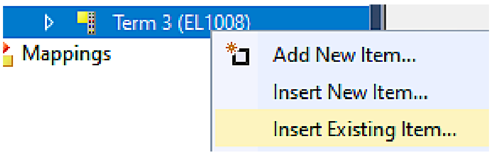
Each IO device can be exported/saved individually:




The xti file can be stored:




and imported again in another TwinCAT system via "Insert Existing item":




## 5.2.8.3 Procedure within and outside TwinCAT with sci file

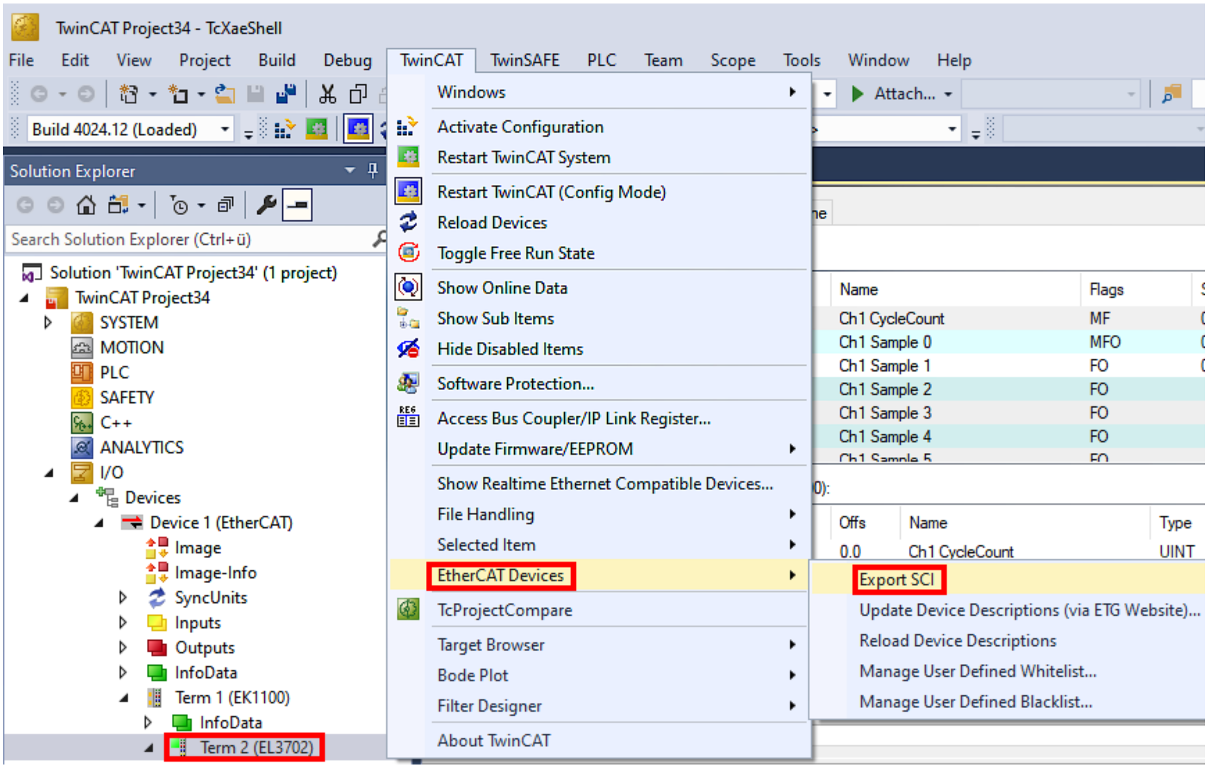
*Note regarding availability (2021/01)*

*The SCI method is available from TwinCAT 3.1 build 4024.14.*

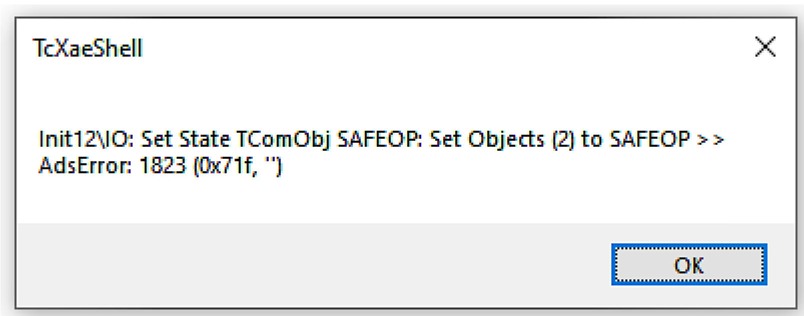
The Slave Configuration Information (SCI) describes a specific complete configuration for an EtherCAT slave (terminal, box, drive...) based on the setting options of the device description file (ESI, EtherCAT Slave Information). That is, it includes PDO, CoE, synchronization.

**Export:**

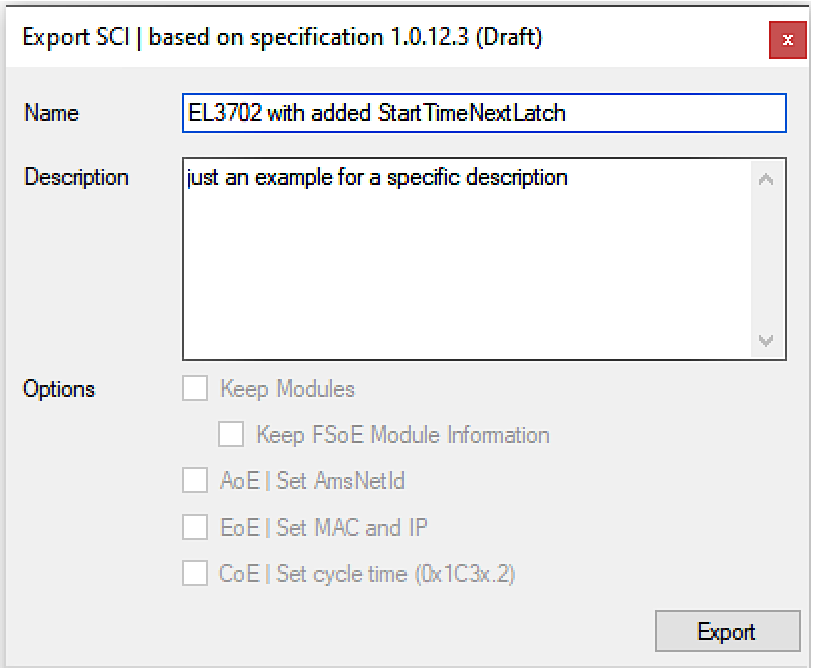
- select a single device via the menu (multiple selection is also possible):
  TwinCAT → EtherCAT Devices → Export SCI.




- If TwinCAT is offline (i.e. if there is no connection to an actual running controller) a warning message may appear, because after executing the function the system attempts to reload the EtherCAT segment. However, in this case this is not relevant for the result and can be acknowledged by clicking OK:



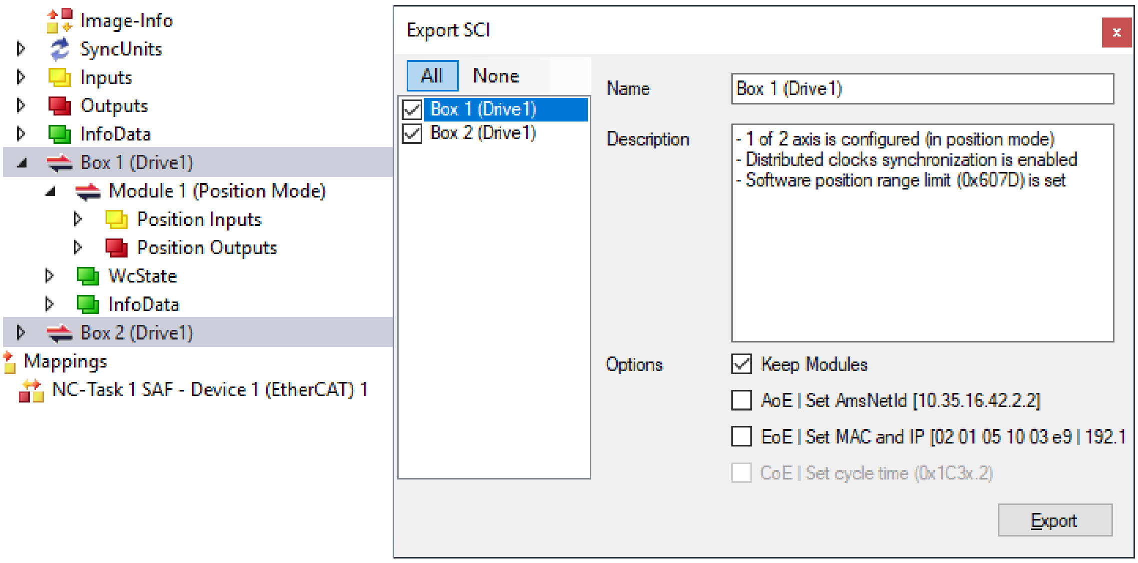
- A description may also be provided:




- Explanation of the dialog box:

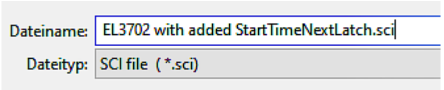
| | | |
|---|---|---|
| Name | | Name of the SCI, assigned by the user. |
| Description | | Description of the slave configuration for the use case, assigned by the user. |
| Options | Keep modules | If a slave supports modules/slots, the user can decide whether these are to be exported or whether the module and device data are to be combined during export. |
| | AoE \| Set AmsNetId | The configured AmsNetId is exported. Usually this is network-dependent and cannot always be determined in advance. |
| | EoE \| Set MAC and IP | The configured virtual MAC and IP addresses are stored in the SCI. Usually these are network-dependent and cannot always be determined in advance. |
| | CoE \| Set cycle time(0x1C3x.2) | The configured cycle time is exported. Usually this is network-dependent and cannot always be determined in advance. |
| ESI | | Reference to the original ESI file. |
| Export | | Save SCI file. |

- A list view is available for multiple selections (*Export multiple SCI files*):

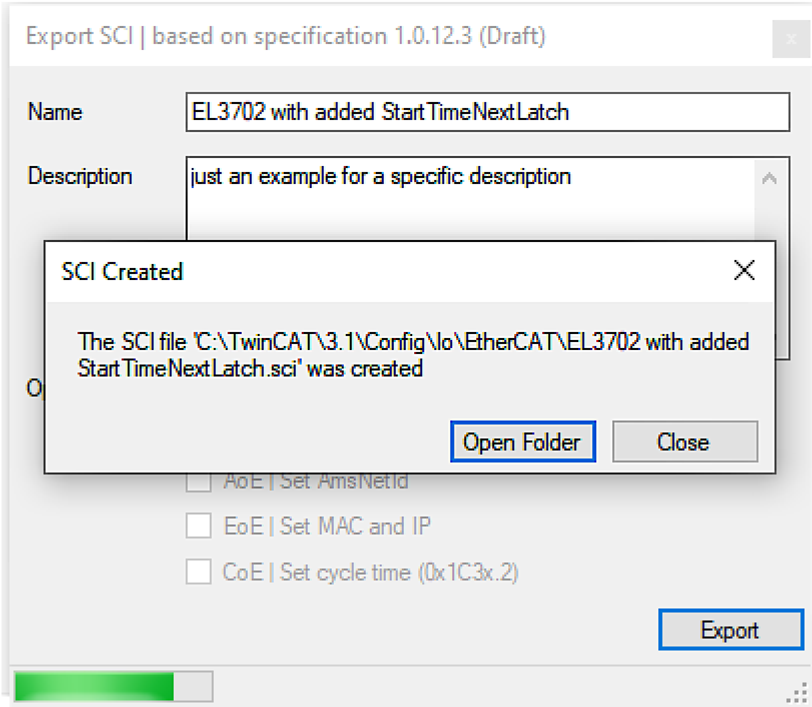



- Selection of the slaves to be exported:
    - All:
      All slaves are selected for export.

  - None:
    All slaves are deselected.
- The sci file can be saved locally:

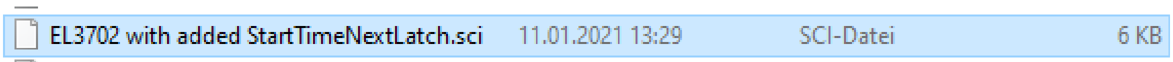



- The export takes place:

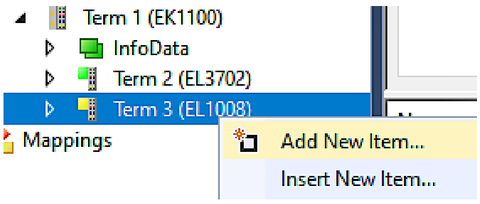



**Import**

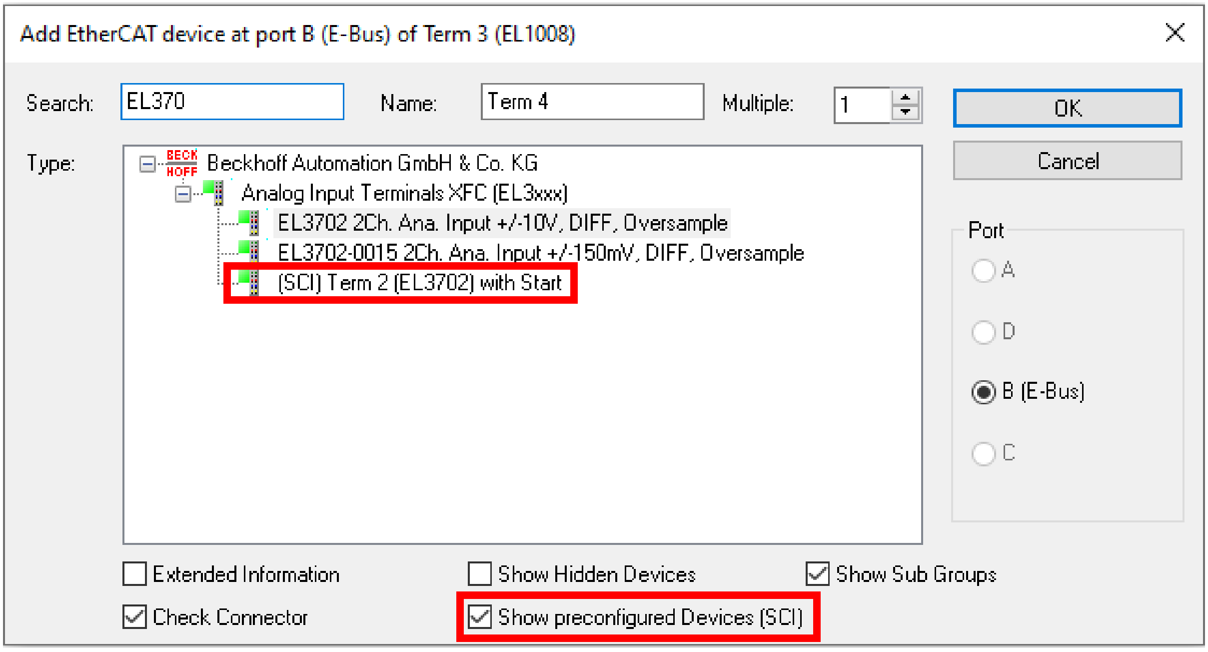
- An sci description can be inserted manually into the TwinCAT configuration like any normal Beckhoff device description.
- The sci file must be located in the TwinCAT ESI path, usually under:
  C:\TwinCAT\3.1\Config\Io\EtherCAT




- Open the selection dialog:

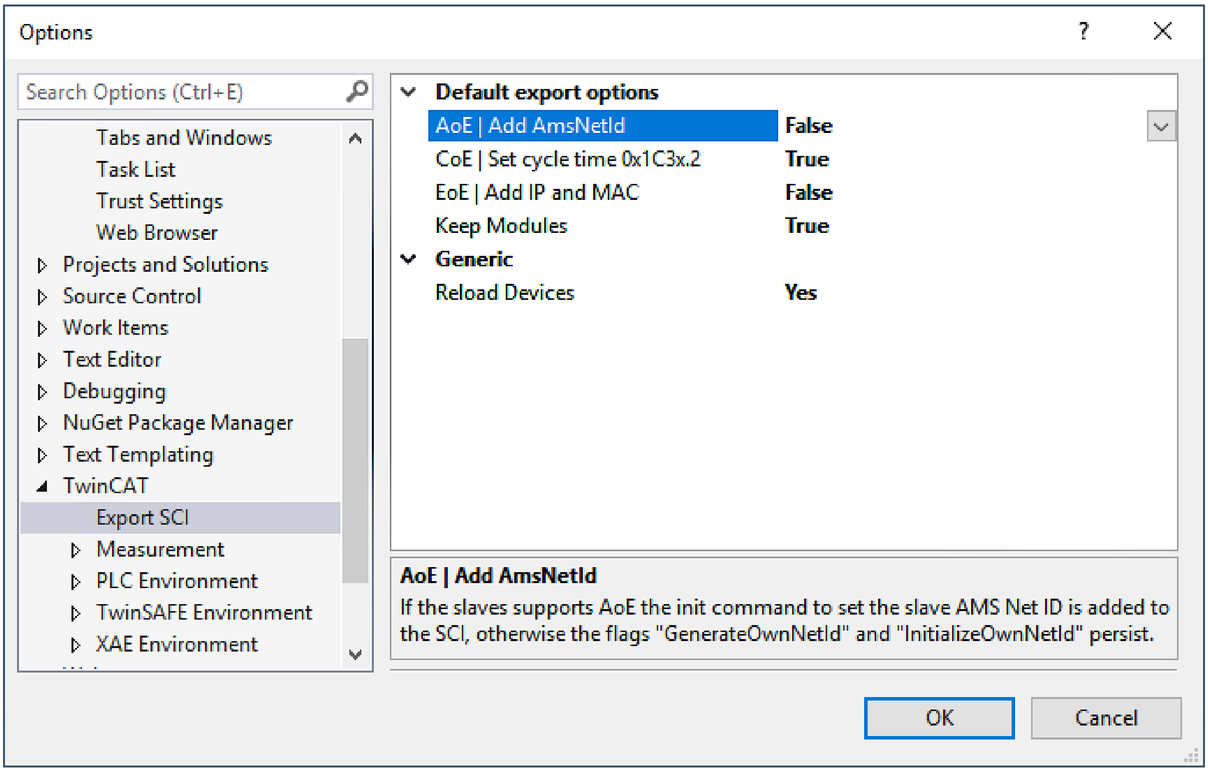


- Display SCI devices and select and insert the desired device:




### Additional Notes

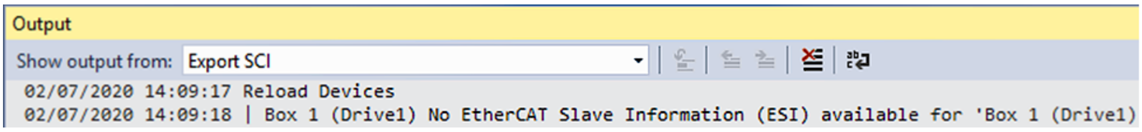
- Settings for the SCI function can be made via the general Options dialog (Tools → Options → TwinCAT → Export SCI):




Explanation of the settings:

| | | |
|---|---|---|
| Default export options | AoE \| Set AmsNetId | Default setting whether the configured AmsNetId is exported. |
| | CoE \| Set cycle time(0x1C3x.2) | Default setting whether the configured cycle time is exported. |
| | EoE \| Set MAC and IP | Default setting whether the configured MAC and IP addresses are exported. |
| | Keep modules | Default setting whether the modules persist. |
| Generic | Reload Devices | Setting whether the Reload Devices command is executed before the SCI export.<br>This is strongly recommended to ensure a consistent slave configuration. |

SCI error messages are displayed in the TwinCAT logger output window if required:




## 5.3 General Notes - EtherCAT Slave Application

This summary briefly deals with a number of aspects of EtherCAT Slave operation under TwinCAT. More detailed information on this may be found in the corresponding sections of, for instance, the EtherCAT System Documentation.

**Diagnosis in real time: WorkingCounter, EtherCAT State and Status**

Generally speaking an EtherCAT Slave provides a variety of diagnostic information that can be used by the controlling task.

This diagnostic information relates to differing levels of communication. It therefore has a variety of sources, and is also updated at various times.

Any application that relies on I/O data from a fieldbus being correct and up to date must make diagnostic access to the corresponding underlying layers. EtherCAT and the TwinCAT System Manager offer comprehensive diagnostic elements of this kind. Those diagnostic elements that are helpful to the controlling task for diagnosis that is accurate for the current cycle when in operation (not during commissioning) are discussed below.

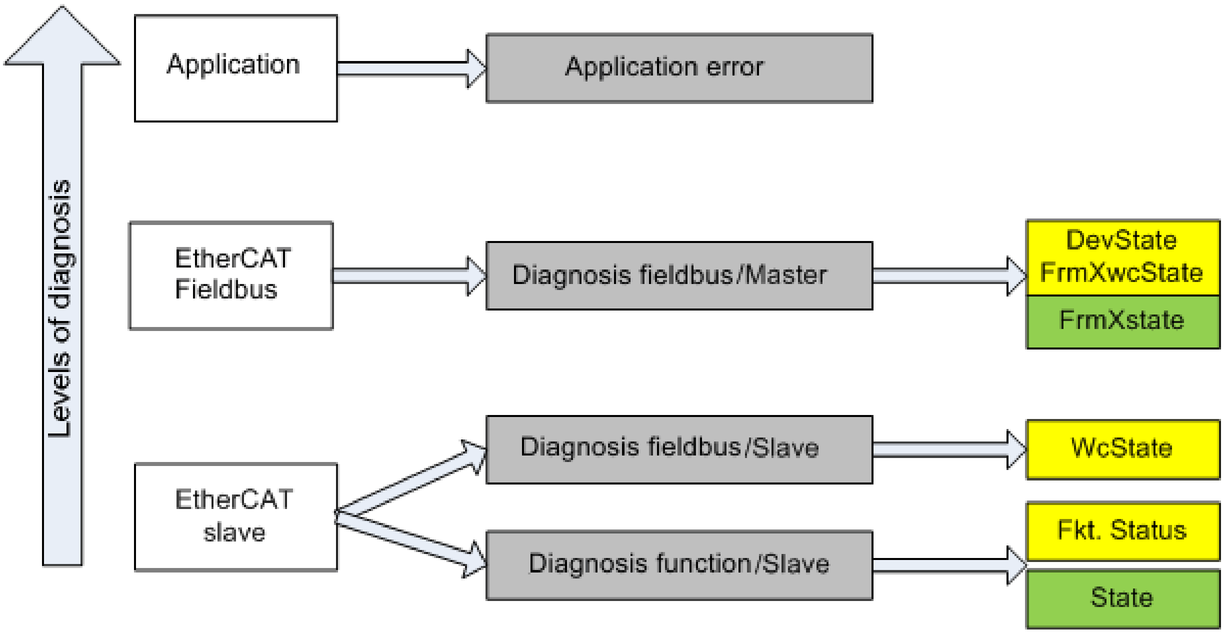



Fig. 149: Selection of the diagnostic information of an EtherCAT Slave

In general, an EtherCAT Slave offers

- communication diagnosis typical for a slave (diagnosis of successful participation in the exchange of process data, and correct operating mode)
  This diagnosis is the same for all slaves.

  as well as
- function diagnosis typical for a channel (device-dependent)
  See the corresponding device documentation

The colors in Fig. *Selection of the diagnostic information of an EtherCAT Slave* also correspond to the variable colors in the System Manager, see Fig. *Basic EtherCAT Slave Diagnosis in the PLC*.

| Colour | Meaning |
|---|---|
| yellow | Input variables from the Slave to the EtherCAT Master, updated in every cycle |
| red | Output variables from the Slave to the EtherCAT Master, updated in every cycle |
| green | Information variables for the EtherCAT Master that are updated acyclically. This means that it is possible that in any particular cycle they do not represent the latest possible status. It is therefore useful to read such variables through ADS. |

Fig. *Basic EtherCAT Slave Diagnosis in the PLC* shows an example of an implementation of basic EtherCAT Slave Diagnosis. A Beckhoff EL3102 (2-channel analogue input terminal) is used here, as it offers both the communication diagnosis typical of a slave and the functional diagnosis that is specific to a channel. Structures are created as input variables in the PLC, each corresponding to the process image.

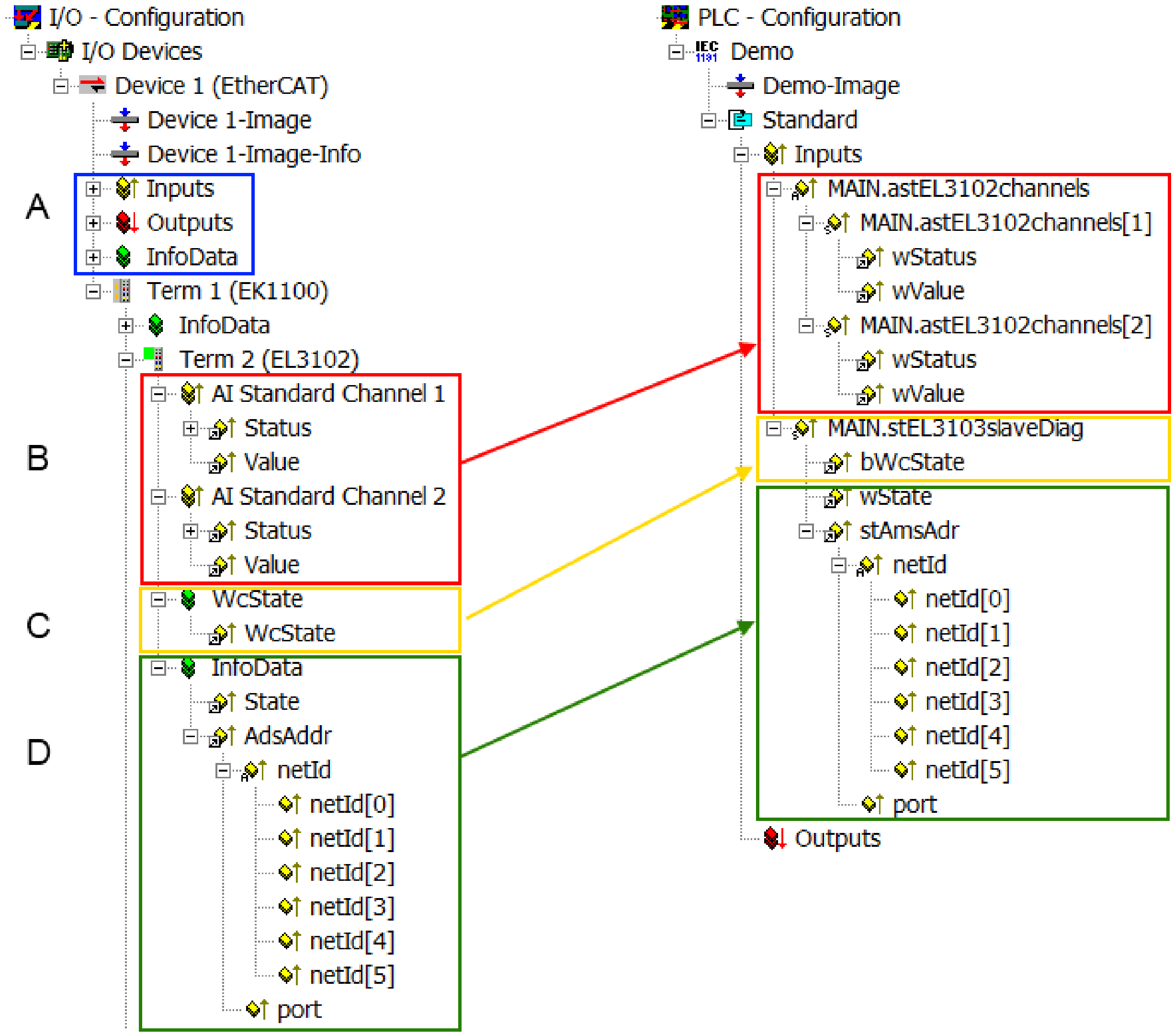



Fig. 150: Basic EtherCAT Slave Diagnosis in the PLC

The following aspects are covered here:

| Code | Function | Implementation | Application/evaluation |
|---|---|---|---|
| A | The EtherCAT Master's diagnostic information<br>updated acyclically (yellow) or provided acyclically (green). | | At least the DevState is to be evaluated for the most recent cycle in the PLC.<br>The EtherCAT Master's diagnostic information offers many more possibilities than are treated in the EtherCAT System Documentation. A few keywords:<br>• CoE in the Master for communication with/through the Slaves<br>• Functions from *TcEtherCAT.lib*<br>• Perform an OnlineScan |
| B | In the example chosen (EL3102) the EL3102 comprises two analogue input channels that transmit a single function status for the most recent cycle. | Status<br>• the bit significations may be found in the device documentation<br>• other devices may supply more information, or none that is typical of a slave | In order for the higher-level PLC task (or corresponding control applications) to be able to rely on correct data, the function status must be evaluated there. Such information is therefore provided with the process data for the most recent cycle. |
| C | For every EtherCAT Slave that has cyclic process data, the Master displays, using what is known as a WorkingCounter, whether the slave is participating successfully and without error in the cyclic exchange of process data. This important, elementary information is therefore provided for the most recent cycle in the System Manager<br>1. at the EtherCAT Slave, and, with identical contents<br>2. as a collective variable at the EtherCAT Master (see Point A)<br>for linking. | WcState (Working Counter)<br>0: valid real-time communication in the last cycle<br>1: invalid real-time communication<br>This may possibly have effects on the process data of other Slaves that are located in the same SyncUnit | In order for the higher-level PLC task (or corresponding control applications) to be able to rely on correct data, the communication status of the EtherCAT Slave must be evaluated there. Such information is therefore provided with the process data for the most recent cycle. |
| D | Diagnostic information of the EtherCAT Master which, while it is represented at the slave for linking, is actually determined by the Master for the Slave concerned and represented there. This information cannot be characterized as real-time, because it<br>• is only rarely/never changed, except when the system starts up<br>• is itself determined acyclically (e.g. EtherCAT Status) | State<br>current Status (INIT..OP) of the Slave. The Slave must be in OP (=8) when operating normally.<br>*AdsAddr*<br>The ADS address is useful for communicating from the PLC/task via ADS with the EtherCAT Slave, e.g. for reading/writing to the CoE. The AMS-NetID of a slave corresponds to the AMS-NetID of the EtherCAT Master; communication with the individual Slave is possible via the *port* (= EtherCAT address). | Information variables for the EtherCAT Master that are updated acyclically. This means that it is possible that in any particular cycle they do not represent the latest possible status. It is therefore possible to read such variables through ADS. |

**NOTE**

**Diagnostic information**

It is strongly recommended that the diagnostic information made available is evaluated so that the application can react accordingly.

### CoE Parameter Directory

The CoE parameter directory (CanOpen-over-EtherCAT) is used to manage the set values for the slave concerned. Changes may, in some circumstances, have to be made here when commissioning a relatively complex EtherCAT Slave. It can be accessed through the TwinCAT System Manager, see Fig. *EL3102, CoE directory*:

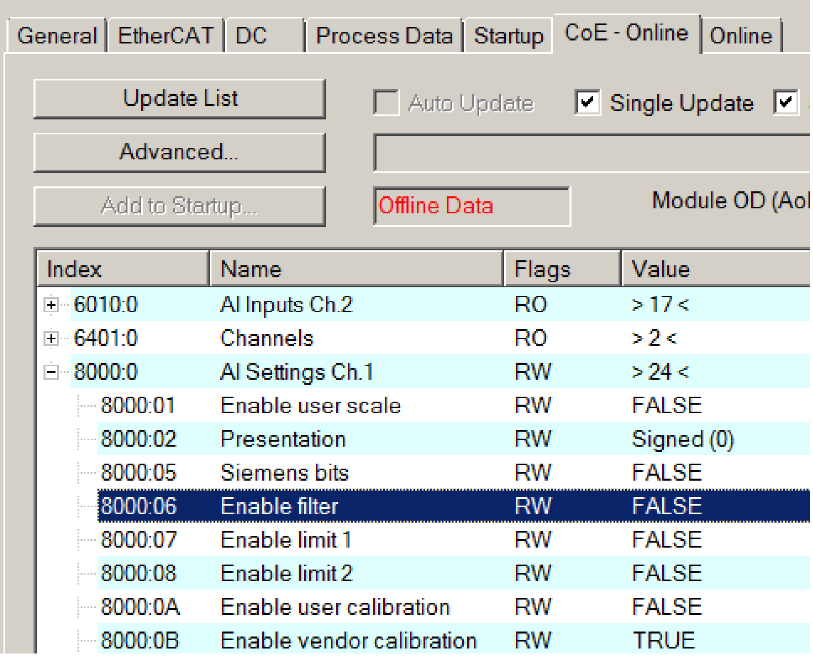



Fig. 151: EL3102, CoE directory

**EtherCAT System Documentation**

The comprehensive description in the EtherCAT System Documentation (EtherCAT Basics --> CoE Interface) must be observed!

