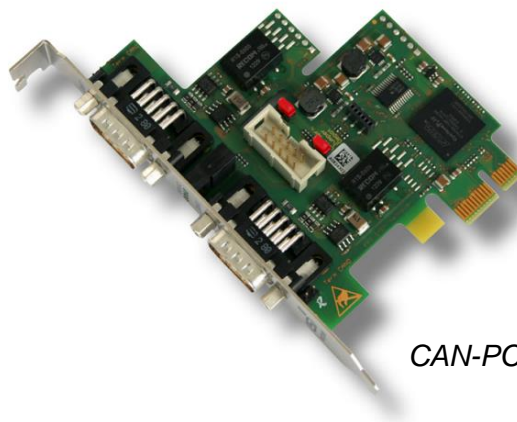




CAN-PCle/402, CAN-PCle/402-FD

**PCI Express® Board
with up to 4 Classical CAN
or CAN FD Interfaces**



CAN-PCle/402-2

Hardware Manual

For products C.2045.02, C.2045.04, - C.2045.06,
C.2045.08, C.2045.10,
C.2045.32, C.2045.34,
C.2045.62, C.2045.64, C.2045.68,
C.2045.92, C.2045.94



Notes

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This manual contains important information and instructions on safe and efficient handling of the CAN-PCle/402. Carefully read this manual before commencing any work and follow the instructions.
The manual is a product component, please retain it for future use.

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Document Information

Document file:	I:\Texte\Doku\MANUALS\CAN\PCI-Express\CAN-PCle402\English\CAN-PCle402_Hardware_en_16.docx
Date of print:	2023-05-23
Document-type number:	DOC0800

Hardware version.:	Revision 1.1		
	Note to CAN FD: For the CAN FD versions the transceiver for the increased CAN FD bit rate (up to 8 Mbit/s, formerly 5 Mbit/s) is only equipped from the batch number as described in the following table:		
	Product	Order No.	Increased bit rate available from batch number
	CAN-PCle/402-1-FD	C.2045.62	IB
	CAN-PCle/402-2-FD	C.2045.64	IC
	CAN-PCle/402-B4-FD	C.2045.68	HF
	CAN-PCle/402-1-LP-FD	C.2045.92	IB

See chapter "Product Label" on page 18

Document History

The changes in the document listed below affect changes in the hardware as well as changes in the description of the facts, only.

Revision	Chapter	Changes versus previous version	Date
1.4	1.3.2, 5.4	Editorial changes only: CAN FD bit rate up to 8 Mbit/s, Intel FPGA	2021-05-03
1.5		For the CAN FD versions the increased CAN FD bit rate (up to 8 Mbit/s) is only ensured from the batch numbers as specified under hardware version above.	2021-12-23
	2.3	New chapter: Product Label"	
	5.4	Note on extended bit rate added.	
1.6		Note on Links inserted (page 2)	2023-05-23
		Safety Instructions and Note on Disposal (page 6) revised	
	All	Editorial revision	
	All	The LIN-adapter has been renamed and is described in a separate manual (1). All CAN-PCle/402 variants without electrical isolation (D-variants) are discontinued.	
	All	Descriptions of variants without electrical isolation are deleted.	
	3.	Description of Uninstalling added.	
	9.	Chapter: "Accessory: LIN Adapter" has been removed. The chapter "References" has been included.	
	11	Order Information revised.	

Technical details are subject to change without further notice.

Classification of Warning Messages and Safety Instructions

This manual contains noticeable descriptions, warning messages and safety instructions, which you must follow to avoid personal injuries or death and property damage.



This is the safety alert symbol.

It is used to alert you to potential personal injury hazards. Obey all safety messages and instructions that follow this symbol to avoid possible injury or death.

DANGER, WARNING, CAUTION

Depending on the hazard level the signal words DANGER, WARNING or CAUTION are used to highlight safety instructions and warning messages. These messages may also include a warning relating to property damage.



DANGER

Danger statements indicate a hazardous situation which, if not avoided, will result in death or serious injury.



WARNING

Warning statements indicate a hazardous situation that, if not avoided, could result in death or serious injury.



CAUTION

Caution statements indicate a hazardous situation that, if not avoided, could result in minor or moderate injury.

NOTICE

Notice statements are used to notify people on hazards that could result in things other than personal injury, like property damage.



NOTICE

This NOTICE statement indicates that the device contains components sensitive to electrostatic discharge.



NOTICE

This NOTICE statement contains the general mandatory sign and gives information that must be heeded and complied with for a safe use.

INFORMATION



INFORMATION

Notes to point out something important or useful.



Safety Instructions

- When working with the CAN-PCle/402 follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-PCle/402 from damage.
- The device is a built-in component. It is essential to ensure that the device is mounted in a way that cannot lead to endangering or injury of persons or damage to objects.
- Do not use damaged or defective cables to connect the CAN-PCle/402 and follow the CAN wiring hints in chapter: "Correct Wiring of Electrically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- The galvanic isolation of the CAN-PCle/402 has only functional tasks and is not a protection against hazardous electrical voltage.
- The CAN-PCle/402 may only be operated on supply circuits that provide sufficient protection against dangerous voltages.
- External circuits connected to the interfaces of the CAN-PCle/402 must be sufficiently protected against dangerous voltage.
- The user is responsible for compliance with the applicable national safety regulations.
- The device must be securely installed in the control cabinet before commissioning.
- Protect the CAN-PCle/402 from dust, moisture, and steam.
- Protect the CAN-PCle/402 from shocks and vibrations.
- The CAN-PCle/402 may become warm during normal use. Always allow adequate ventilation around the CAN-PCle/402 and use care when handling.
- Do not operate the CAN-PCle/402 adjacent to heat sources and do not expose it to unnecessary thermal radiation. Ensure an ambient temperature as specified in the technical data.



DANGER

Hazardous Voltage - **Risk of electric shock** due to unintentional contact with uninsulated live parts with high voltages inside of the system into which the CAN-PCle/402 is to be integrated.

- Disconnect all hazardous voltages (mains voltage) before opening the system.
- Ensure the absence of voltage before starting any electrical work



NOTICE

Electrostatic discharges may cause damage to electronic components.

- To avoid this, please discharge the static electricity from your body before you touch the CAN-PCle/402.
- Furthermore, you should prevent your clothes from touching the CAN-PCle/402, because your clothes might be electrostatically charged as well.

Qualified Personnel

This documentation is directed exclusively towards personnel qualified in control and automation engineering. The installation and commissioning of the product may only be carried out by qualified personnel, which is authorized to put devices, systems, and electric circuits into operation according to the applicable national standards of safety engineering.

Conformity

The CAN-PCle/402 is an industrial product and meets the demands of the EU regulations and EMC standards printed in the conformity declaration at the end of this manual.

Intended Use

The intended use of the CAN-PCle/402 is the operation as a PCI Express interface for PCs.

The guarantee given by esd does not cover damages which result from improper use, usage not in accordance with regulations or disregard of safety instructions and warnings.

- The CAN-PCle/402 is intended for installation in a PCI Express slot of an industrial home computer.
- The operation of the CAN-PCle/402 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-PCle/402 for medical purposes is prohibited.

Service Note

The CAN-PCle/402 does not contain any parts that require maintenance by the user. The CAN-PCle/402 does not require any manual configuration of the hardware except the configuration of the jumpers as described in chapter “PCB View with Connectors”. Unauthorized intervention in the device voids warranty claims.

Disposal



Products marked with a crossed-out dustbin must not be disposed of with household waste. Devices which have become defective in the long run must be disposed in an appropriate way or must be returned to the manufacturer for proper disposal. Please, contribute to environmental protection.

Typographical Conventions

Throughout this manual the following typographical conventions are used to distinguish technical terms.

Convention	Example
File and path names	<code>/dev/null</code> or <code><stdio.h></code>
Function names	<code>open()</code>
Programming constants	<code>NULL</code>
Programming data types	<code>uint32_t</code>
Variable names	<i><code>Count</code></i>

Number Representation

All numbers in this document are base 10 unless designated otherwise. Hexadecimal numbers have a prefix of 0x, and binary numbers have a prefix of 0b. For example, 42 is represented as 0x2A in hexadecimal and 0b101010 in binary.

Abbreviations

API	Application Programming Interface
CAN	Controller Area Network
CPU	Central Processing Unit
CiA	CAN in Automation
HW	Hardware
I/O	Input/Output
LSB	Least Significant Bit
MSB	Most Significant Bit
n.a.	not applicable
OS	Operating System
SDK	Software Development Kit

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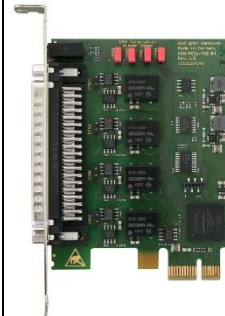

1 Overview

1.1 About this Manual



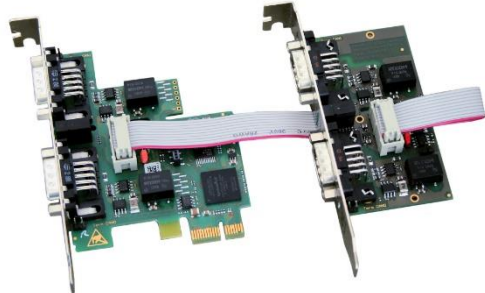
In this hardware manual all versions of the CAN-PCle/402 are described together as CAN-PCle/402. Differences of the CAN-PCle/402 variants are noted accordingly.



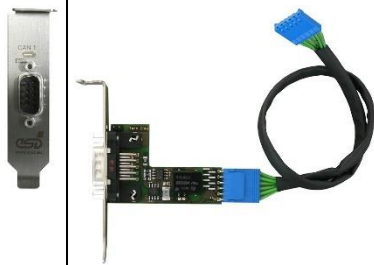
Available features, options, and supplied items may vary depending on the CAN-PCle/402 version you selected.



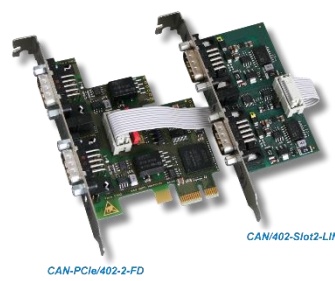
1.2 Overview of Hardware Versions

1x CAN Version			
CAN-PCle/402-1 1 CAN interface, 1x DSUB9, electrical isolation (C.2045.02)			
CAN-PCle/402-1-FD 1 CAN FD interface, 1x DSUB9, electrical isolation (C.2045.62)			
2x CAN Version			
CAN-PCle/402-2 2 CAN interfaces, 2x DSUB9, electrical isolation (C.2045.04)			
CAN-PCle/402-2-FD 2 CAN FD interfaces, 2x DSUB9, electrical isolation (C.2045.64)			
4x CAN, DSUB37-Version		Accessories	
CAN-PCle/402-B4/1 Slot 4 CAN interfaces, 1x DSUB37, electrical isolation (C.2045.08)			CAN-PCI/4xx-B4-1C4 DSUB37-to-4xDSUB9 CAN Adapter Cable 1x DSUB37 to 4x DSUB9 (C.2041.18) 
CAN-PCle/402-B4-FD 1 Slot 4 CAN FD interfaces, 1x DSUB37, electrical isolation (C.2045.68)			

Overview

4x CAN with Adapter Board		
CAN-PCle/402-Slot2 Adapter Board with 2 CAN interfaces, 2x DSUB9, electrical isolation (C.2045.10) includes ribbon cable		
CAN-PCle/402-4/2Slot 4 CAN interfaces with electrical isolation (C.2045.06) includes C.2045.04 and adapter board C.2045.10		

Low Profile Versions				
CAN-PCle/402-1-LP 1 CAN interface, 1x DSUB9, electrical isolation (C.2045.32)			CAN-PCle/402-1-LP-2 Extension board 1 CAN interface, 1x DSUB9, electrical isolation (C.2045.34), cable included	
CAN-PCle/402-1-LP-FD 1 CAN FD interface, 1x DSUB9, electrical isolation (C.2045.92)			CAN-PCle/402-1-LP2-FD Extension board 1 CAN FD inter- face, 1x DSUB9, electrical isolation (C.2045.94), cable included	

Accessories: LIN-Adapter Board for CAN-PCle/402-2-FD			
CAN/402-Slot2-LIN LIN-Adapter Board with 2 LIN interfaces, 2x DSUB9, electrical isolation (C.2045.12) includes ribbon cable The LIN Adapter is described in a separate manual (1).			CAN-PCle/402-2-FD with CAN/402-Slot2-LIN Adapter  <small>CAN-PCle/402-2-FD</small> <small>CAN/402-Slot2-LIN</small>

1.3 Description

1.3.1 CAN-PCle/402 - Classical CAN Versions

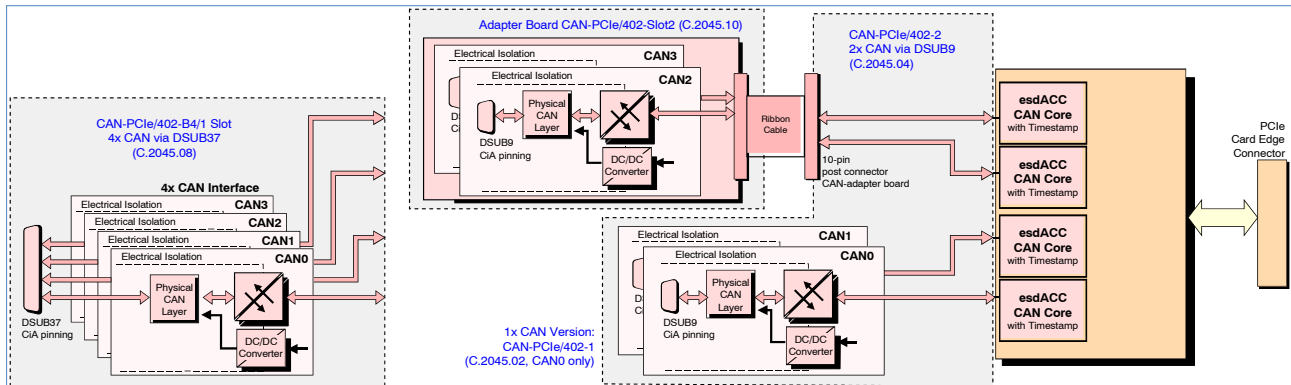


Figure 1: Block circuit diagram

The CAN-PCle/402 is a PC board designed for the PCIe bus, available in a wide choice of hardware designs. It features one (CAN-PCle/402-1), two (CAN-PCle/402-2) or four (CAN-PCle/402-4/2Slot) electrically isolated CAN High-Speed interfaces according to ISO 11898-2.

