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# EPOS4 EtherCAT Card

## Hardware Reference

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# TABLE OF CONTENTS

## READ THIS FIRST

*These instructions are intended for qualified technical personnel. Prior commencing with any activities…*
- *you must carefully read and understand this manual and*
- *you must follow the instructions given therein.*

# 1 ABOUT

## 1.1 About this Document

### 1.1.1 Intended Purpose

*Use the docu-
ment to…
–stay safe,
–be fast,
–end up with set
up and ready-to-
go equipment.*

The purpose of the present document is to familiarize you with the EPOS4 EtherCAT Card. It will highlight the tasks for safe and adequate installation and/or commissioning. Follow the described instructions …

- to avoid dangerous situations,
- to keep installation and/or commissioning time at a minimum,
- to increase reliability and service life of the described equipment.

The present document is part of a documentation set and contains performance data and specifications, information on fulfilled standards, details on connections and pin assignment, and wiring examples. The below overview shows the documentation hierarchy and the interrelationship of its individual parts:
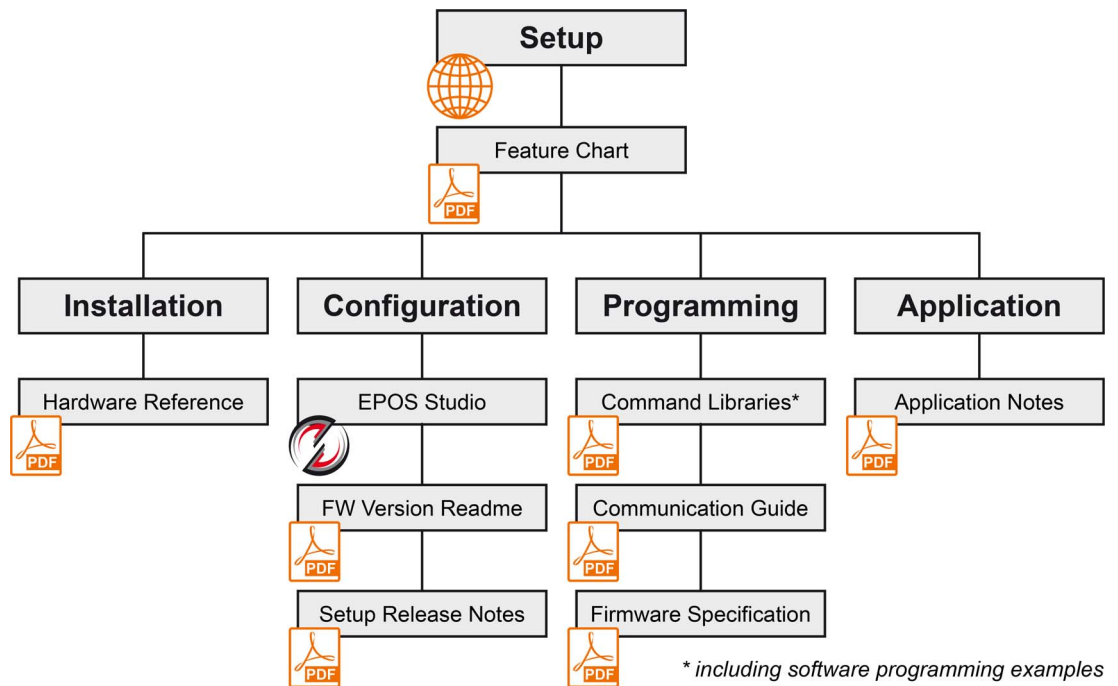


Figure 1-1 Documentation structure

### 1.1.2 Target Audience

The present document is intended for trained and skilled personnel. It conveys information on how to under-stand and fulfill the respective work and duties.

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### 1.1.3 How to use

Throughout the document, the following notations and codes will be used.

| Notation | Meaning |
|---|---|
| **Module** | refers to an EPOS4 Module (such as «EPOS4 Module 24/1.5», «EPOS4 Module 50/15»,and others) |
| **(n)** | refers to an item (such as part numbers, list items, etc.) |
| **➔** | denotes "see", "see also", "take note of" or "go to" |

Table 1-1    Notation used

### 1.1.4 Symbols & Signs

In the course of the present document, the following symbols and signs will be used.

| Type | Symbol | Meaning | |
|---|---|---|---|
| **Safety alert** | (typical) | DANGER | Indicates an **imminent hazardous situation**. If not avoided, it **will result in death or serious injury**. |
| | | WARNING | Indicates a **potential hazardous situation**. If not avoided, it **can result in death or serious injury**. |
| | | CAUTION | Indicates a **probable hazardous situation** or calls the attention to unsafe practices. If not avoided, it **may result in injury**. |
| **Prohibited action** | (typical) | Indicates a dangerous action. Hence, **you must not**! | |
| **Mandatory action** | (typical) | Indicates a mandatory action. Hence, **you must**! | |
| **Information** | | Requirement / Note / Remark | Indicates an activity you must perform prior continuing, or gives information on a particular item you need to observe. |
| | | Best practice | Indicates an advice or recommendation on the easiest and best way to further proceed. |
| | | Material Damage | Indicates information particular to possible damage of the equipment. |

Table 1-2    Symbols and signs

### 1.1.5 Trademarks and Brand Names

For easier legibility, registered brand names are listed below and will not be further tagged with their respective trademark. It must be understood that the brands (the list below is not necessarily concluding) are protected by copyright and/or other intellectual property rights even if their legal trademarks are omitted in the later course of this document.

