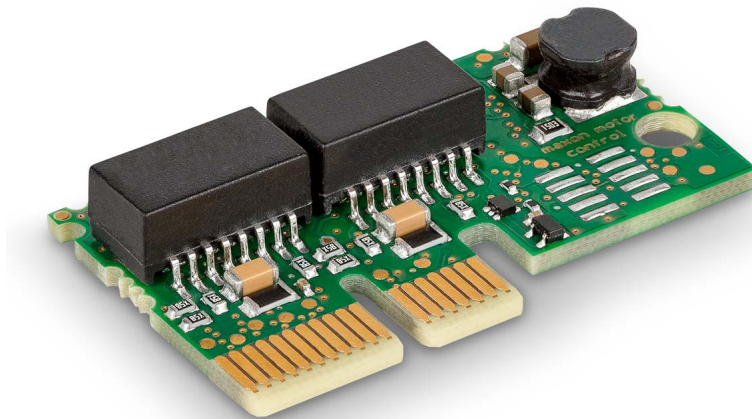


EPOS4 EtherCAT Card

Extension Card
P/N 581245

Hardware Reference



EtherCAT®



epos.maxonmotor.com

Document ID: rel7777

TABLE OF CONTENTS

1	About	3
1.1	About this Document	3
1.2	About the Device	5
1.3	About the Safety Precautions	6
2	Specifications	7
2.1	Technical Data	7
2.2	Dimensional Drawings	8
2.3	Standards	9
3	Setup	11
3.1	Generally applicable Rules	11
3.2	Connections	11
3.3	Installation	13
3.3.1	EPOS4 Controllers with encased Housing	13
3.3.2	EPOS4 Modules	15
4	Motherboard Design Guide	17
4.1	Schematic Overview	17
4.2	Requirements for Components of Third-party Suppliers	18
4.2.1	Card Edge Connector & Socket Headers	18
4.2.2	Supply Voltage	18
4.2.3	EtherCAT Status LEDs	19
4.2.4	EtherCAT Port LEDs	20
4.2.5	EtherCAT Connectors	21
4.2.6	Recommended Components and Manufacturers	23
4.3	THT Footprint	24

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 document 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:

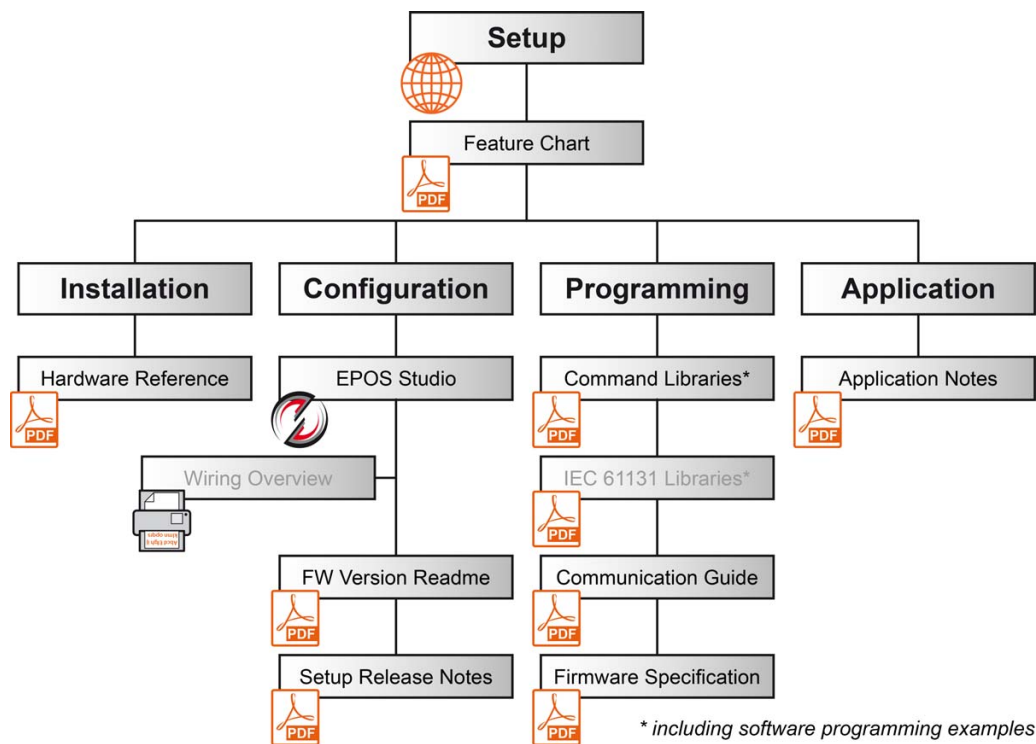


Figure 1-1 Documentation structure

1.1.2 Target Audience

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

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

1.1.6 Copyright

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1.2 About the Device

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

maxon motor control'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.maxonmotor.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>



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 motor.



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
Environmental Conditions	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)

Legend

- 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

2.2 Dimensional Drawings

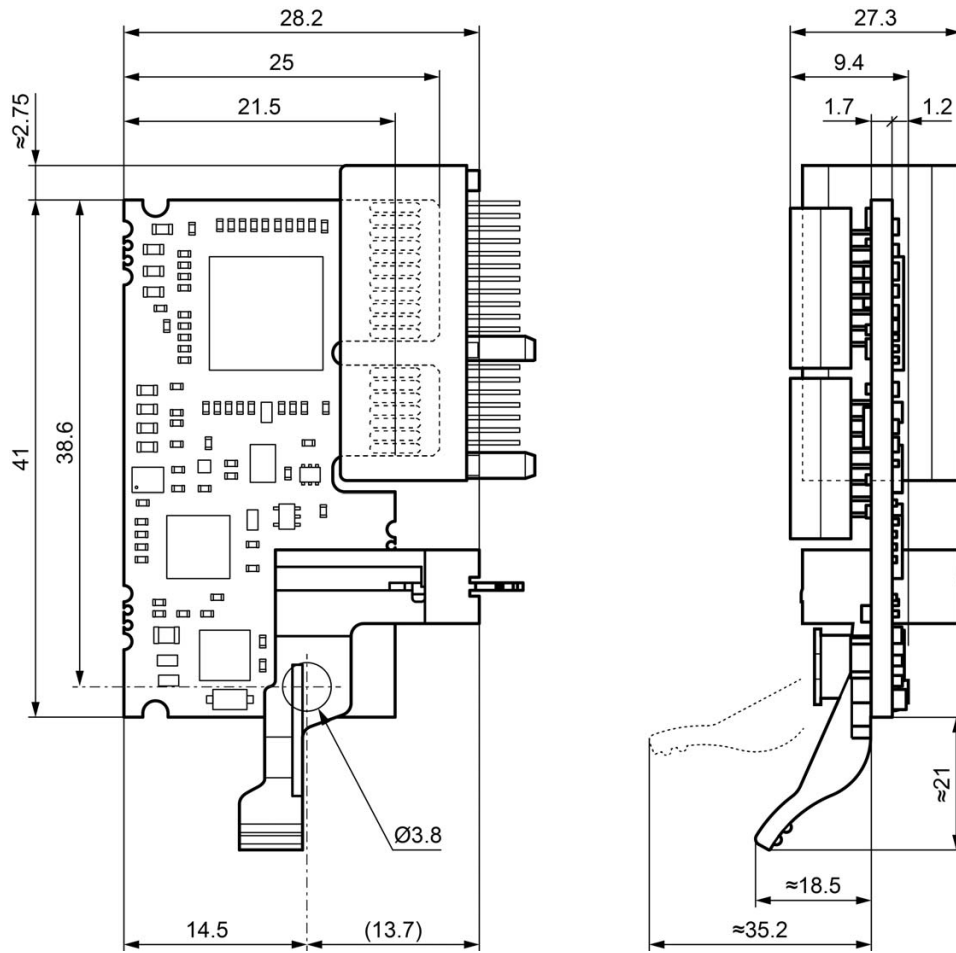


Figure 2-2 EPOS4 EtherCAT Card with card edge connector & retainer – Dimensional drawing [mm]