The CAN-PCle/402-4/2Slot version consists of the two-channel version CAN-PCle/402-2 and the extension board CAN-PCle/402CAN-PCle/402-Slot2 with two additional CAN interfaces via its separate slot bracket.

All these CAN-PCle/402 variants come with one DSUB9 connector per CAN channel.

In the CAN-PCle/402-B4/1Slot version all four CAN interfaces are connected via one 37-pin DSUB connector with pin contacts.

Equipped with one CAN interface (CAN0) the lower part of the CAN-PCle/402-2 board is available as low-profile version (CAN-PCle/402-1-LP) with a smaller front panel. This version can be extended to 2x CAN with the CAN-PCle/402-1-LP-2 extension board. The extension board consists of the remaining upper part of the CAN-PCle/402-2 board but without front panel. Furthermore, the CAN interface CAN2 is physical layer only.

The CAN interfaces are driven by the esdACC (esd Advanced CAN Core), which is implemented in an FPGA. The esdACC is developed by esd and certified according to ISO 16845:2004

The design includes a bus mastering unit (first-party DMA) to exchange the CAN data.

This allows the CAN interface to initiate write cycles to the CPU RAM independently of the host system's CPU or DMA controller. This reduces the CPU load of the host system and the overall system latency.

MSI (Message Signalled Interrupts) support makes it possible to use the CAN interface in hypervisor environments, among others.

The module also supports high-resolution 64-bit hardware timestamps to enable highly accurate reception and transmission of CAN messages.

1.3.2 CAN-PCIe/402-FD - CAN FD Versions

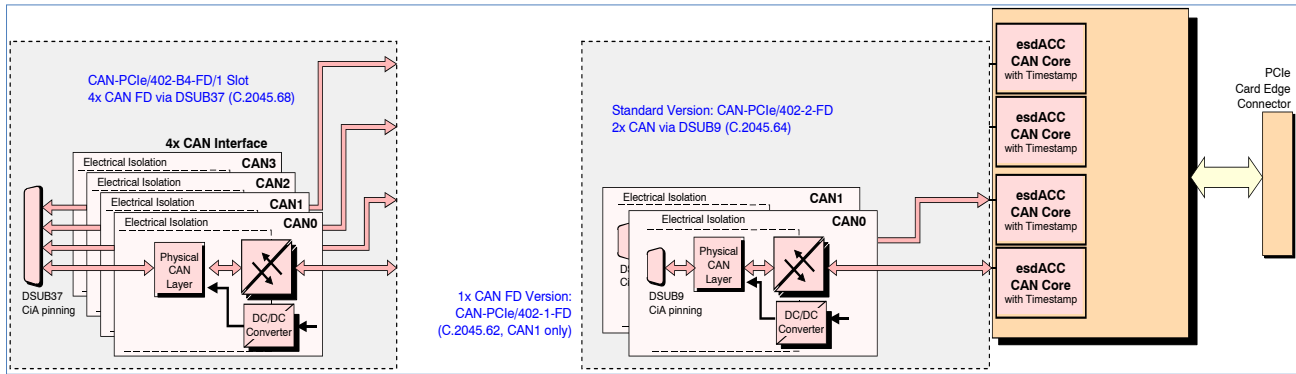


Figure 2: Block circuit diagram of CAN FD versions

In the CAN FD-versions of the CAN-PCIe/402 the CAN interfaces are CAN FD-capable.

The CAN FD interface is based on a CAN core architecture (esdACC) implemented in a modern FPGA. The interface can send and receive ISO conform CAN FD (up to 8 Mbit) or CAN 2.0 A/B messages. The CAN-FD bit rate range is validated from 10 kbit/s up to 8 Mbit/s.

It features one (CAN-PCIe/402-1-FD) or two (CAN-PCIe/402-2-FD) electrically isolated CAN FD interfaces according to ISO 11898-2. These CAN-PCIe/402 variants come with one DSUB9 connector with pin contacts per CAN FD channel.

In the CAN-PCIe/402-B4-FD version all four CAN FD interfaces are connected via one 37-pin DSUB connector in the front panel.

Equipped with one CAN interface (CAN0) the lower part of the CAN-PCIe/402-2-FD board is available as low-profile version (CAN-PCIe/402-1-LP-FD) with a smaller front panel. This version can be extended to 2x CAN with the CAN-PCIe/402-1-LP-2-FD extension board. The extension board consists of the remaining upper part of the CAN-PCIe/402-2-FD board. Furthermore, the CAN interface CAN1 is physical layer only.

CAN FD

With a higher bit rate in the data phase in combination with the increase of efficiency by a higher number of user-data bytes, CAN FD offers a higher data throughput while maintaining the benefits of Classical CAN.

The Classical CAN versions of CAN-PCIe/402 can only be used in Classical CAN applications because its controller is not CAN FD capable.

The CAN FD versions of CAN-PCIe/402 are fully backwards compatible with CAN and can also be used in Classical CAN applications.



INFORMATION

Every CAN FD controller is backward compatible to the Classical CAN protocol. Classical CAN nodes and CAN FD nodes can communicate with each other as long as the CAN FD frame format remains unused!

You can insert for example the CAN FD version CAN-PCIe/402-2-FD in your Classical CAN application if you want to replace a Classical CAN component. The CAN FD board automatically communicates like a Classical CAN board (the existing program code can be used unchanged). The CAN-PCIe/402-2-FD has to communicate with the CAN nodes via Classical CAN frames, because Classical CAN controller do not tolerate CAN FD frames. All controllers have to use the same Classical CAN bitrate.

**INFORMATION**

During the initialisation of the CAN controller of the CAN FD boards the application determines via software if the CAN FD boards communicate with Classical CAN or with CAN FD.

See NTCAN-API Manual Part 1: “Application Developers Manual” (2) for further information.

**NOTICE**

The system integrator must verify that all CAN nodes on the bus are set to the same bit rate!

If you work with a Classical CAN application and want to migrate to CAN FD in the future, you can replace your Classical CAN nodes one after another until all CAN nodes are replaced by CAN FD nodes.

esdACC

The independent CAN FD or CAN nets according to ISO 11898-1:2015 are driven by the esdACC (esd Advanced CAN Core) implemented in the Intel FPGA.

LIN

The optional LIN extension CAN/402-Slot2-LIN is available as accessory for the esd CAN-PCIe/402-2-FD board. For further information about the extension please refer to the hardware manual of CAN/402-Slot2-LIN (1).

2 PCB View with Connectors and Jumpers

2.1 CAN-PCIe/402-2 Version with 2 CAN Interfaces

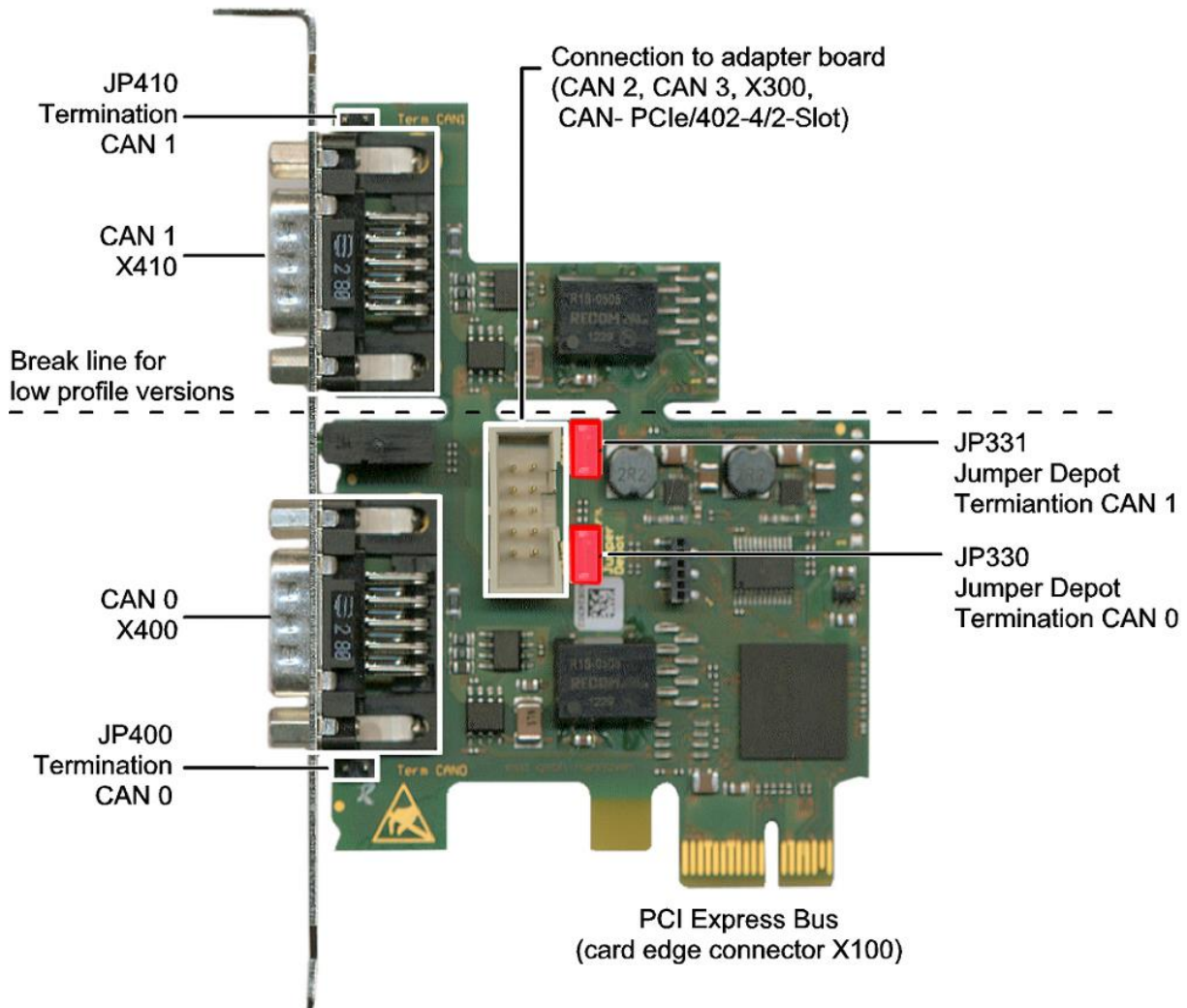


Figure 3: Top layer view of the CAN-PCIe/402-2 with 2x CAN (Order No.: C.2045.04)

See page 28 for signal assignment of the CAN connectors.

The figure above shows the module in the standard version CAN-PCIe/402-2. Please refer to "Overview of Hardware Versions" on page 9 for an overview of the available hardware designs.



NOTICE

Read chapter "Hardware Installation" on page 19, before you start with the installation of the hardware!