| Brand name | Trademark owner |
| --- | --- |
| Adobe® Reader® | © Adobe Systems Incorporated, USA-San Jose, CA |
| EtherCAT® | © EtherCAT Technology Group, DE-Nuremberg, licensed by Beckhoff Automation GmbH, DE-Verl |
| PCI Express® PCIe® | © PCI-SIG, USA-Beaverton, OR |
| Windows® | © Microsoft Corporation, USA-Redmond, WA |

Table 1-3          Brand names and trademark owners

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CCMC | EPOS4 EtherCAT Card Hardware Reference | Edition 2019-11 | DocID rel8613

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CH-6072 Sachseln          www.maxongroup.com

## 1.2 About the Device

*Capabilities of the device, included features, and supported controllers.*

maxon's «EPOS4 EtherCAT Card» is a plug-in extension card to provide complete EtherCAT communication capability for an EPOS4 positioning controller. It is optionally available to equip either an EPOS4 encased housing variant or an EPOS4 Module with full EtherCAT functionality. For the latter, development of an own motherboard as to particular guidelines is needed (for details ➔chapter "4 Motherboard Design Guide" on page 4-17).

Find the latest edition of the present document as well as additional documentation and software for EPOS4 positioning controllers also on the Internet: ➔http://epos.maxongroup.com

In addition, you may wish to browse the EPOS video library. It features video tutorials that provide easy to follow instructions on how to get started with «EPOS Studio» and shows you tips and tricks on how to setup communication interfaces, and so on. Explore on Vimeo: ➔https://vimeo.com/album/4646388

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## 1.3    About the Safety Precautions

*Keep in mind:*
*Safety      first!*
*Always!*

• Make sure that you have read and understood the note "READ THIS FIRST" on page A-2!

• Do not engage with any work unless you possess the stated skills (➔chapter "1.1.2 Target Audience" on page 1-3)!

• Refer to ➔chapter "1.1.4 Symbols & Signs" on page 1-4 to understand the subsequently used indicators!

• You must observe any regulation applicable in the country and/or at the site of implementation with regard to health and safety/accident prevention and/or environmental protection!

> **DANGER**
>
> ***High voltage and/or electrical shock***
> ***Touching live wires causes death or serious injuries!***
> • *Consider any power cable as connected to live power, unless having proven the opposite!*
> • *Make sure that neither end of cable is connected to live power!*
> • *Make sure that power source cannot be engaged while work is in process!*
> • *Obey lock-out/tag-out procedures!*
> • *Make sure to securely lock any power engaging equipment against unintentional engagement and tag it with your name!*

***Requirements***
• *Make sure that all associated devices and components are installed according to local regulations.*
• *Be aware that, by principle, an electronic apparatus cannot be considered fail-safe. Therefore, you must make sure that any machine/apparatus has been fitted with independent monitoring and safety equipment. If the machine/apparatus should break down, if it is operated incorrectly, if the control unit breaks down or if the cables break or get disconnected, etc., the complete drive system must return – and be kept – in a safe operating mode.*
• *Be aware that you are not entitled to perform any repair on components supplied by maxon.*

***Electrostatic sensitive device (ESD)***
• *Wear working cloth and use equipment in compliance with ESD protective measures.*
• *Handle device with extra care.*

***Hot plugging/hot swapping the card may cause hardware damage***
*Switch off the controller's power supply before removing or inserting an extension card.*

# 2 SPECIFICATIONS

## 2.1 Technical Data

| EPOS4 EtherCAT Card (581245) | | | |
|---|---|---|---|
| **Electrical Rating** | Nominal power supply voltage $+V_{CC}$ | | 10…70 VDC |
| | Absolute supply voltage $+V_{min}$ / $+V_{max}$ | | 8 VDC / 76 VDC |
| **Interface** | EtherCAT input EtherCAT output | | As to IEEE 802.3 100 Base T |
| | Max. bit rate | | 100 Mbit/s (full duplex) |
| **Physical** | Weight | | approx. 7 g |
| | Dimensions (L x W x H) | | 41 x 25 x 9.2 mm |
| | Mounting | | Card edge connector, PCIe; 2x18 position |
| **Environment** | Temperature | Operation | −30…+60 °C |
| | | Extended range [1] | For details consult Hardware Reference of respective EPOS4 controller |
| | | Storage | −40…+85 °C |
| | Altitude [2] | Operation | 0…10'000 m MSL |
| | Humidity | | 5…90% (condensation not permitted) |

(1) Operation within the extended range is permitted. However, a respective derating (declination of output current $I_{cont}$) as to the stated values will apply.

(2) Operating altitude in meters above Mean Sea Level, MSL.