A few brief extracts:

- Whether changes in the online directory are saved locally in the slave depends on the device. EL terminals (except the EL66xx) are able to save in this way.
- The user must manage the changes to the StartUp list.

### Commissioning aid in the TwinCAT System Manager

Commissioning interfaces are being introduced as part of an ongoing process for EL/EP EtherCAT devices. These are available in TwinCAT System Managers from TwinCAT 2.11R2 and above. They are integrated into the System Manager through appropriately extended ESI configuration files.

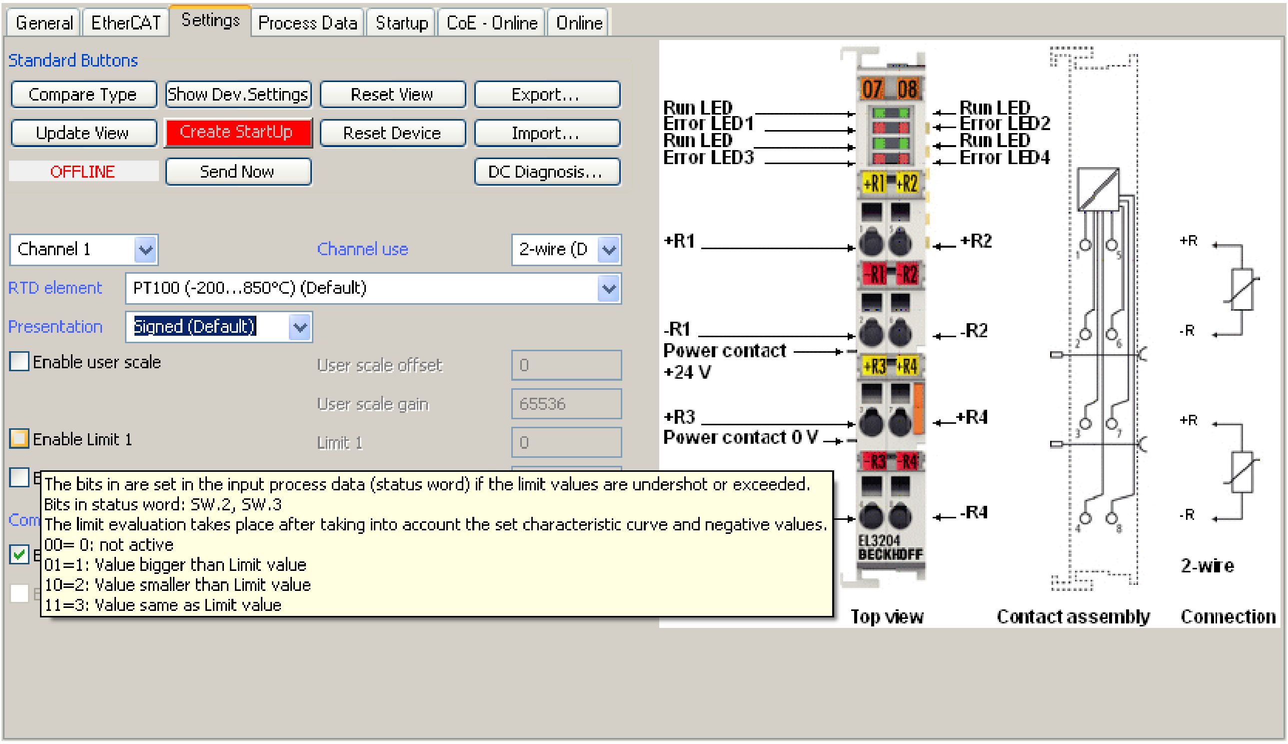



Fig. 152: Example of commissioning aid for a EL3204

This commissioning process simultaneously manages

- CoE Parameter Directory
- DC/FreeRun mode
- the available process data records (PDO)

Although the "Process Data", "DC", "Startup" and "CoE-Online" that used to be necessary for this are still displayed, it is recommended that, if the commissioning aid is used, the automatically generated settings are not changed by it.

The commissioning tool does not cover every possible application of an EL/EP device. If the available setting options are not adequate, the user can make the DC, PDO and CoE settings manually, as in the past.

**EtherCAT State: automatic default behaviour of the TwinCAT System Manager and manual operation**

After the operating power is switched on, an EtherCAT Slave must go through the following statuses

- INIT
- PREOP
- SAFEOP
- OP

to ensure sound operation. The EtherCAT Master directs these statuses in accordance with the initialization routines that are defined for commissioning the device by the ES/XML and user settings (Distributed Clocks (DC), PDO, CoE). See also the section on "Principles of Communication, EtherCAT State Machine [▶ 215]" in this connection. Depending how much configuration has to be done, and on the overall communication, booting can take up to a few seconds.

The EtherCAT Master itself must go through these routines when starting, until it has reached at least the OP target state.

The target state wanted by the user, and which is brought about automatically at start-up by TwinCAT, can be set in the System Manager. As soon as TwinCAT reaches the status RUN, the TwinCAT EtherCAT Master will approach the target states.

### Standard setting

The advanced settings of the EtherCAT Master are set as standard:

- EtherCAT Master: OP
- Slaves: OP
  This setting applies equally to all Slaves.

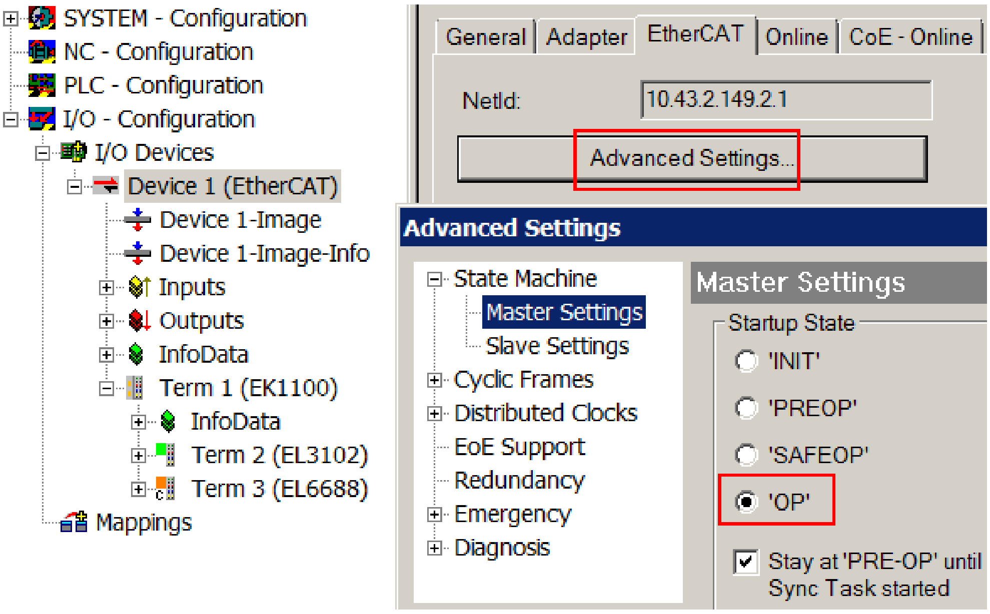



Fig. 153: Default behaviour of the System Manager

In addition, the target state of any particular Slave can be set in the “Advanced Settings” dialogue; the standard setting is again OP.

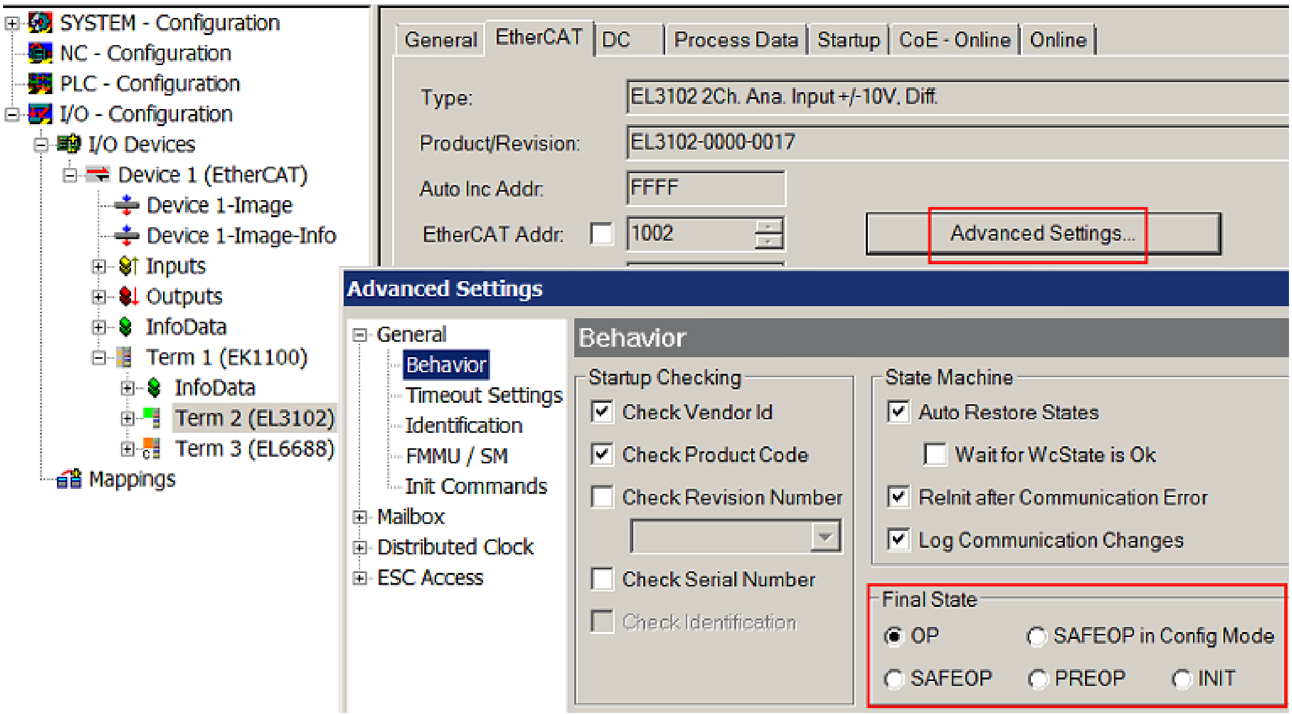



Fig. 154: Default target state in the Slave

### Manual Control

There are particular reasons why it may be appropriate to control the states from the application/task/PLC. For instance:

- for diagnostic reasons
- to induce a controlled restart of axes
- because a change in the times involved in starting is desirable

In that case it is appropriate in the PLC application to use the PLC function blocks from the *TcEtherCAT.lib*, which is available as standard, and to work through the states in a controlled manner using, for instance, *FB_EcSetMasterState*.

It is then useful to put the settings in the EtherCAT Master to INIT for master and slave.

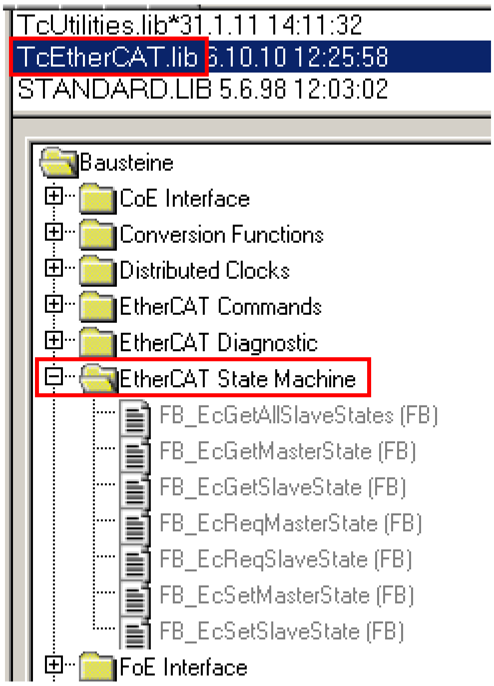
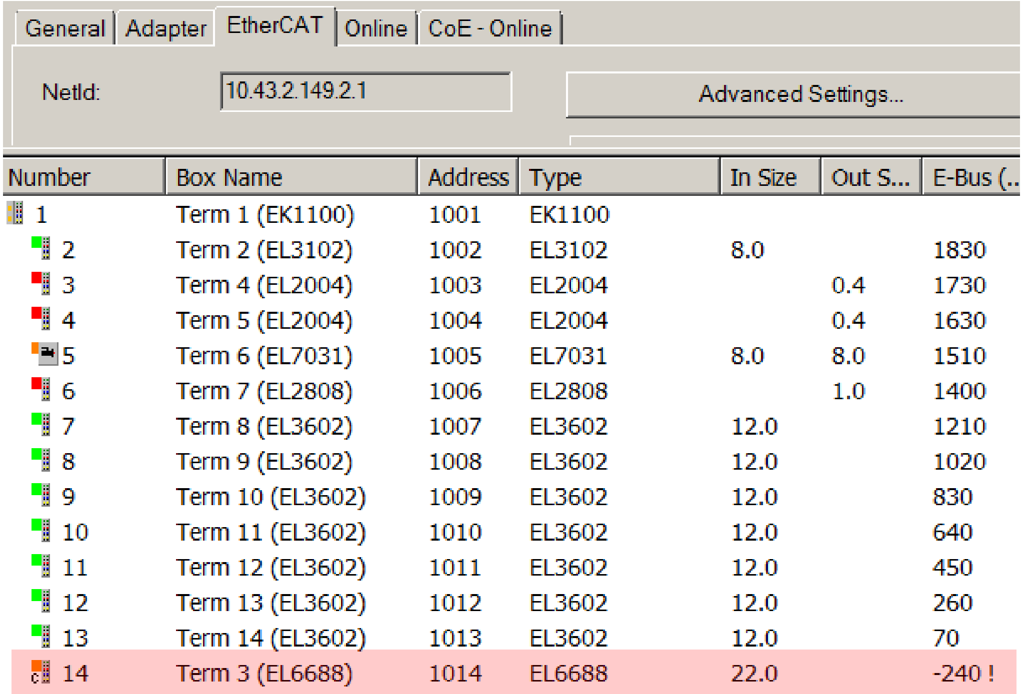



Fig. 155: PLC function blocks

### Note regarding E-Bus current

EL/ES terminals are placed on the DIN rail at a coupler on the terminal strand. A Bus Coupler can supply the EL terminals added to it with the E-bus system voltage of 5 V; a coupler is thereby loadable up to 2 A as a rule. Information on how much current each EL terminal requires from the E-bus supply is available online and in the catalogue. If the added terminals require more current than the coupler can supply, then power feed terminals (e.g. EL9410) must be inserted at appropriate places in the terminal strand.

The pre-calculated theoretical maximum E-Bus current is displayed in the TwinCAT System Manager as a column value. A shortfall is marked by a negative total amount and an exclamation mark; a power feed terminal is to be placed before such a position.




| Number | Box Name | Address | Type | In Size | Out S... | E-Bus (.. |
|---|---|---|---|---|---|---|
| 1 | Term 1 (EK1100) | 1001 | EK1100 | | | |
| 2 | Term 2 (EL3102) | 1002 | EL3102 | 8.0 | | 1830 |
| 3 | Term 4 (EL2004) | 1003 | EL2004 | | 0.4 | 1730 |
| 4 | Term 5 (EL2004) | 1004 | EL2004 | | 0.4 | 1630 |
| 5 | Term 6 (EL7031) | 1005 | EL7031 | 8.0 | 8.0 | 1510 |
| 6 | Term 7 (EL2808) | 1006 | EL2808 | | 1.0 | 1400 |
| 7 | Term 8 (EL3602) | 1007 | EL3602 | 12.0 | | 1210 |
| 8 | Term 9 (EL3602) | 1008 | EL3602 | 12.0 | | 1020 |
| 9 | Term 10 (EL3602) | 1009 | EL3602 | 12.0 | | 830 |
| 10 | Term 11 (EL3602) | 1010 | EL3602 | 12.0 | | 640 |
| 11 | Term 12 (EL3602) | 1011 | EL3602 | 12.0 | | 450 |
| 12 | Term 13 (EL3602) | 1012 | EL3602 | 12.0 | | 260 |
| 13 | Term 14 (EL3602) | 1013 | EL3602 | 12.0 | | 70 |
| 14 | Term 3 (EL6688) | 1014 | EL6688 | 22.0 | | -240 ! |

Fig. 156: Illegally exceeding the E-Bus current

From TwinCAT 2.11 and above, a warning message “E-Bus Power of Terminal...” is output in the logger window when such a configuration is activated:

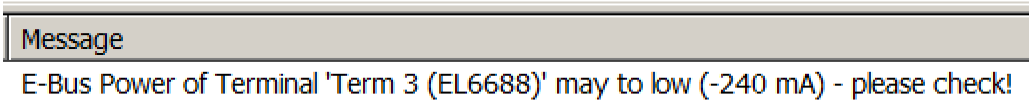



Fig. 157: Warning message for exceeding E-Bus current

**NOTE**

**Caution! Malfunction possible!**

The same ground potential must be used for the E-Bus supply of all EtherCAT terminals in a terminal block!

# 5.4 TwinSAFE SC

## 5.4.1 TwinSAFE SC - operating principle

The TwinSAFE SC (Single Channel) technology enables the use of standard signals for safety tasks in any networks of fieldbuses. To do this, EtherCAT Terminals from the areas of analog input, angle/displacement measurement or communication (4…20 mA, incremental encoder, IO-Link, etc.) are extended by the TwinSAFE SC function. The typical signal characteristics and standard functionalities of the I/O components are retained. TwinSAFE SC I/Os have a yellow strip at the front of the housing to distinguish them from standard I/Os.

The TwinSAFE SC technology enables communication via a TwinSAFE protocol. These connections can be distinguished from the usual safe communication via Safety over EtherCAT.

The data of the TwinSAFE SC components are transferred via a TwinSAFE protocol to the TwinSAFE logic, where they can be used in the context of safety-relevant applications. Detailed examples for the correct application of the TwinSAFE SC components and the respective normative classification, which were confirmed/calculated by TÜV SÜD, can be found in the TwinSAFE application manual.

## 5.4.2 TwinSAFE SC - configuration

The TwinSAFE SC technology enables communication with standard EtherCAT terminals via the Safety over EtherCAT protocol. These connections use another checksum, in order to be able to distinguish between TwinSAFE SC and TwinSAFE. Eight fixed CRCs can be selected, or a free CRC can be entered by the user.

By default the TwinSAFE SC communication channel of the respective TwinSAFE SC component is not enabled. In order to be able to use the data transfer, the corresponding TwinSAFE SC module must first be added under the Slots tab. Only then is it possible to link to a corresponding alias device.

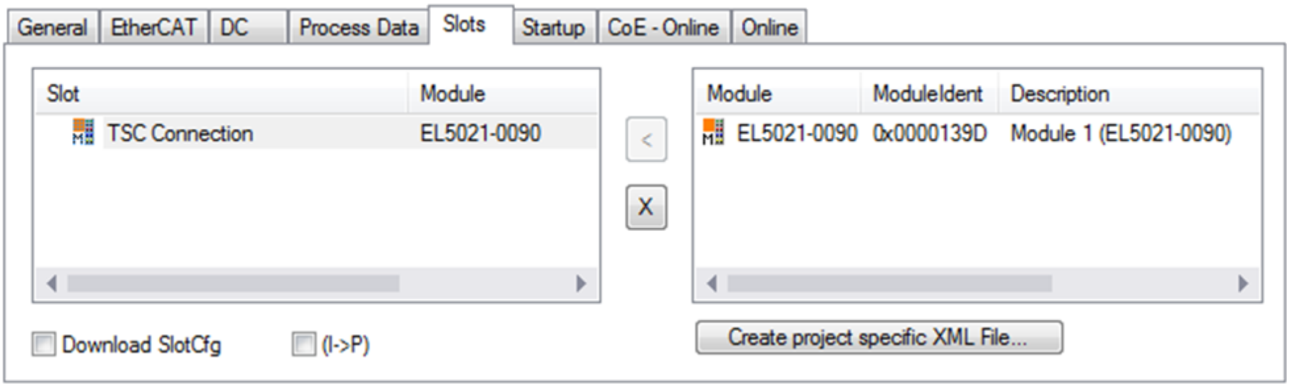



Fig. 158: Adding the TwinSAFE SC process data under the component, e.g. EL5021-0090

Additional process data with the ID TSC Inputs, TSC Outputs are generated (TSC - TwinSAFE Single Channel).

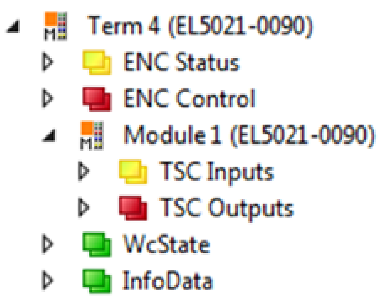



Fig. 159: TwinSAFE SC component process data, example EL5021-0090

A TwinSAFE SC connection is added by adding an alias devices in the safety project and selecting TSC (*TwinSAFE Single Channel*)

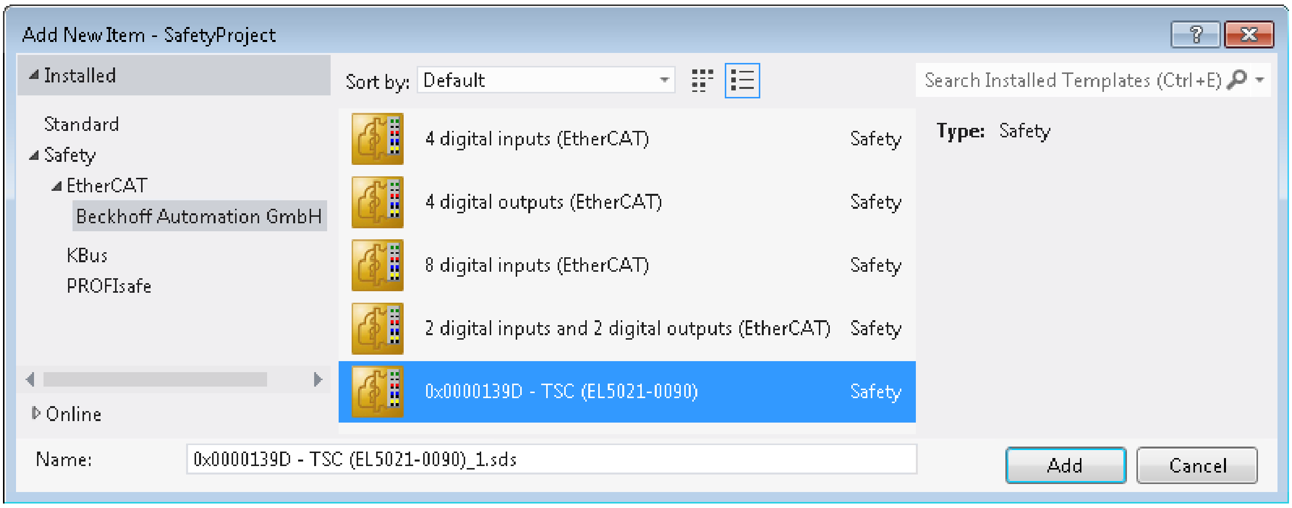



Fig. 160: Adding a TwinSAFE SC connection

After opening the alias device by double-clicking, select the Link button  next to *Physical Device,* in order to create the link to a TwinSAFE SC terminal. Only suitable TwinSAFE SC terminals are offered in the selection dialog.

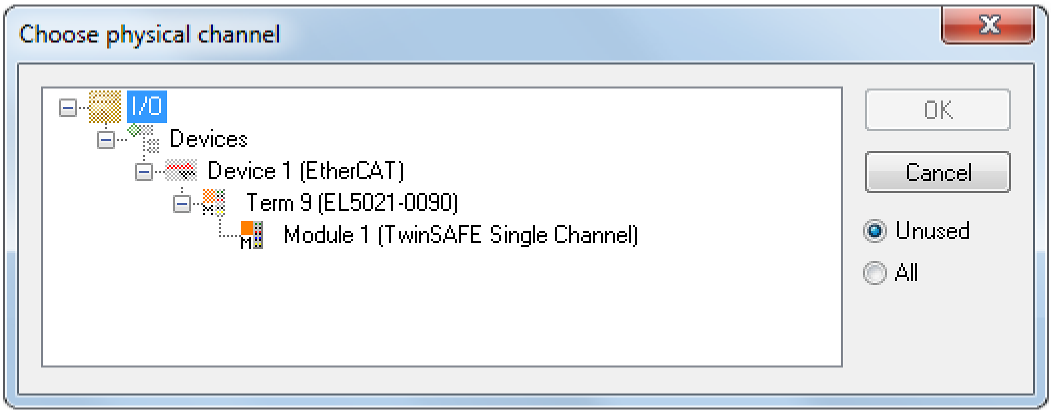



Fig. 161: Creating a link to TwinSAFE SC terminal

The CRC to be used can be selected or a free CRC can be entered under the Connection tab of the alias device.

| Entry Mode | Used CRCs |
|---|---|
| TwinSAFE SC CRC 1 master | 0x17B0F |
| TwinSAFE SC CRC 2 master | 0x1571F |
| TwinSAFE SC CRC 3 master | 0x11F95 |
| TwinSAFE SC CRC 4 master | 0x153F1 |
| TwinSAFE SC CRC 5 master | 0x1F1D5 |
| TwinSAFE SC CRC 6 master | 0x1663B |
| TwinSAFE SC CRC 7 master | 0x1B8CD |
| TwinSAFE SC CRC 8 master | 0x1E1BD |

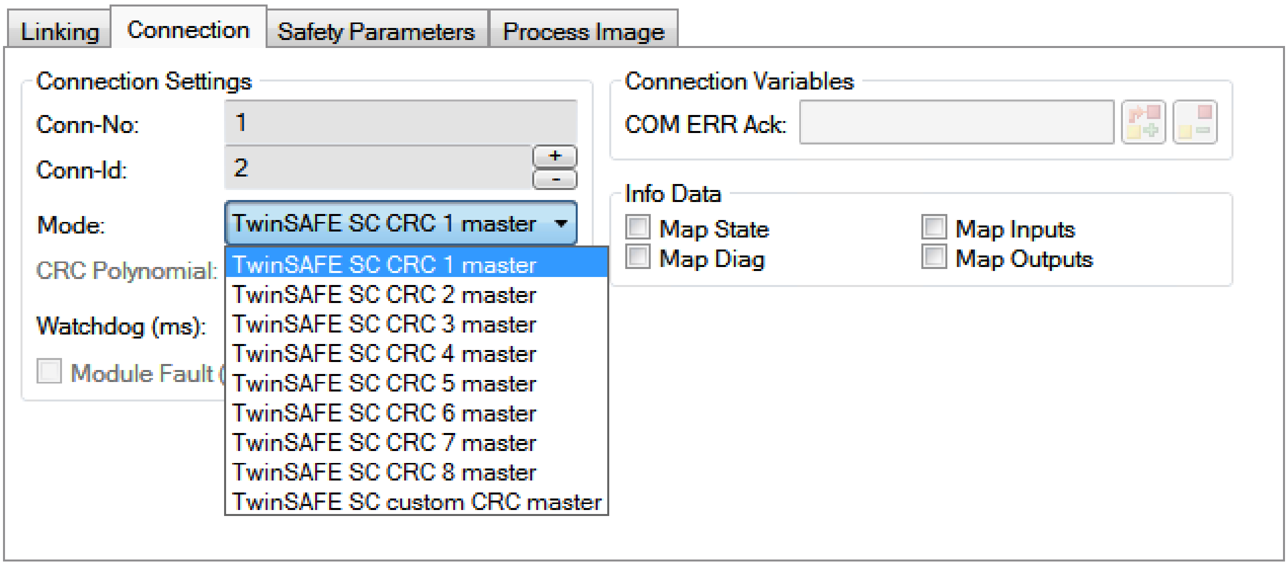



Fig. 162: Selecting a free CRC

These settings must match the settings in the CoE objects of the TwinSAFE SC component.
The TwinSAFE SC component initially makes all available process data available. The *Safety Parameters* tab typically contains no parameters. The process data size and the process data themselves can be selected under the *Process Image* tab.

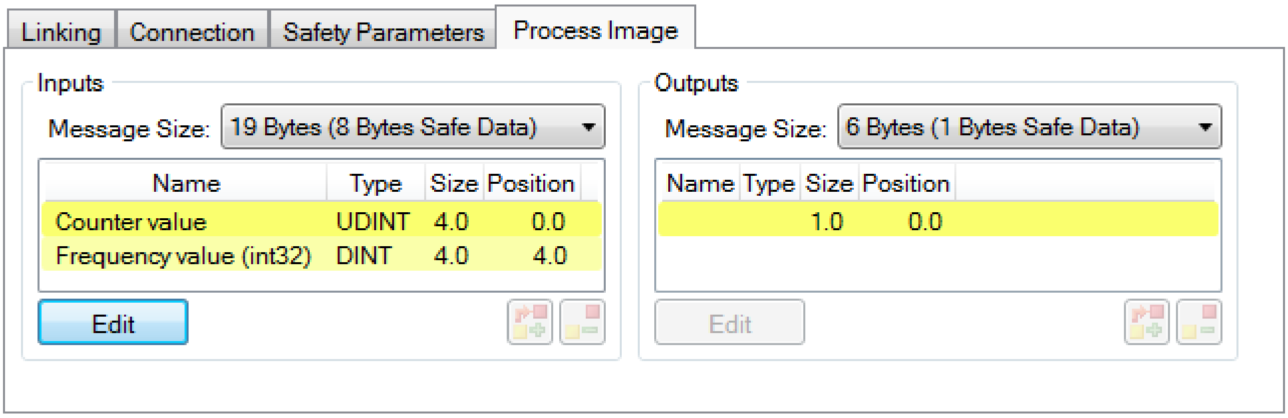



Fig. 163: Selecting the process data size and the process data

The process data (defined in the ESI file) can be adjusted to user requirements by selecting the *Edit* button in the dialog *Configure I/O element(s)*.

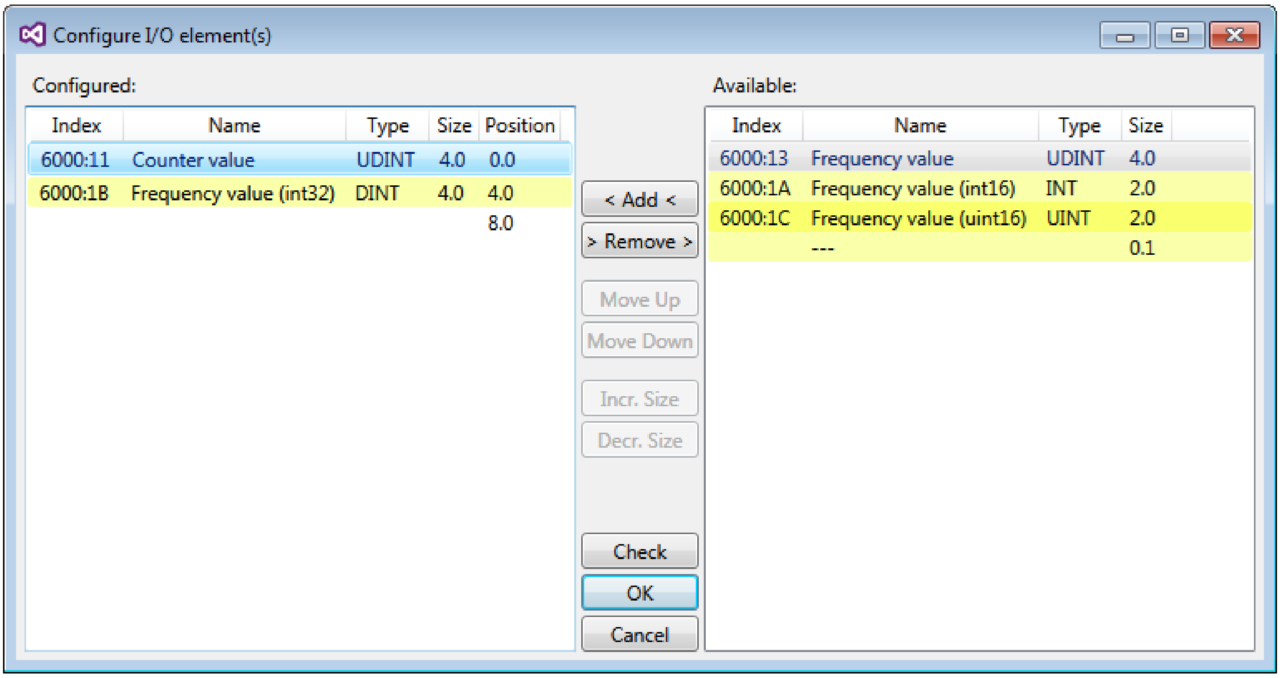



Fig. 164: Selection of the process data

The safety address together with the CRC must be entered on the TwinSAFE SC slave side. This is done via the CoE objects under *TSC settings* of the corresponding TwinSAFE SC component (here, for example, EL5021-0090, 0x8010: 01 and 0x8010: 02). The address set here must also be set in the *alias device* as *FSoE* address under the *Linking* tab.

Under the object 0x80n0:02 Connection Mode the CRC to be used is selected or a free CRC is entered. A total of 8 CRCs are available. A free CRC must start with 0x00ff in the high word.