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 Environment: Ground, benign (GB) Ambient temperature: 298 K (25 °C) Component stress: In accordance with circuit diagram and nominal power 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

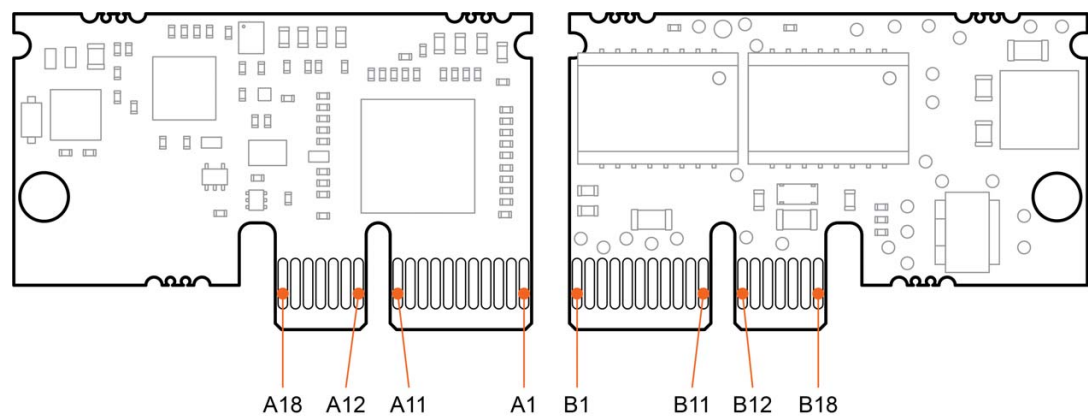


Figure 3-3 EPOS4 EtherCAT Card – PCB with connector arrays

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.

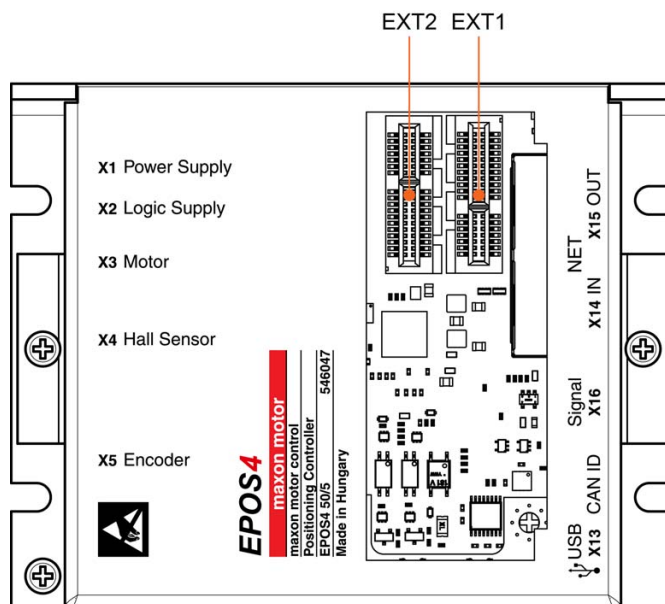
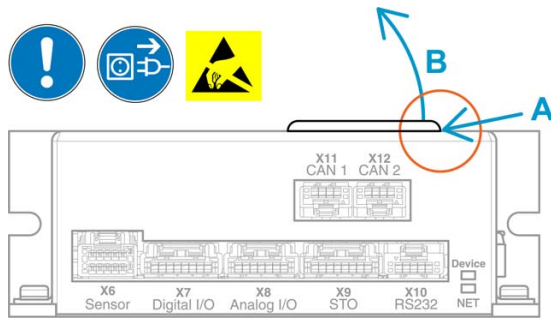


Figure 3-4 Extension slots – as an example «EPOS4 50/5»

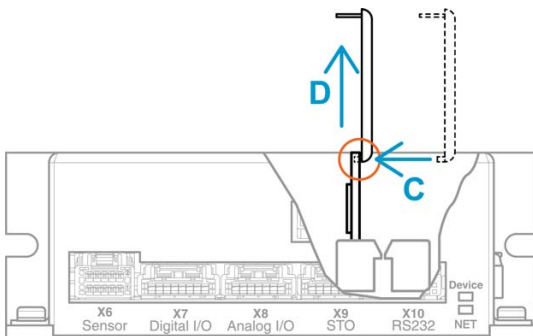
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Switch off the controller's power supply.
Comply with ESD protective measures.