2.1.1 CAN-PCIe/402-4 Version with 4 CAN Interfaces

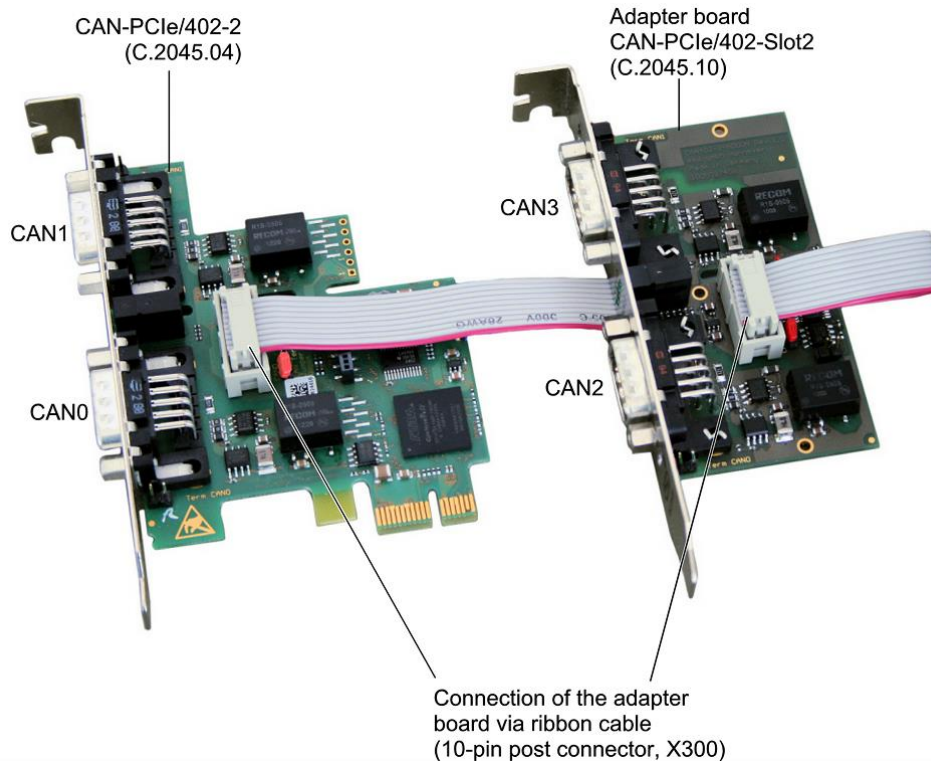


Figure 4: View of CAN-PCIe/402-4/2Slot with ribbon cable (Order No.: C.2045.06)

In the CAN-PCIe/402-4/2Slot version, the board comes with four CAN interfaces. This version contains the CAN-PCIe/402-2 and an additional extension board CAN-PCIe/402-Slot2. The physical layers of the additional CAN interfaces are placed on the adapter board. This module type uses two additional CAN transceivers.

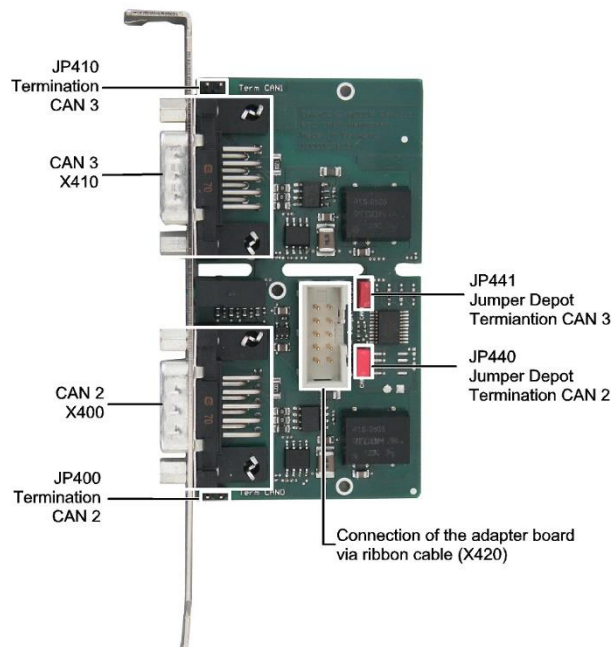


Figure 5: Top view of the CAN-PCIe/402-Slot2 adapter view



NOTICE

Read chapter “Hardware Installation” on page 19, before you start with the installation of the hardware!

2.1.2 Jumpers for CAN Termination and Jumper Depot

An on-board termination resistor of 120Ω can be individually enabled for each CAN interface via jumpers. For the position of the jumper see Figure 3, page 14.

Jumper	Jumper set	Jumper not set
JP410	internal termination of CAN interface CAN1	CAN1 must be terminated externally
JP400	internal termination of CAN interface CAN0	CAN0 must be terminated externally

The jumper positions of the CAN interfaces CAN2 and CAN3 on the add-on board correspond to the positions shown in **Figure 3**.



NOTICE

It is strongly recommended to keep the jumpers which are not needed for CAN termination on the corresponding jumper depots CAN0 - CAN3!
A missing jumper in the depot will be interpreted as an internally terminated CAN interface.

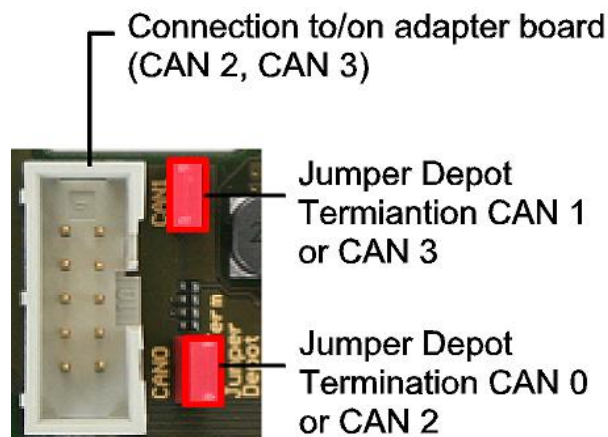


Figure 6: Positions of the Jumper Depots CAN0 and CAN1 or CAN2 and CAN3

2.2 CAN-PCIe/402-B4/1 Slot Versions

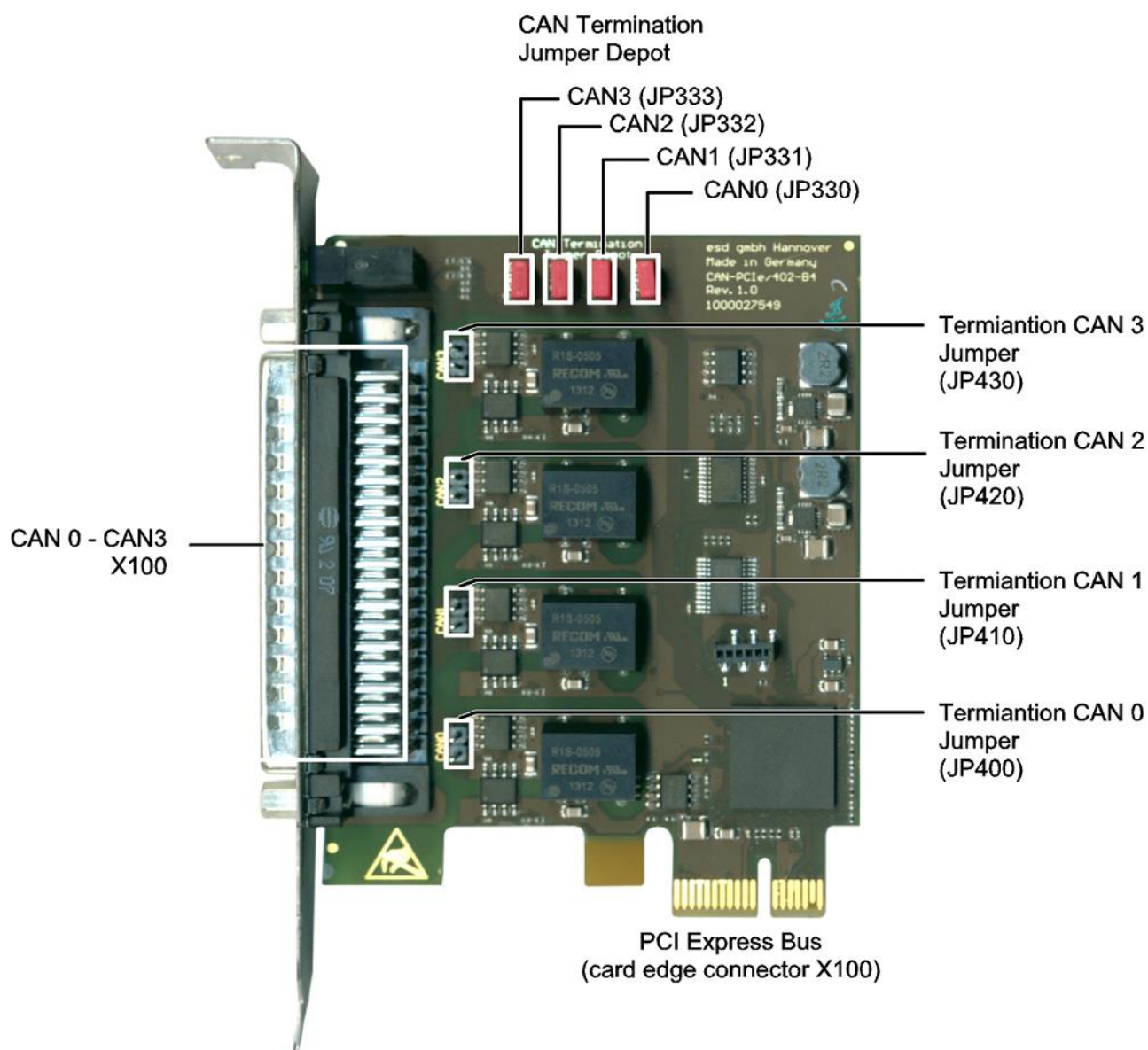


Figure 7: Top layer view of the CAN-PCIe/402-B4/1 Slot with 4x CAN (Order No.: C.2045.08)

The figure above shows the module in the version CAN-PCIe/402-B4/1 Slot (C.2045.08). In the CAN-PCIe/402-B4/1Slot version, the board comes with four CAN interfaces. The CAN-PCIe/402-B4-FD 1Slot (C.2045.68) provides 4 CAN FD interfaces. The physical layer of the four CAN interfaces is placed on the board.

See from page 29 for signal assignment of the CAN connector.

Please refer to “Overview of Hardware Versions” on page 9 for an overview of the available hardware designs.

2.2.1 Jumpers for CAN Termination and Jumper Depot

An on-board termination resistor of 120Ω can be individually enabled for each CAN interface via jumpers. For the position of the jumper and the jumper depot see **Figure 7**.

Jumper	Jumper set	Jumper not set
JP430	internal termination of CAN interface CAN3	CAN3 must be terminated externally
JP420	internal termination of CAN interface CAN2	CAN2 must be terminated externally
JP410	internal termination of CAN interface CAN1	CAN1 must be terminated externally
JP400	internal termination of CAN interface CAN0	CAN0 must be terminated externally



NOTICE

It is strongly recommended to keep the jumpers which are not needed for CAN termination on the corresponding jumper depots CAN0 - CAN3!
A missing jumper in the depot will be interpreted as an internally terminated CAN interface.

2.3 Product Label

The product label is described using the example of the CAN-PCI/402-2-FD product label.


<p>esd Product label example</p> 	<p>The esd product label is placed on the PCB and shows:</p> <ul style="list-style-type: none"> - CE label - esd logo - esd order number (PN:) - Batch and serial number (SN:) - Product name - Data matrix code - Field for quality assurance (T) 	<p>Example:</p> <p>C.2049.64 Batch: GH, Serial no.: 000432 CAN-PCI/402-2-FD</p>
---	---	---

Figure 8: Example of product label (order of the items may deviate)

3 Hardware Installation

**NOTICE**

Read the safety instructions at the beginning of this document carefully before you start with the hardware installation!

**WARNING**

Hazardous Voltage - Risk of electric shock due to unintentional contact with uninsulated live parts with high voltages inside of the system into which the CAN-PCIe/402 is to be integrated.

- Disconnect all hazardous voltages (mains voltage) before opening the system.
Never carry out work while power supply voltage is switched on!
- Ensure the absence of voltage before starting any electrical work.

**NOTICE**

Electrostatic discharges may cause damage to electronic components.

- To avoid this, please discharge the static electricity from your body by touching the metal case of the PCI system *before* you touch the CAN-PCIe/402.
- Furthermore, you should prevent your clothes from touching the CAN-PCIe/402, because your clothes might be electrostatically charged as well.

Procedure:

1. Switch off your system and all connected peripheral devices (monitor, printer, etc.).
Switch off the connected CAN devices.
2. Discharge your body as described above.
3. Disconnect the power supply of the PC from the mains.
Make sure that no risk arises from the system into which the CAN-PCIe/402 shall be inserted.
Read the manual of the system used and follow the instructions of the system manufacturer.

**DANGER**

Hazardous Voltage

Risk of electric shock due to unintentional contact with uninsulated live parts with high voltages inside of the system into which the CAN-PCIe/402 is to be integrated.