Table 2-4        Technical data

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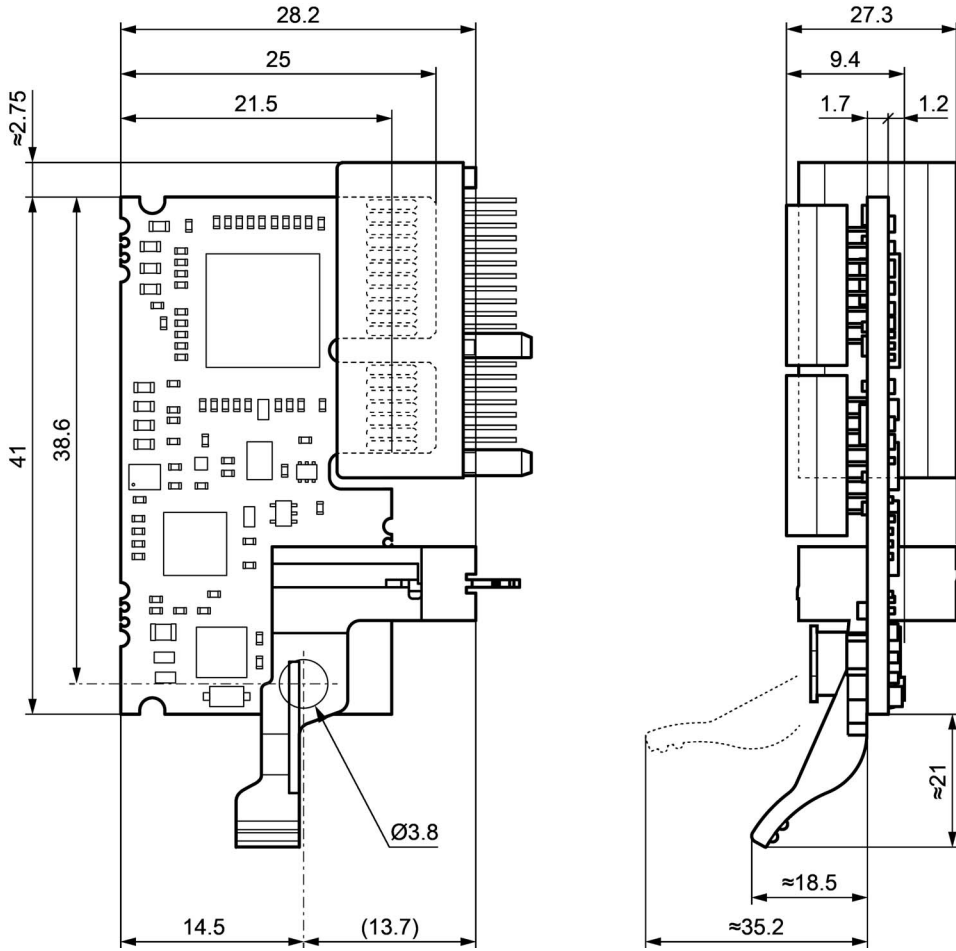## 2.2    Dimensional Drawings



Figure 2-2        EPOS4 EtherCAT Card with card edge connector & retainer – Dimensional drawing [mm]

## 2.3 Standards

The described device has been successfully tested for compliance with the below listed standards. In practical terms, only the complete system (the fully operational equipment comprising all individual components, such as motor, servo controller, power supply unit, EMC filter, cabling etc.) can undergo an EMC test to ensure interference-free operation.

*Important notice*
*The device's compliance with the mentioned standards does not imply its compliance within the final, ready to operate setup. In order to achieve compliance of your operational system, you must perform EMC testing of the involved equipment as a whole.*

| Electromagnetic Compatibility | | |
|---|---|---|
| **Generic** | IEC/EN 61000-6-2 | Immunity for industrial environments |
| | IEC/EN 61000-6-3 | Emission standard for residential, commercial and light-industrial environments |
| **Applied** | IEC/EN 55022 (CISPR22) | Radio disturbance characteristics / radio interference |
| | IEC/EN 61000-4-3 | Radiated, radio-frequency, electromagnetic field immunity test >10 V/m |
| | IEC/EN 61000-4-4 | Electrical fast transient/burst immunity test ±2 kV |
| | IEC/EN 61000-4-6 | Immunity to conducted disturbances, induced by radio-frequency fields 10 Vrms |

| Others | | |
|---|---|---|
| **Environment** | IEC/EN 60068-2-6 | Environmental testing – Test Fc: Vibration (sinusoidal, 10…500 Hz, 20 m/s$^2$) |
| | MIL-STD-810F | Random transport (10…500 Hz up to 2.53 $g_{rms}$) |
| **Safety** | UL File Number | Unassembled printed circuit board: E207844 |
| **Reliability** | MIL-HDBK-217F | Reliability prediction of electronic equipment<br>Environment: Ground, benign (GB)<br>Ambient temperature: 298 K (25 °C)<br>Component stress: In accordance with circuit diagram and nominal power<br>Mean Time Between Failures (MTBF) 544'021 hours |

Table 2-5         Standards

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# 3 SETUP

## 3.1 Generally applicable Rules

***Maximal permitted supply voltage***
- *Make sure that supply power is between 10…70 VDC.*
- *Supply voltages above 76 VDC, or wrong polarity will destroy the unit.*

***Hot plugging/hot swapping the card may cause hardware damage***
*Switch off the controller's power supply before removing or inserting an extension card.*
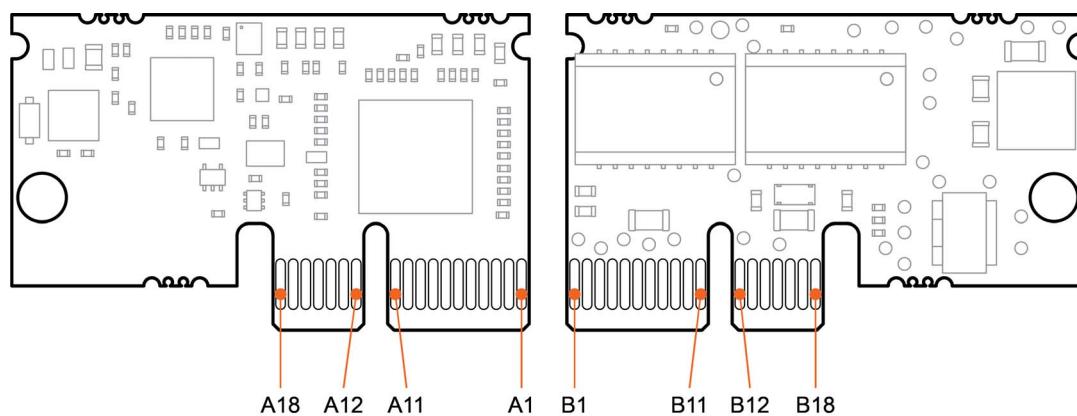
## 3.2 Connections