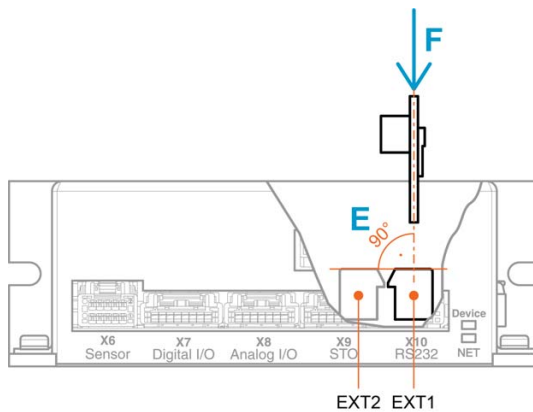
Open plastic lid

- 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.

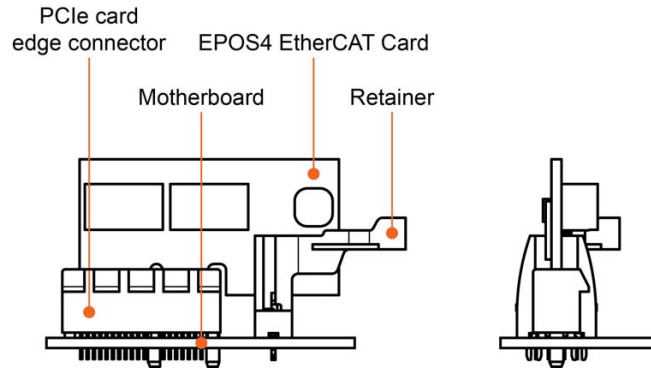


Figure 3-6 EPOS4 EtherCAT Card with PCIe card edge connector and retainer

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4 Motherboard Design Guide

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 motor will be happy to provide you with a quote for designing and manufacturing a motherboard for your specific application.

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)