- Disconnect all hazardous voltages (mains voltage) before opening the system.
- If the system does not have a flexible mains cable, but is directly connected to mains, disconnect the power supply via the safety fuse and make sure that the fuse cannot switch on again unintentionally (e.g. with caution label).
- Ensure the absence of voltage before starting any electrical work.
- Cover or block off adjacent live parts.

4. Open the case if necessary.

To install, continue as described from steps 5. to 14.

To uninstall, continue from step 15.

5. Set the jumpers for the internal termination of the CAN interfaces according to your needs (see page 16).
6. Select an open PCI Express slot and remove the slot cover at the back of the PC.
The CAN module can be inserted into every PCI Express slot.

7. If you are installing the CAN-PCle/402-4/2Slot module with 4 CAN, you have to install the adapter board in the PCI Express slot next to the CAN-PCle/402-2 board.
Connect the two boards with the included ribbon cable (see **Figure 4** on page 15) via the 10-pin shrouded box headers on the board and on the adapter. Be sure to route the connection cable behind the adapter to the CAN board, see **Figure 4**.
Remove the cover of the slot for the adapter at the back of the PC.
This applies accordingly if you install the CAN-PCle/402-2-FD with the optional LIN extension CAN/402-Slot2-LIN, see (1).
8. Insert the CAN-PCle/402 board and, if used, the adapter into the selected PCI Express slots. Carefully push the boards down until they snap into place.
9. Attach the board.
10. Close the computer case again.
11. Connect the CAN wire.

**NOTICE**

Please note that the CAN bus has to be terminated at both ends!

CAN-PCle/402-2:

The first CAN interface (CAN 0) has to be connected via the lower DSUB connector (X400) and the second CAN interface (CAN 1) has to be connected via the upper DSUB connector (X410). You will find **Figure 3** showing the connectors on page 14.

CAN-PCle/402-4/2Slot:

If you are installing a CAN-PCle/402-4/2Slot with adapter board, you have to connect the third CAN interface via the lower DSUB connector of the adapter board and the fourth CAN interface via the upper DSUB connector of the adapter board (see **Figure 4**, page 15).

CAN-PCle/402-B4/1Slot and CAN-PCle/402-B4-FD:

Connect the CAN interfaces CAN0 - CAN3 to the DSUB37 connector (see Figure 11, page 30), e.g. by means of the adapter cable CAN-PCI/4XX-B4-1C4, see chapter “Adapter cable CAN-PCI/4XX-B4-1C4” page 30.

Refer to chapter “Overview of Hardware Versions” on page 9 to verify your hardware configuration.

If the integrated CAN termination of the CAN interface is not set via the jumpers, the interface has to be terminated externally, read chapter “Correct Wiring of Electrically Isolated CAN Networks“, from page 33.

For external termination esd offers suitable termination connectors for the CAN bus. Additionally, the CAN_GND signal has to be connected to earth at exactly one point. A CAN participant with electrical connection to earth potential acts as an earth connection.

12. Connect the system to mains again (mains connector or safety fuse).
13. Switch on the system and the peripheral devices.
14. End of hardware installation.

Continue with the software installation as described in the manual ‘CAN-API, Installation Guide’(3).

To uninstall the CAN-PCle/402 continue as described below after you have performed steps 1.-4.:

15. Disconnect the CAN-PCle/402 from the connected interfaces.
Loosen the fastening of the CAN-PCle/402.
Carefully pull the CAN-PCle/402 out of the slot.
If necessary, close the housing cover again.

4 Front Panel View with LED-Display

4.1 CAN-PCle/402-2 LEDs

The CAN-PCle/402-2 is equipped with four green LEDs in the front panel.

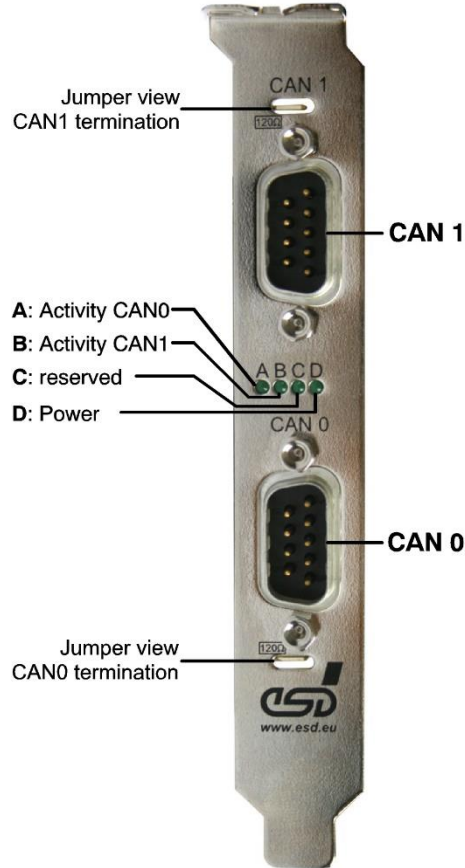


Figure 9: Front panel view of CAN-PCle/402-2

Label	Name	Indicator State	Description	LED name in schematic diagram
A	Activity CAN0	off	no CAN bus connection and/or no CAN data transfer on CAN0	D300A
		on	connected to CAN bus 0 and CAN data transfer on CAN0	
B	Activity CAN1	off	no CAN bus connection and/or no CAN data transfer on CAN1	D300B
		on	connected to CAN bus 1 and CAN data transfer on CAN1	
C	reserved	-	-	D300C
D	Power	off	power supply voltage off	D300D
		on	power supply voltage on	

Table 1: LEDs

4.2 Additional LEDs on CAN-PCle/402-4 Adapter Board

The CAN-PCle/402-4 is equipped with four LEDs as described in **Table 1** and with four additional green LEDs in the front panel of the adapter board.

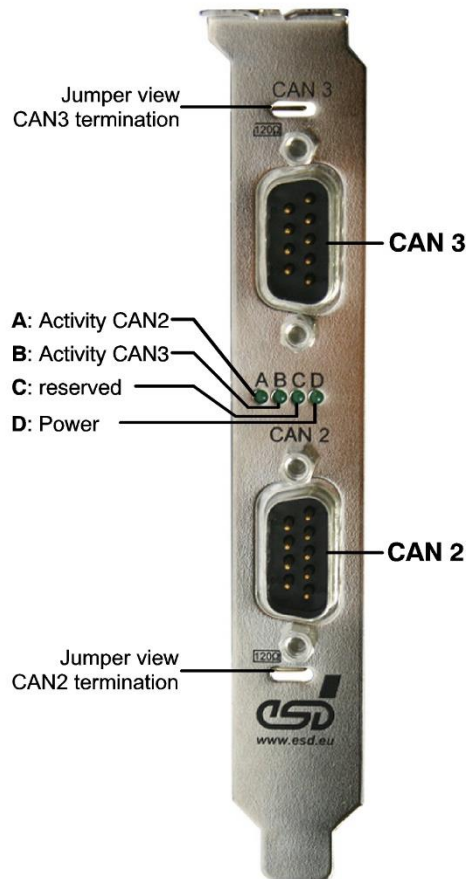


Figure 10: Front panel view of CAN-PCle/402-Slot2 Adapter

Label	Name	Indicator State	Description
A	Activity CAN2	off	no CAN bus connection and/or no CAN data transfer on CAN2
		on	connected to CAN bus 2 and CAN data transfer on CAN2
B	Activity CAN3	off	no CAN bus connection and/or no CAN data transfer on CAN3
		on	connected to CAN bus 3 and CAN data transfer on CAN3
C	reserved	-	-
D	Power	off	power supply voltage off
		on	power supply voltage on

Table 2: Additional LEDs on adapter board

4.3 CAN-PCIe/402-B4 LEDs (C.2045.08, C.2045.68 only)

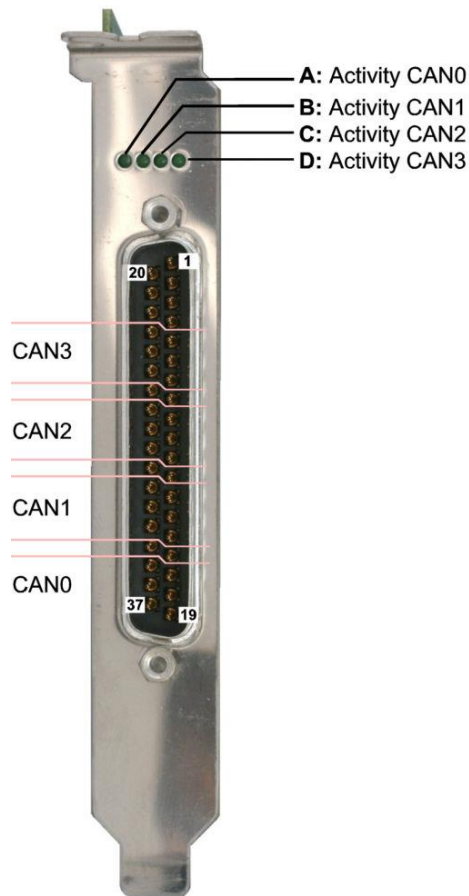


Figure 11: Front panel view CAN-PCIe/402-B4

Label	Name	Indicator State	Description
A	Activity CAN0	off	no CAN bus connection and/or no CAN data transfer on CAN0
		on	connected to CAN bus 0 and CAN data transfer on CAN0
B	Activity CAN1	off	no CAN bus connection and/or no CAN data transfer on CAN1
		on	connected to CAN bus 1 and CAN data transfer on CAN1
C	Activity CAN2	off	no CAN bus connection and/or no CAN data transfer on CAN2
		on	connected to CAN bus 2 CAN data transfer on CAN2
D	Activity CAN3	off	no CAN bus connection and/or no CAN data transfer on CAN3
		on	connected to CAN bus 3 and CAN data transfer on CAN3

Table 3: CAN-PCIe/402-B4 LED Description

Ambient temperature	0...75°C
Humidity	90 %, non-condensing
Supply voltage	<div> <div>3.3 V ±5% /</div> <div>2x CAN: I_{max} = 280 mA, 4x CAN: I_{max} = 290 mA</div> </div> <div> <div>12 V ±5% /</div> <div>2x CAN: I_{max} = 180 mA, 4x CAN: I_{max} = 230 mA</div> </div>
Plug- and socket connectors	<div> <div>CAN</div> <div> - All except CAN-PCle/402-B4 1Slot-versions and LP versions: 1x 9-pin DSUB per CAN channel or CAN FD channel, connector with pin contacts - CAN-PCle/402-B4 1Slot-versions (C.2045.08, C.2045.68) only: 1x 37-pin DSUB, connector with pin contacts - Low profile versions only: 1x 6-pin DUBOX per CAN or CAN FD channel </div> </div> <div> <div>PCle</div> <div>- (card edge connector, X100)</div> </div> <div> <div>X300</div> <div>- connection to adapter board via ribbon cable (10-pin shrouded box header)</div> </div> <div> <div>For factory test only:</div> <div>X200 - FPGA initialising</div> </div> <div> <div>Additional connectors equipped on CAN-PCle/402-4 adapter board (C.2045.10):</div> <div>CAN2 - CAN interface 2 (9-pin DSUB / pin contacts)</div> <div>CAN3 - CAN interface 3 (9-pin DSUB / pin contacts)</div> <div>X300 - connection to CAN-PCle/402 board via ribbon cable (10-pin shrouded box header)</div> </div>
LEDs	CAN Activity, Power
Dimensions (Width x hight)	<div>CAN-PCle/402-2(-FD): 70 mm x 95 mm (board only)</div> <div>CAN-PCle/402-Slot2: adapter board: 44 mm x 82 mm (board only)</div> <div>CAN-PCle/402-B4/1Slot(-FD): 70 mm x 95 mm (board only)</div> <div>CAN-PCle/402-1-LP: 70 mm x 57 mm (board only)</div> <div>CAN-PCle/402-1-LP-2.: 50 mm x 35 mm (board only)</div>
Weight	<div>CAN-PCle/402-2(-FD) (order No.: C.2045.04, C.2045.64): 60 g</div> <div>CAN-PCle/402-B4 1Slot(-FD) (order No.: C.2045.08, C.2045.68): 65 g</div>

5.2 PCI Express Interface

PCIe port	according to PCI Express Specification R1.0a, Link width 1x
Memory	Block RAM:
Connector	PCI-card edge connector

Table 5: PCI bus data

5.3 CAN Interfaces

Number of CAN interfaces	CAN-PCIe/402-2: 2x CAN high-speed interfaces (CAN0, CAN1) CAN-PCIe/402-1: 1x CAN high-speed interface (CAN0) CAN-PCIe/402-4/2Slot: 4x CAN high-speed interfaces (CAN0 - CAN3) CAN-PCIe/402-B4 1Slot: 4x CAN high-speed interfaces (CAN0 - CAN3) CAN-PCIe/402-1-LP: 1x CAN high-speed interface (CAN0)
CAN controller	esdACC in EP4CGX Intel® FPGA, According to ISO11898-1 (CAN 2.0A/2.0B)
CAN protocol	According to ISO11898-1
Physical Layer	Physical layer according to ISO 11898-2, Bit rate up to 1 Mbit/s
Bus termination	Terminating resistors can be set via jumpers
Electrical isolation	Electrical isolation via digital isolator and DC/DC-converters: Voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to host/system ground; CAN to CAN): 500V DC @ 1s ($I < 1 \text{ mA}$)
Connector	1x 9-pin DSUB per CAN channel, pin contacts (all except C.2045.08) 1x 37-pin DSUB, pin contacts (only C.2045.08)

