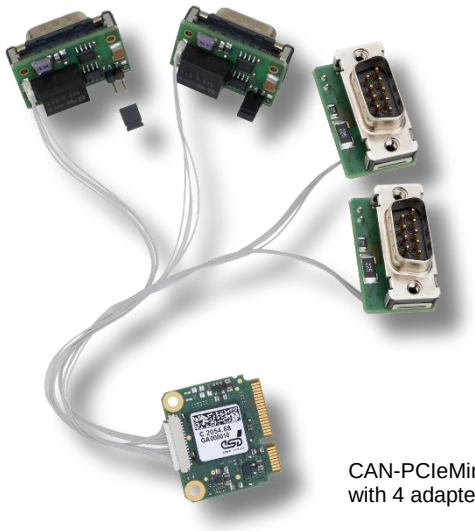
CAN-PCIeMiniHS/402-4-FD
CAN-PCIeMiniHS/402-4-FD-T

Half-Size PCI Express® Mini Card with 4 CAN FD Interfaces



CAN-PCIeMiniHS/402-4-FD
with 4 adapters

Hardware Manual

For Products: C.2054.68,
C.2054.69

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Notes

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This manual contains important information and instructions on safe and efficient handling of the CAN-PCIeMiniHS/402-4-FD. 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 History

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

Rev.	Chapter	Changes versus previous version	Date
1.1	1.2	Editorial change only: Block circuit diagram revised	2024-04-29
1.0	-	First English manual of CAN-PCIeMiniHS/402-4-FD and CAN-PCIeMiniHS/402-4-FD-T and optional DSUB9 adapters.	2024-02-05

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-PCIeMiniHS/402-4-FD follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-PCIeMiniHS/402-4-FD 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-PCIeMiniHS/402-4-FD 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 CAN-PCIeMiniHS/402-4-FD is not protected against hazardous electrical voltage.
- The CAN-PCIeMiniHS/402-4-FD may only be operated on supply circuits that provide sufficient protection against dangerous voltages.
- External circuits connected to the interfaces of the CAN-PCIeMiniHS/402-4-FD must be sufficiently protected against dangerous voltage.
- The user is responsible for compliance with the applicable national safety regulations.

- The device has to be securely installed in the control cabinet before commissioning.
- Protect the CAN-PCIeMiniHS/402-4-FD from dust, moisture and steam.
- Protect the CAN-PCIeMiniHS/402-4-FD from shocks and vibrations.
- The CAN-PCIeMiniHS/402-4-FD may become warm during normal use. Always allow adequate ventilation around the CAN-PCIeMiniHS/402-4-FD and use care when handling.
- Do not operate the CAN-PCIeMiniHS/402-4-FD 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-PCIeMiniHS/402-4-FD 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.

→ Take the appropriate precautions for handling electrostatic discharge sensitive devices.
→ Discharge the static electricity from your body before touching the CAN-PCIeMiniHS/402-4-FD.
→ Transport and store the CAN-PCIeMiniHS/402-4-FD only in an electrostatically safe bag, as when delivered.

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-PCIeMiniHS/402-4-FD 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.

Warning: In a residential, commercial, or light industrial environment the CAN-PCIeMiniHS/402-4-FD may cause radio interferences in which case the user may be required to take adequate measures.

The CAN-PCIeMiniHS/402-4-FD is a sub-assembly intended for incorporation into an apparatus by a manufacturer and NOT by the end user. The manufacturer of the final system must decide whether additional EMC or EMI protection requirements are necessary.

Intended Use

The intended use of the CAN-PCIeMiniHS/402-4-FD is the operation as CAN interface for Embedded systems. 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-PCIeMiniHS/402-4-FD is intended for installation in an Embedded system or PC, with indoor use only.
- The operation of the CAN-PCIeMiniHS/402-4-FD in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-PCIeMiniHS/402-4-FD for medical purposes is prohibited.

Service Note

The CAN-PCIeMiniHS/402-4-FD does not contain any parts that require maintenance by the user. The CAN-PCIeMiniHS/402-4-FD does not require any manual configuration of the hardware, apart from the CAN termination jumpers. 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	**`/dev/null`** or **`<stdio.h>`**
Function names	***open()***
Programming constants	`NULL`
Programming data types	`uint32_t`
Variable names	*Count*

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.