| A18 | A12 | A11 | A1 | B1 | B11 | B12 | B18 |

Figure 3-3        EPOS4 EtherCAT Card – PCB with connector arrays

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| Array A | | | Array B | | |
|---|---|---|---|---|---|
| Pin | Signal | Description | Pin | Signal | Description |
| A1 | – | Connect to EtherCAT OUT X15 \| 4 | B1 | TX+_OUT | EtherCAT OUT Transmission Data+ |
| A2 | – | Connect to EtherCAT OUT X15 \| 5 | B2 | TX−_OUT | EtherCAT OUT Transmission Data− |
| A3 | – | Connect to EtherCAT OUT X15 \| 7 | B3 | RX+_OUT | EtherCAT OUT Receive Data+ |
| A4 | – | Connect to EtherCAT OUT X15 \| 8 | B4 | RX−_OUT | EtherCAT OUT Receive Data− |
| A5 | – | Connect to EtherCAT IN X14 \| 4 | B5 | TX+_IN | EtherCAT IN Transmission Data+ |
| A6 | – | Connect to EtherCAT IN X14 \| 5 | B6 | TX−_IN | EtherCAT IN Transmission Data− |
| A7 | – | Connect to EtherCAT IN X14 \| 7 | B7 | RX+_IN | EtherCAT IN Receive Data+ |
| A8 | – | Connect to EtherCAT IN X14 \| 8 | B8 | RX−_IN | EtherCAT IN Receive Data− |
| A9 | LED_EtherCAT_OUT | Link activity of port EtherCAT OUT X15 | B9 | LED_EtherCAT_IN | Link activity of port EtherCAT IN X14 |
| A10 | – | not connected | B10 | – | not connected |
| A11 | LED_Status_red | EtherCAT status "Error" | B11 | LED_Status_green | EtherCAT status "Run" |
| A12 | Shield | Cable shield | B12 | SPI_SOMI | SPI Slave output/Master input |
| A13 | GND | Ground | B13 | SPI_SIMO | SPI Slave input/Master output |
| A14 | GND | Ground | B14 | SPI_CLK | SPI clock |
| A15 | – | not connected | B15 | SPI_CS2 | SPI chip select 2 |
| A16 | – | not connected | B16 | SPI_IRQ | SPI interrupt request |
| A17 | GND | Ground | B17 | – | not connected |
| A18 | +$V_{CC}$ | Nominal power supply voltage (+10…+70 VDC) | B18 | – | not connected |

Table 3-6        Connector arrays – Pin assignment

## 3.3 Installation

The procedure varies depending on the type of controller you are using:

- EPOS4 controllers with **encased housing** feature two ready-to-use extension slots.
- EPOS4 **Modules** require a custom-made motherboard (for details on design and layout ➔chapter "4 Motherboard Design Guide" on page 4-17) with a PCIe card edge connector.

**Hot plugging/hot swapping the card may cause hardware damage**
*Switch off the controller's power supply before removing or inserting an extension card.*

**Electrostatic sensitive device (ESD)**
- *Wear working cloth and use equipment in compliance with ESD protective measures.*
- *Handle device with extra care.*

### 3.3.1 EPOS4 Controllers with encased Housing

The controllers provide two extension slots (EXT1 & EXT2) located underneath the plastic lid at the housing's top face (➔Figure 3-4). The plastic lid will mechanically interlock the inserted extension card in both horizontal and vertical direction.

- **EXT1** hosts the «EPOS4 EtherCAT Card».
- **EXT2** provides connectivity for advanced signal extension cards, such as for additional absolute sensors or customized signal extensions.
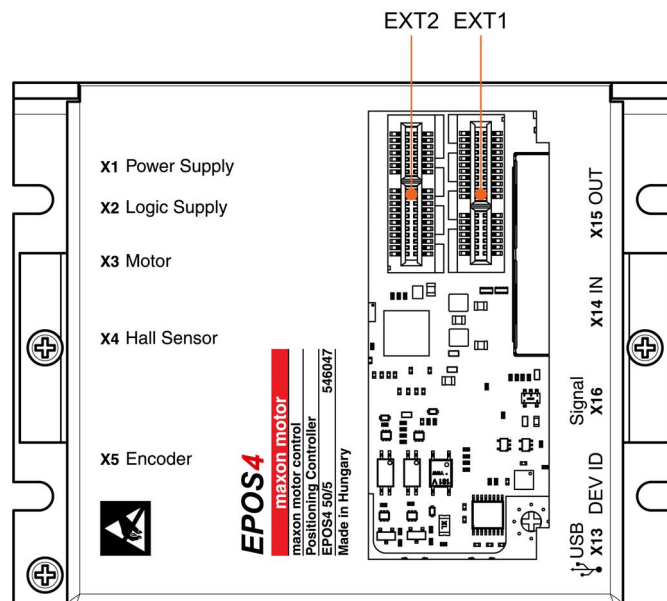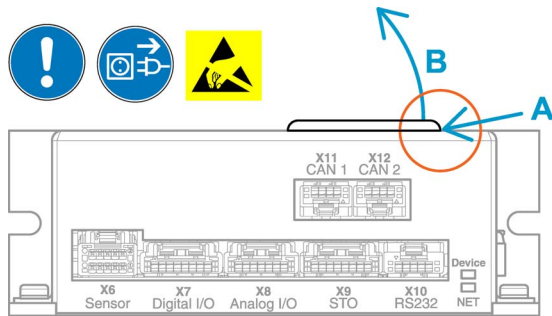