Table 6: Data of the CAN interface

5.4 CAN FD Interfaces (C.2045.62 – C.2045.94)


Number of CAN FD interfaces	CAN-PCle/402-1-FD: 1x CAN FD interface (CAN0) CAN-PCle/402-2-FD: 2x CAN FD interfaces (CAN0, CAN1) CAN-PCle/402-B4-FD: 4x CAN FD interfaces (CAN0 – CAN3) CAN-PCle/402-1-LP-FD: 1x CAN FD interface (CAN0)
CAN controller	esdACC in EP4CGX Intel FPGA, According to ISO11898-1:2015
CAN protocol	According to ISO11898-1
Physical Layer	Physical layer according to ISO 11898-2, CAN bit rates from 10 kbit/s up to 8 Mbit/s with the same CAN transceiver
	 INFORMATION Please note that the increased CAN FD bit rate (up to 8 Mbit/s, formerly 5 Mbit/s) is only ensured for products with batch numbers as specified in the table “Hardware” on page 3.
Bus termination	On-board terminating resistors can be individually set between CAN-H and CAN_L via jumpers
Electrical isolation	Electrical isolation via digital isolator and DC/DC-converters: Voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to host/system ground; CAN to CAN): 500V DC @ 1s ($I < 1 \text{ mA}$)
Connector	1x 9-pin DSUB per CAN FD channel, pin contacts (all except C.2045.68) 1x 37-pin DSUB, pin contacts (only C.2045.68)

Table 7: Data of the CAN interface

5.5 Software Support

CAN layer 2 (CAN-API) software drivers for Windows® and Linux® are included in delivery of the CAN-PCle/402 boards. They can also be downloaded from the CAN-PCle/402 product page on our website: <https://esd.eu/en/products/can-pcie-402>

Additional CAN layer 2 object licences for the real-time operating systems such as VxWorks®, QNX® and RTX64 are available.

Higher layer protocols (CANopen®, J1939, ARINC825) are supported for Classical CAN applications. See Order Information on page 47 for availability of the drivers.

Drivers for other operating systems are available on request. For detailed information about the driver availability for your operating system, please contact our sales team: sales@esd.eu

The CAN layer 2 (CAN-API) software installation and the software drivers are described in the manuals:

“NTCAN-API Part 1: Structure, Function and C/C++ API” Application Developers Manual (2) and
“NTCAN-API Part 2: Installation, Configuration and Firmware Update” Installation Guide (3)

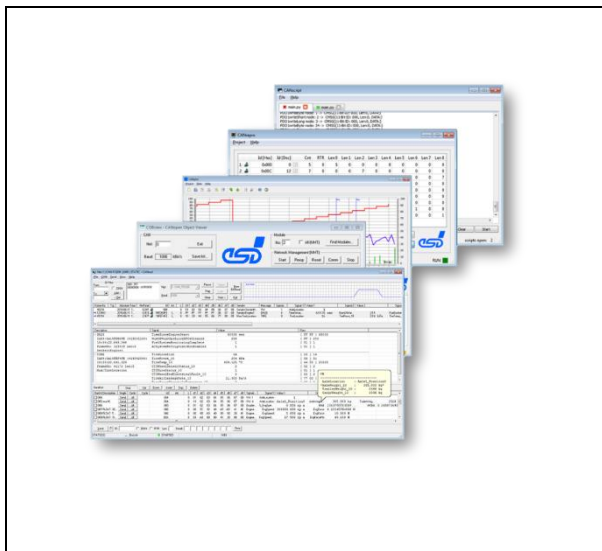
The manuals can be downloaded free of charge from our website via the product page of the CAN-PCle/402 or the CAN-SDK page: <https://esd.eu/produkte/can-sdk>

CAN Tools

esd offers additional free-of-charge tools which support efficient setup and analysis of Classical CAN applications and networks.

The CAN Tools are operational with all esd PC-CAN interfaces (e.g. PCIe, USB, EtherCAN/2 ...)

The following CAN Tools are available:



CANreal	Display and record of CAN message frames
CANplot	Graphical display of CAN data
CANrepro	Replay of pre-recorded CAN messages
CANscript	Python based scripting tool
COBview	Analysis and diagnostics of CANopen® nodes

System Requirements:

- Windows 32-bit or 64-bit system
- 30 MB free HD drive space
- esd CAN driver installed

As part of the esd software development kit (CAN SDK) of the NTCAN-API the CAN Tools are included in delivery of the CAN-CD.

The CAN SDK can also be downloaded free-of-charge from the esd website.

6 Connector Pin Assignments

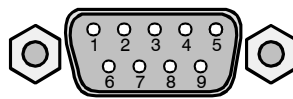
6.1 CAN via DSUB9

This chapter applies to all CAN-PCIe/402 variants except CAN-PCI/402-B4(-FD) (C.2045.08 and C.2045.68)

The two independent DSUB9 connectors of CAN0 and CAN1 and of the additional CAN interfaces CAN2 and CAN3 (CAN-PCI/402-4/2Slot) have the same pin assignment.

Device connector: DSUB9 connector with pin contacts.

Pin Position:



Pin Assignment:

Signal	Pin		Signal
CANx_GND	6	1	Reserved
		2	CANx_L
CANx_H	7	3	CANx_GND
Reserved	8	4	Reserved
Reserved	9	5	Shield

Signal Description

x ...	Number of CAN interface. x = 0, for the signals of CAN0, x = 1, for the signals of CAN1. Additional interfaces, CAN-PCIe/402-4/2Slot only: x = 2, for the signals of CAN2, x = 3, for the signals of CAN3
CANx_L, CANx_H	CAN signal lines of CAN net x
CANx_GND	Reference potential of the local CAN physical layer x
Shield	Shielding (connected with the case of the 9-pin DSUB connector)
Reserved	Reserved for future applications, do not connect!

6.2 CAN via DSUB37 (B4-Variants only)

This chapter applies to the CAN-PCIe/402-B4(-FD) variants (C.2045.08 and C.2045.68) only.

All four CAN interfaces are attached via DSUB37 panel connector with pin contacts.

Pin Position:



Pin Assignment:

Signal	Pin		Signal	Channel
reserved	20	1	reserved	
reserved		2	reserved	
reserved		3	reserved	
reserved		4	reserved	
CAN3_GND	23	5	CAN3_GND	CAN3
CAN3_H		6	CAN3_H	
CAN3_L		7	CAN3_L	
reserved		8	reserved	
CAN2_GND	27	9	CAN2_GND	CAN2
CAN2_H		10	CAN2_H	
CAN2_L		11	CAN2_L	
reserved		12	reserved	
CAN1_GND	31	13	CAN1_GND	CAN1
CAN1_H		14	CAN1_H	
CAN1_L		15	CAN1_L	
reserved		16	reserved	
CAN0_GND	35	17	CAN0_GND	CAN0
CAN0_H		18	CAN0_H	
CAN0_L		19	CAN0_L	

Signal Description

CANx_L, CANx_H...

CANx_GND ...

reserved ...

CAN signal lines of the CAN interface x (x = 0 ... 3)

Reference potential of the local CAN physical layer (x = 0 ... 3)

Reserved

6.2.1 Adapter Cable CAN-PCI/4XX-B4-1C4

The adapter cable CAN-PCI/4XX-B4-1C4 is designed for the connection to the DSUB37 panel connector (pin contacts) of the CAN-PCI/402-B4/1Slot. The signals of the four CAN interfaces are connected to four DSUB9 plugs with pin contacts.

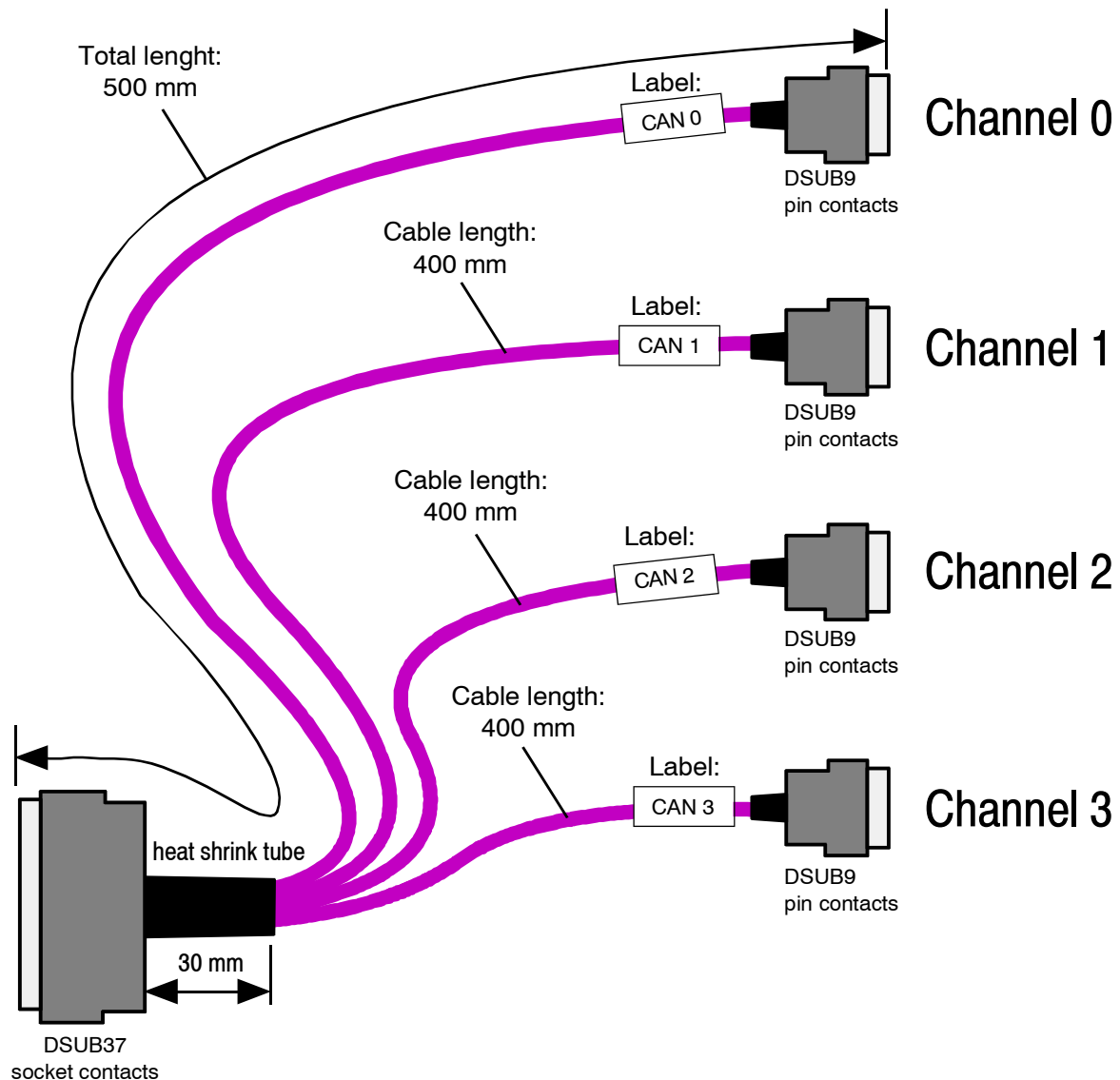


Figure 12: Adapter cable CAN-PCI/4XX-B4-1C4

Connector A		Cable		Connectors B		Signal Name
Connector type	Pin no.	Label	Color (internal)	Connector type	Pin no.	
DSUB37 Socket contacts	1	-	-	-	-	-
	:	-	-	-	-	-
	4	-	-	-	-	-
	5	CAN3	shield	DSUB9 pin contacts	3 + Housing	CAN3_GND*
	6		brown		7	CAN3_H
	7		white		2	CAN3_L
	8	-	-	-	-	-
	9	CAN2	shield	DSUB9 pin contacts	3 + Housing	CAN2_GND*
	10		brown		7	CAN2_H
	11		white		2	CAN2_L
	12	-	-	-	-	-
	13	CAN1	shield	DSUB9 pin contacts	3 + Housing	CAN1_GND*
	14		brown		7	CAN1_H
	15		white		2	CAN1_L
	16	-	-	-	-	-
	17	CAN0	shield	DSUB9 pin contacts	3 + Housing	CAN0_GND*
	18		brown		7	CAN0_H
	19		white		2	CAN0_L
	20	-	-	-	-	-
	:					
	37					
	Housing not connected	-	-	-	-	-

*... CANx_GND are isolated from each other. They are not tied together by the adapter cable.