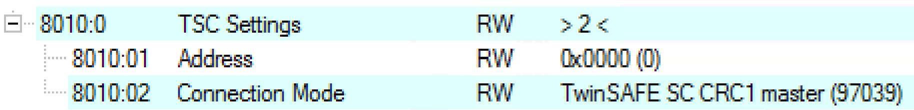



Fig. 165: CoE objects 0x8010:01 and 0x8010:02

**Object *TSC Settings***

Depending on the terminal, the index designation of the configuration object *TSC Settings* can vary.
Example:
- EL3214-0090 and EL3314-0090, TSC Settings, Index 8040
- EL5021-0090, TSC Settings, Index 8010
- EL6224-0090, TSC Settings, Index 800F

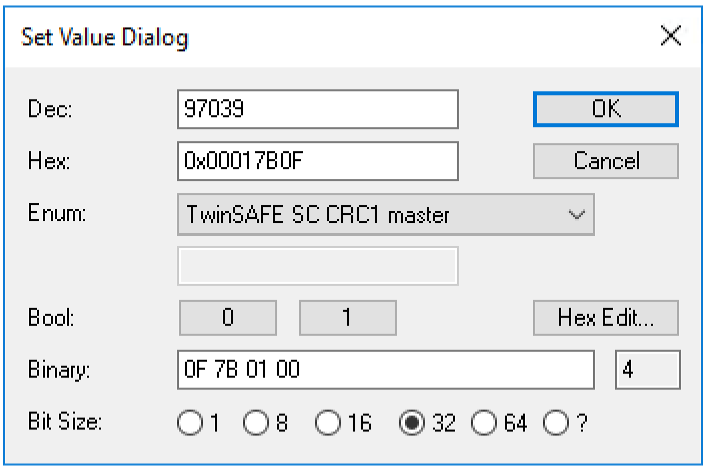



Fig. 166: Entering the safety address and the CRC

**TwinSAFE SC connections**

If several TwinSAFE SC connections are used within a configuration, a different CRC must be selected for each TwinSAFE SC connection.

# 5.5 Process data

## 5.5.1 Sync Manager

**PDO allocation (for channel 1 - 8, 0 ≤ n ≤ 7)**

| SM2, PDO assignment 0x1C12 | | | | |
|---|---|---|---|---|
| **Index** | **Index of excluded PDOs** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x160n | - | 2.0 | TC Outputs Channel n | Index 0x70n0:11 - CJCompensation |

| SM3, PDO Assignment 0x1C13 | | | | |
|---|---|---|---|---|
| **Index** | **Index of excluded PDOs** | **Size (byte.bit)** | **Name** | **PDO content** |
| 0x1A0n (default) | - | 4.0 | TC Inputs Channel n | Index 0x60n0:01 - Underrange<br>Index 0x60n0:02 - Overrange<br>Index 0x60n0:03 - limit 1 (not EL3318)<br>Index 0x60n0:05 - limit 2 (not EL3318)<br>Index 0x60n0:07 – Error<br>Index 0x60n0:0F - TxPDO Status<br>Index 0x180n:09- TxPDO Toggle<br>Index 0x60n0:11 - Value |

*Table 1: SyncManager PDO assignment*

## 5.5.2 Process data preselection (predefined PDOs)

An EtherCAT device usually offers several different process data objects (PDO) for input and output data, which can be configured in the System Manager, i.e. they can be activated or deactivated for cyclic transmission.

From TwinCAT 2.11, for suitable EtherCAT devices (as per ESI/XML description) the process data for input and output can be activated simultaneously through suitable predefined sets via "Predefined PDO assignment".

The EL33xx devices have the following "Predefined PDO" sets in the "Process data" tab (EL3318 shown in the example):

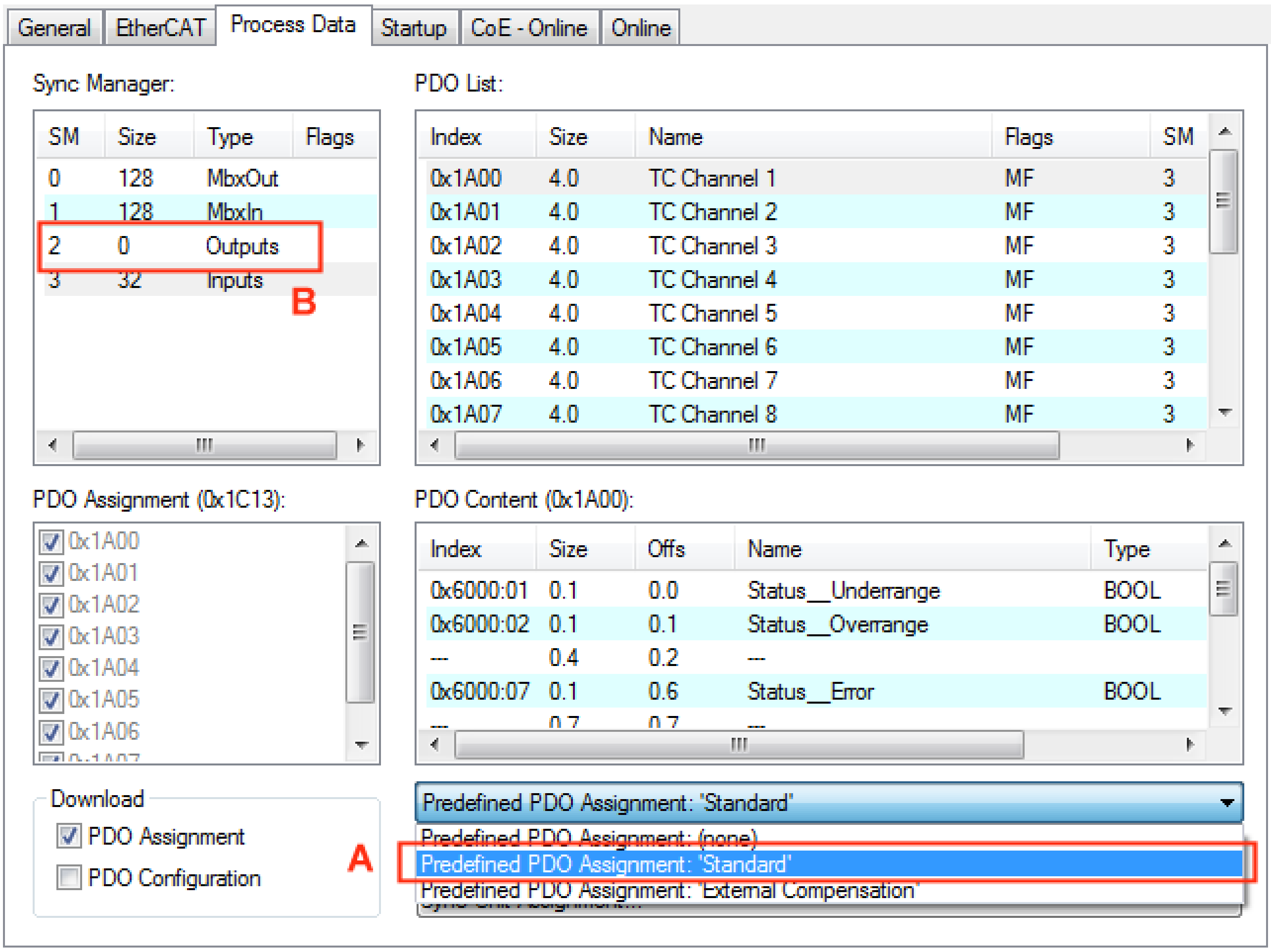



Fig. 167: TwinCAT System Manager with predefined PDO option "Standard"

In the "Standard" option [A] (or "inputs only", EL3311, EL3312, EL3314), the input PDOs 0x1A0n are activated for the corresponding input channels. The output PDOs 0x160n of Sync Manager 2 [B] are disabled.

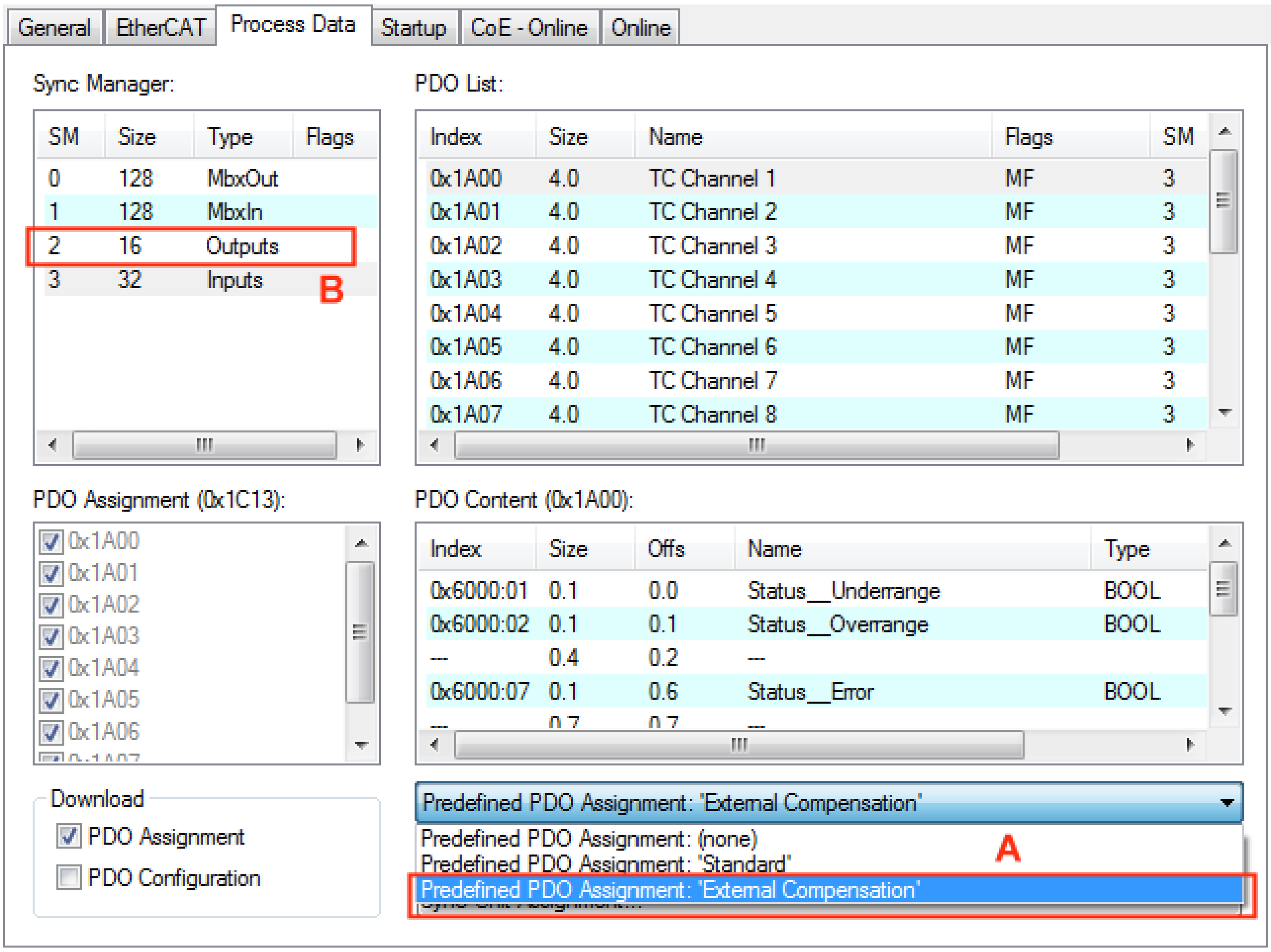



Fig. 168: TwinCAT System Manager with the predefined PDO selection "External Compensation"

In the "External Compensation" option [A] (or "with ColdJunction Compensation", EL3311, EL3312, EL3314), the input and output PDOs 0x1A0n / 0x160n of the respective channels are enabled.

### 5.5.3 Data processing

EL33xx TC temperature

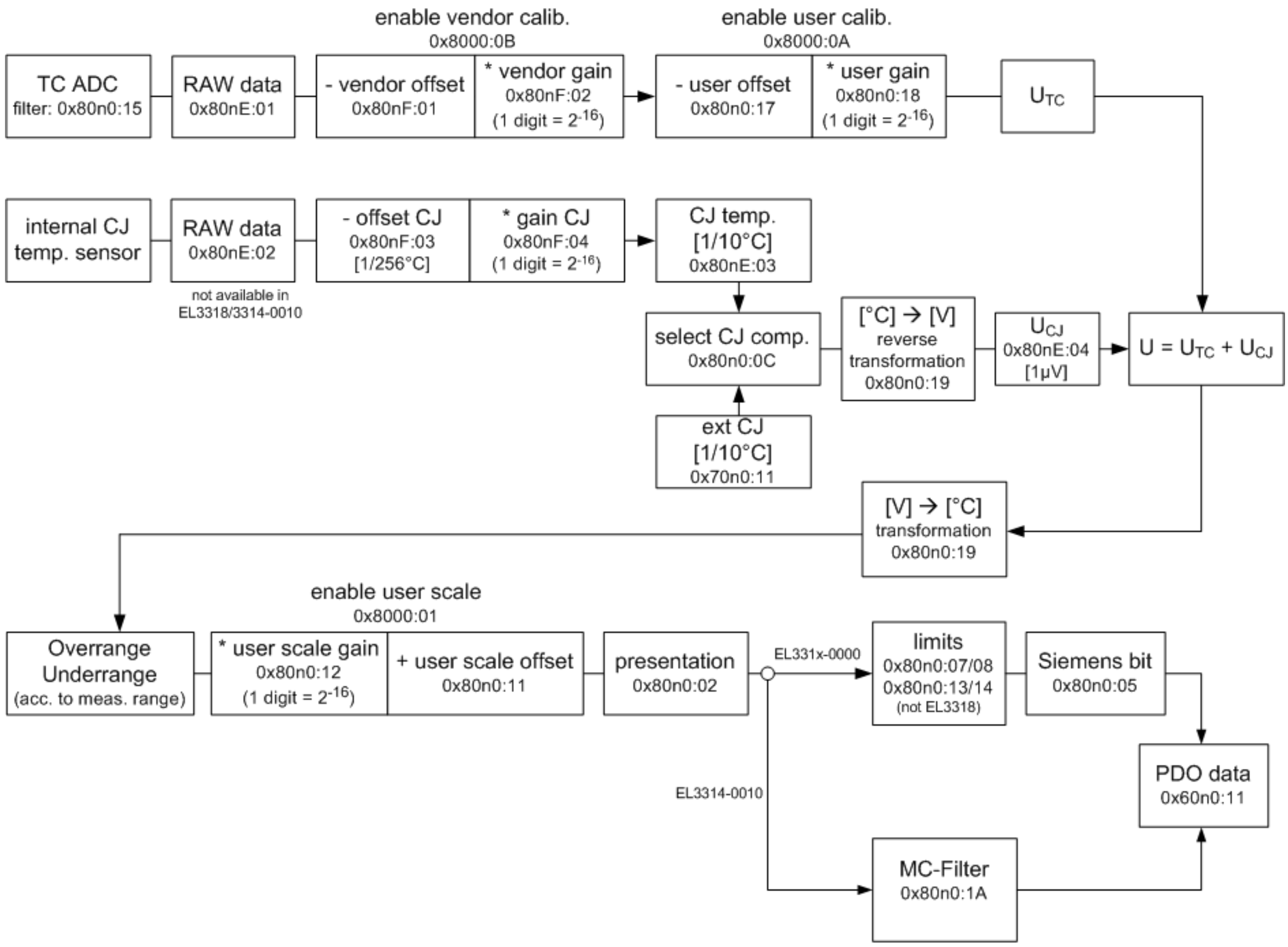



Fig. 169: EL33xx Dataflow

### 5.5.4 TwinSAFE SC process data EL3314-0090

The EL3314-0090 transmits the following process data to the TwinSAFE logic:

| Index | Name | Type | Size |
|---|---|---|---|
| 6000:11 | AI Module 1.Value | INT | 2.0 |
| 6010:11 | AI Module 2.Value | INT | 2.0 |
| 6020:11 | AI Module 2.Value | INT | 2.0 |
| 6030:11 | AI Module 2.Value | INT | 2.0 |

The process data of all four channels are transmitted by default. Via the „Process Image“ tab, the other data types of the frequency value can be selected or completely deselected in the Safety Editor.

Depending on the TwinCAT 3.1 version, process data can be renamed automatically when linking to the Safety Editor.

# 5.6 Brief instructions for commissioning / quick start

## 5.6.1 Notes on commissioning

- When operating the EL33xx analog EtherCAT terminals, high frequency superimposed signals from interfering devices (e.g. proportional valves, stepper motors or DC motor output stages) can be picked up by the terminal. In order to guarantee interference-free operation, we recommend the use of separate power supply units for the terminals and the interference-causing devices.
- Without additional protective measures, the maximum cable length from the EtherCAT Terminal to the thermocouple is 30 m. For longer cable lengths, suitable surge protection should be provided.
- A modification of the sensor circuit with additional devices such as change over switches or multiplexer decreases the measuring accuracy. We strongly advise against such modifications.
- When using the EL3314-0002, EL3314-0010 and EL3314-0030 high-precision thermocouple terminals, it is recommended to use thermocouples of a correspondingly high accuracy class. The use of compensation wires is not recommended when using the high-precision thermocouple terminals.

## 5.6.2 Commissioning of the temperature or voltage measurement

For simple commissioning of the EL331x-xxxx, the thermocouple or the voltage to be measured must first be connected to the terminal in the 2-wire connection configuration. The connection of the terminals can be found in the specific chapter "Connection" under the selected product in the Product overview.

The basic setting for a channel of the EL3314 is shown here as an example. The procedure is the same for all EL331x-xxxx terminals. It differs only in the selectable measuring ranges and the number of channels for which these settings must be made.

All channel-specific settings are located in the CoE object 0x80n0 [▸ 329], where n+1 specifies the number of the channel to be parameterized.

For simple commissioning, it is only necessary to specify the thermocouple type or the measuring range. For simple commissioning with the use of the internal cold junction measurement, make sure that the value "internal (0)" is selected in the object 0x80n0:0C [▸ 328] Cold junction compensation (see Fig. "Setting the measuring range", A). To specify the type of thermocouple or the voltage measuring range, the object 0x80n0:19 [▸ 328] TC element must be opened with a double click (see fig. "Setting the measuring range", B). There, in the dropdown list (see fig. "Setting the measuring range", C), you can choose between all possible ranges. This setting must then be made specifically for each wired channel. The measurement can then be started and the measured value is displayed in the process data in the preset display.

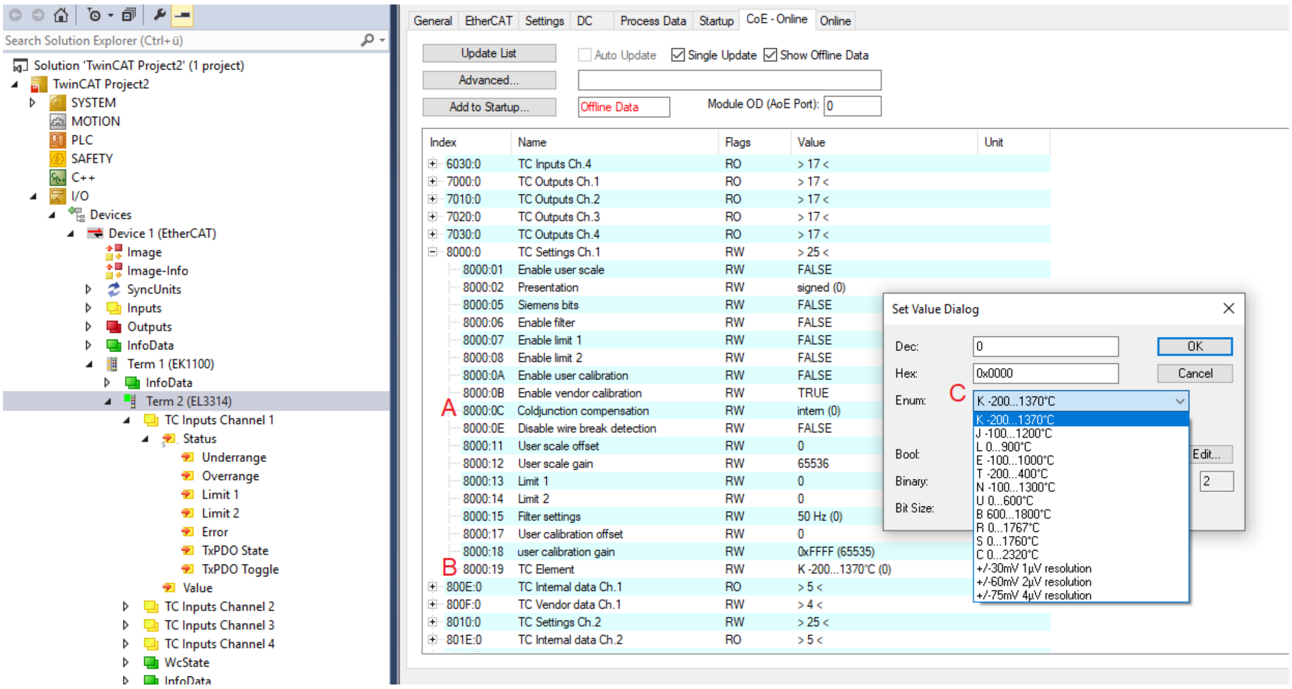



Fig. 170: Setting the measuring range

Further parameterization options for the individual channels are described in the chapter Settings.

# 5.7 Settings

## 5.7.1 Presentation, index 0x80n0:02

In the delivery state, the measured value is output in increments of 1/10° C in two's complement format (signed integer).
Index 0x80n0:02 offers the possibility to change the method of representation of the measured value.

| Measured value | Output (hexadecimal) | Output (signed integer, decimal) |
|---|---|---|
| -200.0 °C | 0nF830 | -2000 |
| -100.0 °C | 0nFC18 | -1000 |
| -0.1 °C | 0nFFFF | -1 |
| 0.0 °C | 0n0000 | 0 |
| 0.1 °C | 0n0001 | 1 |
| 100.0 °C | 0n03E8 | 1000 |
| 200.0 °C | 0n07D0 | 2000 |
| 500.0 °C | 0x1388 | 5000 |
| 850.0 °C | 0x2134 | 8500 |
| 1000.0 °C | 0x2170 | 10000 |

*Table 2: Output of measured value and process data*

- **Signed Integer:**
  The measured value is presented in two’s complement format.
  Maximum presentation range for 16 bit = -32768 .. +32767
  - Example:
  - 1000 0000 0000 0000$_{bin}$ = 0x8000$_{hex}$ = - 32768$_{dec}$
  - 1111 1111 1111 1110$_{bin}$ = 0nFFFE$_{hex}$ = - 2$_{dec}$
  - 1111 1111 1111 1111$_{bin}$ = 0nFFFF$_{hex}$ = - 1$_{dec}$
  - 0000 0000 0000 0001$_{bin}$ = 0n0001$_{hex}$ = +1$_{dec}$
  - 0000 0000 0000 0010$_{bin}$ = 0n0002$_{hex}$ = +2$_{dec}$
  - 0111 1111 1111 1111$_{bin}$ = 0x7FFF$_{hex}$ = +32767$_{dec}$
- **Absolute value with MSB as sign:**
  The measured value is output in magnitude-sign format.
  Maximum presentation range for 16 bit = -32767 .. +32767
  - Example:
  - 1111 1111 1111 1111$_{bin}$ = 0nFFFF$_{hex}$ = - 32767$_{dec}$
  - 1000 0000 0000 0010$_{bin}$ = 0x8002$_{hex}$ = - 2$_{dec}$
  - 1000 0000 0000 0001$_{bin}$ = 0x8001$_{hex}$ = - 1$_{dec}$
  - 0000 0000 0000 0001$_{bin}$ = 0n0001$_{hex}$ = +1$_{dec}$
  - 0000 0000 0000 0010$_{bin}$ = 0n0002$_{hex}$ = +2$_{dec}$
  - 0111 1111 1111 1111$_{bin}$ = 0x7FFF$_{hex}$ = +32767$_{dec}$
- High resolution (1/100 C°):
  The measured value is output in 1/100 °C steps.

## 5.7.2 Siemens bits, index 0x80n0:05

If the bit in index 0x80n0:05 is set, status displays are shown for the lowest 3 bits. In the error case "overrange" or "underrange", bit 0 is set.

## 5.7.3 Underrange, Overrange

**Undershoot and overshoot of the measuring range (underrange, overrange), index 0x60n0:02, 0x60n0:03**

- $U_k$ > $Uk_{max}$: Index 0x60n0:02 and index 0x60n0:07 (overrange and error bit) are set. The linearization of the characteristic curve is continued with the coefficients of the overrange limit up to the limit stop of the A/D converter or to the maximum value of 0x7FFF.
- $U_k$ < $Uk_{max}$: Index 0x60n0:01 and index 0x60n0:07 (underrange and error bit) are set. The linearization of the characteristic curve is continued with the coefficients of the underrange limit up to the limit stop of the A/D converter or to the minimum value of 0x8000.

For overrange or underrange the red error LED is switched on.

## 5.7.4 Notch filter (conversion times)

**Notch filter, index 0x80n0:06**

The EL33xx terminals are equipped with a digital filter. The filter performs a notch filter function and determines the conversion time of the terminal. It is parameterized via the indices 0x80n0:15. The higher the filter frequency, the faster the conversion time.

**Index 0x80n0:06**

The filter function is always active even if the bit is not set, since this is obligatory for the measurement process!

**The filter characteristics are set via index 0x8000:15**

The filter frequencies are set for all channels of the EL33xx terminals centrally via index 0x8000:15 (channel 1). The corresponding indices 0x8010:15 of the EL3312 or 0x8010:15, 0x8020:15, 0x8030:15 of the EL3314 have no parameterization function.

**Conversion time**

The conversion time is determined as follows:
No. of active channels * no. of measurements * no. of filter periods + computing time = conversion time

**Example: EL3311 (1 channel), 3 measurements (thermocouple, wire breakage, cold junction), filter 50 Hz**

1 channel * 3 measurements * (1/50 Hz) + 3 ms ≈ 63 ms

**Example: EL3314 (2 channels), 3 measurements (thermocouple, wire breakage, cold junction), filter 50 Hz**

2 channels * 3 measurements * (1/50 Hz) + 6 ms ≈ 126 ms

**Example: EL3314 (4 channels), 3 measurements (thermocouple, wire breakage, cold junction), filter 50 Hz**

4 channels * 3 measurements * (1/50 Hz) + 12 ms ≈ 252 ms

*Table 1: Typical conversion times with 3 measurements (thermocouple, broken wire, cold junction)*

| | Conversion time (update time) | | | | |
|---|---|---|---|---|---|
| **Filter frequency** | **EL3311** | **EL3312** | **EL3314** | **EL3314-0010** | **EL3318** |
| 5 Hz | 0.6 s | 1.2 s | 2.4 s | 1.6 s | 3.5 s |
| 10 Hz | 0.3 s | 0.6 s | 1.2 s | 800 ms | 1.75 s |
| 50 Hz | 63 ms | 126 ms | 250 ms | 165 ms | 380 ms |
| 60 Hz | 53 ms | 106 ms | 210 ms | 145 ms | 320 ms |
| 100 Hz | 33 ms | 66 ms | 130 ms | 86 ms | 200 ms |
| 500 Hz | 9 ms | 18 ms | 33 ms | 26 ms | 70 ms |
| 1000 Hz | 6 ms | 12 ms | 24 ms | 18 ms | 50 ms |
| 2000 Hz | 5 ms | 10 ms | 20 ms | 14 ms | 40 ms |
| 3750 Hz | 4 ms | 8 ms | 19 ms | 12 ms | 35 ms |
| 7500 Hz | 4 ms | 7 ms | 19 ms | 12 ms | 30 ms |
| 15000 Hz | 3 ms | 7 ms | 19 ms | 12 ms | 30 ms |
| 30000 Hz | 3 ms | 7 ms | 19 ms | 12 ms | 30 ms |
| mV range | 3 ms | 6 ms | 12 ms | 12 ms | 25 ms |

*Table 3: Conversion times in relation to the filter frequencies*

## 5.7.5 Limit 1 and Limit 2

**Limit 1 and limit 2, index 0x80n0:13, index 0x80n0:14 (not for EL3318)**

A temperature range can be set that is limited by the values in the indices 0x80n0:13 and 0x80n0:14. If the limit values are overshot, the bits in indices 0x80n0:07 and 0x80n0:08 are set.

The temperature value is entered with a resolution of 0.1 °C.

**Example:**

Limit 1= 30 °C
Value index 0x80n0:13 = 300

## 5.7.6 Calibration

**Vendor calibration, index 0x80n0:0B**

The vendor calibration is enabled via index 0x80n0:0B. Parameterization takes place via the indices

- 0x80nF:01
  Thermocouple offset (vendor calibration)
- 0x80nF:02
  Thermocouple gain (vendor calibration)
- 0x80nF:03
  Reference point offset [Pt1000] (vendor calibration)
- 0x80nF:04
  Reference point gain [Pt1000] (vendor calibration)

**Vendor and user calibration**

User calibration (index 0x80n0:0A) should only be performed instead of the vendor calibration (index 0x80n0:0B), but this is generally only necessary in exceptional cases.

**User calibration , index 0x80n0:0A**

User calibration is enabled via index 0x80n0:0A. Parameterization takes place via the indices

- 0x80n0:17
  Thermocouple offset (index 0x80nF:01, user calibration)
- 0x80n0:18
  Thermocouple gain (index 0x80nF:02, user calibration)

**User scaling, index 0x80n0:01**

The user scaling is enabled via index 0x80n0:01. Parameterization takes place via the indices

- 0x80n0:11
  User scaling offset

  The offset describes a vertical shift of the characteristic curve by a linear amount.
  At a resolution of 0.1°, 1 digit$_{(dec)}$ corresponds to an increase in measured value by 0.1°
  At a resolution of 0.01°, 1 digit$_{(dec)}$ corresponds to an increase in measured value by 0.01
- 0x80n0:12
  User scaling gain
-

  The default value of 65536$_{(dec)}$ corresponds to gain = 1.
  The new gain value for 2-point user calibration after offset calibration is determined as follows:

  Gain_new = reference temperature / measured value x 65536$_{(dec)}$

**Calculation of process data**

*The concept "calibration", which has historical roots at Beckhoff, is used here even if it has nothing to do with the deviation statements of a calibration certificate. Actually, this is a description of the vendor or customer calibration data/adjustment data used by the device during operation in order to maintain the assured measuring accuracy.*

The terminal constantly records measured values and saves the raw values from its A/D converter in the ADC raw value objects 0x80nE:01, 0x80nE:02. After each recording of the analog signal, the correction calculation takes place with the vendor and user calibration data as well as the user scaling, if these are activated (see following picture).

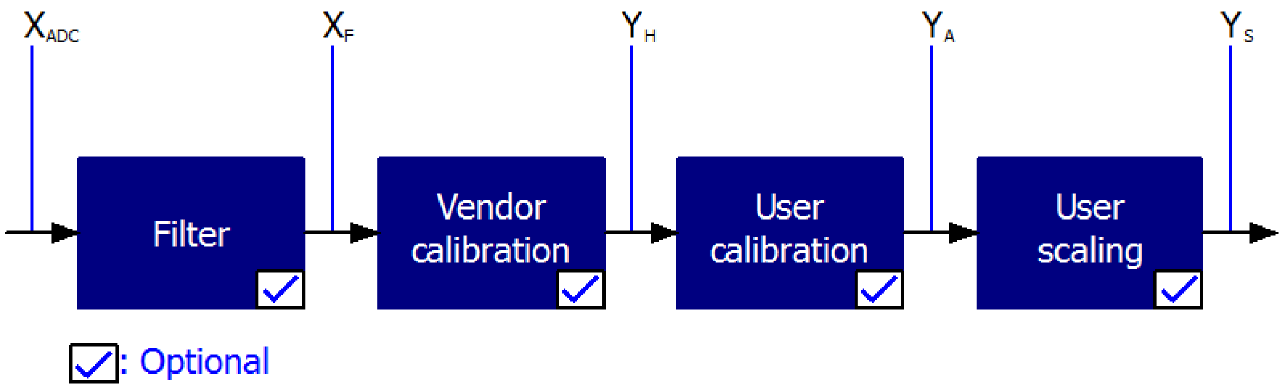



Fig. 171: *Calculation of process data*

| Calculation | Designation |
| --- | --- |
| $X_{ADC}$ | Output of the A/D converter |
| $X_F$ | Output value after the filter |
| $Y_H = (X_{ADC} – B_H) \times A_H \times 2^{-14}$ | Measured value after vendor calibration, |
| $Y_A = (Y_H – B_A) \times A_A \times 2^{-14}$ | Measured value after vendor and user calibration |
| $Y_S = Y_A \times A_S \times 2^{-16} + B_S$ | Measured value following user scaling |

*Table 2: Legend*

| Name | Designation | Index |
| --- | --- | --- |
| $X_{ADC}$ | Output value of the A/D converter | 0x80nE:01 |
| $X_F$ | Output value after the filter | - |
| $B_H$ | Vendor calibration offset (not changeable) | 0x80nF:01 |
| $A_H$ | Vendor calibration gain (not changeable) | 0x80nF:02 |
| $B_A$ | User calibration offset (can be activated via index 0x80n0:0A) | 0x80n0:17 |
| $A_A$ | User calibration gain (can be activated via index 0x80n0:0A) | 0x80n0:18 |
| $B_S$ | User scaling offset (can be activated via index 0x80n0:01) | 0x80n0:11 |
| $A_S$ | User scaling gain (can be activated via index 0x80n0:01) | 0x80n0:12 |
| $Y_S$ | Process data for controller | - |

**Measurement result**

The accuracy of the result may be reduced if the measured value is smaller than 32767 / 4 due to one or more multiplications.