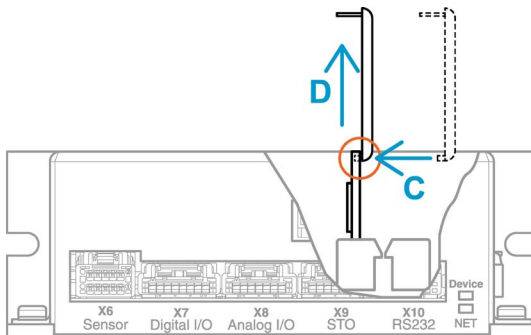Figure 3-4    Extension slots – as an example «EPOS4 50/5»

Continued on next page.

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**Switch off the controller's power supply. Comply with ESD protective measures.**
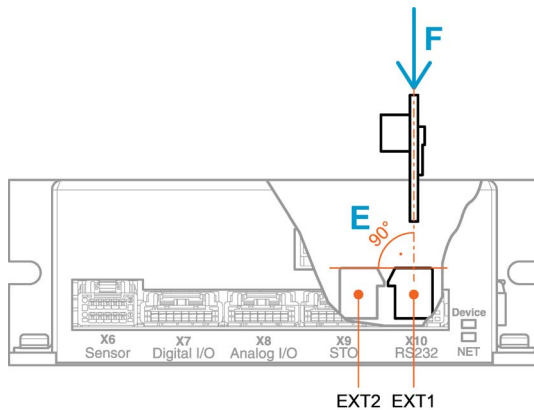
**Open plastic lid**

1) Unlock the two latches (A) on the plastic lid.

2) Lift the plastic lid upward (B) and remove.

**Remove extension card, if necessary**

3) Turn the plastic lid over and look for the molded catch in one of its corners.

4) Insert the catch into the extension card's bore (C).

5) Pull both – the plastic lid together with the extension card – straight upward (D).

**Make sure that the extension slots are clean and free of any foreign objects.**

**Insert extension card**

6) Align the extension card with the PCIe card edge connector and keep it right-angled (E).

7) Carefully insert the extension card in the extension slot EXT1 while keeping it right-angled and press down all the way into the PCIe card edge connector (F).
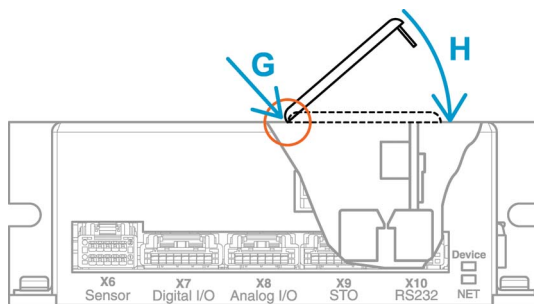
**Close plastic lid**

8) Engage the plastic lid at its rear edge (G).

9) Fold down the plastic lid (H), press it down firmly, and let the two latches snap into place.

Figure 3-5        EPOS4 EtherCAT Card – Installation & removal

### 3.3.2 EPOS4 Modules

The connection of the «EPOS4 EtherCAT Card» can be established via a custom-made motherboard which defines the actual installation procedure.

Depending on the case of application (with possibly involved strong movements and high dynamic accelerations) and to guarantee failsafe operation, you might wish to consider the use of a PCIe card edge connector with retainer (➔Figure 3-6). The retainer will mechanically interlock the inserted extension card in both horizontal and vertical direction.
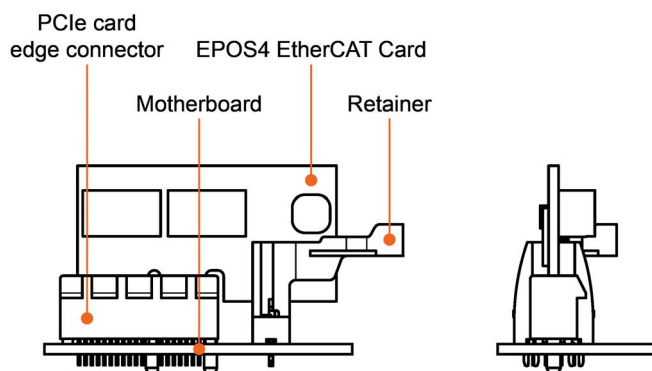


Figure 3-6          EPOS4 EtherCAT Card with PCIe card edge connector and retainer

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# 4 MOTHERBOARD DESIGN GUIDE

4-17

The «Motherboard Design Guide» provides helpful information on integrating the EPOS4 EtherCAT Card on a printed circuit board. It contains recommendations for the motherboard layout and specifies external components that may be required, pin assignments, and connection examples.