Table 8: Assignments of the cable connectors of CAN-PCI/4XX-B4-1C4



NOTICE

The CAN-GND signals of the cables of the 4-channel cable adapter "CAN-PCI/4XX-B4-1C4" are connected via the wire shield if the adapter is connected to the esd hardware. Thus, the housings of the 9-pin DSUB connectors are connected to the respective CAN-GND, because no other potential is available on these connectors. There is no connection between the cable shield and the earth potential i.e., to the DSUB37 connector housing.

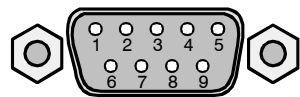
Please note that in accordance with the wiring instructions the CAN-GND signal has to be connected to the earth potential at an appropriate position (see point 3 of the "General Rules" at the beginning of chapter 7).

Connector Pin Assignments

The signals of a CAN channel are conducted to one of the four DSUB9 plugs of the adapter cable (CAN-PCI/4XX-B4-1C4).

Device connector: DSUB9 connector with pin contacts.

Pin Position:



Pin Assignment:

Signal	Pin		Signal
reserved	6	1	reserved
CANx_H		2	CANx_L
reserved	7	3	CANx_GND
reserved		4	reserved
reserved	8	5	reserved

Signal Description

x ...	Number of CAN interface. x = 0, for the signals of CAN0, x = 1, for the signals of CAN1, x = 2, for the signals of CAN2, x = 3, for the signals of CAN3
CANx_L, CANx_H	CAN signal lines of CAN net x
CANx_GND	reference potential of the local CAN physical layer x
Reserved	reserved for future applications, do not connect!

7 Correct Wiring of Electrically Isolated CAN Networks



NOTICE

This chapter applies to CAN networks with bit rates up to 1 Mbit/s.

If you work with higher bit rates, as for example used for CAN FD, the information given in this chapter must be examined for applicability in each individual case.

For further information refer to the CiA® CAN FD guidelines and recommendations (<https://www.can-cia.org/>).

For the CAN wiring all applicable rules and regulations (EU, DIN), such as regarding electromagnetic compatibility, security distances, cable cross-section or material, must be observed.

7.1 CAN Wiring Standards

The flexibility in CAN network design is a major strength of the various extensions based on the original CAN standard ISO 11898-2, such as CANopen®, ARINC825, DeviceNet® and NMEA2000. However, taking advantage of this flexibility absolutely requires a network design that considers the interactions of all network parameters.

In some cases, the CAN organizations have adapted the scope of CAN in their specifications to enable applications outside the ISO 11898 standard. They have imposed system-level restrictions on data rate, line length and parasitic bus loads.

However, when designing CAN networks, a margin must always be planned for signal losses over the entire system and cabling, parasitic loads, network imbalances, potential differences against earth potential, and signal integrities. **Therefore, the maximum achievable number of nodes, bus lengths and stub lengths may differ from the theoretically possible number!**

esd has limited its recommendations for CAN wiring to the specifications of ISO 11898-2.

A description of the special features of the derived specifications CANopen, ARINC825, DeviceNet, and NMEA2000 is omitted here

The consistent compliance with the ISO 11898-2 standard offers significant advantages:

- Reliable operation due to proven design specifications
- Minimization of error sources due to sufficient distance to the physical limits.
- Easy maintenance because there are no "special cases" to consider for future network modifications and troubleshooting.

Of course, reliable networks can be designed according to the specifications of CANopen, ARINC825, DeviceNet and NMEA2000, **however it must be observed that it is strictly not recommended to mix the wiring guidelines of the various specifications!**

7.2 Light Industrial Environment (*Single Twisted Pair Cable*)

7.2.1 General Rules



NOTICE

esd grants the EU Conformity of the product, if the CAN wiring is carried out with at least single shielded **single** twisted pair cables that match the requirements of ISO 11898-2. Single shielded *double* twisted pair cable wiring as described in chapter 7.3 ensures the EU Conformity as well.

The following **general rules** for CAN wiring with single shielded *single* twisted pair cable should be followed:

1	A suitable cable type with a wave impedance of about $120\ \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22\ \text{mm}^2$) must be used. The voltage drop over the wire must be considered.
2	For light industrial environment use at least a two-wire CAN cable, the wires of which must be assigned as follows: <ul style="list-style-type: none"> • Two twisted wires must be assigned to the data signals (CAN_H, CAN_L). • The cable shield must be connected to the reference potential (CAN_GND).
3	The reference potential CAN_GND must be connected to the functional earth (FE) at exactly one point.
4	A CAN bus line must not branch (exception: short cable stubs) and must be terminated with the characteristic impedance of the line (generally $120\ \Omega \pm 10\%$) at both ends (between the signals CAN_L and CAN_H and not at CAN_GND).
5	Keep cable stubs as short as possible ($l < 0.3\ \text{m}$).
6	Select a working combination of bit rate and cable length.
7	Keep away cables from disturbing sources. If this cannot be avoided, double shielded wires are recommended.

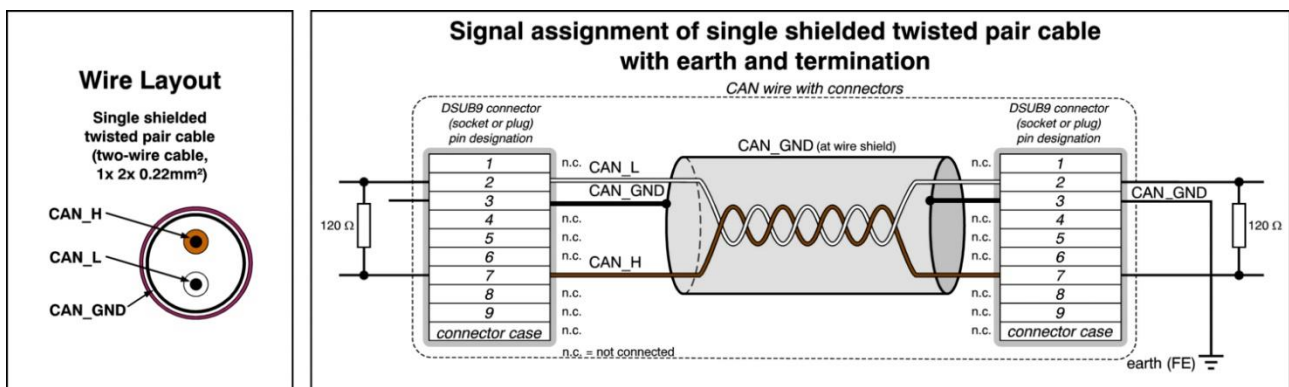


Figure 13: CAN wiring for light industrial environment

7.2.2 Cabling

- To connect CAN devices with just one CAN connector per net use a short stub (< 0.3 m) and a T-connector (available as accessory). If these devices are located at the end of the CAN network, the CAN terminator “CAN-Termination-DSUB9” can be used.

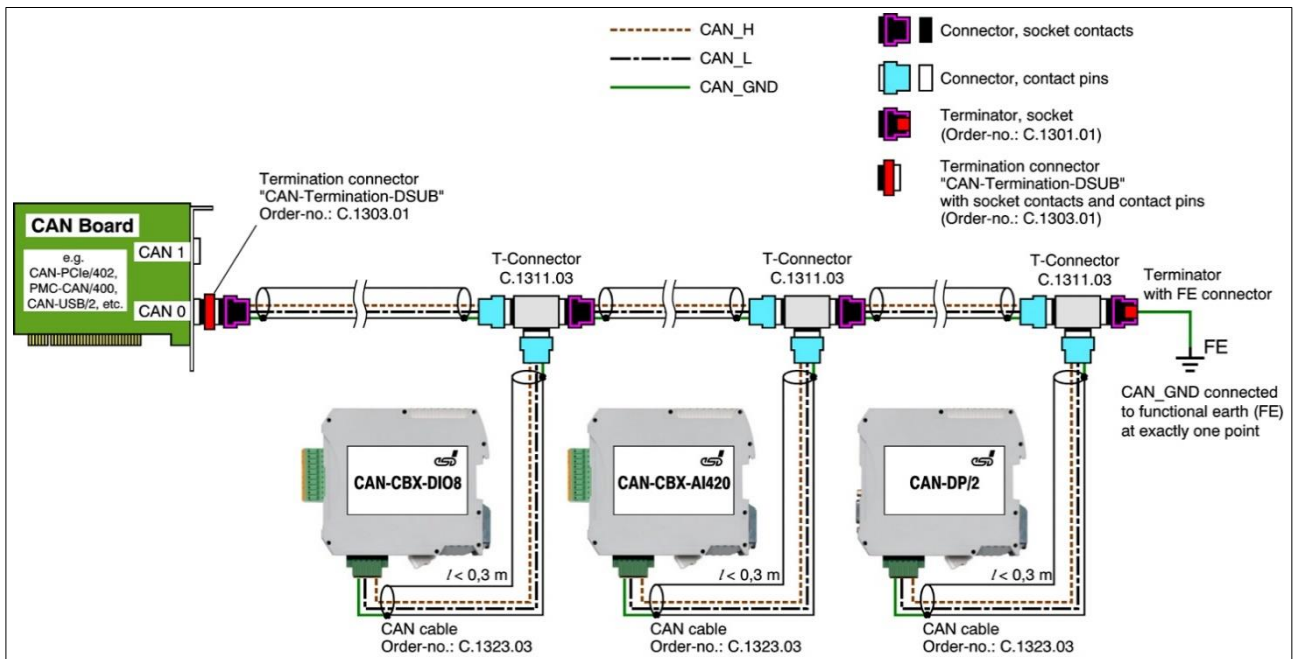


Figure 14: Example for proper wiring with single shielded single twisted pair wires

7.2.3 Branching

- In principle the CAN bus must be realized in a line. The nodes are connected to the main CAN bus line via short cable stubs. This is normally realised by so called T-connectors. esd offers the CAN-T-Connector (Order No.: C.1311.03)
- If a mixed application of single twisted and double twisted cables cannot be avoided, ensure that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by using repeaters.

7.2.4 Termination Resistor

- A termination resistor must be connected at both ends of the CAN bus. If an integrated CAN termination resistor is connected to the CAN interface at the end of the CAN bus, this integrated termination must be used instead of an external CAN termination resistor.
- 9-pole DSUB-termination connectors with integrated termination resistor and pin contacts and socket contacts are available from esd (order no. C.1303.01).
- For termination of the CAN bus and grounding of the CAN_GND, DSUB terminators with pin contacts (order no. C.1302.01) or socket contacts (order no. C.1301.01) and with additional functional earth contact are available.

7.3 Heavy Industrial Environment (Double Twisted Pair Cable)

7.3.1 General Rules

The following **general rules** for the CAN wiring with single shielded *double* twisted pair cable should be followed:

1	A suitable cable type with a wave impedance of about $120\ \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22\ \text{mm}^2$) must be used. The voltage drop over the wire must be considered.
2	For heavy industrial environment use a four-wire CAN cable, the wires of which must be assigned as follows: <ul style="list-style-type: none"> • Two twisted wires must be assigned to the data signals (CAN_H, CAN_L) and • The other two twisted wires must be assigned to the reference potential (CAN_GND). • The cable shield must be connected to functional earth (FE) at least at one point.
3	The reference potential CAN_GND must be connected to the functional earth (FE) at exactly one point.
4	A CAN bus line must not branch (exception: short cable stubs) and must be terminated with the characteristic impedance of the line (generally $120\ \Omega \pm 10\%$) at both ends (between the signals CAN_L and CAN_H and not to CAN_GND).
5	Keep cable stubs as short as possible ($l < 0.3\ \text{m}$).
6	Select a working combination of bit rate and cable length.
7	Keep away CAN cables from disturbing sources. If this cannot be avoided, double shielded cables are recommended.