## 5.7.7 Producer Codeword

**Producer Codeword**

The vendor reserves the authority for the basic calibration of the terminals. The Producer codeword is therefore at present reserved.

## 5.8 Operation with an external cold junction

The EL331x supports operation with an internal cold junction as standard. This means that the thermocouple is attached to the terminal points at the front of the terminal housing, so that the material transition and the cold junction are located at the front of the terminal housing. The terminal measures the cold junction temperature with its own internal temperature sensor and calculates the desired measuring point temperature value.

In special applications, operation with an external cold junction is required. The external cold junction is connected to the EL331x with a normal copper connection cable, the material transition then takes place in the external connection point. This is supported by the EL331x-xxxx.

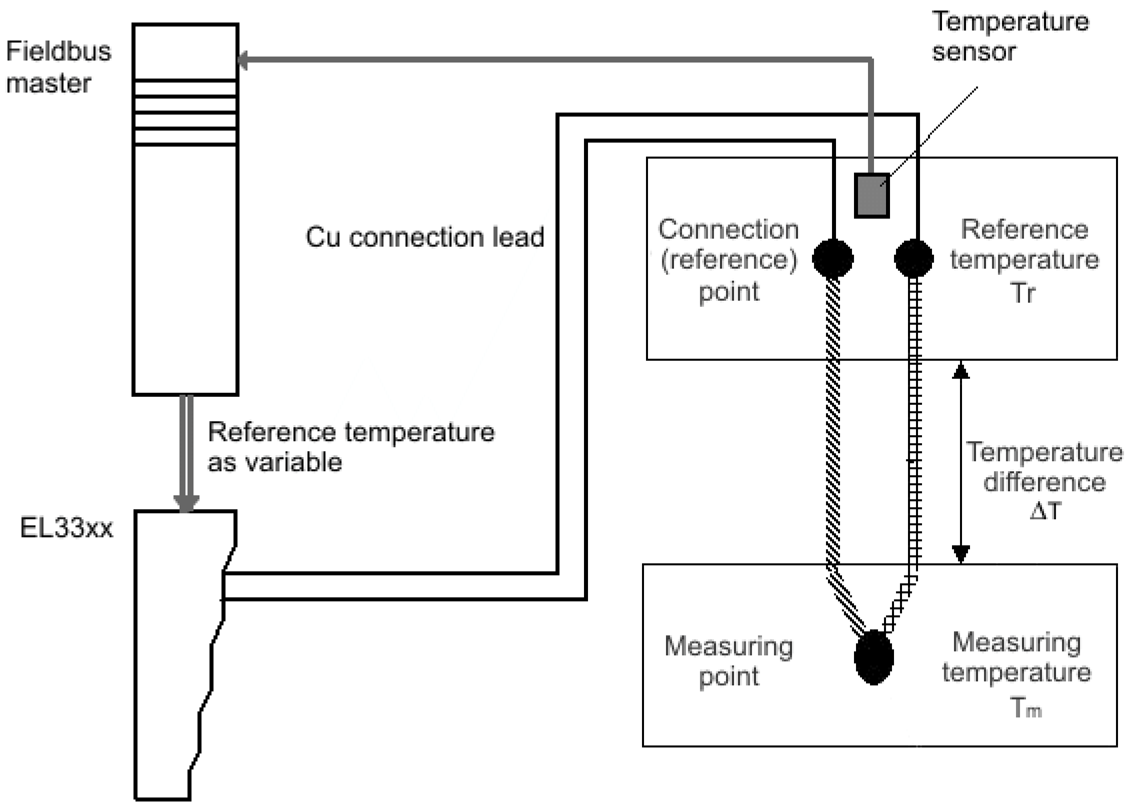



Fig. 172: External cold junction

For this operation the following must be set

- all CJCompensation PDO of the terminal must be activated, even if the "external cold junction" function is only used on isolated channels

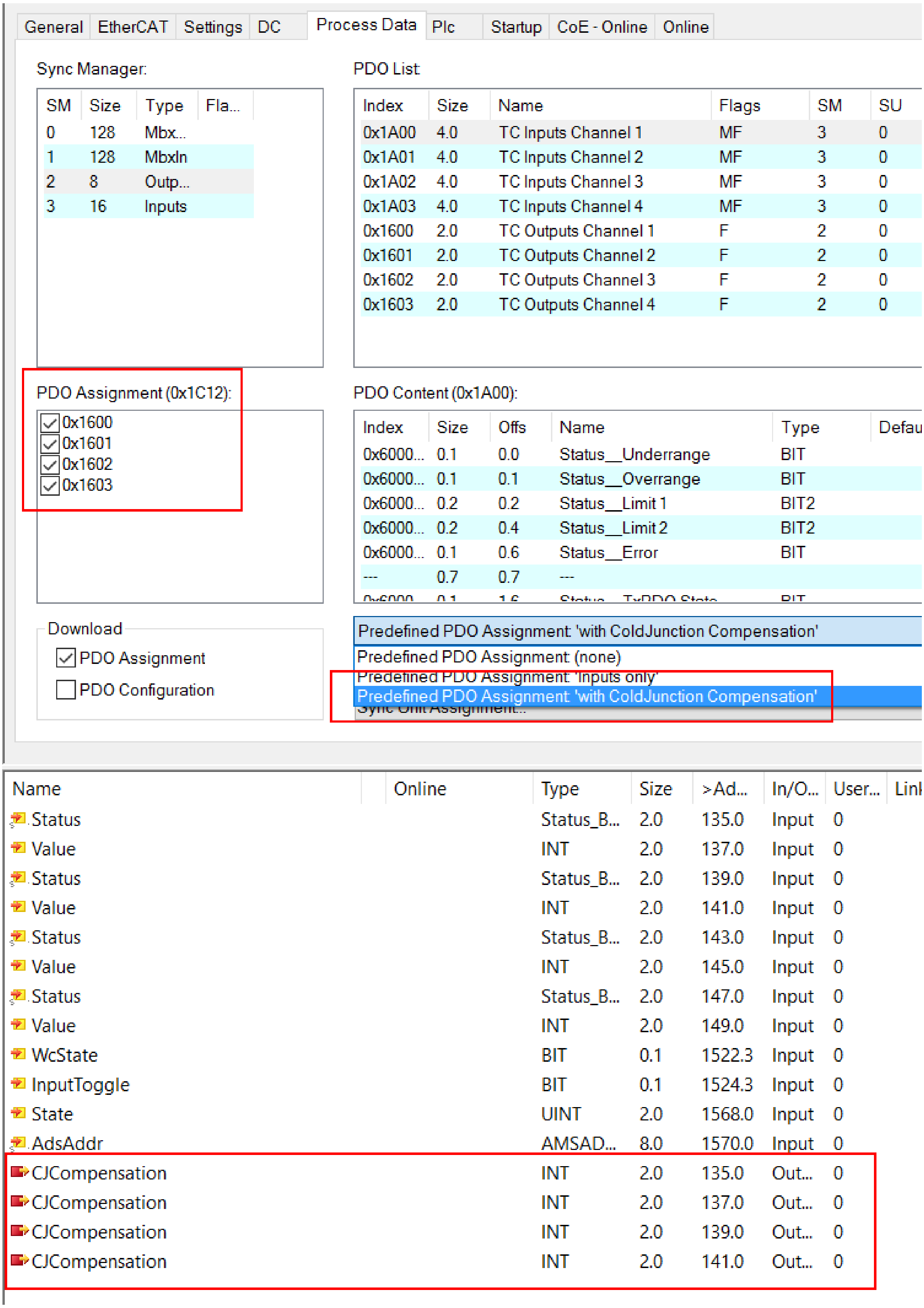



Fig. 173: Activation of all CJ-PDO via Predefined PDO

- In CoE 0x80n0:0C of the desired channel, the external cold junction calculation must be activated by the value "2" (external process data).

| | | | |
|---|---|---|---|
| 8000:0 | TC Settings Ch.1 | RW | > 25 < |
| 8000:01 | Enable user scale | RW | FALSE |
| 8000:02 | Presentation | RW | signed (0) |
| 8000:05 | Siemens bits | RW | FALSE |
| 8000:06 | Enable filter | RW | FALSE |
| 8000:07 | Enable limit 1 | RW | FALSE |
| 8000:08 | Enable limit 2 | RW | FALSE |
| 8000:0A | Enable user calibration | RW | FALSE |
| 8000:0B | Enable vendor calibration | RW | TRUE |
| 8000:0C | Coldjunction compensation | RW | extern processdata (1/10°C) (2) |
| 8000:11 | User scale offset | RW | 0 |

Fig. 174: Setting the cold junction billing in the CoE

The cold junction temperature $T_v$ must now be recorded by a separate temperature sensor at the cold junction and fed to the terminal via the fieldbus master and the fieldbus as a linked variable ("external") (see Fig. *External cold junction*).

The separate measurement can technically be done via another thermocouple connected to an EL331x, or an RTD element connected to an EL32xx, or any other temperature measurement whose value is known to the controller.

The EL331x then supplies the measured value *Value*, taking into account the temperature value supplied with *CJCompensation*:

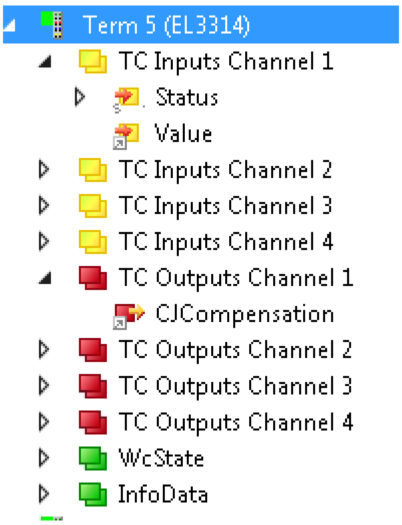



Fig. 175: Display of the "Value" in the TwinCAT tree

The comparison data is written to CoE 0x70n0:11.

**Alternative to cold junction measurement**

As an alternative to the procedure described above, the cold junction can be maintained at a defined temperature through ice water (0° C), for example. In this case, the temperature is known without measurement of the cold junction temperature (Fig. *External cold junction*) and can be reported to the EL33xx via the process data.

**EL3314-0002, EL3314-0010**

The EL3314-0002 since FW01 and the EL3314-0010 since FW03 does also support the external reference point measurement. The user have to ensure, that an application of external cold junction measurement have no negative effect to the measurement accuracy.

## 5.9 Interference from equipment

When operating the EL33xx analog EtherCAT terminals, high frequency superimposed signals from interfering devices (e.g. proportional valves, stepper motors or DC motor output stages) can be picked up by the terminal. In order to guarantee interference-free operation, we recommend the use of separate power supply units for the terminals and the interference-causing devices.

## 5.10 Wire break detection

The EL33xx-xxxx terminals provides a wire break detection of the connected thermocouple. A periodical testing current of several µA will be given to the thermocouple for detection. No voltage measurement takes place during test.

Due to particular cases, the testing current could have a disturbing effect, the wire break detection can be disabled by CoE (object 0x80n0:0E, „Disable wire break detection“) since following firmware versions:

| | **EL3311** | **EL3312** | **EL3314** | **EL3314-0002** | **EL3314-0010**<br>**EL3314-0020** | **EL3314-0090** | **EL3318** |
|---|---|---|---|---|---|---|---|
| Firmware | Disabling not possible | | 04 | 01 | 04 | 02 | 03 |
| ESI/<br>Revision | | | 0024 | 0016 | 0021 | 0017 | 0021 |

# 5.11 Object description and parameterization

**EtherCAT XML Device Description**

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)**

The EtherCAT device is parameterized via the CoE-Online tab [▶ 290] (double-click on the respective object) or via the Process Data tab [▶ 287](allocation of PDOs). Please note the following general CoE notes [▶ 216] when using/manipulating the CoE parameters:

- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- use "CoE reload" for resetting changes

**Introduction**

The CoE overview contains objects for different intended applications:

- Objects required for parameterization during commissioning:
  - Restore object [▶ 328] index 0x1011
  - Configuration data [▶ 329] index 0x80n0 (described in more detail in Settings of the configuration data in the CoE)
- Profile-specific objects:
  - Configuration data (manufacturer-specific) [▶ 331] index 0x80nF
  - Input data index 0x60n0
  - Output data index 0x70n0
  - Information and diagnostic data index 0x80nE, 0xF000, 0xF008, 0xF010
- Standard objects

The following section first describes the objects required for normal operation, followed by a complete overview of missing objects.

## 5.11.1 Restore object

**Index 1011 Restore default parameters**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1011:0 | Restore default parameters [▶ 416] | Restore default parameters | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1011:01 | SubIndex 001 | If this object is set to **"0x64616F6C"** in the set value dialog, all backup objects are reset to their delivery state. | UINT32 | RW | 0x00000000 ($0_{dec}$) |

## 5.11.2 EL3311 - Object description and parameterization

### 5.11.2.1 EL3311 - Configuration data

**Index 8000 TC Settings**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8000:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x19 ($25_{dec}$) |
| 8000:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:02 | Presentation | 0: Signed presentation, 0.1°C/digit<br>1: Absolute value with MSB as sign (signed amount representation), 0.1°C/digit<br>2: High resolution (0.01°C/digit) | BIT3 | RW | 0x00 ($0_{dec}$) |
| 8000:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:06 | Enable filter | This setting generally activates the basic filters in object 0x8000:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 8000:07 | Enable limit 1 | Limit 1 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:08 | Enable limit 2 | Limit 2 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 8000:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 8000:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 8000:11 | User scale offset | User scaling offset<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000)<br>Adjustable values: -2147483648…2147483647 | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 8000:13 | Limit 1 | First limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:14 | Limit 2 | Second limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:15 | Filter settings | This object determines the basic digital filter settings.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3,75 kHz<br>7: 7,5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11:10 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 8000:19 | TC Element | Thermocouple (implemented temperature range) or measured value<br>0: Type: K -200°C to 1370°C<br>1: Type: J -100°C to 1200°C<br>2: Type: L  0°C to 900°C<br>3: Type: E -100°C to 1000°C<br>4: Type: T -200°C to 400°C<br>5: Type: N -100°C to 1300°C<br>6: Type: U 0°C to 600°C<br>7: Type: B 600°C to 1800°C<br>8: Type: R 0°C to 1767°C<br>9: Type: S 0°C to 1760°C<br>10: Type: C 0°C to 2320°C | UINT16 | RW | 0x0000 ($0_{dec}$) |

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| | | 100: ± 30 mV (1 µV resolution)<br>101: ± 60 mV (2 µV resolution)<br>102: ± 75 mV (4 µV resolution) | | | |

## 5.11.2.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

## 5.11.2.3 EL3311 - Configuration data (vendor-specific)

### Index 800F TC Vendor data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 800F:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 800F:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT166 | RW | 0x002D ($45_{dec}$) |
| 800F:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT16 | RW | 0x5B9A ($23450_{dec}$) |
| 800F:03 | Calibration offset CJ | Cold junction offset [Pt1000] (vendor calibration) | INT16 | RW | 0x01B8 ($440_{dec}$) |
| 800F:04 | Calibration gain CJ | Cold junction gain [Pt1000] (vendor calibration) | UINT16 | RW | 0x39B2 ($14770_{dec}$) |

## 5.11.2.4 EL3311 - Input data

### Index 6000 TC Inputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6000:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 6000:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x6000:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:03 | Limit 1 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 6000:05 | Limit 2 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 6000:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 6000:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x8000:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.2.5 EL3311 - Output data

#### Index 7000 TC Outputs

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 7000:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 7000:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▶ 329], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.2.6 EL3311 - Information and diagnostic data

#### Index 800E TC Internal data

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 800E:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x05 ($5_{dec}$) |
| 800E:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 800E:02 | ADC raw value PT1000 | ADC raw value PT1000 | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 800E:03 | CJ temperature | Cold junction temperature (resolution [1/10]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 800E:04 | CJ voltage | Cold junction voltage (resolution 1 µV) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 800E:05 | CJ resistor | Cold junction resistance (PT1000 temperature sensor) (resolution 1/10 Ohm) | UINT16 | RO | 0x0000 ($0_{dec}$) |

#### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0001 ($1_{dec}$) |

#### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### 5.11.2.7 EL3311 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

#### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [ ] |

#### Index 1008 Device name

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

#### 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 | [ ] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 1600 RxPDO-Map

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1600:0 | RxPDO-Map | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 1600:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7000 (TC Outputs), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x7000:11, 16 |

### Index 1A00 TxPDO-Map

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A00:0 | TxPDO-MapCh.1 | PDO Mapping TxPDO 1 | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A00:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x01 (Underrange)) | UINT32 | RW | 0x6000:01, 1 |
| 1A00:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x02 (Overrange)) | UINT32 | RW | 0x6000:02, 1 |
| 1A00:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x03 (Limit 1)) | UINT32 | RW | 0x6000:03, 2 |
| 1A00:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x05 (Limit 2)) | UINT32 | RW | 0x6000:05, 2 |
| 1A00:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x07 (Error)) | UINT32 | RW | 0x6000:07, 1 |
| 1A00:06 | SubIndex 006 | 6. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A00:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x6000:0F, 1 |
| 1A00:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x6000 (TxPDO-ParCh.1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x6000:10, 1 |
| 1A00:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x6000 (TC Inputs Ch.1), entry 0x11 (Value)) | UINT32 | RW | 0x6000:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x01 ($1_{dec}$) |
| 1C12:01 | Subindex 001 | 1. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x1601 |

### Index 1C13 TxPDO assign

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x01 ($1_{dec}$) |
| 1C13:01 | Subindex 001 | 1. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A01 |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▶ 336], 0x1C33:09 are updated with the maximum measured values.<br>For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▶ 336] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▶ 336] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▶ 336] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▶ 336] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the in-puts (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▶ 336] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▶ 336] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▶ 336] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▶ 336] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.11.3 EL3312 - Object description and parameterization

### 5.11.3.1 EL3312 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 2 (0 ≤ n ≤ 1))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x19 ($25_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:02 | Presentation | 0: Signed presentation, 0.1°C/digit<br>1: Absolute value with MSB as sign (signed amount representation), 0.1°C/digit<br>2: High resolution (0.01°C/digit) | BIT3 | RW | 0x00 ($0_{dec}$) |
| 80n0:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:07 | Enable limit 1 | Limit 1 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:08 | Enable limit 2 | Limit 2 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000)<br>Adjustable values: -2147483648…2147483647 | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 80n0:13 | Limit 1 | First limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:14 | Limit 2 | Second limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3.75 kHz<br>7: 7.5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11:10 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 80n0:19 | TC Element | Thermocouple (implemented temperature range) or measured value<br><br>0: Type: K -200°C to 1370°C<br>1: Type: J -100°C to 1200°C<br>2: Type: L 0°C to 900°C<br>3: Type: E -100°C to 1000°C<br>4: Type: T -200°C to 400°C<br>5: Type: N -100°C to 1300°C<br>6: Type: U 0°C to 600°C<br>7: Type: B 600°C to 1800°C<br>8: Type: R 0°C to 1767°C<br>9: Type: S 0°C to 1760°C<br>10: Type: C 0°C to 2320°C | UINT16 | RW | 0xFFFF ($65535_{dec}$) |

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| | | 100: ± 30 mV (1 µV resolution)<br>101: ± 60 mV (2 µV resolution)<br>102: ± 75 mV (4 µV resolution) | | | |

## 5.11.3.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

## 5.11.3.3 EL3312 - Configuration data (vendor-specific)

### Index 80nF TC Vendor data (for Ch. 1 – 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT166 | RW | 0x002D ($45_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT16 | RW | 0x5B9A ($23450_{dec}$) |
| 80nF:03 | Calibration offset CJ | Cold junction offset [Pt1000] (vendor calibration) | INT16 | RW | 0x01B8 ($440_{dec}$) |
| 80nF:04 | Calibration gain CJ | Cold junction gain [Pt1000] (vendor calibration) | UINT16 | RW | 0x39B2 ($14770_{dec}$) |

## 5.11.3.4 EL3312 - Input data

### Index 60n0 TC Inputs (for Ch. 1 - 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:03 | Limit 1 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:05 | Limit 2 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.3.5 EL3312 - Output data

#### Index 70n0 TC Outputs (for Ch. 1 - 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▶ 337], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.3.6 EL3312 - Information and diagnostic data

#### Index 80nE TC Internal data (for Ch. 1 - 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x05 ($5_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:02 | ADC raw value PT1000 | ADC raw value PT1000 | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature (resolution [1/10]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:04 | CJ voltage | Cold junction voltage (resolution 1 µV) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:05 | CJ resistor | Cold junction resistance (PT1000 temperature sensor) (resolution 1/10 Ohm) | UINT16 | RO | 0x0000 ($0_{dec}$) |

#### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0002 ($2_{dec}$) |

#### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### 5.11.3.7 EL3312 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

#### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [ ] |

#### Index 1008 Device name

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

#### 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 | [ ] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 2 (0 ≤ n ≤ 1))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch.n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x03 (Limit 1)) | UINT32 | RW | 0x60n0:03, 2 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x05 (Limit 2)) | UINT32 | RW | 0x60n0:05, 2 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TxPDO-ParCh.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 2 (1 ≤ n ≤ 2))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 2 (1 ≤ n ≤ 2))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▸ 344], 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 344] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 344] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 344] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 344] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the in-puts (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 344] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 344] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 344] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 344] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.11.4 EL3314 - Object description and parameterization

### 5.11.4.1 EL3314 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x19 ($25_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:02 | Presentation | 0: Signed presentation, 0.1°C/digit<br>1: Absolute value with MSB as sign (signed amount representation), 0.1°C/digit<br>2: High resolution (0.01°C/digit) | BIT3 | RW | 0x00 ($0_{dec}$) |
| 80n0:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:07 | Enable limit 1 | Limit 1 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:08 | Enable limit 2 | Limit 2 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 80n0:0E | Disable wire break detection | 0: Wire break detection is active<br>1: Wire break detection is not active | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000)<br>Adjustable values: -2147483648…2147483647 | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 80n0:13 | Limit 1 | First limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:14 | Limit 2 | Second limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3.75 kHz<br>7: 7.5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11:10 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 80n0:19 | TC Element | Thermocouple (implemented temperature range) or measured value<br><br>0: Type: K -200°C to 1370°C<br>1: Type: J -100°C to 1200°C<br>2: Type: L 0°C to 900°C<br>3: Type: E -100°C to 1000°C<br>4: Type: T -200°C to 400°C<br>5: Type: N -100°C to 1300°C<br>6: Type: U 0°C to 600°C<br>7: Type: B 600°C to 1800°C | UINT16 | RW | 0x0000 ($0_{dec}$) |

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| | | 8: Type: R 0°C to 1767°C<br>9: Type: S 0°C to 1760°C<br>10: Type: C 0°C to 2320°C<br>100: ± 30 mV (1 µV resolution)<br>101: ± 60 mV (2 µV resolution)<br>102: ± 75 mV (4 µV resolution) | | | |

### 5.11.4.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

### 5.11.4.3 EL3314 - Configuration data (vendor-specific)

**Index 80nF TC Vendor data (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT166 | RW | 0x002D ($45_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT16 | RW | 0x5B9A ($23450_{dec}$) |
| 80nF:03 | Calibration offset CJ | Cold junction offset [Pt1000] (vendor calibration) | INT16 | RW | 0x01B8 ($440_{dec}$) |
| 80nF:04 | Calibration gain CJ | Cold junction gain [Pt1000] (vendor calibration) | UINT16 | RW | 0x39B2 ($14770_{dec}$) |

### 5.11.4.4 EL3314 - Input data

**Index 60n0 TC Inputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:03 | Limit 1 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:05 | Limit 2 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

## 5.11.4.5 EL3314 - Output data

### Index 70n0 TC Outputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▶ 345], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

## 5.11.4.6 EL3314 - Information and diagnostic data

### Index 80nE TC Internal data (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x05 ($5_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:02 | ADC raw value PT1000 | ADC raw value PT1000 | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature (resolution [1/10]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:04 | CJ voltage | Cold junction voltage (resolution 1 µV) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:05 | CJ resistor | Cold junction resistance (PT1000 temperature sensor) (resolution 1/10 Ohm) | UINT16 | RO | 0x0000 ($0_{dec}$) |

### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0004 ($4_{dec}$) |

### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

## 5.11.4.7 EL3314 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [ ] |

### Index 1008 Device name

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

### 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 | [ ] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch. n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x03 (Limit 1)) | UINT32 | RW | 0x60n0:03, 2 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x05 (Limit 2)) | UINT32 | RW | 0x60n0:05, 2 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TxPDO-Par Ch.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▸ 352], 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 352] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 352] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 352] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 352] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 352] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 352] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 352] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 352] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.11.5 EL3314-0002 - Object description and parameterization

### 5.11.5.1 EL3314-0002 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x1A ($26_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:02 | Presentation | 0: 0.1°C/digit<br>2: 0.01°C/digit (default)<br>3: 0.001°C/digit | BIT3 | RW | 0x00 ($0_{dec}$) |
| 80n0:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:07 | Enable limit 1 | Limit 1 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:08 | Enable limit 2 | Limit 2 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 80n0:0E | Disable wire break detection | 0: Wire break detection is active<br>1: Wire break detection is not active | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000) | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 80n0:13 | Limit 1 | First limit value for setting the status bits (resolution 0.1 °C) | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:14 | Limit 2 | Second limit value for setting the status bits (resolution 0.1 °C) | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings.<br>The possible settings are sequentially numbered.<br>0: 2.5 Hz<br>1: 5 Hz<br>2: 10 Hz<br>3: 16.6 Hz<br>4: 20 Hz<br>5: 50 Hz<br>6: 60 Hz<br>7: 100 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 80n0:19 | TC Element | Thermocouple<br>Implemented temperature range<br>0: Type: K -270°C to 1372°C<br>1: Type: J -210°C to 1200°C<br>2: Type: L -50°C to 900°C<br>3: Type: E -270°C to 1000°C<br>4: Type: T -270°C to 400°C<br>5: Type: N -270°C to 1300°C<br>6: Type: U -50°C to 600°C<br>7: Type: B 200°C to 1820°C<br>8: Type: R -50°C to 1768°C<br>9: Type: S -50°C to 1768°C<br>10: Type: C 0°C to 2329°C<br>100: ± 78 mV (1 µV resolution)<br>103: ± 2.5 V (1 µV resolution) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:1A | MC filter | The EL3314-0002, EL3314-0010 has an optional additional software filter in the microcontroller (MC), which can be parameterized via this setting | UINT16 | RW | 0x0000 ($0_{dec}$) |

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| | | 0: Inactive<br>1: IIR 1<br>2: IIR 2<br>3: IIR 3<br>4: IIR 4 | | | |

## 5.11.5.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

## 5.11.5.3 EL3314-0002 - Configuration data (vendor-specific)

### Index 80nF TC Vendor data (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x05 ($5_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT32 | RW | 0x00000000 ($0_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT32 | RW | 0x003BB400 ($3912704_{dec}$) |
| 80nF:03 | Calibration offset 2,5 V | Offset 2.5 V-Measurement (vendor calibration) | INT32 | RW | 0x00000000 ($0_{dez}$) |
| 80nF:04 | Calibration offset 2,5 V | Gain 2.5 V-Measurement (vendor calibration) | UINT32 | RW | 0x001312D ($1250000_{dec}$) |
| 80nF:05 | CJ Offset 1/256 °C | Offset Coldjunction (vendor calibration) | UINT32 | RW | 0x00000000 ($0_{dez}$) |

## 5.11.5.4 EL3314-0002 - Input data

### Index 60n0 TC Inputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:03 | Limit 1 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:05 | Limit 2 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.5.5 EL3314-0002 - Output data

#### Index 70n0 TC Outputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▸ 353], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.5.6 EL3314-0002 - Information and diagnostic data

#### Index 80nE TC Internal data (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature (resolution [1/100]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:04 | CJ voltage | Cold junction voltage (resolution 10 nV) | INT16 | RO | 0x0000 ($0_{dec}$) |

#### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0004 ($4_{dec}$) |

#### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### 5.11.5.7 EL3314-0002 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

#### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [] |

#### Index 1008 Device name

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

#### 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 | [] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch.n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (4 bits align) | UINT32 | RW | 0x0000:00, 4 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TxPDO-Par Ch.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▶ 359], 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 359] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 359] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 359] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 359] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 359] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 359] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 359] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 359] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### 5.11.6 EL3314-0010, EL3314-0020, EL3314-0030 - Object description and parameterization

#### 5.11.6.1 EL3314-0010 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x1A (26$_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 80n0:02 | Presentation | 0: 0.1°C/digit<br>2: 0.01°C/digit (default)<br>3: 0.001°C/digit | BIT3 | RW | 0x00 (0$_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 (1$_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 (1$_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 (0$_{dec}$) |
| 80n0:0E | Disable wire break detection | 0: Wire break detection is active<br>1: Wire break detection is not active | BOOLEAN | RW | 0x00 (0$_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset | INT16 | RW | 0x0000 (0$_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000) | INT32 | RW | 0x00010000 (65536$_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings. The possible settings are sequentially numbered.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3,75 kHz<br>7: 7,5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11: 10 Hz | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 (0$_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF (65535$_{dec}$) |
| 80n0:19 | TC Element | Thermocouple<br>Implemented temperature range<br>0: Type: K -270°C to 1372°C<br>1: Type: J -210°C to 1200°C<br>2: Type: L -50°C to 900°C<br>3: Type: E -270°C to 1000°C<br>4: Type: T -270°C to 400°C<br>5: Type: N -270°C to 1300°C<br>6: Type: U -50°C to 600°C<br>7: Type: B 200°C to 1820°C<br>8: Type: R -50°C to 1768°C<br>9: Type: S -50°C to 1768°C<br>10: Type: C 0°C to 2329°C<br>104: ± 78 mV (10 nV resolution) | UINT16 | RW | 0x0000 (0$_{dec}$) |
| 80n0:1A | MC filter | The EL3314-0002, EL3314-0010 has an optional additional software filter in the microcontroller (MC), which can be parameterized via this setting<br>0: Inactive<br>1: IIR 1<br>2: IIR 2<br>3: IIR 3<br>4: IIR 4<br>5: FIR 4<br>6: FIR 8<br>7: FIR 16<br>8: FIR 32 | UINT16 | RW | 0x0000 (0$_{dec}$) |

### 5.11.6.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

### 5.11.6.3 EL3314-0010 - Configuration data (vendor-specific)

**Index 80nF TC Vendor data (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT32 | RW | 0x00000000 ($0_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT32 | RW | 0x00EE6B28 ($15625000_{dec}$) |
| 80nF:03 | CJ Offset 1/256 °C | Cold junction offset (vendor calibration) | INT32 | RW | 0x00000000 ($0_{dec}$) |

### 5.11.6.4 EL3314-0010 - Input data

**Index 60n0 TC Inputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.6.5 EL3314-0010 - Output data

**Index 70n0 TC Outputs (for Ch. 1 - 4 (0 ≤ n ≤  3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▶ 360], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.6.6 EL3314-0010 - Information and diagnostic data

**Index 80nE TC Internal data (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature  (resolution [1/100]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:04 | CJ voltage | Cold junction voltage  (resolution 10 nV) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0004 ($4_{dec}$) |

### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

## 5.11.6.7 EL3314-0010 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [ ] |

### Index 1008 Device name

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

### 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 | [ ] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch.n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (4 bits align) | UINT32 | RW | 0x0000:00, 4 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TxPDO-Par Ch.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▸ 366], 0x1C33:09 are updated with the maximum measured values.<br>For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▸ 366] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▸ 366] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▸ 366] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▸ 366] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the in-puts (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▸ 366] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▸ 366] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▸ 366] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▸ 366] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.11.7 EL3314-0090 - Object description and parameterization

### 5.11.7.1 EL3314-0090 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 4 (0 ≤ n ≤ 3))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x19 ($25_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:02 | Presentation | 0: Signed presentation, 0.1°C/digit<br>1: Absolute value with MSB as sign (signed amount representation), 0.1°C/digit<br>2: High resolution (0.01°C/digit) | BIT3 | RW | 0x00 ($0_{dec}$) |
| 80n0:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:07 | Enable limit 1 | Limit 1 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:08 | Enable limit 2 | Limit 2 enabled | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 80n0:0E | Disable wire break detection | 0: Wire break detection is active<br>1: Wire break detection is not active | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000)<br>Adjustable values: -2147483648…2147483647 | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 80n0:13 | Limit 1 | First limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:14 | Limit 2 | Second limit value for setting the status bits (resolution 0.1 °C)<br>Adjustable values: -32768…32767 | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3.75 kHz<br>7: 7.5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11:10 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 80n0:19 | TC Element | Thermocouple (implemented temperature range) or measured value<br><br>0: Type: K -200°C to 1370°C<br>1: Type: J -100°C to 1200°C<br>2: Type: L 0°C to 900°C<br>3: Type: E -100°C to 1000°C<br>4: Type: T -200°C to 400°C<br>5: Type: N -100°C to 1300°C<br>6: Type: U 0°C to 600°C<br>7: Type: B 600°C to 1800°C | UINT16 | RW | 0x0000 ($0_{dec}$) |