> **CAUTION**
>
> *Dangerous action*
> *Errors in implementing the design can result in serious Injury!*
> - *Only proceed if you are skilled in electronics design!*
> - *Designing a printed circuit board requires special skills and knowledge and may only be performed by experienced electronic developers!*
> - *This quick guide is only intended as an aid, does not make any claim to completeness, and will not automatically result in a functional component!*

> *Get help*
> *If you are not trained in the design and development of printed circuit boards, you will need additional support for this point.*
> *maxon will be happy to provide you with a quote for designing and manufacturing a motherboard for your specific application.*

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## 4.1 Schematic Overview

Motherboard (customer-specific)

EPOS4 Module 24/1.5 (536630)
EPOS4 Module 50/5 (534130)
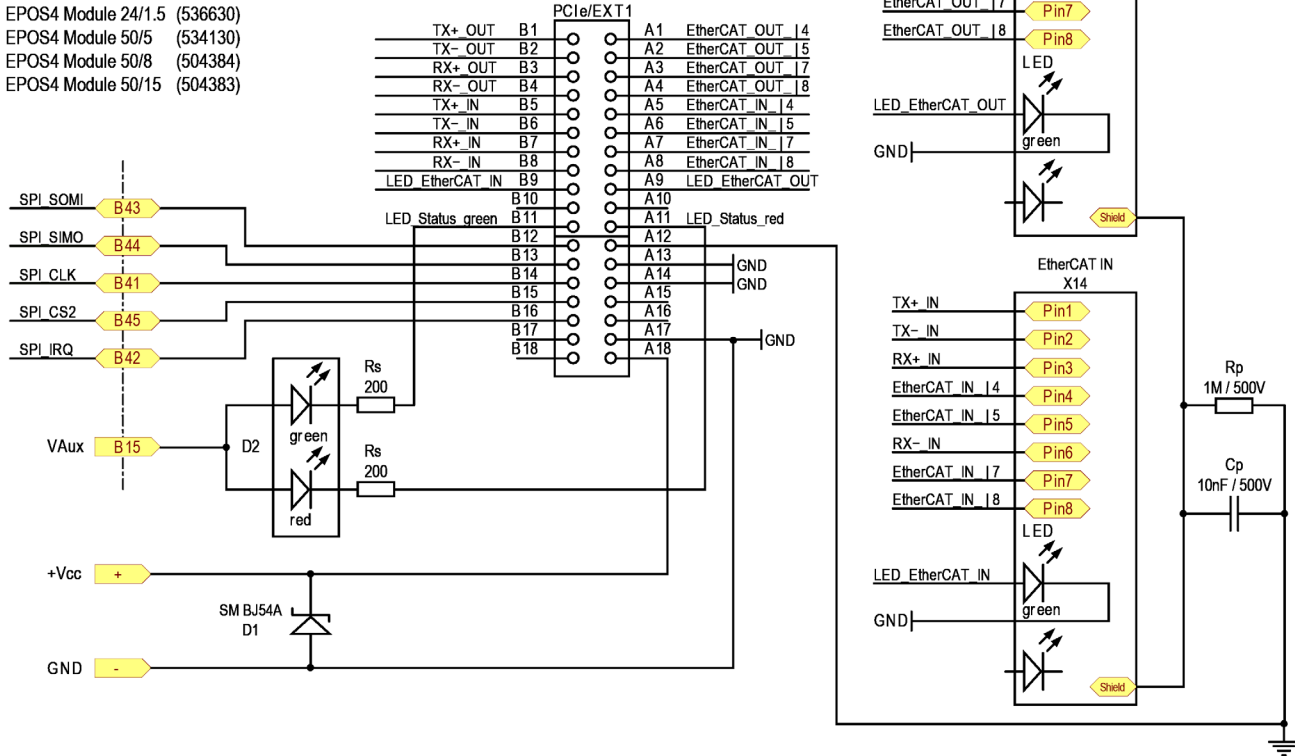EPOS4 Module 50/8 (504384)
EPOS4 Module 50/15 (504383)

Figure 4-7    Schematic overview

## 4.2 Requirements for Components of Third-party Suppliers

**Best practice**
*For references and recommended components consult ➜Table 4-14.*

### 4.2.1 Card Edge Connector & Socket Headers

For implementation of the «EPOS4 EtherCAT Card», a PCIe 2x18 position connector is required.

EPOS4 modules are available with two different types of socket headers.

- **EPOS4 Module 24/1.5** (536630) and **EPOS4 Module 50/5** (534130) feature 1.27 mm box headers.

- **EPOS4 Module 50/8** (504384) and **EPOS4 Module 50/15** (504383) have pin headers that permit two ways of mounting. They can either be plugged in a socket header or be directly soldered to a printed circuit board.

Find further details on the hardware in the ➜separate document «Hardware Reference» of th e respective EPOS4 Module.

### 4.2.2 Supply Voltage

For voltage supply of the «EPOS4 EtherCAT Card», you may employ the EPOS4 Module's power supply. For details ➔ separate document «Hardware Reference» of the respective EPOS4 Module.

If you intend to use another source as power supply, we recommend to connect a TVS (transient voltage suppressor) diode (D1) to the voltage supply line to protect against overvoltage resulting from voltage transients or brake energy feedback.