Table of Contents

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1 Overview

1.1 About this Manual

In this hardware manual the CAN-PCIeMiniHS/402-4-FD and CAN-PCIeMiniHS/402-4-FD-T are collectively referred to as CAN-PCIeMiniHS/402-4-FD. They only differ in the temperature range. Differences of the CAN-PCIeMiniHS/402-4-FD variants are noted accordingly where relevant. Available features, options and supplied items may vary depending on the CAN-PCIeMiniHS/402-4-FD version you selected.

1.2 Description of CAN-PCIeMiniHS/402-4-FD

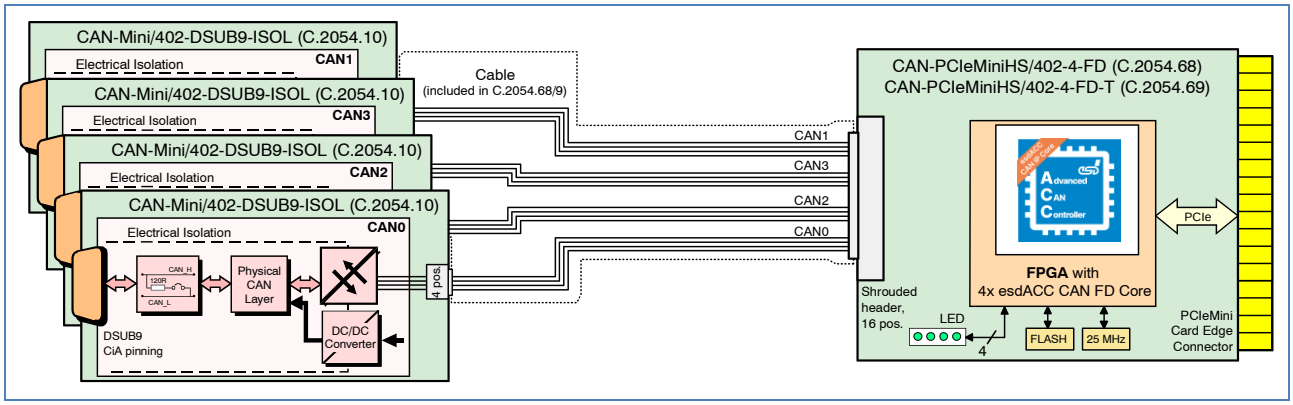


Figure 1: Block circuit diagram of CAN-PCIeMiniHS/402-4-FD

The CAN-PCIeMiniHS/402-4-FD is an add-in half-size PCI Express Mini Card. It features four CAN FD interfaces with TTL-level. The CAN FD interfaces are based on the esd Advanced CAN Core (esdACC) according to ISO 11898-1:2015. The CAN status is displayed via four LEDs. The variant CAN-PCIeMiniHS/402-4-FD-T is designed for operation in the extended temperature range. A 1-to-4 cable is included in delivery.

An optional bidirectional TTL-level to CAN-signal-level adapter CAN-Mini/402-DSUB9-ISOL can be connected to every channel individually via the cable. The adapter provides galvanic isolation of the CAN FD interfaces. It is equipped with a jumper for selectable onboard CAN termination and a DSUB9 plug for the connection to a CAN FD net.

The ISO 11898-2-compatible CAN FD interfaces allow each a maximum data transfer rate of 8 Mbit/s, or 1 Mbit/s for CAN CC applications. The CAN FD interfaces are fully backwards compatible and can also be used in CAN Classic (CAN CC) applications.
The CAN FD interfaces are controlled by the esdACC (esd Advanced CAN Core) developed by esd and certified according to ISO 16845:2004, which is implemented in an FPGA.
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.

Due to the support of MSI (Message Signaled Interrupts) CAN-PCIeMiniHS/402-4-FD can be operated for example in Hypervisor environments. The CAN-PCIeMiniHS/402-4-FD supports high resolution 64-bit hardware timestamps to enable highly accurate reception and transmission of CAN messages.

CAN layer 2 (CAN-API) software drivers for Windows® and Linux® are included in the scope of delivery. See “Order Information” on page 29 for availability of other drivers.