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| | | 8: Type: R 0°C to 1767°C<br>9: Type: S 0°C to 1760°C<br>10: Type: C 0°C to 2320°C<br>100: ± 30 mV (1 µV resolution)<br>101: ± 60 mV (2 µV resolution)<br>102: ± 75 mV (4 µV resolution) | | | |

### Index 8040 TSC Settings

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 8040:0 | TSC Settings [▶ 309] | Max. subindex | UINT8 | RO | 0x02 ($2_{dec}$) |
| 8040:01 | Address | TwinSAFE SC Address | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 8040:02 | Connection Mode | Selection of TwinSAFE SC CRC | UINT32 | RO | 0x00000000 ($0_{dec}$) |

## 5.11.7.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

## 5.11.7.3 EL3314-0090 - Configuration data (vendor-specific)

### Index 80nF TC Vendor data (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x04 ($4_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT166 | RW | 0x002D ($45_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT16 | RW | 0x5B9A ($23450_{dec}$) |
| 80nF:03 | Calibration offset CJ | Cold junction offset [Pt1000] (vendor calibration) | INT16 | RW | 0x01B8 ($440_{dec}$) |
| 80nF:04 | Calibration gain CJ | Cold junction gain [Pt1000] (vendor calibration) | UINT16 | RW | 0x39B2 ($14770_{dec}$) |

## 5.11.7.4 EL3314-0090 - Input data

### Index 60n0 TC Inputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded.<br>("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:03 | Limit 1 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:05 | Limit 2 | Limit value monitoring<br><br>0: not activated<br>1: limit range exceeded<br>2: limit range undershot | BIT2 | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value<br>(resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### Index 6040 TSC Slave Frame Elements (only EL3314-0090)

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 6040:0 | TSC Slave Frame Elements [▸ 309] | Max. subindex | UINT8 | RO | 0x06 ($7_{dec}$) |
| 6040:01 | TSC__Slave Cmd | reserved | UINT8 | RO | 0x00 ($0_{dec}$) |
| 6040:02 | TSC__Slave ConnID | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 6040:03 | TSC__Slave CRC_0 | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 6040:04 | TSC__Slave CRC_1 | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 6040:05 | TSC__Slave CRC_2 | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 6040:06 | TSC__Slave CRC_3 | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |

## 5.11.7.5 EL3314-0090 - Output data

### Index 70n0 TC Outputs (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▸ 367], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### Index 7040 TSC Master Frame Elements

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 7040:0 | TSC Master Frame Elements | Max. subindex | UINT8 | RO | 0x03 ($3_{dec}$) |
| 7040:01 | TSC__Master Cmd | reserved | UINT8 | RO | 0x00 ($0_{dec}$) |
| 7040:02 | TSC__Master ConnID | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 7040:03 | TSC__Master CRC_0 | reserved | UINT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.7.6 EL3314-0090 - Information and diagnostic data

#### Index 80nE TC Internal data (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x05 ($5_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:02 | ADC raw value PT1000 | ADC raw value PT1000 | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature (resolution [1/10]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:04 | CJ voltage | Cold junction voltage (resolution 1 µV) | INT16 | RO | 0x0000 ($0_{dec}$) |
| 80nE:05 | CJ resistor | Cold junction resistance (PT1000 temperature sensor) (resolution 1/10 Ohm) | UINT16 | RO | 0x0000 ($0_{dec}$) |

#### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0004 ($4_{dec}$) |

#### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### 5.11.7.7 EL3314-0090 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

#### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [] |

#### Index 1008 Device name

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

#### 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 | [] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 4 (0 ≤ n ≤ 3))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch. n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x09 ($9_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x03 (Limit 1)) | UINT32 | RW | 0x60n0:03, 2 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x05 (Limit 2)) | UINT32 | RW | 0x60n0:05, 2 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TxPDO-Par Ch.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1604 TSC RxPDO-Map Master Message

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1604:0 | TSC RxPDO-Map Master Message | PDO Mapping RxPDO | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1604:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x01 (TSC__Master Cmd)) | UINT32 | RO | 0x7040:01, 8 |
| 1604:02 | SubIndex 002 | 2. PDO Mapping entry (8 bits align) | UINT32 | RO | 0x0000:00, 8 |
| 1604:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x03 (TSC__Master CRC_0)) | UINT32 | RO | 0x7040:03, 16 |
| 1604:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x7040 (TSC Master Frame Elements), entry 0x02 (TSC__Master ConnID)) | UINT32 | RO | 0x7040:02, 16 |

### Index 1A04 TSC TxPDO-Map Slave Message

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A04:0 | TSC TxPDO-Map Slave Message | PDO Mapping TxPDO | UINT8 | RW | 0x0A ($10_{dec}$) |
| 1A04:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x01 (TSC__Slave Cmd)) | USINT8 | RW | 0x6040:01, 8 |
| 1A04:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x11 (Counter value)) | INT16 | RW | 0x6000:11, 16 |
| 1A04:03 | SubIndex 003 | 3. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x03 (TSC__Slave CRC_0)) | UINT16 | RW | 0x6040:03, 16 |
| 1A04:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x6010 (ENC Inputs), entry 0x11 (Counter value)) | INT16 | RW | 0x6010:11, 16 |
| 1A04:05 | SubIndex 005 | 5. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x04 (TSC__Slave CRC_1)) | UINT16 | RW | 0x6040:04, 16 |
| 1A04:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x6020 (ENC Inputs), entry 0x11 (Counter value)) | INT16 | RW | 0x6020:11, 16 |
| 1A04:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x05 (TSC__Slave CRC_2)) | UINT16 | RW | 0x6040:05, 16 |
| 1A04:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x6030 (ENC Inputs), entry 0x11 (Counter value)) | INT16 | RW | 0x6030:11, 16 |
| 1A04:09 | SubIndex 009 | 9. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x06 (TSC__Slave CRC_3)) | UINT16 | RW | 0x6040:06, 16 |
| 1A04:0A | SubIndex 010 | 10. PDO Mapping entry (object 0x6040 (TSC Slave Frame Elements), entry 0x02 (TSC__Slave ConnID)) | UINT16 | RW | 0x6040:02, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 4 (1 ≤ n ≤ 4))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

## Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0x8007 ($32775_{dec}$) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▸ 375], 0x1C33:09 are updated with the maximum measured values.<br>For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▶ 375] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▶ 375] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▶ 375] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▶ 375] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the in-puts (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▶ 375] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▶ 375] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▶ 375] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▶ 375] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.11.8 EL3318 - Object description and parameterization

### 5.11.8.1 EL3318 - Configuration data

**Index 80n0 TC Settings (for Ch. 1 - 8 (0 ≤ n ≤ 7))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80n0:0 | TC Settings | Maximum subindex | UINT8 | RO | 0x19 ($25_{dec}$) |
| 80n0:01 | Enable user scale | User scaling is active. | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:02 | Presentation | 0: Signed presentation, 0.1°C/digit<br>1: Absolute value with MSB as sign (signed amount representation), 0.1°C/digit<br>2: High resolution (0.01°C/digit) | BIT3 | RW | 0x00 ($0_{dec}$) |
| 80n0:05 | Siemens bits | The S5 bits are displayed in the three low-order bits | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:06 | Enable filter | This setting generally activates the basic filters in object 0x80n0:15. In the EL33xx these are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object. | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0A | Enable user calibration | Enabling of the user calibration | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:0B | Enable vendor calibration | Enabling of the vendor calibration | BOOLEAN | RW | 0x01 ($1_{dec}$) |
| 80n0:0C | Coldjunction compensation | 0: internal<br>1: no<br>Cold junction compensation is not active<br>2: Extern process data<br>Cold junction compensation takes place via the process data (resolution [1/10]°C) | BIT2 | RW | 0x00 ($0_{dec}$) |
| 80n0:0E | Disable wire break detection | 0: Wire break detection is active<br>1: Wire break detection is not active | BOOLEAN | RW | 0x00 ($0_{dec}$) |
| 80n0:11 | User scale offset | User scaling offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 8000:12 | User scale gain | User scaling gain.<br>The gain is represented in fixed-point format, with the factor $2^{-16}$.<br>The value 1 corresponds to 65536 (0x00010000) | INT32 | RW | 0x00010000 ($65536_{dec}$) |
| 80n0:15 | Filter settings | This object determines the basic digital filter settings.<br>The possible settings are sequentially numbered.<br>0: 50 Hz<br>1: 60 Hz<br>2: 100 Hz<br>3: 500 Hz<br>4: 1 kHz<br>5: 2 kHz<br>6: 3,75 kHz<br>7: 7,5 kHz<br>8: 15 kHz<br>9: 30 kHz<br>10: 5 Hz<br>11:10 Hz | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:17 | User calibration offset | User calibration offset | INT16 | RW | 0x0000 ($0_{dec}$) |
| 80n0:18 | User calibration gain | User calibration gain | UINT16 | RW | 0xFFFF ($65535_{dec}$) |
| 80n0:19 | TC Element | Thermocouple<br>Implemented temperature range<br>0: Type: K -200°C to 1370°C<br>1: Type: J -100°C to 1200°C<br>2: Type: L  0°C to 900°C<br>3: Type: E -100°C to 1000°C<br>4: Type: T -200°C to 400°C<br>5: Type: N -100°C to 1300°C<br>6: Type: U 0°C to 600°C<br>7: Type: B 600°C to 1800°C<br>8: Type: R 0°C to 1767°C<br>9: Type: S 0°C to 1760°C<br>10: Type: C 0°C to 2320°C<br><br>100:  ± 30 mV (1 µV resolution)<br>101:  ± 60 mV (2 µV resolution)<br>102:  ± 75 mV (4 µV resolution) | UINT16 | RW | 0x0000 ($0_{dec}$) |

### 5.11.8.2 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

### 5.11.8.3 EL3318 - Configuration data (vendor-specific)

**Index 80nF TC Vendor data (for Ch. 1 - 8 (0 ≤ n ≤ 7))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nF:0 | TC Vendor data | Maximum subindex | UINT8 | RO | 0x03 ($3_{dec}$) |
| 80nF:01 | Calibration offset TC | Thermocouple offset (vendor calibration) | INT166 | RW | 0x002D ($45_{dec}$) |
| 80nF:02 | Calibration gain TC | Thermocouple gain (vendor calibration) | UINT16 | RW | 0x5B9A ($23450_{dec}$) |
| 80nF:03 | CJOffset | Cold junction offset [Pt1000] (vendor calibration) | INT16 | RW | 0x0000 ($0_{dec}$) |

### 5.11.8.4 EL3318 - Input data

**Index 60n0 TC Inputs (for Ch. 1 - 8 (0 ≤ n ≤ 7))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 60n0:0 | TC Inputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 60n0:01 | Underrange | Value below measuring range. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:02 | Overrange | Measuring range exceeded. ("wire breakage" together with "error" [index 0x60n0:07]) | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:07 | Error | The error bit is set if the value is invalid (wire breakage, overrange, underrange). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:0F | TxPDO State | Validity of the data of the associated TxPDO (0 = valid, 1 = invalid). | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:10 | TxPDO Toggle | The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. | BOOLEAN | RO | 0x00 ($0_{dec}$) |
| 60n0:11 | Value | Analog input value (resolution: see Configuration data index 0x80n0:02) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.8.5 EL3318 - Output data

**Index 70n0 TC Outputs (for Ch. 1 - 8 (0 ≤ n ≤ 7))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 70n0:0 | TC Outputs | Maximum subindex | UINT8 | RO | 0x11 ($17_{dec}$) |
| 70n0:11 | CJCompensation | Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C [▸ 376], comparison via the process data) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 5.11.8.6 EL3318 - Information and diagnostic data

**Index 80nE TC Internal data (for Ch. 1 - 8 (0 ≤ n ≤ 7))**

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 80nE:0 | TC Internal data | Maximum subindex | UINT8 | RO | 0x03 ($3_{dec}$) |
| 80nE:01 | ADC raw value TC | ADC raw value thermocouple | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 80nE:03 | CJ temperature | Cold junction temperature (resolution [1/10]°C) | INT16 | RO | 0x0000 ($0_{dec}$) |

### 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 ($2_{dec}$) |
| F000:01 | Module index distance | Index spacing of the objects of the individual channels | UINT16 | RO | 0x0010 ($16_{dec}$) |
| F000:02 | Maximum number of modules | Number of channels | UINT16 | RO | 0x0004 ($4_{dec}$) |

### Index F008 Code word

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F008:0 | Code word | currently reserved | UINT32 | RW | 0x00000000 ($0_{dec}$) |

### Index F010 Module list (for Ch. 1 - 8 (1 ≤ n ≤ 8))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| F010:0 | Module list | Maximum subindex | UINT32 | RW | 0x0n ($n_{dec}$) |
| F010:0n | SubIndex 00n | TC Profile | UINT32 | RW | 0x0000014A ($330_{dec}$) |

## 5.11.8.7 EL3318 - Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

### Index 1000 Device type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1000:0 | Device type | Device type of the EtherCAT slave: the Lo-Word contains the CoE profile used (5001). The Hi-Word contains the module profile according to the modular device profile. | UINT32 | RO | [ ] |

### Index 1008 Device name

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

### 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 | [ ] |

### Index 1018 Identity

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1018:0 | Identity | Information for identifying the slave | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave | UINT32 | RO | 0x00000002 ($2_{dec}$) |
| 1018:02 | Product code | Product code of the EtherCAT slave | UINT32 | RO | [terminal-specific] |
| 1018:03 | Revision | Revision number of the EtherCAT slave; the low word (bit 0-15) indicates the special terminal number, the high word (bit 16-31) refers to the device description | UINT32 | RO | [terminal-specific] |
| 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 ($0_{dec}$) |

### 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 ($1_{dec}$) |
| 10F0:01 | Checksum | Checksum across all backup entries of the EtherCAT slave | UINT32 | RO | 0x00000000 ($0_{dec}$) |

### Index 160n RxPDO-Map (for Ch. 1 - 8 (0 ≤ n ≤ 7))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 160n:0 | RxPDO-Map Ch. n+1 | PDO Mapping RxPDO | UINT8 | RW | 0x01 ($1_{dec}$) |
| 160n:01 | SubIndex 001 | n. PDO Mapping entry (object 0x70n0 (TC Outputs Ch. n+1), entry 0x11 (CJCompensation)) | UINT32 | RW | 0x70n0:11, 16 |

### Index 1A0n TxPDO-Map (for Ch. 1 - 8 (0 ≤ n ≤ 7))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1A0n:0 | TxPDO-Map Ch.n+1 | PDO Mapping TxPDO | UINT8 | RW | 0x08 ($8_{dec}$) |
| 1A0n:01 | SubIndex 001 | 1. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x01 (Underrange)) | UINT32 | RW | 0x60n0:01, 1 |
| 1A0n:02 | SubIndex 002 | 2. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x02 (Overrange)) | UINT32 | RW | 0x60n0:02, 1 |
| 1A0n:03 | SubIndex 003 | 3. PDO Mapping entry (4 bits align) | UINT32 | RW | 0x0000:00, 4 |
| 1A0n:04 | SubIndex 004 | 4. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x07 (Error)) | UINT32 | RW | 0x60n0:07, 1 |
| 1A0n:05 | SubIndex 005 | 5. PDO Mapping entry (7 bits align) | UINT32 | RW | 0x0000:00, 7 |
| 1A0n:06 | SubIndex 006 | 6. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x0F (TxPDO State)) | UINT32 | RW | 0x60n0:0F, 1 |
| 1A0n:07 | SubIndex 007 | 7. PDO Mapping entry (object 0x60n0 (TxPDO-ParCh.n+1), entry 0x10 (TxPDO-Toggle)) | UINT32 | RW | 0x60n0:10, 1 |
| 1A0n:08 | SubIndex 008 | 8. PDO Mapping entry (object 0x60n0 (TC Inputs Ch.n+1), entry 0x11 (Value)) | UINT32 | RW | 0x60n0:11, 16 |

### Index 1C00 Sync manager type

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C00:0 | Sync manager type | Using the sync managers | UINT8 | RO | 0x04 ($4_{dec}$) |
| 1C00:01 | SubIndex 001 | Sync-Manager Type Channel 1: Mailbox Write | UINT8 | RO | 0x01 ($1_{dec}$) |
| 1C00:02 | SubIndex 002 | Sync-Manager Type Channel 2: Mailbox Read | UINT8 | RO | 0x02 ($2_{dec}$) |
| 1C00:03 | SubIndex 003 | Sync-Manager Type Channel 3: Process Data Write (Outputs) | UINT8 | RO | 0x03 ($3_{dec}$) |
| 1C00:04 | SubIndex 004 | Sync-Manager Type Channel 4: Process Data Read (Inputs) | UINT8 | RO | 0x04 ($4_{dec}$) |

### Index 1C12 RxPDO assign (für Ch. 1 - 8 (1 ≤ n ≤ 8))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C12:0 | RxPDO assign | PDO Assign Outputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C12:0n | Subindex 00n | n. allocated RxPDO (contains the index of the associated RxPDO mapping object) | UINT16 | RW | 0x160n |

### Index 1C13 TxPDO assign (for Ch. 1 - 8 (1 ≤ n ≤ 8))

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C13:0 | TxPDO assign | PDO Assign Inputs | UINT8 | RW | 0x0n ($n_{dec}$) |
| 1C13:0n | Subindex 00n | n. allocated TxPDO (contains the index of the associated TxPDO mapping object) | UINT16 | RW | 0x1A0n |

### Index 1C32 SM output parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
| --- | --- | --- | --- | --- | --- |
| 1C32:0 | SM output parameter | Synchronization parameters for the outputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C32:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 2 Event<br>• 2: DC-Mode - Synchron with SYNC0 Event<br>• 3: DC-Mode - Synchron with SYNC1 Event | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:02 | Cycle time | Cycle time (in ns):<br>• Free Run: Cycle time of the local timer<br>• Synchron with SM 2 event: Master cycle time<br>• DC mode: SYNC0/SYNC1 Cycle Time | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:03 | Shift time | Time between SYNC0 event and output of the outputs (in ns, DC mode only) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C32:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0 = 1: free run is supported<br>• Bit 1 = 1: Synchron with SM 2 event is supported<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 01: Output shift with SYNC1 event (only DC mode)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08) | UINT16 | RO | 0xC001 ($49153_{dec}$) |
| 1C32:05 | Minimum cycle time | Minimum cycle time (in ns) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:06 | Calc and copy time | Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:08 | Command | • 0: Measurement of the local cycle time is stopped<br>• 1: Measurement of the local cycle time is started<br>The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▸ 382], 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C32:09 | Delay time | Time between SYNC1 event and output of the outputs (in ns, DC mode only) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C32:0B | SM event missed counter | Number of missed SM events in OPERATIONAL (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0C | Cycle exceeded counter | Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:0D | Shift too short counter | Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only) | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C32:20 | Sync error | The synchronization was not correct in the last cycle (outputs were output too late; DC mode only) | BOOLEAN | RO | 0x00 ($0_{dec}$) |

### Index 1C33 SM input parameter

| Index (hex) | Name | Meaning | Data type | Flags | Default |
|---|---|---|---|---|---|
| 1C33:0 | SM input parameter | Synchronization parameters for the inputs | UINT8 | RO | 0x20 ($32_{dec}$) |
| 1C33:01 | Sync mode | Current synchronization mode:<br>• 0: Free Run<br>• 1: Synchron with SM 3 event (no outputs available)<br>• 2: DC - Synchron with SYNC0 Event<br>• 3: DC - Synchron with SYNC1 Event<br>• 34: Synchron with SM 2 event (outputs available) | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:02 | Cycle time | as 0x1C32:02 [▶ 382] | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:03 | Shift time | Time between SYNC0 event and reading of the inputs (in ns, only DC mode) | UINT32 | RW | 0x00000000 ($0_{dec}$) |
| 1C33:04 | Sync modes supported | Supported synchronization modes:<br>• Bit 0: free run is supported<br>• Bit 1: Synchron with SM 2 Event is supported (outputs available)<br>• Bit 1: Synchron with SM 3 Event is supported (no outputs available)<br>• Bit 3:2 = 10: DC mode is supported<br>• Bit 5:4 = 10: input shift through local event (outputs available)<br>• Bit 5:4 = 101: input shift with SYNC1 event (no outputs available)<br>• Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08 [▶ 382] or 0x1C33:08) | UINT16 | RO | 0x8007 ($32775_{dec}$)<br>0xC001 (EL3318) |
| 1C33:05 | Minimum cycle time | as 0x1C32:05 [▶ 382] | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 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 ($0_{dec}$) |
| 1C33:08 | Command | as 0x1C32:08 [▶ 382] | UINT16 | RW | 0x0000 ($0_{dec}$) |
| 1C33:09 | Delay time | Time 0x1between SYNC1 event and reading of the inputs (in ns, only DC mode) | UINT32 | RO | 0x00000000 ($0_{dec}$) |
| 1C33:0B | SM event missed counter | as 0x1C32:11 [▶ 382] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0C | Cycle exceeded counter | as 0x1C32:12 [▶ 382] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:0D | Shift too short counter | as 0x1C32:13 [▶ 382] | UINT16 | RO | 0x0000 ($0_{dec}$) |
| 1C33:20 | Sync error | as 0x1C32:32 [▶ 382] | BOOLEAN | RO | 0x00 ($0_{dec}$) |

## 5.12 Status word

The status information for each channel of the EL32xx and EL33xx is transmitted cyclically from the terminal to the EtherCAT Master as process data (PDO). Two versions of the device description are available for the EL32xx and EL33xx, representing the process image in individual and extended forms.

The difference can be seen in the revision number EL3xxxx-xxxx-**XXXX**.

The EL32xx or EL33xx transmit the following process data:

- **Underrange**: Measurement is below range
- **Overrange**: Range of measurement exceeded ("Cable break" together with "Error")
- **Limit 1:** Limit value monitoring 0: ok, 1: Limit value overshot , 2: limit range undershot
- **Limit 2:** Limit value monitoring 0: ok, 1: Limit value overshot , 2: limit range undershot
- **Error**: The error bit is set if the process data is invalid (cable break, overrange, underrange)
- **TxPDO State:** Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).
- **TxPDO Toggle**: The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated. This allows the currently required conversion time to be derived.

The limit evaluation is set in the "8000" objects in the CoE directory.

**Differences in the versions of the EL32xx and EL33xx series**

The revision differences are illustrated below, using the EL32xx series as an example. The principles of the description apply equally to the EL33xx series.

**Revision -0016 (EL32xx-xxxx-0016)**

These terminal revisions have the **single process image**, see fig. *EL32xx-0000-0016 process image in the TwinCAT 2.11 representation.*
Each item of status information is transmitted as a single, linkable process data.

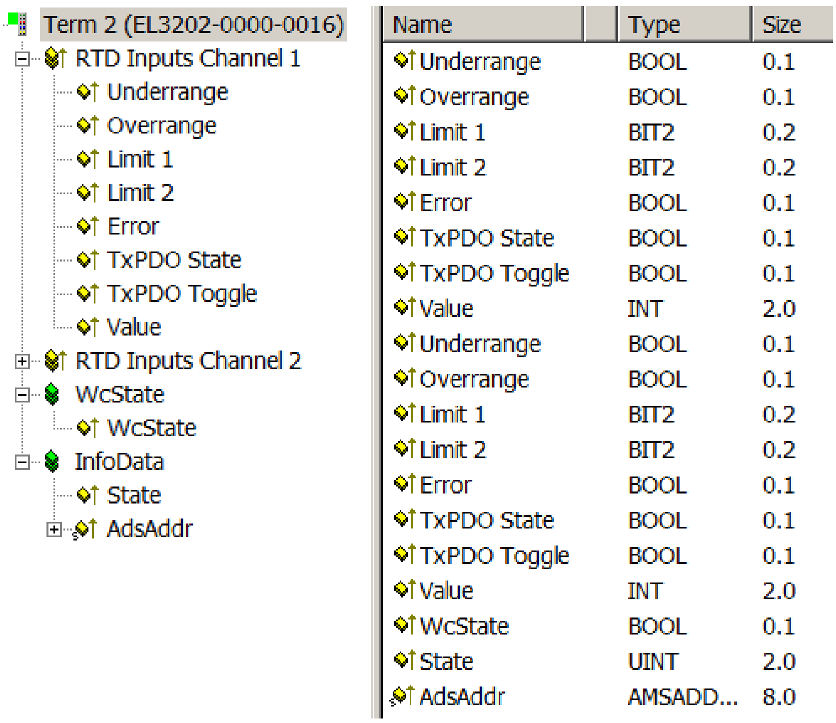



Fig. 176: EL32xx-0000-0016 process image in the TwinCAT 2.11 representation

### Revisions -0017 (EL32xx-xxxx-0017) and higher

These terminal revisions also have the **summarized process image**, see *EL32xx-0000-0017 process image in the TwinCAT 2.11 representation.*
The individual units of information are assembled here in the usual Beckhoff representation as a 16-bit status word, and can be linked into the controller in this way.

*Table 3: Status word*

| **Bit** | SW.15 | SW.14 | SW.13 - SW.7 | SW.6 | SW. 5 | SW. 4 | SW. 3 | SW. 2 | SW.1 | SW.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | TxPDO Toggle | TxPDO State | - | Error | Limit 2 | | Limit 1 | | Overrange | Underrange |

In addition to this, the consolidated "status" can be folded out through the "+" symbol, and the items of process data linked individually.

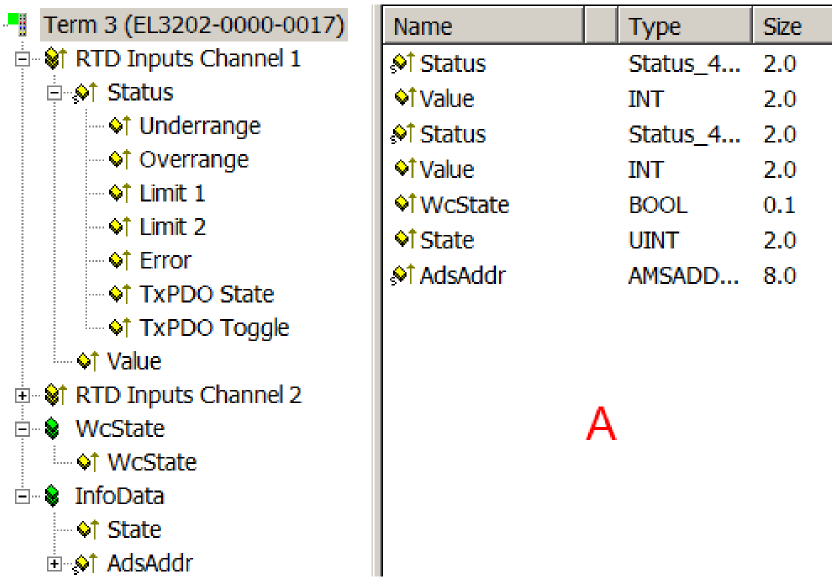



Fig. 177: EL32xx-0000-0017 process image in the TwinCAT 2.11 representation

The individual items of information can also be displayed in the overview window (A) on the right. By clicking on the button

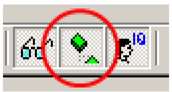
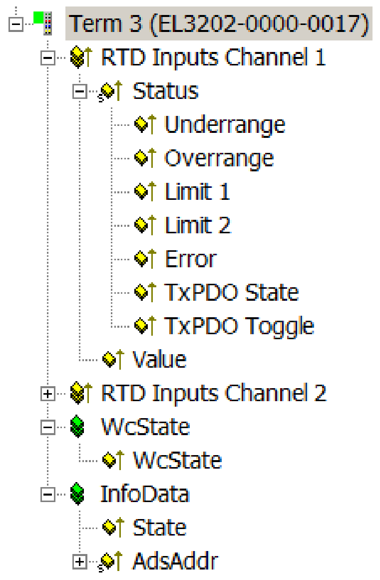


Fig. 178: Button show subvariables

in the menu bar the information can also be displayed there.




| Name | Type | Size |
|---|---|---|
| Status | Status_4096 | 2.0 |
| Underrange | BOOL | 0.1 |
| Overrange | BOOL | 0.1 |
| Limit 1 | BIT2 | 0.2 |
| Limit 2 | BIT2 | 0.2 |
| Error | BOOL | 0.1 |
| TxPDO State | BOOL | 0.1 |
| TxPDO To... | BOOL | 0.1 |
| Value | INT | 2.0 |
| Status | Status_4096 | 2.0 |
| Underrange | BOOL | 0.1 |
| Overrange | BOOL | 0.1 |
| Limit 1 | BIT2 | 0.2 |
| Limit 2 | BIT2 | 0.2 |
| Error | BOOL | 0.1 |
| TxPDO State | BOOL | 0.1 |
| TxPDO To... | BOOL | 0.1 |
| Value | INT | 2.0 |
| WcState | BOOL | 0.1 |
| State | UINT | 2.0 |
| AdsAddr | AMSADDRESS | 8.0 |
| netId | ARRAY [0..5] OF USINT | 6.0 |
| netId[0] | USINT | 1.0 |
| netId[1] | USINT | 1.0 |
| netId[2] | USINT | 1.0 |
| netId[3] | USINT | 1.0 |
| netId[4] | USINT | 1.0 |
| netId[5] | USINT | 1.0 |
| port | UINT | 2.0 |

Fig. 179: Consolidated process image in the extended representation under TwinCAT 2.11

**Notes**

- The **consolidated representation** is only visible from TwinCAT 2.11 and above. For reasons of compatibility, if a EL32xx-xxxx-0017 (or later) is operated in earlier TwinCAT configurations, the individual process image is displayed, prepended with the identifier "Status__".

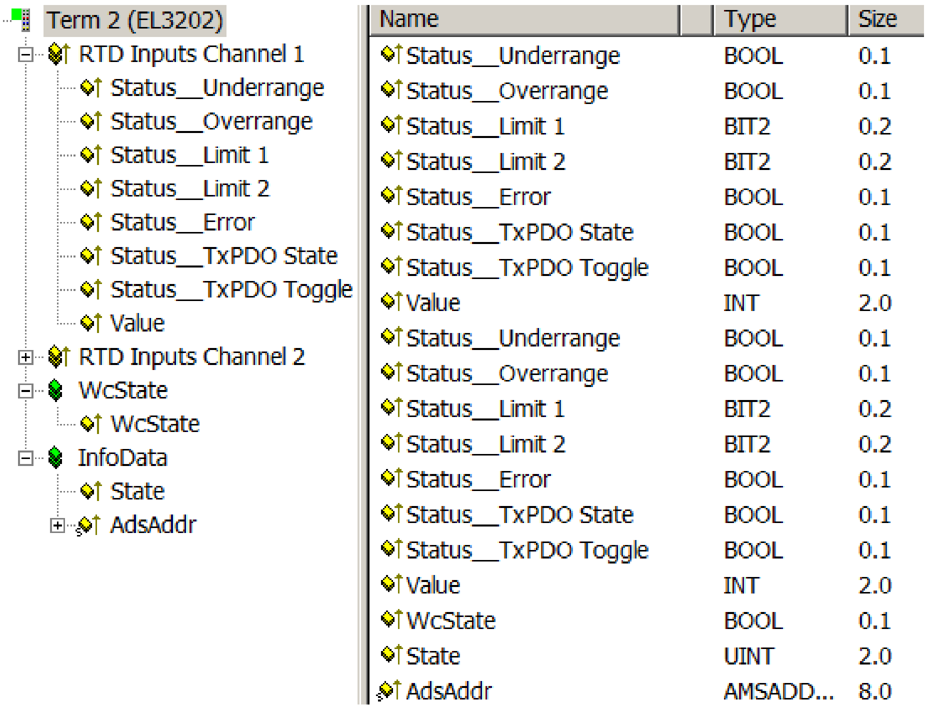



Fig. 180: Consolidated process image represented under TwinCAT 2.10

- Revisions -0016 and -0017 do not depend on the revision of the firmware installed in the terminal. This means that terminals that were supplied as EL32xx-xxxx-0016 can also be operated with a "newer" -0017 configuration, and therefore can be addressed using the consolidated process image.
  This case of "upwards compatibility" is permitted for the EL32xx-xxxx-0016 and -0017.
- The easiest way to determine the revision that is installed in the terminal is through a scan of the EtherCAT system. The comparison report shows the differences.