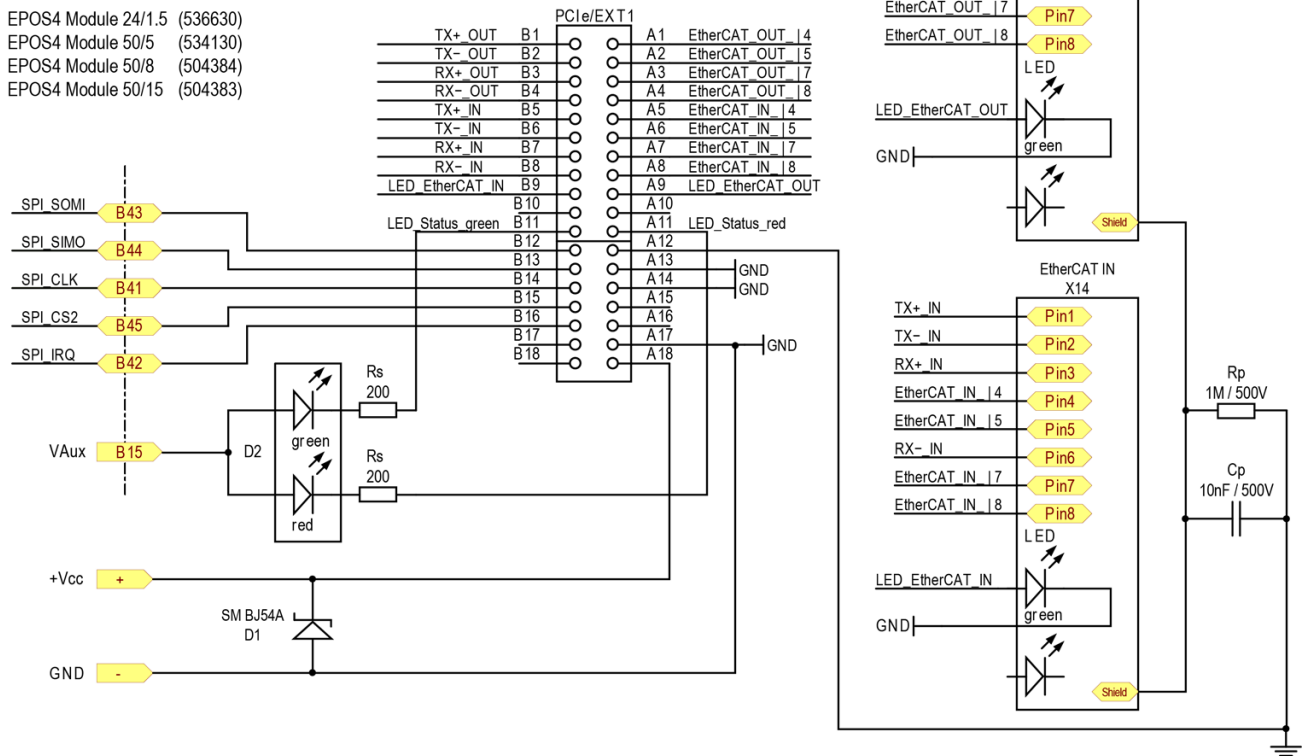


Figure 4-7 Schematic overview

4.2 Requirements for Components of Third-party Suppliers



Best practice

For references and recommended components consult →Table 4-11.

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 the 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.

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 <i>Example: Timeout of Sync Manager Watchdog</i>
—	Single flash	EPOS4 has changed the COM state due to an internal error <i>Example: Change of state “Op” to “SafeOpError” due to Sync Error</i>
—	Blink	General Configuration Error <i>Example: State change commanded by master is not possible due to actual settings (register, object, hardware configuration)</i>

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

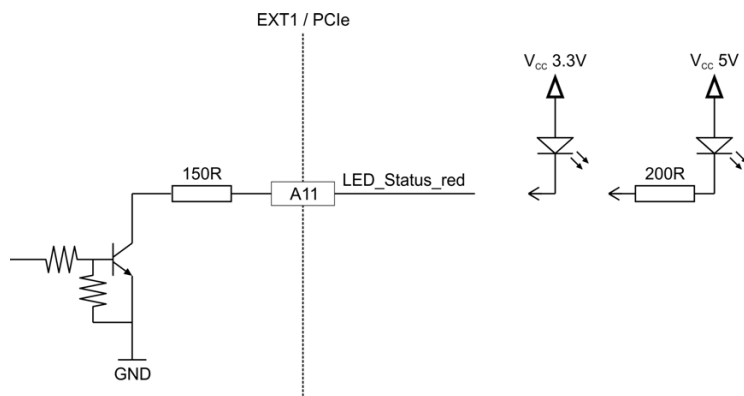


Figure 4-8 EtherCAT status LED “sinks” (analogously valid for B11)

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 (≈ 10 Hz)	

Table 4-8 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	$U_{Out} = 3.3\text{ V} - (I_{Load} \times 150\ \Omega)$
Max. load current	10 mA

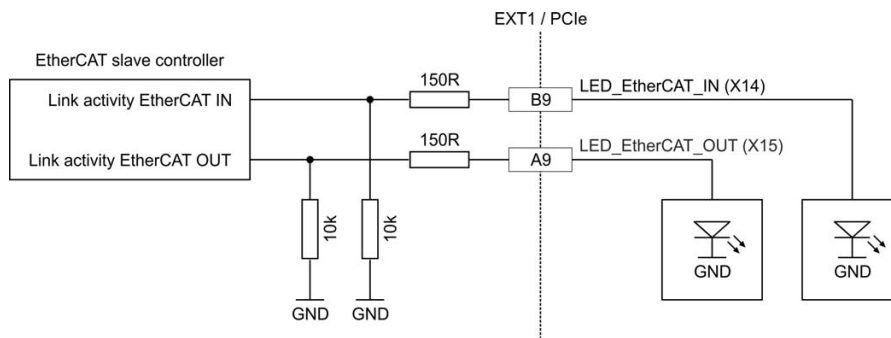


Figure 4-9 EtherCAT port activity LED "source"

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».