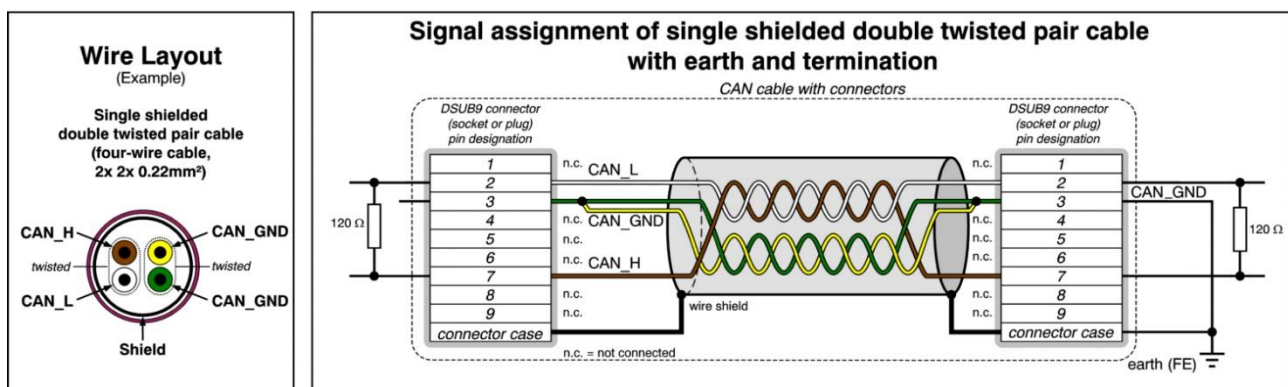


Figure 15: CAN wiring for heavy industrial environment

7.3.2 Device Cabling

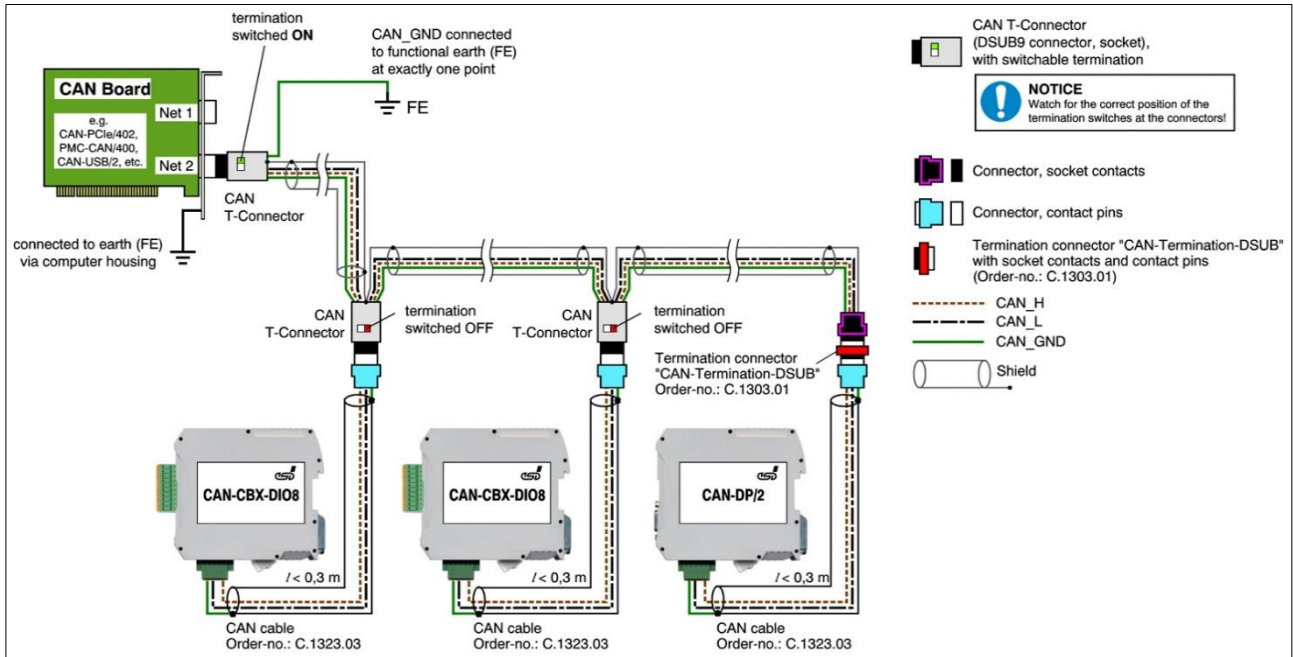


Figure 16: Example of proper wiring with single shielded double twisted pair cables

7.3.3 Branching

- In principle, the CAN bus must be realized in a line. The nodes are connected to the main CAN bus line via short cable stubs. This is usually realised via so called T-connectors. When using esd's CAN-T-Connector (order no.: C.1311.03) in heavy industrial environment and with four-wire twisted cables, it must be noted that the shield potential of the conductive DSUB housing is not looped through this type of T-connector. This interrupts the shielding. Therefore, you must take appropriate measures to connect the shield potentials, as described in the manual of the CAN-T-Connector. For further information on this, please refer to the CAN-T-Connector Manual (order no.: C.1311.21). Alternatively, a T-connector can be used, in which the shield potential is looped through, for example the DSUB9 connector from ERNI (ERBIC CAN BUS MAX, order no.:154039).
- If a mixed application of single twisted and double twisted cables cannot be avoided, ensure that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by using repeaters.

7.3.4 Termination Resistor

- A termination resistor must be connected at both ends of the CAN bus. If an integrated CAN termination resistor is connected to the CAN interface at the end of the CAN bus, this integrated termination must be used instead of an external CAN termination resistor.
- 9-pole DSUB-termination connectors with integrated termination resistor and pin contacts and socket contacts are available from esd (order no. C.1303.01).
- 9-pole DSUB-connectors with integrated switchable termination resistor can be ordered for example from ERNI (ERBIC CAN BUS MAX, socket contacts, order no.:154039).

7.4 Electrical Grounding

- For CAN devices with electrical isolation the CAN_GND must be connected between the CAN devices.
- CAN_GND should be connected to the earth potential (FE) at **exactly one** point of the network.
- Each *CAN interface with electrical connection to earth potential* acts as a grounding point. For this reason, it is recommended not to connect more than one *CAN device with electrical connection to earth potential*.
- Grounding can be done for example at a termination connector (e.g. order no. C.1302.01 or C.1301.01).

7.5 Bus Length

The bus length of a CAN network must be adapted to the set bit rate. The maximum values result from the fact that the time required for a bit to be transmitted in the bus system is shorter the higher the transmission rate is. However, as the line length increases, so does the time it takes for a bit to reach the other end of the bus. It should be noted that the signal is not only transmitted, but the receiver must also respond to the transmitter within a certain time. The transmitter, in turn, must detect any change in bus level from the receiver(s). Delay times on the line, the transceiver, the controller, oscillator tolerances and the set sampling time must be considered.

In the following table you will find guide values for the achievable bus lengths at certain bit rates.

Bit Rate [kbit/s]	Theoretical values of reachable wire length with esd interface l_{\max} [m]	CiA recommendations (07/95) for reachable wire lengths l_{\min} [m]	Standard values of the cross-section according to CiA 303-1 [mm ²]
1000	37	25	0.25 to 0.34
800	59	50	0.34 to 0.6
666. $\overline{6}$	80	-	
500	130	100	
333. $\overline{3}$	180	-	
250	270	250	
166	420	-	0.5 to 0.6
125	570	500	
100	710	650	0.75 to 0.8
83. $\overline{3}$	850	-	
66. $\overline{6}$	1000	-	
50	1400	1000	
33. $\overline{3}$	2000	-	not defined in CiA 303-1
20	3600	2500	
12.5	5400	-	
10	7300	5000	

Table 9: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

Optical couplers are delaying the CAN signals. esd modules typically achieve a wire length of 37 m at 1 Mbit/s within a proper terminated CAN network without impedance disturbances, such as those caused by cable stubs > 0.3 m.



NOTICE

Please note that the cables, connectors, and termination resistors used in CANopen networks shall meet the requirements defined in ISO 11898-2. In addition, further recommendations of the CiA, like standard values of the cross section, depending on the cable length, are described in the CiA recommendation CiA 303-1 (see CiA 303 CANopen Recommendation - Part 1: "Cabling and connector pin assignment," Version 1.9.0, Table 2). Recommendations for pin-assignment of the connectors are described in CiA 106: "Connector pin-assignment recommendations".

7.6 Examples for CAN Cables

esd recommends the following two-wire and four-wire cable types for CAN network design. These cable types are used by esd for ready-made CAN cables, too.

7.6.1 Cable for Light Industrial Environment Applications (Two-Wire)

Manufacturer	Cable Type
U.I. LAPP GmbH Schulze-Delitzsch-Straße 25 70565 Stuttgart Germany www.lappkabel.com	e.g. UNITRONIC ®-BUS CAN UL/CSA (1x 2x 0.22) (UL/CSA approved) Part No.: 2170260
	UNITRONIC ®-BUS-FD P CAN UL/CSA (1x 2x 0.25) (UL/CSA approved) Part No.: 2170272
ConCab GmbH Äußerer Eichwald 74535 Mainhardt Germany www.concab.de	e. g. BUS-PVC-C (1x 2x 0.22 mm²) Order No.: 93 022 016 (UL appr.)
	BUS-Schleppflex-PUR-C (1x 2x 0.25 mm²) Order No.: 94 025 016 (UL appr.)

7.6.2 Cable for Heavy Industrial Environment Applications (Four-Wire)

Manufacturer	Cable Type
U.I. LAPP GmbH Schulze-Delitzsch-Straße 25 70565 Stuttgart Germany www.lappkabel.com	e.g. UNITRONIC ®-BUS CAN UL/CSA (2x 2x 0.22) (UL/CSA approved) Part No.: 2170261
	UNITRONIC ®-BUS-FD P CAN UL/CSA (2x 2x 0.25) (UL/CSA approved) Part No.: 2170273
ConCab GmbH Äußerer Eichwald 74535 Mainhardt Germany www.concab.de	e. g. BUS-PVC-C (2x 2x 0.22 mm²) Order No.: 93 022 026 (UL appr.)
	BUS-Schleppflex-PUR-C (2x 2x 0.25 mm²) Order No.: 94 025 026 (UL appr.)



INFORMATION

Ready-made CAN cables with standard or custom length can be ordered from **esd**.

8 CAN Troubleshooting Guide

The CAN Troubleshooting Guide is a guide to finding and eliminating the most common problems and errors when setting up CAN bus networks and CAN-based systems.

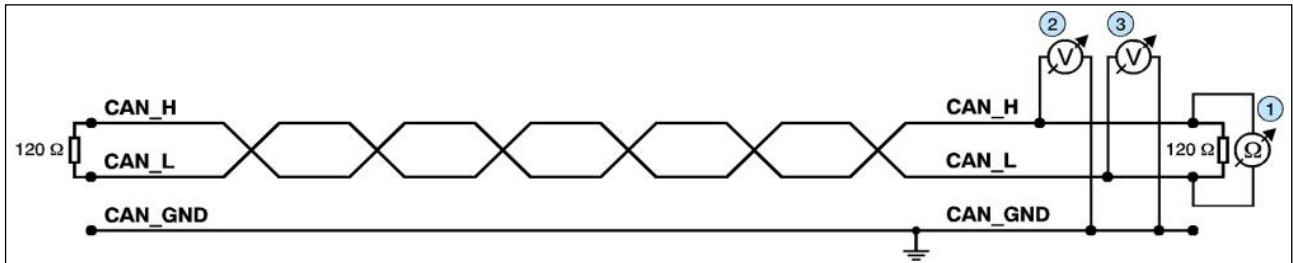


Figure 17: Simplified diagram of a CAN network

8.1 Termination

The bus termination is used to match impedance of a node to the impedance of the bus line used. If the impedance is mismatched, the transmitted signal is not completely absorbed by the load and will be partially reflected back into the transmission line.

If the impedances of the sources, transmission lines and loads are equal, the reflections are avoided. This test measures the total resistance of the two CAN data lines and the connected terminating resistors.

To test this, please proceed as follows:

1. Switch off the supply voltages of all connected CAN nodes.
2. Measure the DC resistance between CAN_H and CAN_L at one end of the network, measuring point ① (see figure above).

Expected result:

The measured value should be between 50 Ω and 70 Ω.

Possible causes of error:

- If the determined value is below 50 Ω, please make sure that:
 - There is no **short circuit** between CAN_H and CAN_L wiring.
 - **No more than two** terminating resistors are connected.
 - The transceivers of the individual nodes are not defective.
- If the determined value is higher than 70 Ω, please make sure that:
 - All CAN_H and CAN_L lines are correctly connected.
 - Two terminating resistors of 120 Ω each are connected to your CAN network (one at each end).

8.2 Electrical Grounding

The CAN_GND of the CAN network should be connected to the functional earth potential (FE) at only **one** point. This test indicates whether the CAN_GND is grounded at one or more points.

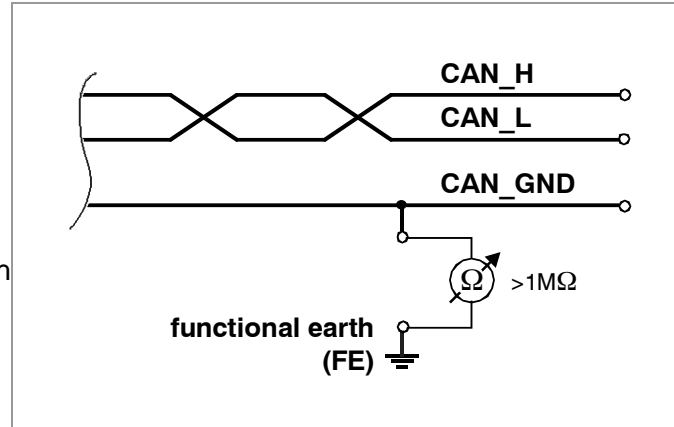
Please note that this test can only be performed with electrically isolated CAN nodes.