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### 4.2.3 EtherCAT Status LEDs

The «EPOS4 EtherCAT Card» provides two outputs to display the actual status and possible errors of the EtherCAT network with LEDs (D2):

- Green LED shows the RUN state

- Red LED indicates errors

| LED | | Description |
|---|---|---|
| **Green** | **Red** | |
| OFF | — | EPOS4 is in state INIT |
| Blink | — | EPOS4 is in state PRE-OPERATIONAL |
| Single flash | — | EPOS4 is in state SAFE-OPERATIONAL |
| ON | — | EPOS4 is in state OPERATIONAL |
| — | OFF | EPOS4 is in operating condition |
| — | Double flash | An application watchdog timeout has occurred<br>*Example: Timeout of Sync Manager Watchdog* |
| — | Single flash | EPOS4 has changed the COM state due to an internal error<br>*Example: Change of state "Op" to "SafeOpError" due to Sync Error* |
| — | Blink | General Configuration Error<br>*Example: State change commanded by master is not possible due to actual settings (register, object, hardware configuration)* |
| Blink = continuous blinking (≈2.5 Hz) | | Flash = Flashing (≈0.2 s), followed by pause of 1 s |

Table 4-7        EtherCAT status LEDs

The outputs are designed as open-collector circuit with internal series resistor of 150 Ohm. An external LED can be mounted as long as the current is limited to less than 20 mA with an matching series resistor (Rs).

| Red/green EtherCAT status LED "sinks" | |
|---|---|
| Max. input voltage | +30 VDC |
| Max. load current | 20 mA |

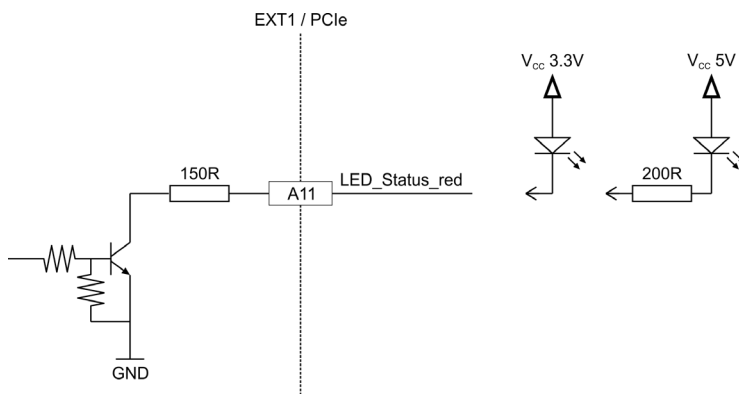Table 4-8        EtherCAT status LED "sinks"



Figure 4-8        EtherCAT status LED "sinks" (analogously valid for B11)

### 4.2.4 EtherCAT Port LEDs

The «EPOS4 EtherCAT Card» provides two outputs to display the EtherCAT port's link activity (applies for both ports, X14 "EtherCAT IN" and X15 "EtherCAT OUT"):

- Green LED indicates link activity

| LED Green | Description |
|---|---|
| OFF | Port is closed |
| Flicker | Port is open / activity is present |
| ON | Port is open |
| — | Data rate is 100 Mbit/s |
| Flicker = Continuous flickering ($\approx$10 Hz) | |

Table 4-9    EtherCAT port LEDs

The outputs are designed to drive integrated LEDs of standard modular port jacks according the following specification:

| Green EtherCAT port activity LED "source" | |
|---|---|
| Output voltage | $U_{Out} = 3.3\ V - (I_{Load}\ x\ 150\ \Omega)$ |
| Max. load current | 10 mA |

Table 4-10    EtherCAT port activity LED "source"
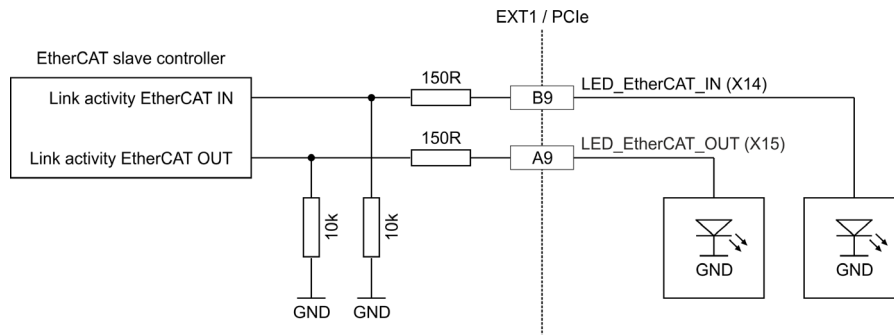


Figure 4-9    EtherCAT port activity LED "source"

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### 4.2.5 EtherCAT Connectors

The «EPOS4 EtherCAT Card» provides both transmission and receive signals for input as well as output for an EtherCAT interface. Unused connections of the EtherCAT IN/OUT connectors (pins 4, 5, 7, and 8) must be connected through to the PCIe plug-in contact.

In respect to short-term signal transmission and propagation times, sufficient short conducting paths and isolation spacing must be provided.

***Wrong plugging may cause hardware damage***

*Even though both sockets are prepared for identical external wiring, make sure to always connect them as follows.*

- *Use only standard Cat5 cables with RJ45 plug, such as maxon's «Ethernet Cable» (422827).*
- *Use EtherCAT IN as «Input».*
- *Use EtherCAT OUT as «Output».*

*For detailed information ➜separate document «EPOS4 Communication Guide».*

***For detailed information ➜separate document «EPOS4 Communication Guide».***
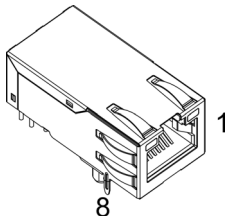


Figure 4-10    EtherCAT connector

| EtherCAT | |
|---|---|
| EtherCAT Standard | IEEE 802.3 100 Base Tx |
| Max. bit rate | 100 Mbit/s (full duplex) |