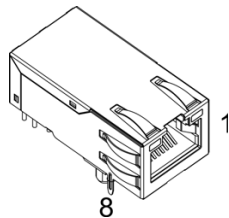


Figure 4-10 EtherCAT connector

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

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 4-9 EtherCAT connectors – Pin assignment

Continued on next page.

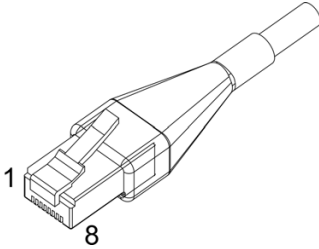
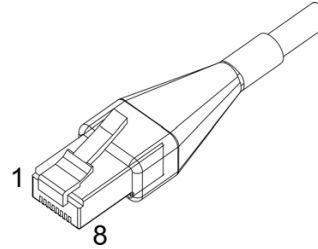
Ethernet Cable (422827)	
A	B
	
Cross-section	Cat. 5e SF/UTP (ISO/IEC 11801), 1:1 patch cable, green
Length	2 m
Head A	RJ45 (8P8CS) EIA/TIA-568B
Head B	RJ45 (8P8CS) EIA/TIA-568B

Table 4-10 Ethernet Cable

4.2.6 Recommended Components and Manufacturers

Recommended components	
Card Edge Connector (EXT1)	PCIe 2x18 Position, THT <ul style="list-style-type: none"> • Amphenol FCI (10018784-10200TLF) • Sullins Connector Solutions (NWE18DHHN-T911) • TE Connectivity (7-1734774-6)
Retainer for Card Edge Connector (optional)	PCI express retainer <ul style="list-style-type: none"> • Amphenol FCI (10042618-002LF)
EtherCAT Two Port Modular Jack (X14/X15)	<ul style="list-style-type: none"> • Amphenol (RJHSE-5381-02) • Würth (615016137721)
TVS Diode (D1)	<ul style="list-style-type: none"> • Vishay (SMBJ54A) $U_R = 54 \text{ V}$, $U_{BR} = 60.0 \dots 66.3 \text{ V @ } 1 \text{ mA}$, $U_C = 87.1 \text{ V @ } 6.9 \text{ A}$ • Fairchild (SMBJ54A) $U_R = 54 \text{ V}$, $U_{BR} = 60.0 \dots 66.3 \text{ V @ } 1 \text{ mA}$, $U_C = 87.1 \text{ V @ } 6.9 \text{ A}$ • Littelfuse (SMBJ54A) $U_R = 54 \text{ V}$, $U_{BR} = 60.0 \dots 66.3 \text{ V @ } 1 \text{ mA}$, $U_C = 87.1 \text{ V @ } 6.9 \text{ A}$
LED (D2)	Dual-sided SMT LED green/red <ul style="list-style-type: none"> • Lite-On (LTST-S326KGJRKT) • Dialight (597-2751-607F) • Avago (HSMF-C144)
Decoupling (Rp/Cp)	R/C chip combination <ul style="list-style-type: none"> • Chip resistor 1 M Ω, 0.25 W, 500 V • Chip capacitor 10 nF, 500 V