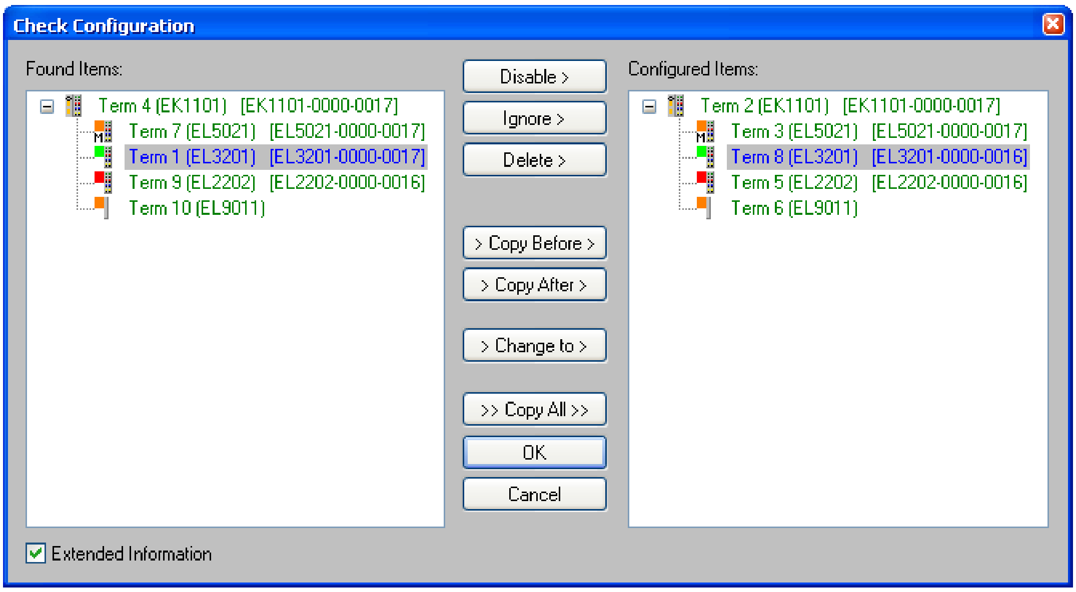
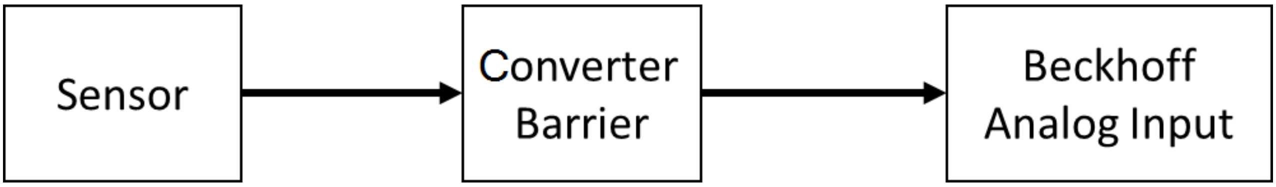



Fig. 181: Typical result after scanning an EtherCAT system

Explanation about fig. *Typical result after scanning an EtherCAT system*: According to the overview on the right, an EL3201-0000-0016 was found in the configuration (*.tsm file), whereas the overview on the left shows revision -0017. The general downward compatibility of the EL terminals ensures that this kind of application is possible.

## 5.13 Basics about signal isolators, barriers

Occasionally, analog signals cannot be fed directly from the sensor to the Beckhoff analog input terminal, in which case a special intermediary device must be added.

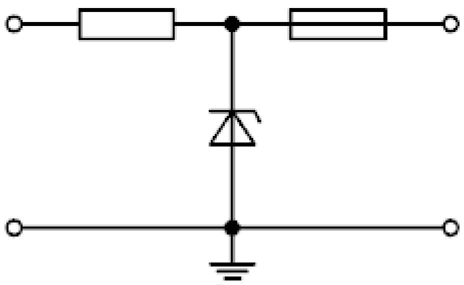



Reasons may include:

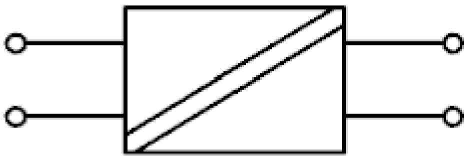
- The sensor may be installed in hazardous locations and protected according to the intrinsic safety ignition protection type (Ex i) while a Beckhoff ELX3xxx terminal is not yet available for the desired application
- Separate electrical isolation between the sensor and the Beckhoff terminal is required
- The sensor has an electrical output signal for which Beckhoff does not yet offer a suitable input terminal.

The type of intermediate device depends on the following criteria

- Electrical signal supplied by the sensor: voltage 10 V or µV, AC or DC, 20 mA or 1 A, resistance, …
- the sensor must be powered in some way, e.g.
    - an IEPE sensor requires 2..8 mA constant current
    - a resistor requires a measuring current
    - an electronic sensor may need a 24V supply, or it may be fed via a 20 mA loop
- What dynamic transmission quality for AC signals must the sensor provide via the intermediate device? Each intermediate device influences the analog signal, e.g. in terms of frequency-dependent attenuation, crosstalk, line resistance or bandwidth. This must be taken into account when an intermediate device is used in a metrological application.
- Is the device used for energy limitation in accordance with the intrinsic safety ignition protection type (Ex i)? In this case, a barrier with appropriate approval is required. Zener barriers are often used in such situations. They are made up of resistors, fuses and Zener diodes.

  As already mentioned, these can influence the analog signal quality with respect to the above features, e.g. by temperature-dependent change of the internal resistance.
  Terms: Zener barrier
- Does it have to ensure electrical isolation of the analog signal?

  Does electrical isolation of the analog signal have to be provided? Devices that electrically isolate the transmitted signal reconfigure the signal, so that in this case special attention must be paid to the signal influence. In this case the analog properties of the isolator and the Beckhoff analog terminal are interlinked. The properties of the isolator are dominant, particularly when Beckhoff ELM measurement terminals or other high-quality analog terminals are used. On the output side, they typically supply standard signals, such as 10 V or 20 mA. Compared with the use of external devices for electrical isolation, the use of Beckhoff input terminals with channel-based electrical isolation is advantageous. Terms: signal isolator, signal converter, signal transducer, isolating amplifier, measuring amplifier, level transducer

- Are both measures, i.e. explosion protection according to ignition protection type Ex i and electrical isolation necessary? In this case, so-called isolation barriers are used, which ensure energy limitation for intrinsic safety and also electrical isolation of the signal. Please refer to the notes on analog signal influence referred to above.

From a metrological point of view, signal-influencing intermediate devices should be avoided if possible.

# 5.14 Notices on analog specifications

Beckhoff I/O devices (terminals, boxes, modules) 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.

## 5.14.1 Full scale value (FSV)

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 device 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.

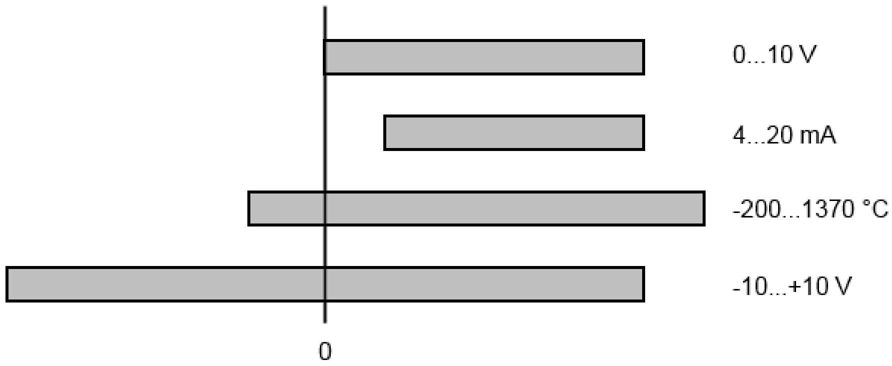



Fig. 182: Full scale value, measuring span

For the above **examples** this means:

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

This applies to analog output terminals/ boxes (and related Beckhoff product groups).

## 5.14.2 Measuring error/ measurement deviation

The relative measuring error (% of the full scale value) 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.

$$\text{Measuring error} = \frac{|\text{max. deviation}|}{\text{full scale value}}$$

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 is 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...10 V and measuring error < ± 0.3 % full scale value → maximum deviation ± 30 mV in the permissible operating temperature range.

**Lower measuring error**

Since this specification also includes the temperature drift, a significantly lower measuring error can usually be assumed in case of a constant ambient temperature of the device and thermal stabilization after a user calibration.

This applies to analog output devices.

## 5.14.3 Temperature coefficient tK [ppm/K]

An electronic circuit is usually temperature dependent to a greater or lesser degree. In analog measurement technology this means that when a measured value is determined by means of an electronic circuit, its deviation from the "true" value is reproducibly dependent on the ambient/operating temperature.

A manufacturer can alleviate this by using components of a higher quality or by software means.

The temperature coefficient, when indicated, specified by Beckhoff allows the user to calculate the expected measuring error outside the basic accuracy at 23 °C.

Due to the extensive uncertainty considerations that are incorporated in the determination of the basic accuracy (at 23 °C), Beckhoff recommends a quadratic summation.

**Example:** Let the basic accuracy at 23 °C be ±0.01% typ. (full scale value), tK = 20 ppm/K typ.; the accuracy A35 at 35 °C is wanted, hence ΔT = 12 K

$$G35 = \sqrt{(0.01\%)^2 + (12K \cdot 20\ \frac{ppm}{K})^2} = 0.026\%\ \text{full scale value, typ}$$

Remarks: ppm ≙ $10^{-6}$ % ≙ $10^{-2}$

## 5.14.4 Long-term use

Analog devices (inputs, outputs) are subject to constant environmental influences during operation (temperature, temperature change, shock/vibration, irradiation, etc.) This can affect the function, in particular the analog accuracy (also: measurement or output uncertainty).

As industrial products, Beckhoff analog devices are designed for 24h/7d continuous operation.

The devices show that they generally comply with the accuracy specification, even in long-term use. However, as is usual for technical devices, an unlimited functional assurance (also applies to accuracy) cannot be given.

Beckhoff recommends checking the usability in relation to the application target within the scope of normal system maintenance, e.g. every 12-24 months.

## 5.14.5 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.

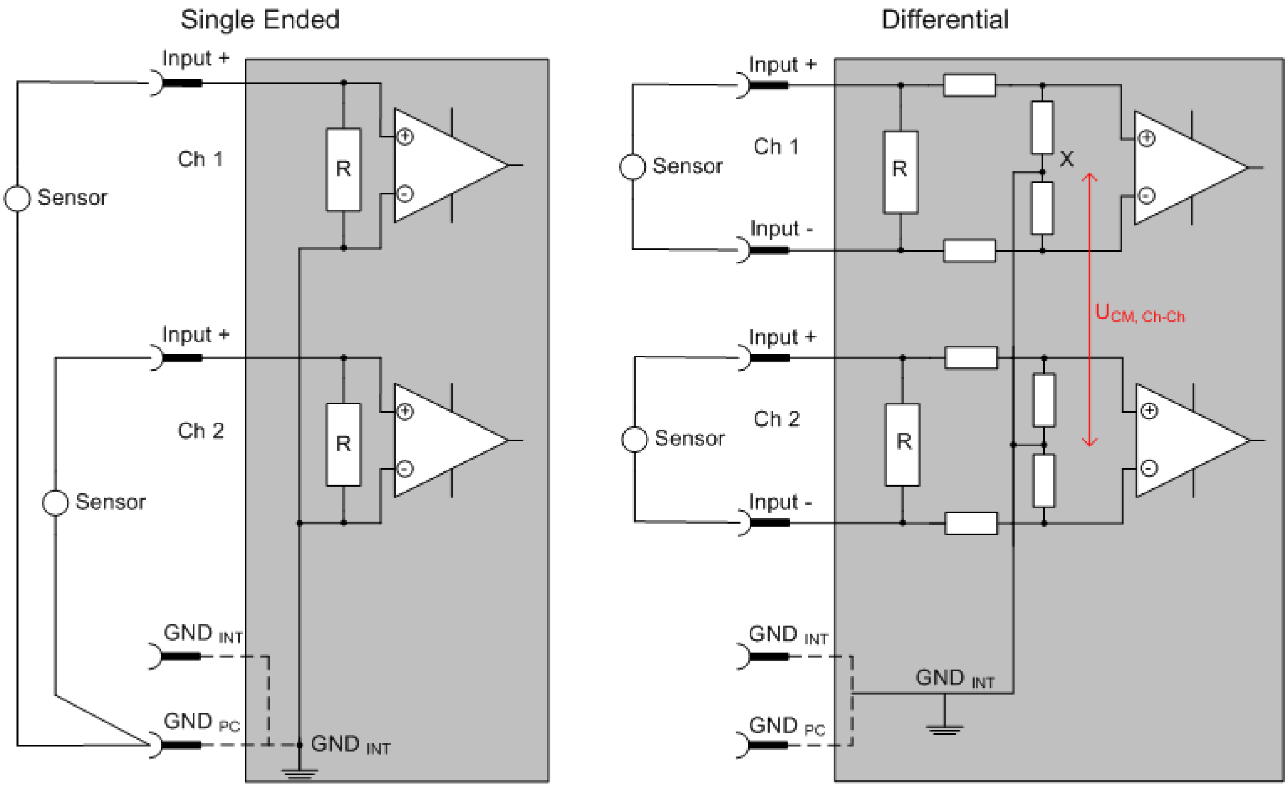



Fig. 183: SE and DIFF module as 2-channel version

Note: Dashed lines indicate that the respective connection may not necessarily be present in each SE or DIFF module. Electrical isolated channels are operating as differential type in general, hence there is no direct relation (voltaic) to ground within the module established at all. Indeed, specified information to recommended and maximum voltage levels have to be taken into account.

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 (and related product groups) 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 (cable), 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/ box documentation for further details.

**Explanation**

- **differential (DIFF)**
    - 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 channel is configured symmetrically internally (cf. Fig. SE and DIFF module as 2-channel variant), 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 $V_{CM}$ (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 $V_{CM,max}$ is not exceeded in the differential sensor cable. If differential channels are not electrically isolated, usually only one $V_{CM, max}$ 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.
    - Further helpfully information on this topic can be found on the documentation page *Configuration of 0/4..20 mA differential inputs* (see documentation for the EL30xx terminals, for example).
- **Single Ended (SE)**

- 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 (cable).
- 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 $V_{CM}$ 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.
- 2-wire connection see Fig. *2-wire connection*, cf. 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.

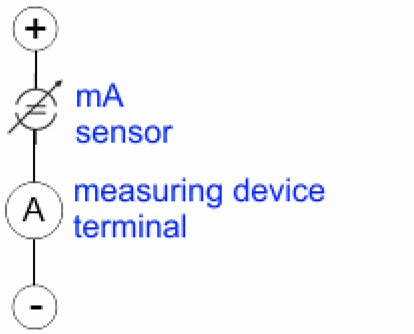



Fig. 184: 2-wire connection

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

they can, however, also be connected to **‘differential’ inputs**, if the termination to GND is then manufactured on the application side – to be connected with the right polarity to +Signal and –Signal
It is important to refer to the information page *Configuration of 0/4..20 mA differential inputs* (see documentation for the EL30xx terminals, for example)!

### 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 two 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: for sensors with 4-wire connection based on +supply/-supply/+signal/-signal, check whether +signal can be connected to +supply or –signal to –supply.

- Yes: then you can connect accordingly to a Beckhoff **'single-ended' input**.

- No: the Beckhoff **'differential' input** for +Signal and –Signal is to be selected; +Supply and –Supply are to be connected via additional cables.
It is important to refer to the information page *Configuration of 0/4..20 mA differential inputs* (see documentation for the EL30xx terminals, for example)!

Note: 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.
Usually there is an internal diode existing within unipolar terminals/ boxes (and related product groups), in this case the polarity/direction of current have to be observed.

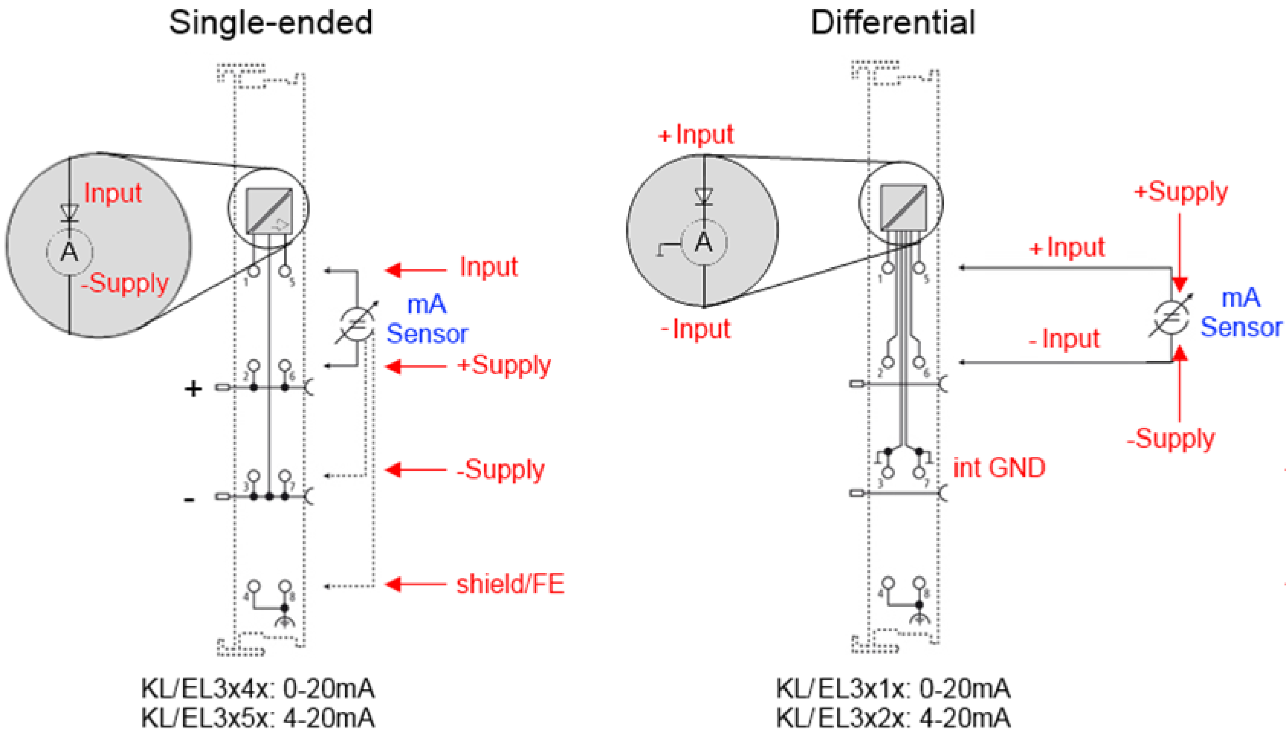



Fig. 185: Connection of externally supplied sensors

Classification of the Beckhoff terminals/ boxes - Beckhoff 0/4-20 mA terminals/ boxes (and related product groups) are available as **differential** and **single-ended** terminals/ boxes (and related product groups):

| **Single-ended** | **Differential** |
| --- | --- |
| EL3x4x: 0-20 mA, EL3x5x: 4-20 mA; KL and related product groups exactly the same | EL3x1x: 0-20 mA, EL3x2x: 4-20 mA; KL and related product groups exactly the same |
| Preferred current direction because of internal diode | Preferred current direction because of internal diode |
| Designed for the connection of externally-supplied sensors with a 3/4-wire connection | The terminal/ box is a passive differential current measuring device; passive means that the sensor is not supplied with power. |
| Designed for the connection of self-supplied sensors with a 2-wire connection | |

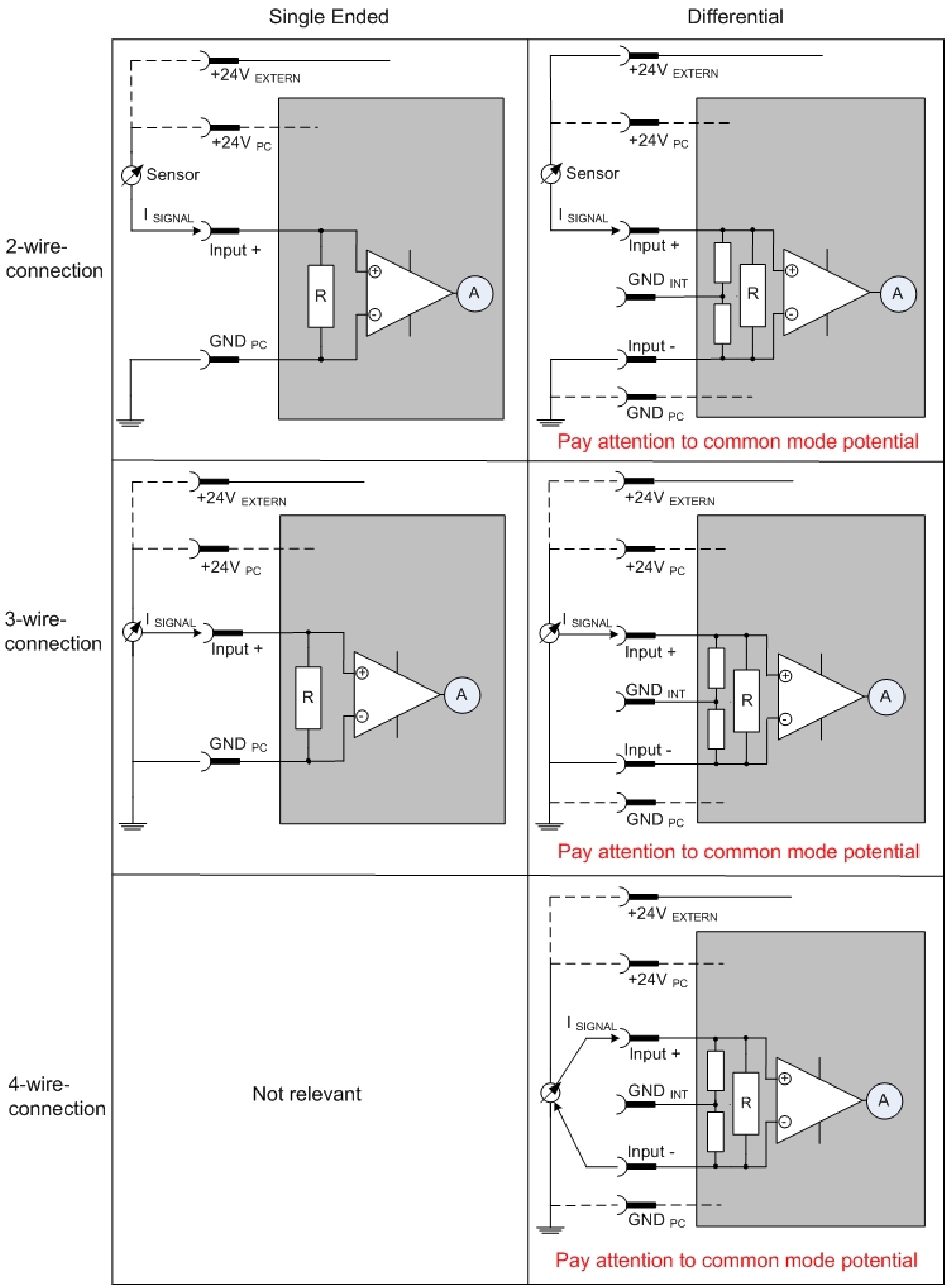



Fig. 186: 2-, 3- and 4-wire connection at single-ended and differential inputs

### 5.14.6 Common-mode voltage and reference ground (based on differential inputs)

Common-mode voltage ($V_{cm}$) is defined as the average value of the voltages of the individual connections/ inputs and is measured/specified against reference ground.

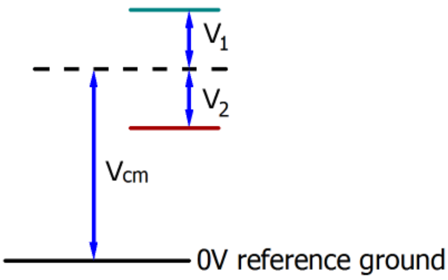



Fig. 187: Common-mode voltage ($V_{cm}$)

The definition of the reference ground is important for the definition of the permitted common-mode voltage range and for measurement of the common-mode rejection ratio (CMRR) for differential inputs.

The reference ground is also the potential against which the input resistance and the input impedance for single-ended inputs or the common-mode resistance and the common-mode impedance for differential inputs is measured.

The reference ground is usually accessible at or near the terminal/ box, e.g. at the terminal contacts, power contacts (cable) or a mounting rail. Please refer to the documentation regarding positioning. The reference ground should be specified for the device under consideration.

For multi-channel terminals/ boxes with resistive (=direct, ohmic, galvanic) or capacitive connection between the channels, the reference ground should preferably be the symmetry point of all channels, taking into account the connection resistances.

**Reference ground samples for Beckhoff IO devices:**

1. Internal AGND fed out: EL3102/EL3112, resistive connection between the channels
2. 0V power contact: EL3104/EL3114, resistive connection between the channels and AGND; AGND connected to 0V power contact with low-resistance
3. Earth or SGND (shield GND):
   - EL3174-0002: Channels have no resistive connection between each other, although they are capacitively coupled to SGND via leakage capacitors
   - EL3314: No internal ground fed out to the terminal points, although capacitive coupling to SGND

### 5.14.7 Dielectric strength

A distinction should be made between:

- Dielectric strength (destruction limit): Exceedance can result in irreversible changes to the electronics
  - Against a specified reference ground
  - Differential
- Recommended operating voltage range: If the range is exceeded, it can no longer be assumed that the system operates as specified
  - Against a specified reference ground
  - Differential

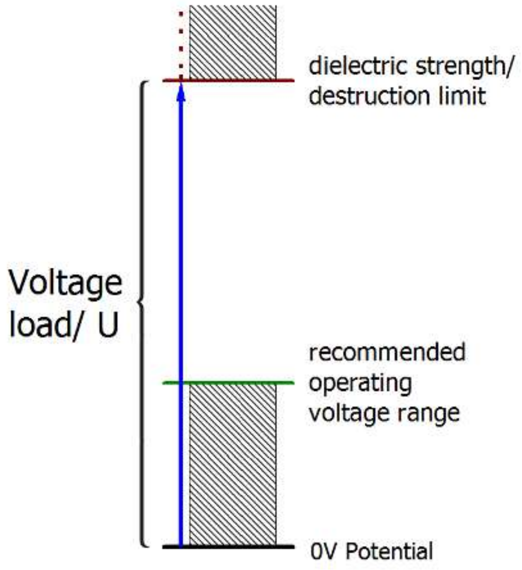



Fig. 188: Recommended operating voltage range

The device documentation may contain particular specifications and timings, taking into account:

- Self-heating
- Rated voltage
- Insulating strength
- Edge steepness of the applied voltage or holding periods
- Normative environment (e.g. PELV)

## 5.14.8 Temporal aspects of analog/digital conversion

The conversion of the constant electrical input signal to a value-discrete digital and machine-readable form takes place in the analog Beckhoff EL/KL/EP input modules with ADC (analog digital converter). Although different ADC technologies are in use, from a user perspective they all have a common characteristic: after the conversion a certain digital value is available in the controller for further processing. This digital value, the so-called analog process data, has a fixed temporal relationship with the “original parameter”, i.e. the electrical input value. Therefore, corresponding temporal characteristic data can be determined and specified for Beckhoff analogue input devices.

This process involves several functional components, which act more or less strongly in every AI (analog input) module:

- the electrical input circuit
- the analog/digital conversion
- the digital further processing
- the final provision of the process and diagnostic data for collection at the fieldbus (EtherCAT, K-bus, etc.)

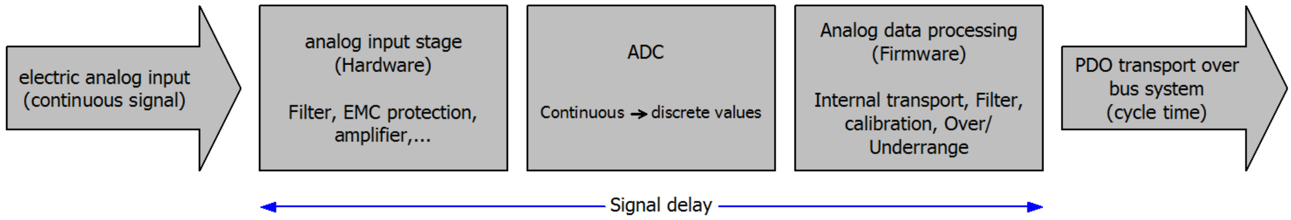



Fig. 189: Signal processing analog input

Two aspects are crucial from a user perspective:

- "How often do I receive new values?", i.e. a sampling rate in terms of speed with regard to the device/ channel
- What delay does the (whole) AD conversion of the device/channel cause?
  I.e. the hardware and firmware components in its entirety. For technological reasons, the signal characteristics must be taken into account when determining this information: the run times through the system differ, depending on the signal frequency.

This is the "external" view of the "Beckhoff AI channel" system – internally the signal delay in particular is composed of different components: hardware, amplifier, conversion itself, data transport and processing. Internally a higher sampling rate may be used (e.g. in the deltaSigma converters) than is offered "externally" from the user perspective. From a user perspective of the "Beckhoff AI channel" component this is usually irrelevant or is specified accordingly, if it is relevant for the function.

For Beckhoff AI devices the following specification parameters for the AI channel are available for the user from a temporal perspective:

### 1. Minimum conversion time [ms, µs]

This is the reciprocal value of the maximum **sampling rate** [sps, samples per second]:
Indicates how often the analog channel makes a newly detected process data value available for collection by the fieldbus. Whether the fieldbus (EtherCAT, K-bus) fetches the value with the same speed (i.e. synchronous), or more quickly (if the AI channel operates in slow FreeRun mode) or more slowly (e.g. with oversampling), is then a question of the fieldbus setting and which modes the AI device supports.
For EtherCAT devices the so-called toggle bit indicates (by toggling) for the diagnostic PDOs when a newly determined analog value is available.
Accordingly, a maximum conversion time, i.e. a smallest sampling rate supported by the AI device, can be specified.
Corresponds to IEC 61131-2, section 7.10.2 2, "Sampling repeat time"

### 2. Typical signal delay

Corresponds to IEC 61131-2, section 7.10.2 1, "Sampling duration". From this perspective it includes all internal hardware and firmware components, but not "external" delay components from the fieldbus or the controller (TwinCAT).
This delay is particularly relevant for absolute time considerations, if AI channels also provide a time stamp that corresponds to the amplitude value – which can be assumed to match the physically prevailing amplitude value at the time.
Due to the frequency-dependent signal delay time, a dedicated value can only be specified for a given signal. The value also depends on potentially variable filter settings of the channel.
A typical characterization in the device documentation may be:

### 2.1 Signal delay (step response)

Keywords: Settling time
The square wave signal can be generated externally with a frequency generator (note impedance!)
The 90 % limit is used as detection threshold.
The signal delay [ms, µs] is then the time interval between the (ideal) electrical square wave signal and the time at which the analog process value has reached the 90 % amplitude.

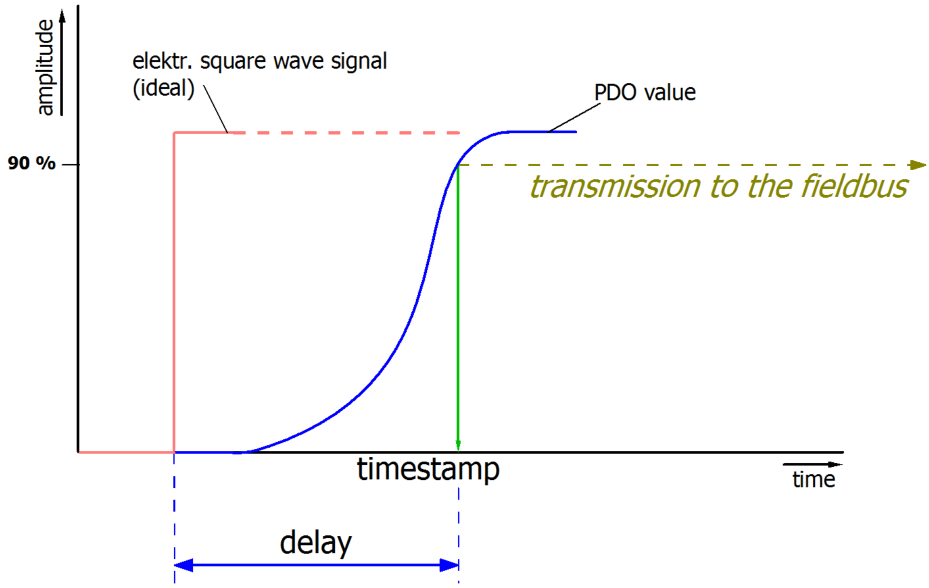



Fig. 190: Diagram signal delay (step response)

**2.2 Signal delay (linear)**

Keyword: Group delay
Describes the delay of a signal with constant frequency
A test signal can be generated externally with a frequency generator, e.g. as sawtooth or sine. A simultaneous square wave signal would be used as reference.
The signal delay [ms, µs] is then the interval between the applied electrical signal with a particular amplitude and the moment at which the analog process value reaches the same value.
A meaningful range must be selected for the test frequency, e.g. 1/20 of the maximum sampling rate.