Table 4-11    EtherCAT interface specification

| Pin | Signal | Description |
|---|---|---|
| 1 | TX+ | Transmission Data+ |
| 2 | TX− | Transmission Data− |
| 3 | RX+ | Receive Data+ |
| 4 | TXCT | not applicable |
| 5 | TXCT | not applicable |
| 6 | RX− | Receive Data− |
| 7 | RXCT | not applicable |
| 8 | RXCT | not applicable |

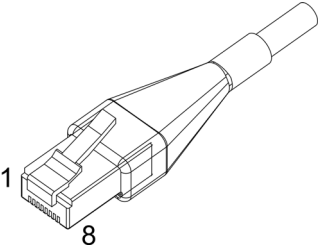Table 4-12    EtherCAT connectors – Pin assignment

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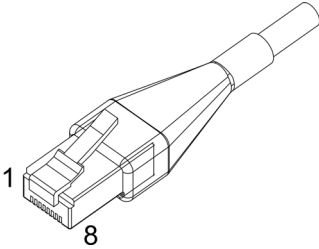
| Ethernet Cable (422827) | |
|---|---|
|  | |
| Cross-section | Cat. 5e SF/UTP (ISO/IEC 11801), 1:1 patch cable, green |
| Length | 2 m |
| Head A | RJ45 (8P8CS) EIA/TIA-568B |
| Head B | RJ45 (8P8CS) EIA/TIA-568B |

Table 4-13        Ethernet Cable

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### 4.2.6 Recommended Components and Manufacturers

| Recommended components | |
|---|---|
| **Card Edge Connector (EXT1)** | PCIe 2x18 Position, THT<br>• Amphenol FCI (10018784-10200TLF)<br>• Sullins Connector Solutions (NWE18DHHN-T911)<br>• TE Connectivity (7-1734774-6) |
| **Retainer for Card Edge Connector (optional)** | PCI express retainer<br>• Amphenol FCI (10042618-002LF) |
| **EtherCAT Two Port Modular Jack (X14/X15)** | • Amphenol (RJHSE-5381-02)<br>• Würth (615016137721) |
| **TVS Diode (D1)** | • Vishay (SMBJ54A)<br>$U_R = 54$ V, $U_{BR} = 60.0\ldots66.3$ V @ 1 mA, $U_C = 87.1$ V @ 6.9 A<br>• Fairchild (SMBJ54A)<br>$U_R = 54$ V, $U_{BR} = 60.0\ldots66.3$ V @ 1 mA, $U_C = 87.1$ V @ 6.9 A<br>• Littelfuse (SMBJ54A)<br>$U_R = 54$ V, $U_{BR} = 60.0\ldots66.3$ V @ 1 mA, $U_C = 87.1$ V @ 6.9 A |
| **LED (D2)** | Dual-sided SMT LED green/red<br>• Lite-On (LTST-S326KGJRKT)<br>• Dialight (597-2751-607F)<br>• Avago (HSMF-C144) |
| **Decoupling (Rp/Cp)** | R/C chip combination<br>• Chip resistor 1 M Ω, 0.25 W, 500 V<br>• Chip capacitor 10 nF, 500 V |

Table 4-14      Motherboard Design Guide – Recommended components

## 4.3 THT Footprint

Depending on your case of application and type of operation, considerable strong movements and high dynamic accelerations may occur. If the case, you might wish to consider using a PCIe card edge connector with retainer which will then mechanically interlock the inserted extension card in both horizontal and vertical direction.

***Possible strong mechanical loads during operation may cause hardware damage***
*Operation involving strong movements and high dynamic accelerations can cause an unsecured extension card to shake loose. This can lead to serious damage of hardware or equipment and to complete failure of the system. To avoid, use a PCIe card edge connector with retainer (➜Figure 4-11).*

**PCIe Card Edge Connector with Retainer**
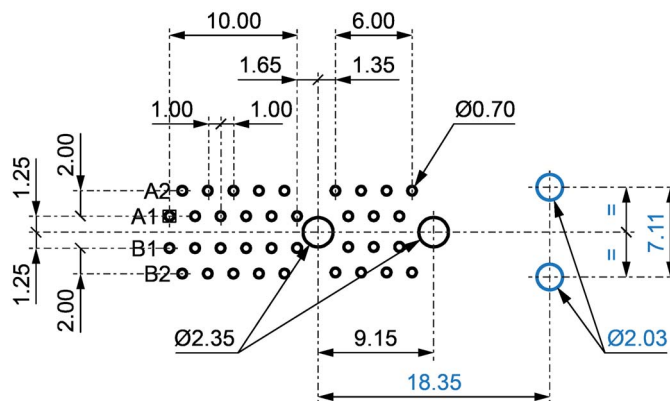


Figure 4-11     PCIe card edge connector with retainer – THT footprint [mm] – Top view

**PCIe Card Edge Connector without Retainer**
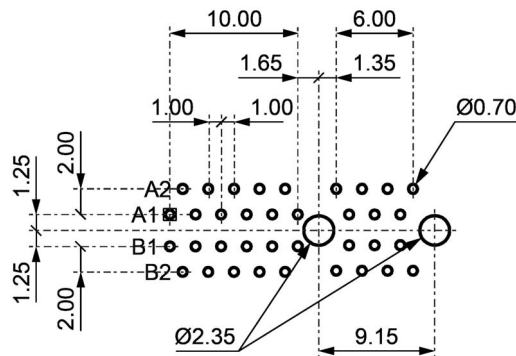


Figure 4-12     PCIe card edge connector – THT footprint [mm] – Top view

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# maxon



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