Table 4-11 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

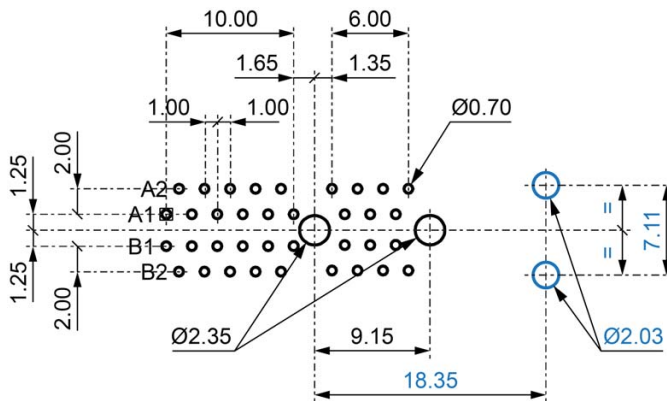


Figure 4-11 PCIe card edge connector with retainer – THT footprint [mm] – Top view

PCIe Card Edge Connector without Retainer

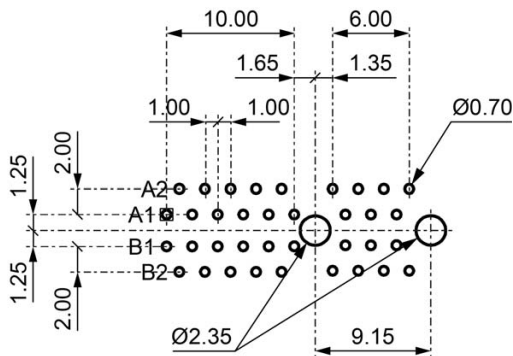


Figure 4-12 PCIe card edge connector – THT footprint [mm] – Top view

LIST OF FIGURES

Figure 1-1	Documentation structure.	3
Figure 2-2	EPOS4 EtherCAT Card with card edge connector & retainer – Dimensional drawing [mm]	8
Figure 3-3	EPOS4 EtherCAT Card – PCB with connector arrays	11
Figure 3-4	Extension slots – as an example «EPOS4 50/5»	13
Figure 3-5	EPOS4 EtherCAT Card – Installation & removal	14
Figure 3-6	EPOS4 EtherCAT Card with PCIe card edge connector and retainer	15
Figure 4-7	Schematic overview	17
Figure 4-8	EtherCAT status LED “sinks” (analogously valid for B11)	19
Figure 4-9	EtherCAT port activity LED “source”.	20
Figure 4-10	EtherCAT connector	21
Figure 4-11	PCIe card edge connector with retainer – THT footprint [mm] – Top view	24
Figure 4-12	PCIe card edge connector – THT footprint [mm] – Top view	24

LIST OF TABLES

Table 1-1	Notation used	4
Table 1-2	Symbols and signs	4
Table 1-3	Brand names and trademark owners	5
Table 2-4	Technical data	7
Table 2-5	Standards	9
Table 3-6	Connector arrays – Pin assignment	12
Table 4-7	EtherCAT status LEDs	19
Table 4-8	EtherCAT port LEDs	20
Table 4-9	EtherCAT connectors – Pin assignment	21
Table 4-10	Ethernet Cable	22
Table 4-11	Motherboard Design Guide – Recommended components	23

INDEX

A

alerts **4**
applicable regulations **6**

C

cables (prefab)
 Ethernet Cable **22**
connectors
 EtherCAT IN **21**
 EtherCAT OUT **21**
 EXT1 **13**
 EXT2 **13**
 PCB connector arrays **11**
 PCIe card edge connector **15**
country-specific regulations **6**

E

ESD **6, 13**

H

how to
 get help in designing the motherboard **17**
 interpret icons (and signs) used in this document **4**

I

informatory signs **4**

L

LEDs
 EtherCAT port activity **20**
 EtherCAT status **19**

M

mandatory action signs **4**

N

notations used **4**

P

part numbers
 422827 **22**
 504383 **18**
 504384 **18**
 534130 **18**
 536630 **18**
 581245 **7**
performance data **7**
pin assignment **12**
precautions **6**
prohibitive signs **4**
protective measures (ESD) **6, 13**
purpose
 of the device **5**
 of the document **3**

R

regulations, applicable **6**

S

safety alerts **4**
safety first! **6**
signs used **4**
standards, fulfilled **9**
symbols used **4**

T

technical data **7**



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