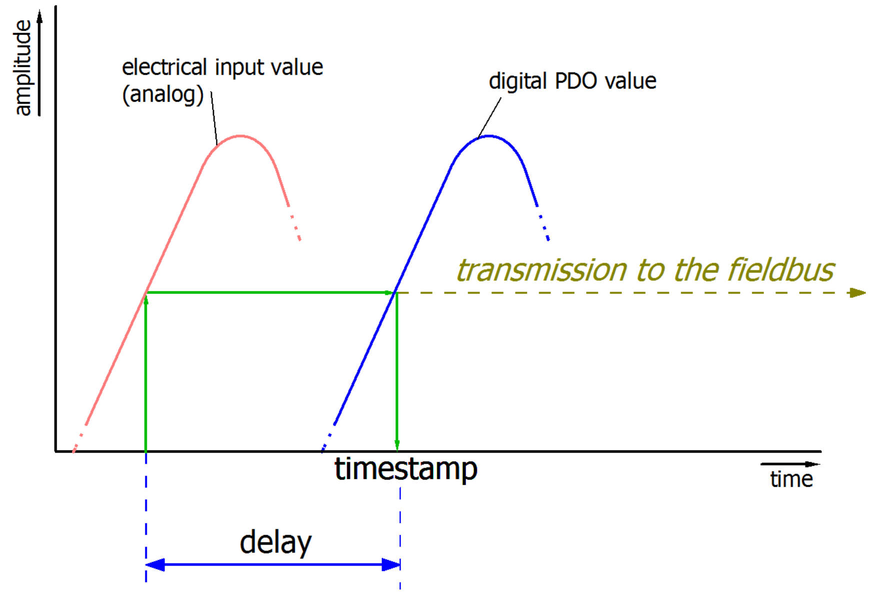



Fig. 191: Diagram signal delay (linear)

**3. Additional Information**

May be provided in the specification, e.g.

- Actual sampling rate of the ADC (if different from the channel sampling rate)
- Time correction values for run times with different filter settings
- etc.

# 6 Appendix

## 6.1 Sample program for individual temperature calculation in the PLC

The terminals from the EL331x-xxxx series are used for the convenient measurement of temperatures with thermocouples. For this purpose they are equipped with various conversion tables for different types of thermocouples as well as an internal cold junction measurement. However, it is possible that a type of thermocouple might be used that is not stored in the firmware. In this case the EL331x offers the following method:

- Measure the thermocouple voltage at the terminal in the **voltage mode** of the EL331x
- Measure the temperature of the internal cold junction (CJ) in the terminal. This is offered in the CoE for each channel.
- Offset the two values in the controller/PLC in consideration of the desired linearization curve/table for the temperature at the place of measurement.

This calculation method, called cold junction compensation (CJC), corresponds approximately to that which is stored in the terminal for the implemented types.

The sample program implements such a procedure and produces a temperature value that takes into account the channel-wise cold junction temperature from the CoE. By way of example the terminal is continually switched between voltage and temperature measurement in the type K, thus enabling a comparison of the two temperature values. A recording of the measured values from channel 1 of the EL3314 on a type K thermocouple with the TwinCAT Scope is illustrated below (units 0.1 °C):

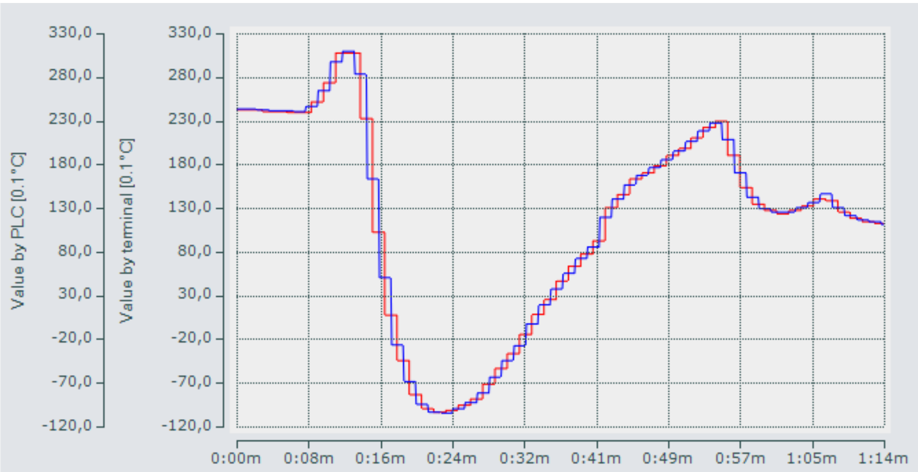



Fig. 192: Blue: temperature values from the PLC calculation; red: PDO values in the temperature measurement range

Notes:

- *the EL331x-xxxx also offers a third way of determining temperature - via an externally measured cold junction. See chapter* "Operation with an external cold junction" [▶ 324] *in this documentation.*
- The sample program operates with a sampling points table with 10 entries for a type K thermocouple. The values must be adjusted accordingly if a different thermocouple is used. The entries in the field variable "aTCElement" are to be made in µV and the temperature values from -30 °C to +60 °C allocated in 10° steps. The assignment of the value for "nBuffer_INT" in nState =14 in MAIN must also be adjusted (e.g. 5 for type N thermocouple).
- The sample program contains a variable "*stUserNetId*" in the function block "FB_COE_ACCESS" in which the AMS-Net-ID of the configuration to be used is to be entered. It is required among other things for reading the cold junction temperatures. If the terminal is not located in the first position after the coupler, then the entry for the variable "nUserSlaveAddr" must also be adjusted.

- After starting the program the terminal is set to the "NoCoEStorage" state so that the continuous CoE access for switching between the temperature and voltage measurement modes does not lead in the long run to damage to the terminal's internal EEPROM. This switching is not necessary if the EL331x only ever operates in voltage measurement mode in real use.
- Note that the EL331x-xxxx approximates the characteristic curve via a second-degree polynomial and thus produces more precise temperature values than the calculation by the sample program, which merely carries out a linear interpolation between the sampling points.

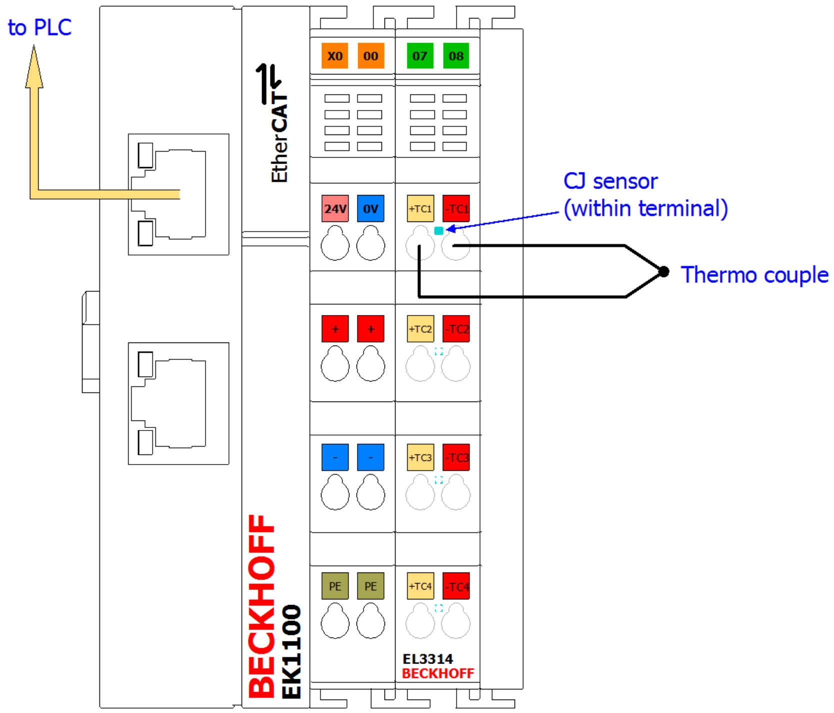



Fig. 193: Structure of the sample program for "separate temperature calculation with CJC in the PLC"

Download: https://infosys.beckhoff.com/content/1033/el33xx/Resources/zip/5273816971.zip

**Preparations for starting the sample programs (tnzip file / TwinCAT 3)**

- Click on the download button to save the Zip archive locally on your hard disk, then unzip the *.tnzip archive file in a temporary folder.

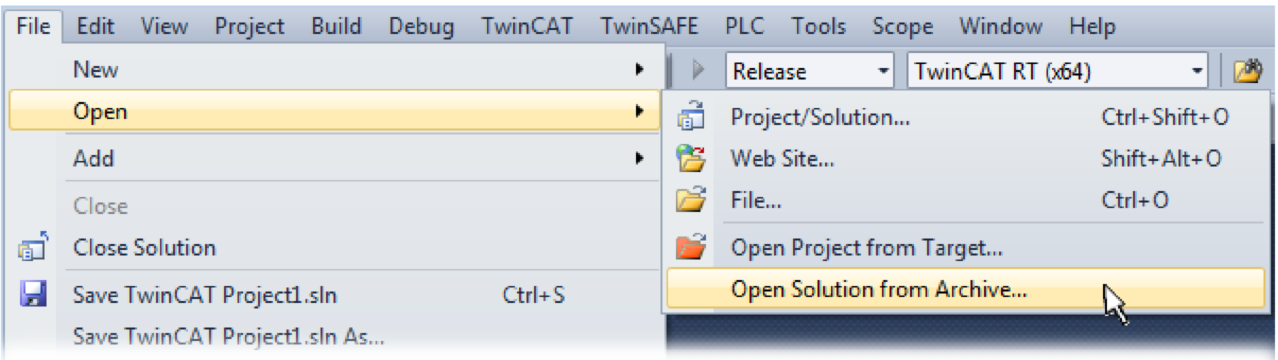



Fig. 194: Opening the *. tnzip archive

- Select the .tnzip file (sample program).
- A further selection window opens. Select the destination directory for storing the project.
- For a description of the general PLC commissioning procedure and starting the program please refer to the terminal documentation or the EtherCAT system documentation.

Extract from the sample program:

Deklarationsteil:

```
// THIS CODE IS ONLY AN EXAMPLE - YOU HAVE TO CHECK APTITUDE FOR YOUR APPLICATION
PROGRAM MAIN
VAR

   nBuffer_INT           : INT;         // Buffer for reading or writing values from/to CoE objects
   aTCElement            : ARRAY[0..9] OF REAL := // Type K µV entries in 10°C Steps:
      [-1156, -778, -392, 0, 397, 798, 1203, 1612, 2023, 2436];
   nTabIndex             : INT;         // Index of node in table

   nT_start              : INT := -300; // -30°C for 0.1°C resolution
   nT_ResTab             : REAL := 100; //  10°C resultion of table (for 0.1°C resolution of values)

   // Variables for calculation:
   // ---------------------------
   nDiff_U_node2node     : REAL;    // Voltage difference of two nodes
   nDiff_U_node2U_TC     : REAL;    // Voltage difference of node and U TC
   nSlope                : REAL;    // Slope for 1st interpolation (temperature to voltage)
   nResidual             : REAL;    // Residual value for interpolation
   nRelation             : REAL;    // Relation for 2nd interpolation (voltage to temperature)
   // ===========================
   nU_TC                 : REAL;     // Voltage of temperature inkl. CJC
   nT_CJ                 : REAL;     // Cold junction temperature
   nU_CJ                 : REAL;     // Corresponding voltage of CJ
   nT_Result             : INT;      // Resulting Temperatur (resolution 0.1°C)
END_VAR
```

Ausführungsteil (nState=100):

```
// Cold junction temperature by CoE:
nT_CJ := INT_TO_REAL(nBuffer_INT);
// 1. Convert temperature to voltage:
// ========================================================================
// Determinate index of table:
nTabIndex := TRUNC_INT((nT_CJ - nT_start)/nT_ResTab);

// Calculate difference of two values with real value between them:
nDiff_U_node2node := (aTCElement[nTabIndex+1]-aTCElement[nTabIndex]);

// Get residual value of real value with integer value:
nResidual := nT_CJ - (nTabIndex * nT_ResTab + nT_start);

// Calculate slope nSlope = DY / DX:
nSlope := nDiff_U_node2node/nT_ResTab;

// Calculate interpolated voltage of the cold junction (m*x+b):
nU_CJ := nSlope * nResidual + aTCElement[nTabIndex];
// ========================================================================

// 2. Add this value to the PDO value:
nU_TC := INT_TO_REAL(nTC_Inputs_Value) + nU_CJ;
// ========================================================================

// 3. Convert calculated voltage to temperature:
// ========================================================================
//  Search index of higher target node:
nTabIndex := 0;
 // Loop as long U TC is greater than a node:
WHILE nU_TC > aTCElement[nTabIndex] DO
   nTabIndex := nTabIndex + 1;
END_WHILE
// Loop ended with resulting nTabIndex

IF nTabIndex = 0 THEN
   // Temperature is below first table entry: end here
   nT_Result := nT_start;
ELSE
   // Voltage difference between U_TC and lower target node
   nDiff_U_node2U_TC := nU_TC - aTCElement[nTabIndex-1];

   // Voltage difference between two target nodes with U_TC nested between them:
   nDiff_U_node2node := aTCElement[nTabIndex]-aTCElement[nTabIndex-1];

   // Relation of the two differencies:
   nRelation := nDiff_U_node2U_TC/nDiff_U_node2node;

   // Resulting temperature in 0.1°C resoltion:
   nT_Result := REAL_TO_INT(nT_start + (nRelation+nTabIndex-1) * nT_ResTab);
END_IF
```

## 6.2 EtherCAT AL Status Codes

For detailed information please refer to the EtherCAT system description.

## 6.3 Firmware Update EL/ES/EM/ELM/EPxxxx

This section describes the device update for Beckhoff EtherCAT slaves from the EL/ES, ELM, EM, EK and EP series. A firmware update should only be carried out after consultation with Beckhoff support.

**NOTE**

**Only use TwinCAT 3 software!**

A firmware update of Beckhoff IO devices must only be performed with a TwinCAT 3 installation. It is recommended to build as up-to-date as possible, available for free download on the Beckhoff website https://www.beckhoff.com/en-us/.

To update the firmware, TwinCAT can be operated in the so-called FreeRun mode, a paid license is not required.

The device to be updated can usually remain in the installation location, but TwinCAT has to be operated in the FreeRun. Please make sure that EtherCAT communication is trouble-free (no LostFrames etc.).

Other EtherCAT master software, such as the EtherCAT Configurator, should not be used, as they may not support the complexities of updating firmware, EEPROM and other device components.

### Storage locations

An EtherCAT slave stores operating data in up to three locations:

- Depending on functionality and performance EtherCAT slaves have one or several local controllers for processing I/O data. The corresponding program is the so-called **firmware** in *.efw format.
- In some EtherCAT slaves the EtherCAT communication may also be integrated in these controllers. In this case the controller is usually a so-called **FPGA** chip with *.rbf firmware.
- In addition, each EtherCAT slave has a memory chip, a so-called **ESI-EEPROM**, for storing its own device description (ESI: EtherCAT Slave Information). On power-up this description is loaded and the EtherCAT communication is set up accordingly. The device description is available from the download area of the Beckhoff website at (https://www.beckhoff.com). All ESI files are accessible there as zip files.

Customers can access the data via the EtherCAT fieldbus and its communication mechanisms. Acyclic mailbox communication or register access to the ESC is used for updating or reading of these data.

The TwinCAT System Manager offers mechanisms for programming all three parts with new data, if the slave is set up for this purpose. Generally the slave does not check whether the new data are suitable, i.e. it may no longer be able to operate if the data are unsuitable.

### Simplified update by bundle firmware

The update using so-called **bundle firmware** is more convenient: in this case the controller firmware and the ESI description are combined in a *.efw file; during the update both the firmware and the ESI are changed in the terminal. For this to happen it is necessary

- for the firmware to be in a packed format: recognizable by the file name, which also contains the revision number, e.g. ELxxxx-xxxx_REV0016_SW01.efw
- for password=1 to be entered in the download dialog. If password=0 (default setting) only the firmware update is carried out, without an ESI update.
- for the device to support this function. The function usually cannot be retrofitted; it is a component of many new developments from year of manufacture 2016.

Following the update, its success should be verified

- ESI/Revision: e.g. by means of an online scan in TwinCAT ConfigMode/FreeRun – this is a convenient way to determine the revision

- Firmware: e.g. by looking in the online CoE of the device

**NOTE**

**Risk of damage to the device!**

✓ Note the following when downloading new device files

a) Firmware downloads to an EtherCAT device must not be interrupted

b) Flawless EtherCAT communication must be ensured. CRC errors or LostFrames must be avoided.

c) The power supply must adequately dimensioned. The signal level must meet the specification.

⇨ In the event of malfunctions during the update process the EtherCAT device may become unusable and require re-commissioning by the manufacturer.

## 6.3.1 Device description ESI file/XML

**NOTE**

**Attention regarding update of the ESI description/EEPROM**

Some slaves have stored calibration and configuration data from the production in the EEPROM. These are irretrievably overwritten during an update.

The ESI device description is stored locally on the slave and loaded on start-up. Each device description has a unique identifier consisting of slave name (9 characters/digits) and a revision number (4 digits). Each slave configured in the System Manager shows its identifier in the EtherCAT tab:

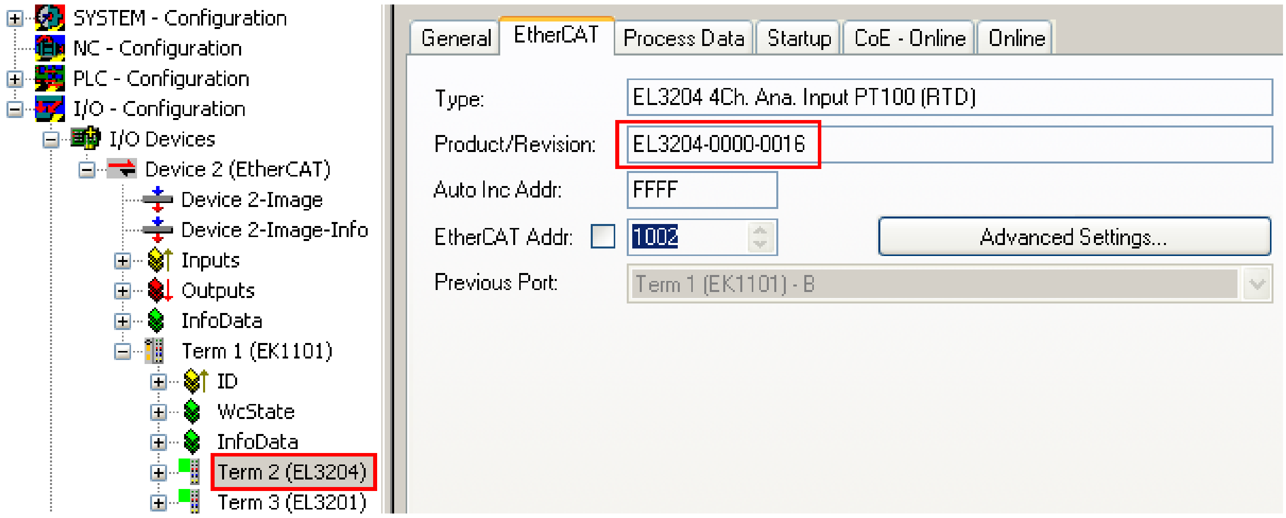



Fig. 195: Device identifier consisting of name EL3204-0000 and revision -0016

The configured identifier must be compatible with the actual device description used as hardware, i.e. the description which the slave has loaded on start-up (in this case EL3204). Normally the configured revision must be the same or lower than that actually present in the terminal network.

For further information on this, please refer to the EtherCAT system documentation.

**Update of XML/ESI description**

The device revision is closely linked to the firmware and hardware used. Incompatible combinations lead to malfunctions or even final shutdown of the device. Corresponding updates should only be carried out in consultation with Beckhoff support.

**Display of ESI slave identifier**

The simplest way to ascertain compliance of configured and actual device description is to scan the EtherCAT boxes in TwinCAT mode Config/FreeRun:

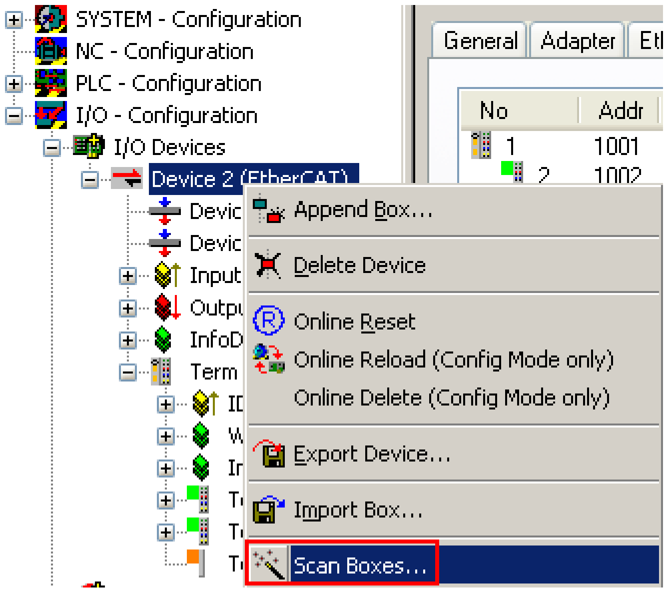



Fig. 196: Scan the subordinate field by right-clicking on the EtherCAT device

If the found field matches the configured field, the display shows

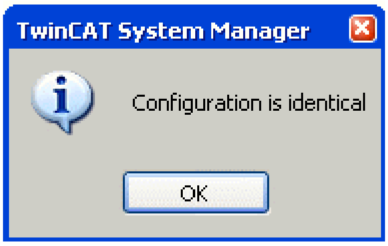



Fig. 197: Configuration is identical

otherwise a change dialog appears for entering the actual data in the configuration.

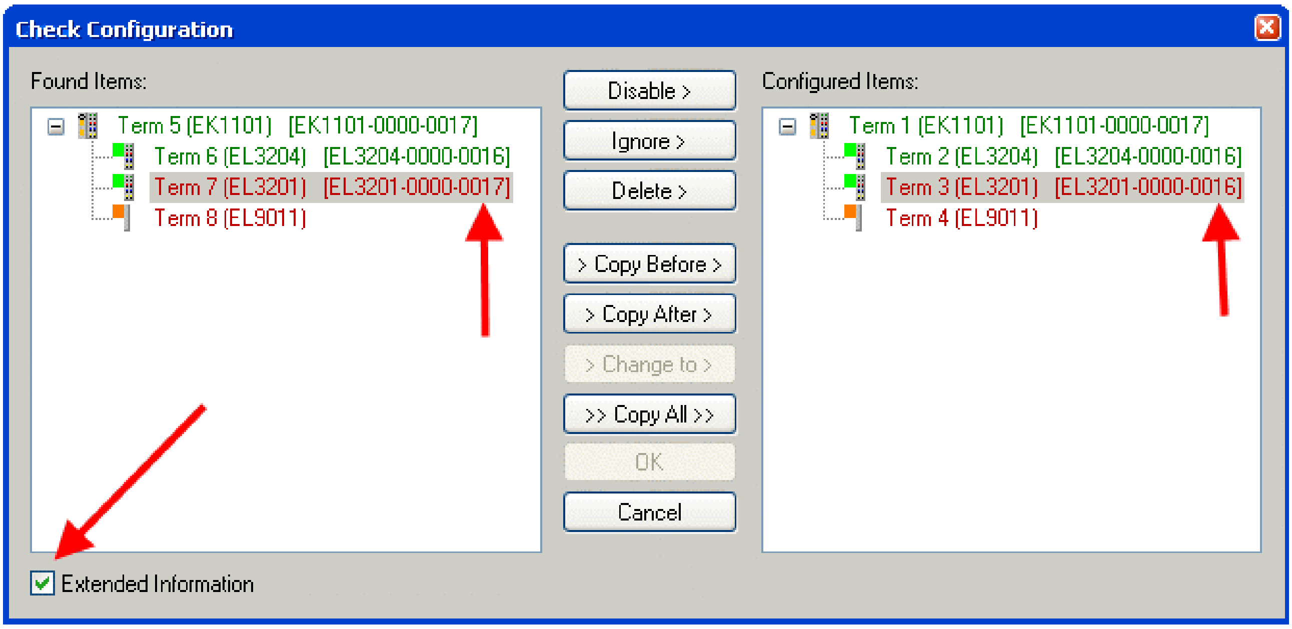



Fig. 198: Change dialog

In this example in Fig. *Change dialog*, an EL3201-0000-**0017** was found, while an EL3201-0000-**0016** was configured. In this case the configuration can be adapted with the *Copy Before* button. The *Extended Information* checkbox must be set in order to display the revision.

### Changing the ESI slave identifier

The ESI/EEPROM identifier can be updated as follows under TwinCAT:

- Trouble-free EtherCAT communication must be established with the slave.
- The state of the slave is irrelevant.
- Right-clicking on the slave in the online display opens the *EEPROM Update* dialog, Fig. *EEPROM Update*

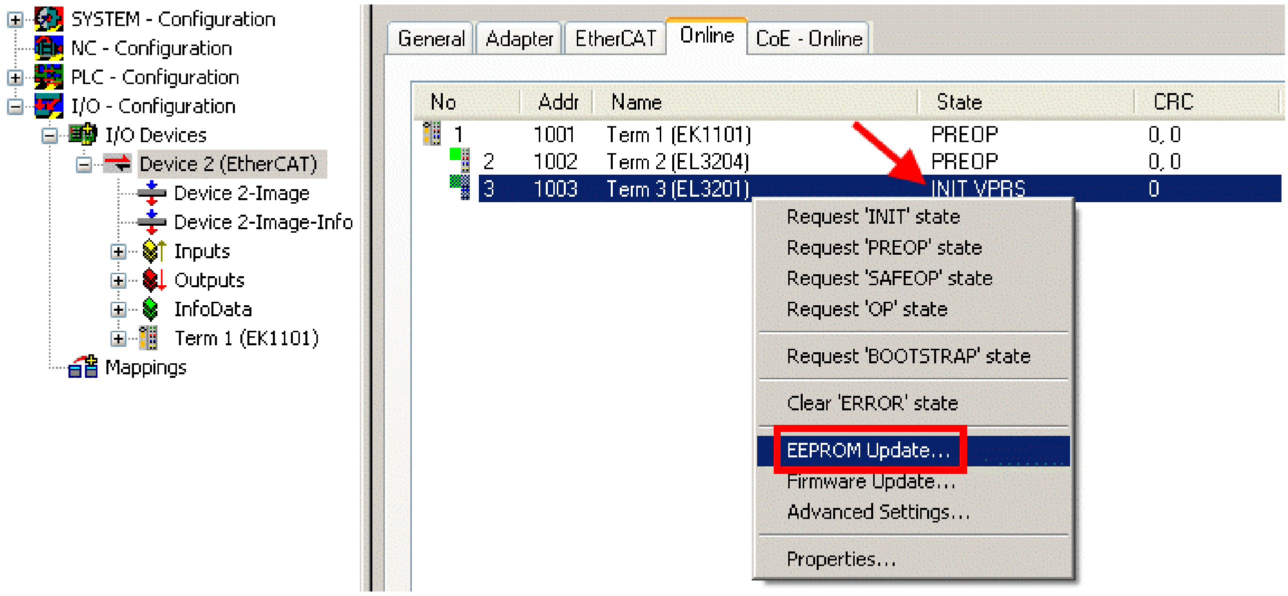



Fig. 199: EEPROM Update

The new ESI description is selected in the following dialog, see Fig. *Selecting the new ESI.* The checkbox *Show Hidden Devices* also displays older, normally hidden versions of a slave.

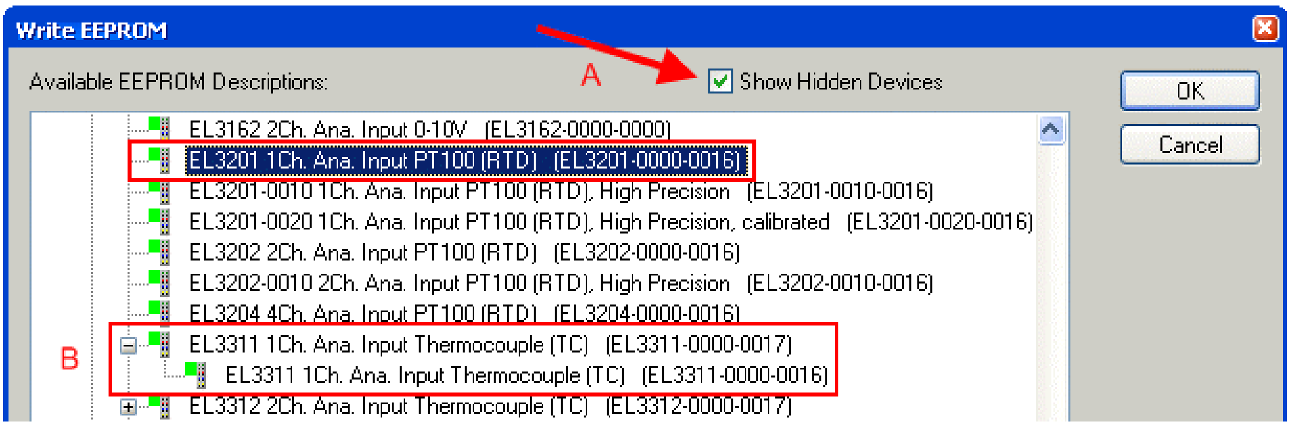



Fig. 200: Selecting the new ESI

A progress bar in the System Manager shows the progress. Data are first written, then verified.

**The change only takes effect after a restart.**

Most EtherCAT devices read a modified ESI description immediately or after startup from the INIT. Some communication settings such as distributed clocks are only read during power-on. The Ether-CAT slave therefore has to be switched off briefly in order for the change to take effect.

## 6.3.2 Firmware explanation

### Determining the firmware version

### Determining the version on laser inscription

Beckhoff EtherCAT slaves feature serial numbers applied by laser. The serial number has the following structure: **KK YY FF HH**

KK - week of production (CW, calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with ser. no.: 12 10 03 02:

12 - week of production 12
10 - year of production 2010
03 - firmware version 03
02 - hardware version 02

### Determining the version via the System Manager

The TwinCAT System Manager shows the version of the controller firmware if the master can access the slave online. Click on the E-Bus Terminal whose controller firmware you want to check (in the example terminal 2 (EL3204)) and select the tab *CoE Online* (CAN over EtherCAT).

**CoE Online and Offline CoE**

Two CoE directories are available:
• **online**: This is offered in the EtherCAT slave by the controller, if the EtherCAT slave supports this. This CoE directory can only be displayed if a slave is connected and operational.
• **offline**: The EtherCAT Slave Information ESI/XML may contain the default content of the CoE. This CoE directory can only be displayed if it is included in the ESI (e.g. “Beckhoff EL5xxx.xml”).

The Advanced button must be used for switching between the two views.

In Fig. *Display of EL3204 firmware version* the firmware version of the selected EL3204 is shown as 03 in CoE entry 0x100A.

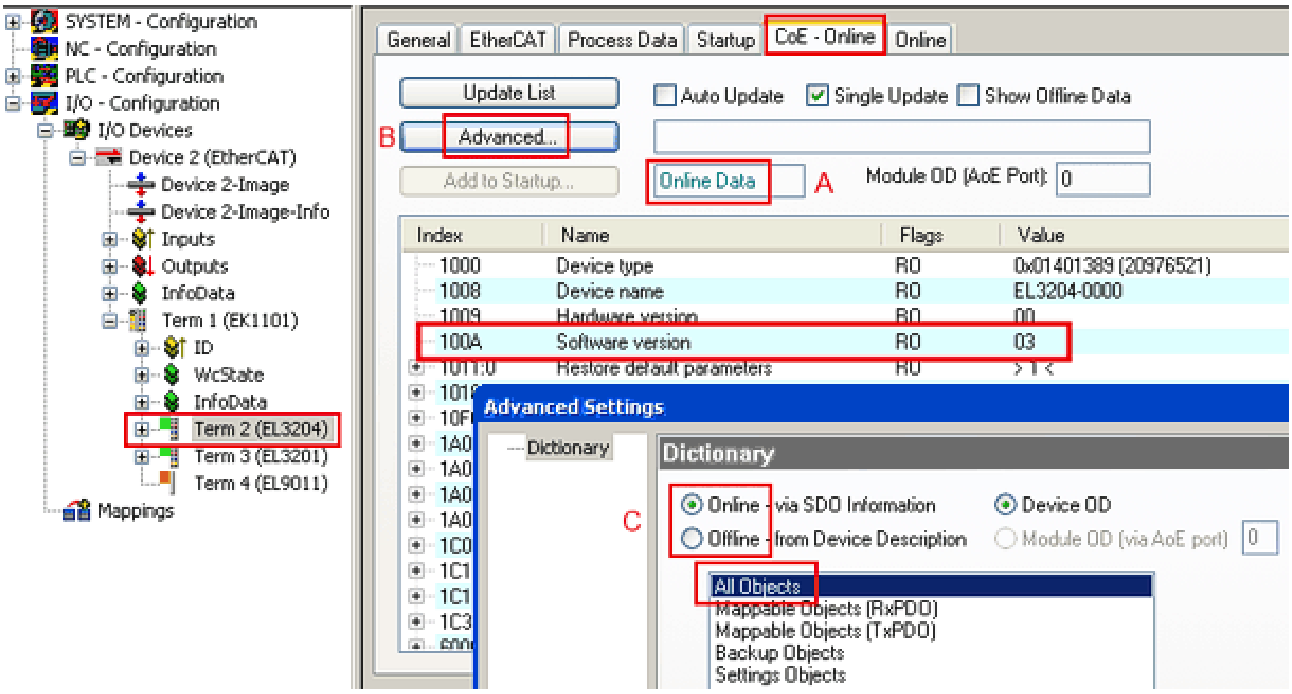



Fig. 201: Display of EL3204 firmware version

In (A) TwinCAT 2.11 shows that the Online CoE directory is currently displayed. If this is not the case, the Online directory can be loaded via the *Online* option in Advanced Settings (B) and double-clicking on *AllObjects*.