To test this, please proceed as follows:

1. Disconnect the CAN_GND from the earth potential (FE).
2. Measure the DC resistance between CAN_GND and earth potential (see figure on the right).

Do not forget to reconnect CAN_GND to earth potential after the test!

Figure 18: Simplified schematic diagram of ground test measurement



Expected result:

The measured resistance should be greater than 1 MΩ. If it is smaller, please search for additional grounding of the CAN_GND wires.

8.3 Short Circuit in CAN Wiring

A CAN bus might possibly still be able to transmit data even if CAN_GND and CAN_L are short-circuited. However, this will usually cause the error rate to rise sharply. Ensure that there is no short circuit between CAN_GND and CAN_L!

8.4 Correct Voltage Levels on CAN_H and CAN_L

Each node contains a CAN transceiver that outputs differential signals. When the network communication is idle the CAN_H and CAN_L voltages are approximately 2.5 V measured to CAN_GND. Defective transceivers can cause the idle voltages to vary and disrupt network communication.

To test for defective transceivers, please proceed as follows:

1. Switch on all supply voltages.
2. Terminate all network communication.
3. Measure the DC voltage between CAN_H and CAN_GND, measuring point ②. (See “Simplified diagram of a CAN network” on previous page).
4. Measure the DC voltage between CAN_L and CAN_GND, measuring point ③. (See “Simplified diagram of a CAN network” on previous page).

Expected result:

The measured voltage should be between 2.0 V and 3.0 V.

Possible causes of error:

- If the voltage is lower than 2.0 V or higher than 3.0 V, it is possible that one or more nodes have defective transceivers.
 - If the voltage is lower than 2.0 V, please check the connections of the CAN_H and CAN_L lines.
- To find a node with a defective transceiver within a network, please check individually the resistances of the CAN transceivers of the nodes (see next section).

8.5 CAN Transceiver Resistance Test

CAN transceivers have circuits that control CAN_H and CAN_L. Experience shows that electrical damage can increase the leakage current in these circuits.

To measure the current leakage through the CAN circuits, please use an ohmmeter and proceed as follows:

1. Switch **off** the node ④ and **disconnect** it from the CAN network.
(See figure below.)
2. Measure the DC resistance between CAN_H and CAN_GND, measuring point ⑤
(See figure below.)
3. Measure the DC resistance between CAN_L and CAN_GND, measuring point ⑥
(See figure below.)

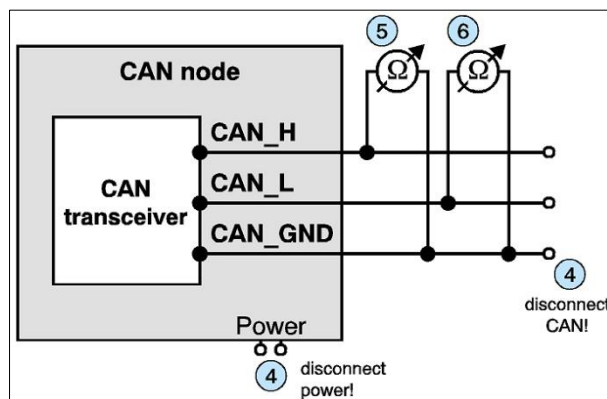


Figure 19: Measuring the internal resistance of CAN transceivers

Expected result:

The measured resistance should be greater than 10 kΩ for each measurement.

Possible causes of error:

- If the resistance is significantly lower, the CAN transceiver may be defective.
- Another indication of a defective CAN transceiver is a very high deviation of the two measured input resistances (>> 200 %).

8.6 Support by esd

If you have followed the troubleshooting steps in this troubleshooting guide and still cannot find a solution to your problem, our support team can help.

Please contact our support by email to support@esd.eu or by phone **+49-511-37298-130**.

9 References

- (1) esd electronics gmbh, "CAN/402-Slot2-LIN Hardware Manual", Hannover, 2022, esd electronics, Revision 1.0
- (2) esd electronics gmbh, "NTCAN-API Part 1: Application Developers Manual", Hannover, 2022-05-30, esd electronics, Revision 5.5
- (3) esd electronics gmbh, "NTCAN-API Part 2: Installation Guide", Hannover, 2021-10-27, esd electronics, Revision 4.7

10 Declaration of Conformity

EU-KONFORMITÄTSERKLÄRUNG EU DECLARATION OF CONFORMITY



Adresse **esd electronics gmbh**
Address **Vahrenwalder Str. 207**
30165 Hannover
Germany

esd erklärt, dass das Produkt
esd declares, that the product

Typ, Modell, Artikel-Nr.
Type, Model, Article No.

CAN-PCle/402-1
CAN-PCle/402-1-D
CAN-PCle/402-2
CAN-PCle/402-2-D
CAN-PCle/402-4/2Slot
CAN-PCle/402-4-D/2Slot
CAN-PCle/402-B4/1Slot
CAN-PCle/402-B4-D/1Slot
CAN-PCle/402-Slot2
CAN-PCle/402-Slot2-D
CAN-PCle/402-1-LP
CAN-PCle/402-1-LP-2
CAN-PCle/402-1-FD
CAN-PCle/402-1-D-FD
CAN-PCle/402-2-FD
CAN-PCle/402-2-D-FD
CAN-PCle/402-B4-FD/1Slot
CAN-PCle/402-1-LP-FD
CAN-PCle/402-1-LP2-FD
CAN-PCI/4xx-B4-1C4 DSUB37-to4xDSUB9

C.2045.02
C.2045.03
C.2045.04
C.2045.05
C.2045.06
C.2045.07
C.2045.08
C.2045.09
C.2045.10
C.2045.11
C.2045.32
C.2045.34
C.2045.62
C.2045.63
C.2045.64
C.2045.65
C.2045.68
C.2045.92
C.2045.94
C.2041.18

die Anforderungen der Normen
fulfills the requirements of the standards

EN 61000-6-2:2005,
EN 61000-6-3:2007+A1:2011

gemäß folgendem Prüfbericht erfüllt.
according to test certificate.

H-K00-0505-13

Das Produkt entspricht damit der EU-Richtlinie „EMV“
Therefore the product corresponds to the EU Directive 'EMC'

2014/30/EU

Das Produkt entspricht den EU-Richtlinien „RoHS“
The product corresponds to the EU Directives 'RoHS'

2011/65/EU, 2015/863/EU

Diese Erklärung verliert ihre Gültigkeit, wenn das Produkt nicht den Herstellerunterlagen entsprechend eingesetzt und betrieben wird, oder das Produkt abweichend modifiziert wird.
This declaration loses its validity if the product is not used or run according to the manufacturer's documentation or if non-compliant modifications are made.

Name / Name T. Bielert
Funktion / Title QM-Beauftragter / QM Representative
Datum / Date Hannover, 2019-04-05

Rechtsgültige Unterschrift / authorized signature

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11 Order Information

11.1 Hardware with Classical CAN Interface

Type	Properties				Order No.
	Description *	Number of CAN Interfaces	CAN Connector Type	PC-Slots required	
CAN-PCle/402-1	1 CAN interface	1	DSUB9	1	C.2045.02
CAN-PCle/402-2	2 CAN interfaces	2	DSUB9	1	C.2045.04
CAN-PCle/402-4/2Slot	4 CAN Interfaces, includes adapter board C.2045.10	4	DSUB9	2	C.2045.06
CAN-PCle/402-B4/1 Slot	4 CAN Interfaces at DSUB37	4	DSUB37	1	C.2045.08
CAN-PCle/402-1-LP	Low profile version with smaller front panel; can be extended to 2x CAN with CAN-PCle/402-1-LP-2 (C.2045.34)	1	DSUB9	1	C.2045.32
* CAN layer 2 drivers for Windows and Linux are included in delivery.					
Accessories					
CAN-PCle/402-1-LP-2	Extension board with 2 nd CAN interface (with physical layer only) and ribbon cable for CAN-PCle/402-1-LP (C.2045.32), without front panel	1	DSUB9	1	C.2045.34
CAN-PCle/402-Slot2	Adapter board (with physical layer only) for CAN 2 and 3 incl. ribbon cable and front panel; for use as extension for 2-CAN interface boards	2	DSUB9	1	C.2045.10
CAN-PCI/4XX-B4-1C4 DSUB37-to-4xDSUB9	Adapter cable for "CAN-PCle/402-B4/1 Slot" (C.2045.08): DSUB37 to 4x DSUB9 incl. 4 CAN cables	4	1x DSUB37+ 4x DSUB9	n.a.	C.2041.18

Table 10: Order information CAN-PCle/402 hardware with Classical CAN interface

11.2 Hardware with CAN FD Interface

Type	Properties				Order No.
	Description *	Number of CAN FD Interfaces	CAN Connector Type	PC-Slots required	
CAN-PCle/402-1-FD	1 CAN FD interface	1	DSUB9	1	C.2045.62
CAN-PCle/402-2-FD	2 CAN FD interfaces	2	DSUB9	1	C.2045.64
CAN-PCle/402-B4-FD	4 CAN FD interfaces	4	DSUB37	1	C.2045.68
CAN-PCle/402-1-LP-FD	Low profile version with smaller front panel; can be extended to 2x CAN FD with CAN-PCle/402-1-LP-2-FD (C.2045.64)	1	DSUB9	1	C.2045.92
* CAN layer 2 drivers for Windows and Linux are included in delivery.					
Accessories					
CAN-PCle/402-1-LP-2-FD	Extension board with 2 nd CAN FD interface (with physical layer only) and ribbon cable for CAN-PCle/402-1-LP-FD (C.2045.62), without front panel	1	DSUB9	1	C.2045.94
CAN/402-Slot2-LIN	Adapter board with 2 LIN interfaces according to ISO 17987-4:2016 electrically isolated - ribbon cable inclusive	-	DSUB9	1	C.2045.12
CAN-PCI/4XX-B4-1C4 DSUB37-to-4xDSUB9	Adapter cable for "CAN-PCle/402-B4-FD 1 Slot" (C.2045.68): DSUB37 to 4x DSUB9 incl. 4 CAN cables	4	1x DSUB37+ 4x DSUB9	n.a.	C.2041.18

Table 11: Order information CAN-PCle/402 hardware with CAN FD interface

11.3 Software

Type	Order No.
CAN layer 2 software drivers for Windows and Linux on CD-ROM are included in delivery of the CAN-PCI/402 variants.	
Additional CAN-layer 2 object licences including CD-ROM:	
CAN-DRV-LCD CDROM+Lizenz QNX	C.1101.32
CAN-DRV-LCD CDROM+Lizenz RTX (incl. RTX64)	C.1101.35
CAN-DRV-LCD CDROM+Lizenz VxWorks	C.1101.55
These drivers are for Classical CAN operation only!	
Higher layer protocols including CD-ROM:	
CANopen Single user runtime license for CANopen Software Stacks in connection with esd CAN hardware and NTCAN API:	
CANopen Software Stack Windows/Linux	C.1101.06
CANopen-LCD CDROM+Lizenz QNX	C.1101.17
CANopen-LCD CDROM+Lizenz RTX (incl. RTX64)	C.1101.16
CANopen-LCD CDROM+Lizenz VxWorks	C.1101.18
J1939 Single-user runtime license for J1939 Software Stack and J1939 Device Simulator & Monitor for use with esd CAN hardware and NTCAN API:	
J1939 Stack for Windows (Object)	C.1130.10
J1939 Stack for Linux (Object)	C.1130.11
J1939 Stack for RTX (Object) (incl. RTX64)	C.1130.12
ARINC825 Licence and CD usable with all esdACC based CAN interfaces:	
ARINC 825-LCD Windows/Linux/LabView	C.1140.06
ARINC 825-LCD CDROM+Lizenz QNX	C.1140.17
ARINC 825-LCD CDROM+Lizenz RTX (incl. RTX64)	C.1140.16
ARINC 825-LCD CDROM+Lizenz VxWorks	C.1140.18

For detailed information about the driver availability for your operating system, please contact our sales team.

Table 12: Order information software

11.4 PDF Manuals

For the availability of the manuals see table below.

Please download the manuals as PDF documents from our esd website <https://www.esd.eu> for free.

Manuals		Order No.
CAN-PCIe/402-ME	Hardware manual in English	C.2045.21
CAN-API-ME	NTCAN-API: Application Developers Manual NTCAN-API: Driver Installation Guide	C.2001.21
CANopen-ME	CANopen manual in English	C.2002.21
CAN/402-Slot2-LIN-ME	Hardware manual of the adapter CAN/402-Slot2-LIN in English	C.2045.23

Table 13: Available Manuals

Printed Manuals

If you need a printout of the manual additionally, please contact our sales team (sales@esd.eu) for a quotation. Printed manuals may be ordered for a fee.