## 6.3.3 Updating controller firmware *.efw

**CoE directory**

The Online CoE directory is managed by the controller and stored in a dedicated EEPROM, which is generally not changed during a firmware update.

Switch to the *Online* tab to update the controller firmware of a slave, see Fig. *Firmware Update.*

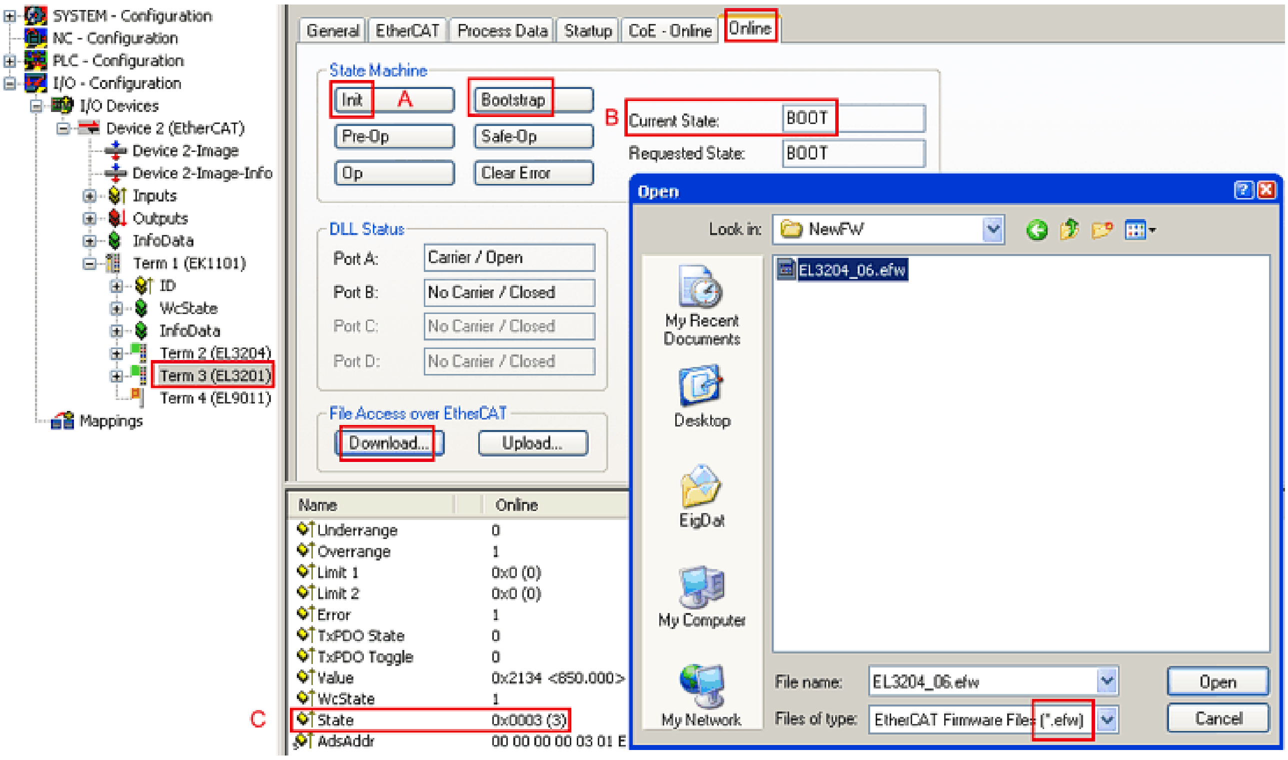
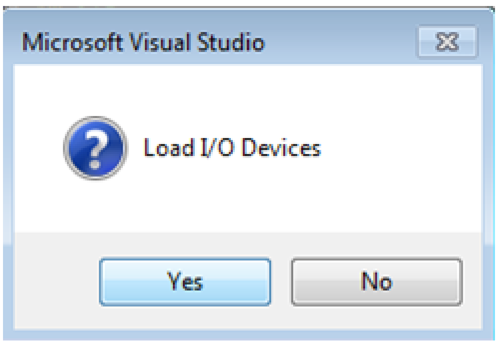
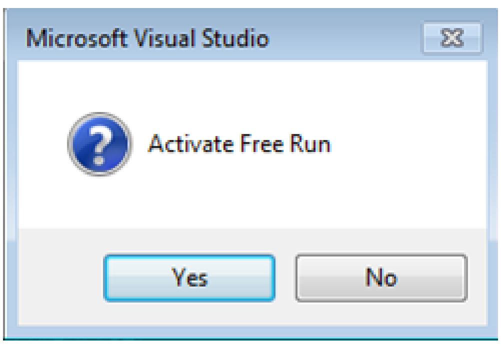



Fig. 202: Firmware Update

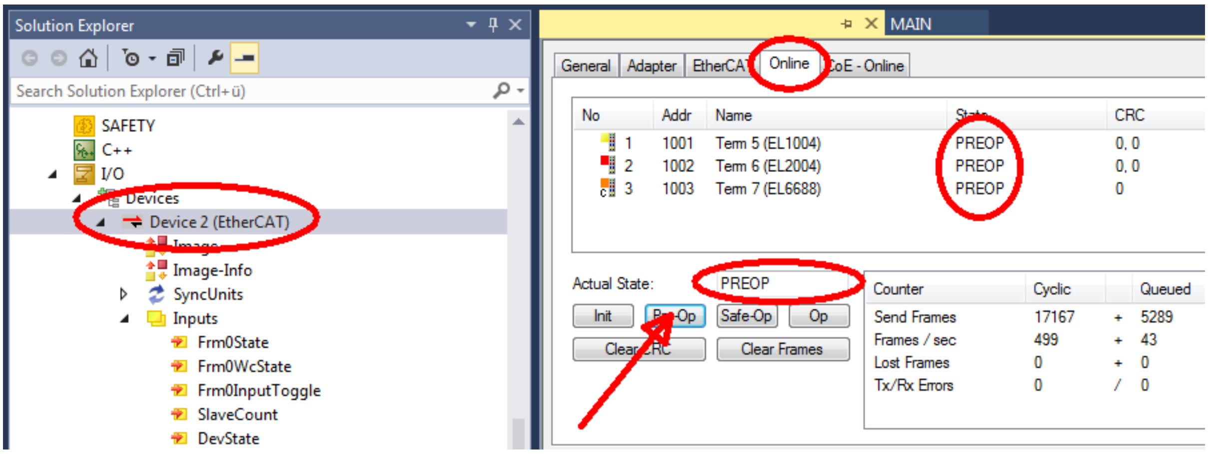
Proceed as follows, unless instructed otherwise by Beckhoff support. Valid for TwinCAT 2 and 3 as EtherCAT master.

- Switch TwinCAT system to ConfigMode/FreeRun with cycle time >= 1 ms (default in ConfigMode is 4 ms). A FW-Update during real time operation is not recommended.

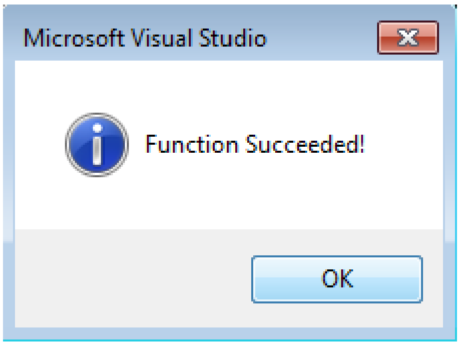


- Switch EtherCAT Master to PreOP




- Switch slave to INIT (A)
- Switch slave to BOOTSTRAP
- Check the current status (B, C)
- Download the new *efw file (wait until it ends). A pass word will not be neccessary usually.




- After the download switch to INIT, then PreOP
- Switch off the slave briefly (don't pull under voltage!)
- Check within CoE 0x100A, if the FW status was correctly overtaken.

## 6.3.4 FPGA firmware *.rbf

If an FPGA chip deals with the EtherCAT communication an update may be accomplished via an *.rbf file.

- Controller firmware for processing I/O signals
- FPGA firmware for EtherCAT communication (only for terminals with FPGA)

The firmware version number included in the terminal serial number contains both firmware components. If one of these firmware components is modified this version number is updated.

**Determining the version via the System Manager**

The TwinCAT System Manager indicates the FPGA firmware version. Click on the Ethernet card of your EtherCAT strand (Device 2 in the example) and select the *Online* tab.

The *Reg:0002* column indicates the firmware version of the individual EtherCAT devices in hexadecimal and decimal representation.

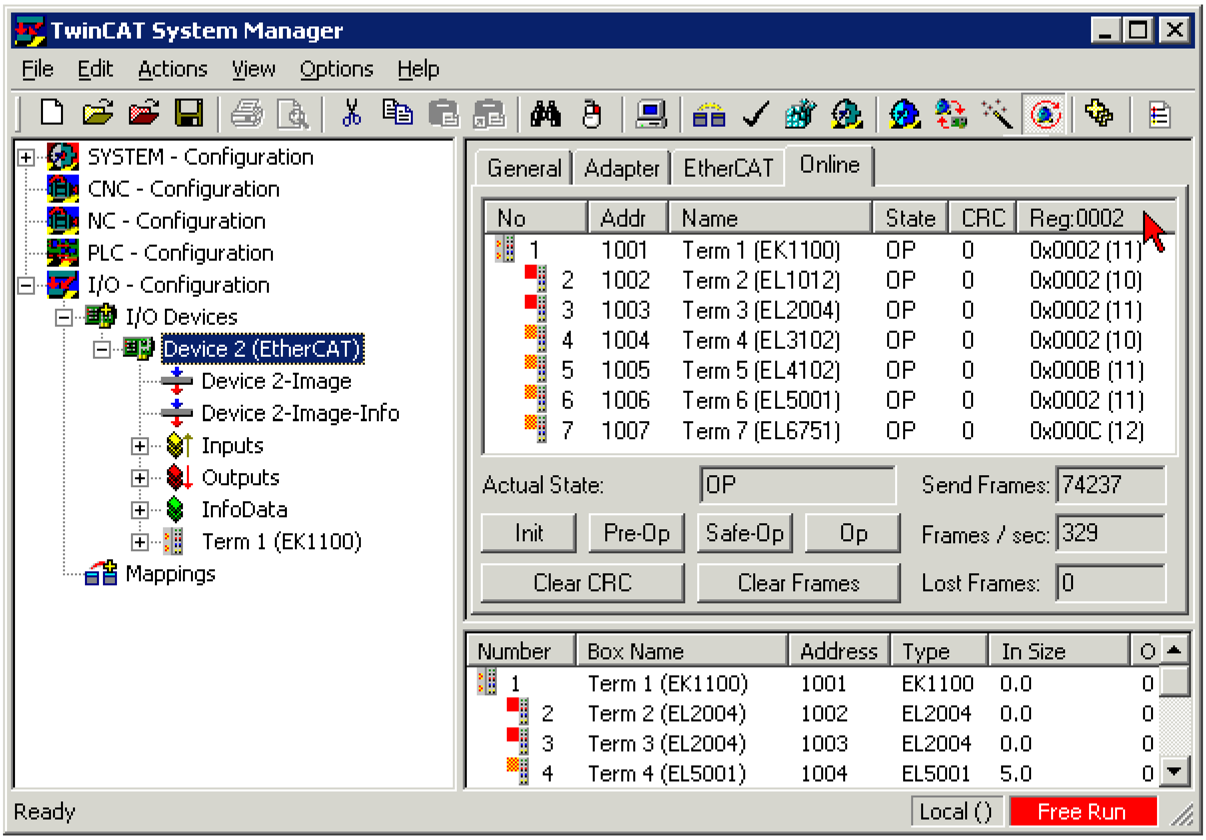



Fig. 203: FPGA firmware version definition

If the column *Reg:0002* is not displayed, right-click the table header and select *Properties* in the context menu.

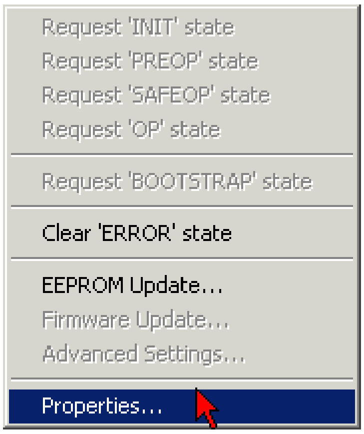



Fig. 204: Context menu *Properties*

The *Advanced Settings* dialog appears where the columns to be displayed can be selected. Under *Diagnosis/***Online View** select the *'0002 ETxxxx Build'* check box in order to activate the FPGA firmware version display.

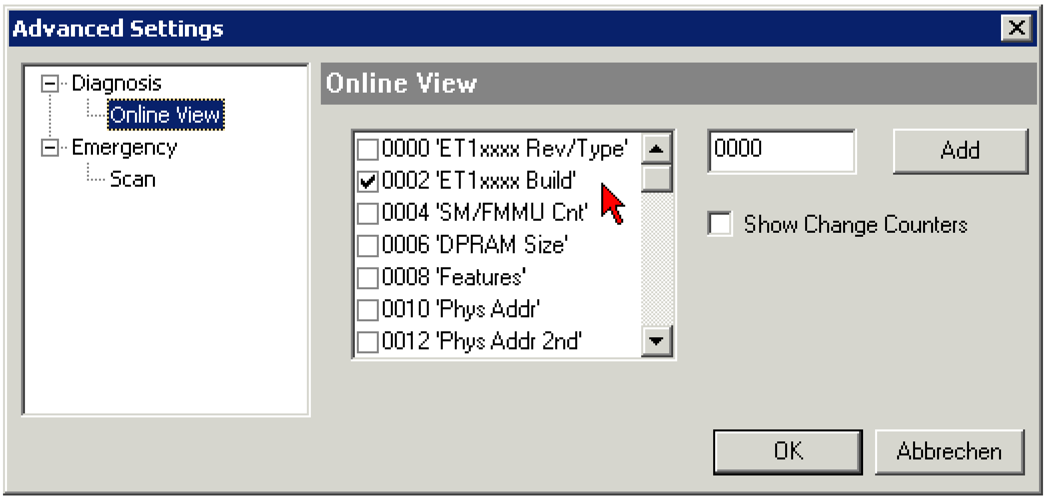



Fig. 205: Dialog *Advanced Settings*

#### Update

For updating the FPGA firmware

- of an EtherCAT coupler the coupler must have FPGA firmware version 11 or higher;
- of an E-Bus Terminal the terminal must have FPGA firmware version 10 or higher.

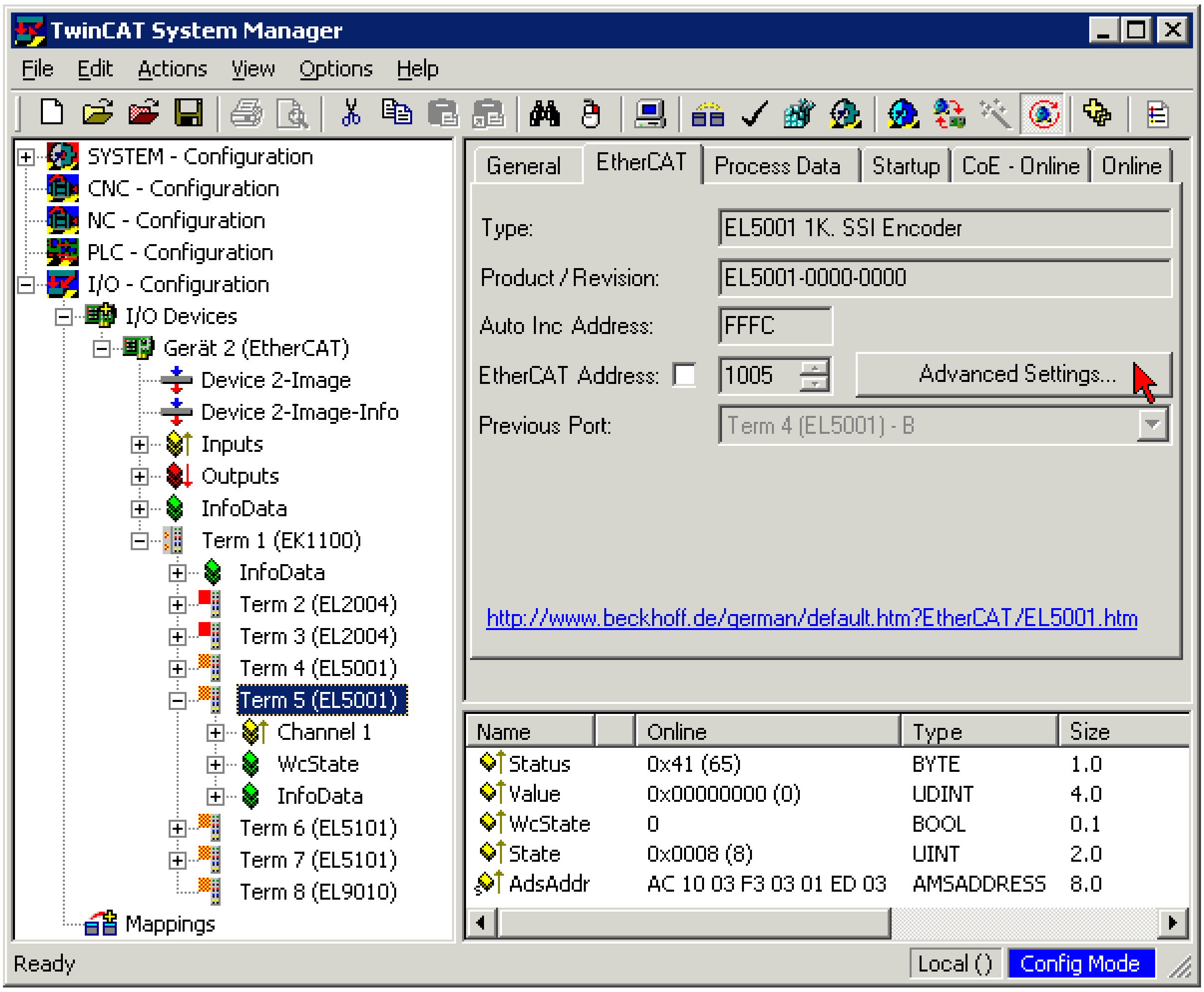
Older firmware versions can only be updated by the manufacturer!

#### Updating an EtherCAT device

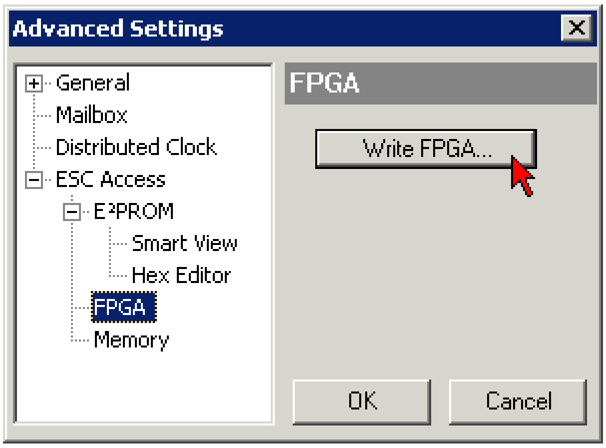
The following sequence order have to be met if no other specifications are given (e.g. by the Beckhoff support):

- Switch TwinCAT system to ConfigMode/FreeRun with cycle time >= 1 ms (default in ConfigMode is 4 ms). A FW-Update during real time operation is not recommended.

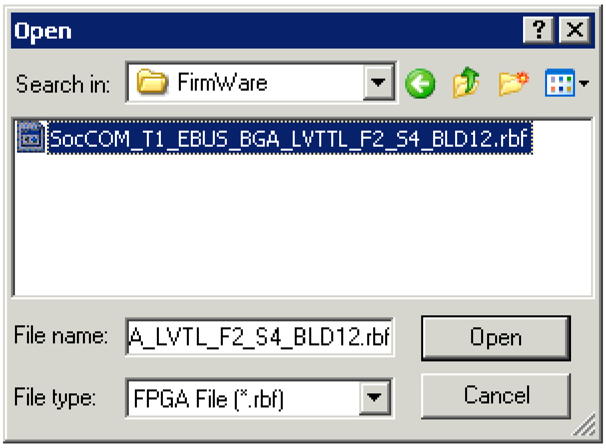
- In the TwinCAT System Manager select the terminal for which the FPGA firmware is to be updated (in the example: Terminal 5: EL5001) and
click the *Advanced Settings* button in the *EtherCAT* tab:



- The *Advanced Settings* dialog appears. Under *ESC Access/E²PROM*/FPGA click on *Write FPGA* button:



- Select the file (*.rbf) with the new FPGA firmware, and transfer it to the EtherCAT device:




- Wait until download ends
- Switch slave current less for a short time (don't pull under voltage!). In order to activate the new FPGA firmware a restart (switching the power supply off and on again) of the EtherCAT device is required.
- Check the new FPGA status

**NOTE**

**Risk of damage to the device!**

A download of firmware to an EtherCAT device must not be interrupted in any case! If you interrupt this process by switching off power supply or disconnecting the Ethernet link, the EtherCAT device can only be recommissioned by the manufacturer!

## 6.3.5 Simultaneous updating of several EtherCAT devices

The firmware and ESI descriptions of several devices can be updated simultaneously, provided the devices have the same firmware file/ESI.

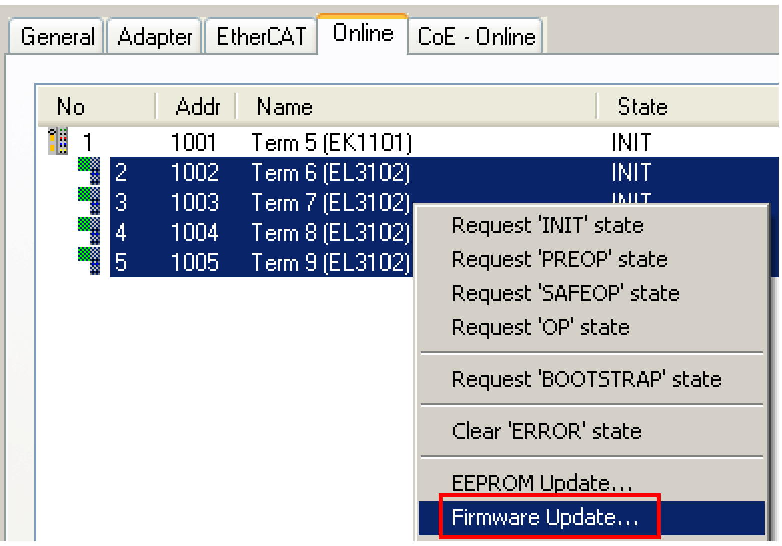



Fig. 206: Multiple selection and firmware update

Select the required slaves and carry out the firmware update in BOOTSTRAP mode as described above.

## 6.4 Firmware compatibility

Beckhoff EtherCAT devices are delivered with the latest available firmware version. Compatibility of firmware and hardware is mandatory; not every combination ensures compatibility. The overview below shows the hardware versions on which a firmware can be operated.

**Note**

- It is recommended to use the newest possible firmware for the respective hardware
- Beckhoff is not under any obligation to provide customers with free firmware updates for delivered products.

**NOTE**

**Risk of damage to the device!**

Pay attention to the instructions for firmware updates on the separate page [▶ 403].
If a device is placed in BOOTSTRAP mode for a firmware update, it does not check when downloading whether the new firmware is suitable.
This can result in damage to the device! Therefore, always make sure that the firmware is suitable for the hardware version!

| EL3311 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 | 01 | EL3311-0000-0016 | 2008/03 |
| 01 - 12* | 02 | EL3311-0000-0017 | 2010/01 |
| | 03 | EL3311-0000-0018 | 2010/06 |
| | 04 | | 2010/07 |
| | | EL3311-0000-0019 | 2012/09 |
| | 05 | | 2013/06 |
| | 06* | | 2013/06 |
| | | EL3311-0000-0020 | 2014/07 |
| | | EL3311-0000-0021 | 2015/01 |
| | | EL3311-0000-0022 | 2016/02 |
| | | EL3311-0000-0023 | 2016/10 |

| EL3312 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 | 01 | EL3312-0000-0016 | 2008/03 |
| 01 | 02 | EL3312-0000-0017 | 2010/01 |
| | 03 | EL3314-0000-0018 | 2010/06 |
| 02 - 11* | 04 | | 2010/07 |
| | 05 | | 2012/07 |
| | | EL3312-0000-0019 | 2012/08 |
| | 06* | | 2013/06 |
| | | EL3312-0000-0020 | 2014/07 |
| | | EL3312-0000-0021 | 2015/01 |
| | | EL3312-0000-0022 | 2016/01 |
| | | EL3312-0000-0023 | 2016/10 |

| EL3314-0000 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 - 11* | 01 | EL3314-0000-0016 | 2009/08 |
| | 02 | EL3314-0000-0017 | 2010/01 |
| | 03 | EL3314-0000-0018 | 2010/06 |
| | 04 | | 2010/07 |
| | 05 | EL3314-0000-0019 | 2012/07 |
| | 06 | | 2013/06 |
| | | EL3314-0000-0020 | 2014/07 |
| | | EL3314-0000-0021 | 2015/01 |
| | | EL3314-0000-0022 | 2016/01 |
| | | EL3314-0000-0023 | 2016/10 |
| | 07* | EL3314-0000-0024 | 2018/09 |

| EL3314-0002 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 - 04* | 01 | EL3314-0002-0016 | 2018/05 |
| | 02* | | 2019/03 |

| EL3314-0010 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 - 07* | 00 | EL3314-0010-0016 | 2012/07 |
| | 01 | EL3314-0010-0017 | 2012/08 |
| | 02 | EL3314-0010-0018 | 2012/12 |
| | | EL3314-0010-0019 | 2014/07 |
| | 03* | EL3314-0010-0020 | 2016/09 |
| | | EL3314-0010-0021 | 2019/05 |

| EL3314-0020 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 05* | 03 | EL3314-0020-001x | 2013/12 |

| EL3314-0030 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00* | 03 | EL3314-0030-0021 | 2019/05 |

| EL3314-0090 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 10 - 11* | 00 | EL3314-0090-0016 | 2016/05 |
| | 01 | | 2017/02 |
| | 02 | EL3314-0090-0017 | 2017/12 |
| | 03* | | 2018/09 |

| EL3318 | | | |
|---|---|---|---|
| **Hardware (HW)** | **Firmware** | **Revision no.** | **Date of release** |
| 00 - 11* | 01 | EL3318-0000-0016 | 2012/02 |
| | | EL3318-0000-0017 | 2012/08 |
| | 02 | | 2013/06 |
| | | EL3318-0000-0018 | 2014/07 |
| | | EL3318-0000-0019 | 2015/01 |
| | | EL3318-0000-0020 | 2016/06 |
| | 03* | EL3318-0000-0021 | 2018/01 |
| | | EL3318-0000-0022 | 2020/02 |

*) This is the current compatible firmware/hardware version at the time of the preparing this documentation. Check on the Beckhoff web page whether more up-to-date documentation is available.

## 6.5 Restoring the delivery state

To restore the delivery state (factory settings) for backup objects in ELxxxx terminals, the CoE object Restore default parameters, *SubIndex 001* can be selected in the TwinCAT System Manager (Config mode) (see Fig. *Selecting the Restore default parameters PDO*)

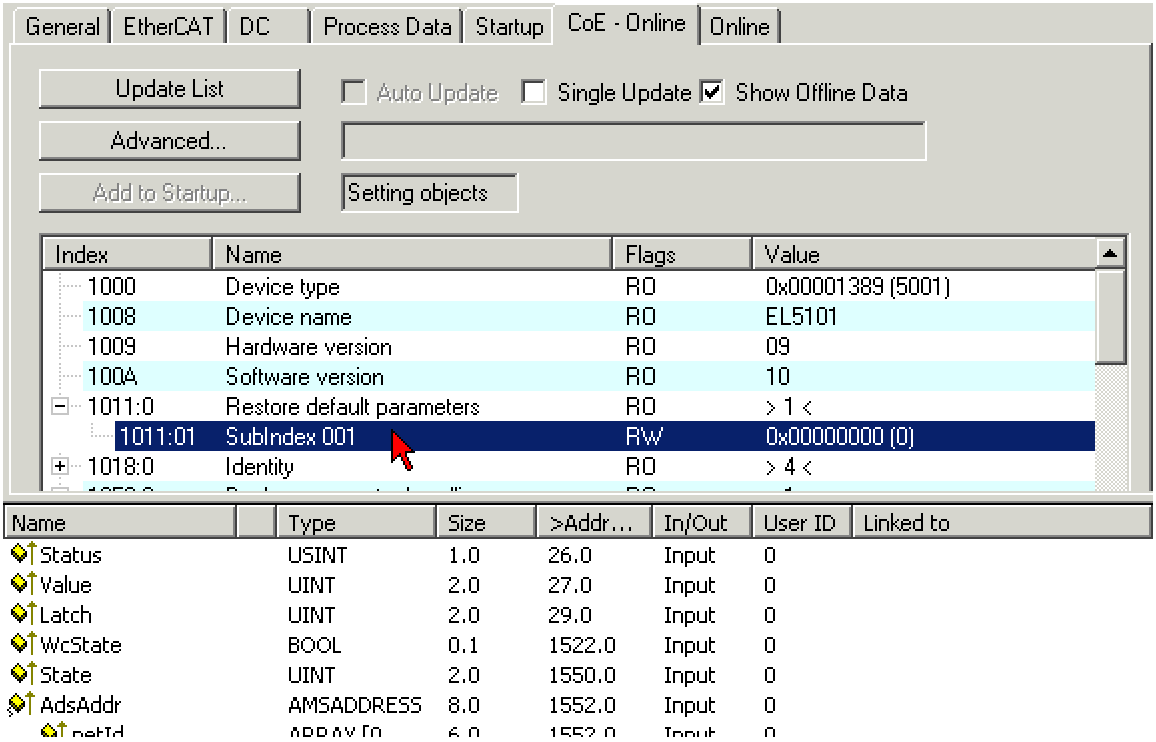



Fig. 207: Selecting the *Restore default parameters* PDO

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* (Fig. *Entering a restore value in the Set Value dialog*). All backup objects are reset to the delivery state.

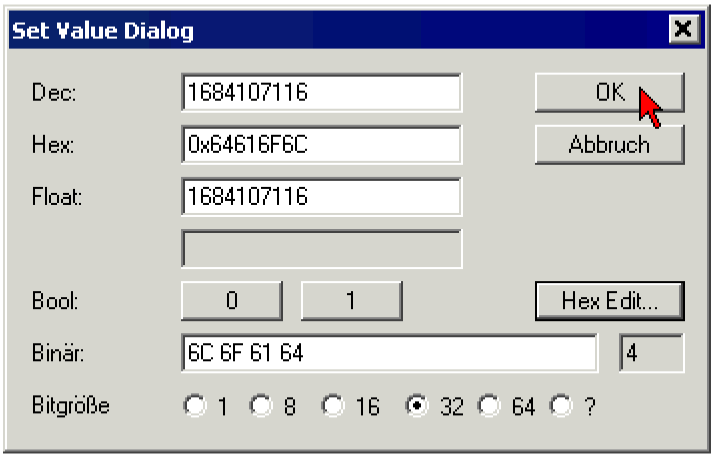



Fig. 208: Entering a restore value in the Set Value dialog

**Alternative restore value**

In some older terminals the backup objects can be switched with an alternative restore value: Decimal value: 1819238756, Hexadecimal value: 0x6C6F6164An incorrect entry for the restore value has no effect.

## 6.6 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

### Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on her internet pages: https://www.beckhoff.com

You will also find further documentation for Beckhoff components there.

### Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

| | |
|---|---|
| Hotline: | +49 5246 963 157 |
| Fax: | +49 5246 963 9157 |
| e-mail: | support@beckhoff.com |

### Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

| | |
|---|---|
| Hotline: | +49 5246 963 460 |
| Fax: | +49 5246 963 479 |
| e-mail: | service@beckhoff.com |

### Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20
33415 Verl
Germany

| | |
|---|---|
| Phone: | +49 5246 963 0 |
| Fax: | +49 5246 963 198 |
| e-mail: | info@beckhoff.com |
| web: | https://www.beckhoff.com |

More Information:
www.beckhoff.com/EL3xxx

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl
Germany
Phone: +49 5246 9630
info@beckhoff.com
www.beckhoff.com