Additional free-of-charge esd CAN tools for Windows are downloadable from our website. The tools offer efficient setup and analysis of CAN CC applications and networks.

Customized options are available for customized serial production in reasonable quantities. Please contact our sales team for detailed information.

1.3 Glossary

Abbreviations

Abbreviation	Term
API	Application Programming Interface
CAN	Controller Area Network
CAN CC	CAN Classic
CAN FD	CAN Flexible Data-Rate
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
PCI	Peripheral Component Interconnect
PCIe	PCI Express
IDC	Insulation Displacement Connector
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network
WPAN	Wireless Personal Area Network

1.4 References

(1) PCI_Express Mini Card Electromechanical Specification, Revision 1.2, October 26,2007, PCI_Express_Mini_CEM_12_26Oct07_ncb
(2) NTCAN-API Part 1: Structure, Function and C/C++ API Application Developers Manual, Revision 5.6, Dec. 2022, Hannover, esd electronics gmbh
(3) NTCAN-API Part 2: Installation, Configuration and Firmware Update Installation Guide, Revision 4.7, Oct. 2021, Hannover, esd electronics gmbh

2 PCB View with Connectors and LEDs

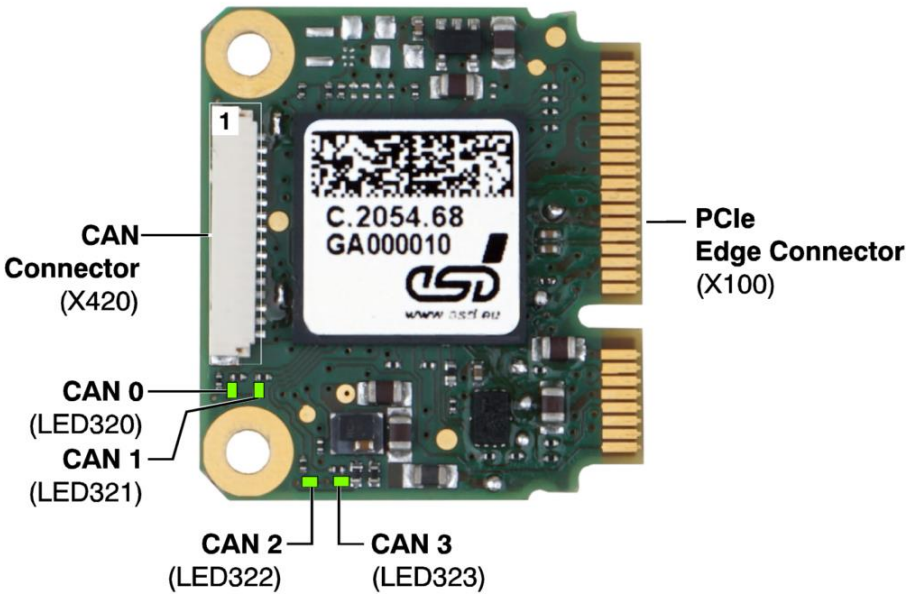


Figure 2: PCB view of CAN-PCIeMiniHS/402-4-FD

NOTICE
Read chapter “Installing and Uninstalling Hardware” on page 16, before you start with the installation of the hardware!

2.1 LED Display

The CAN-PCIeMiniHS/402-4-FD comes with four green LEDs, which are equipped on the top layer, see Figure 2.

Name	Function	Indicator State	Description	LED name in schematic diagram
CAN 0	Activity CAN0	off	No CAN bus connection and/or no data transfer on CAN0	LED320
		on	Connected to CAN bus 0 and data transfer on CAN0	
CAN 1	Activity CAN1	off	No CAN bus connection and/or no data transfer on CAN1	LED321
		on	Connected to CAN bus 1 and data transfer on CAN1	
CAN 2	Activity CAN2	off	No CAN bus connection and/or no data transfer on CAN2	LED322
		on	Connected to CAN bus 2 and data transfer on CAN2	
CAN 3	Activity CAN3	off	No CAN bus connection and/or no data transfer on CAN3	LED323
		on	Connected to CAN bus 3 and data transfer on CAN3	

Table 1: LEDs

2.2 Product Label

The product label is stuck on the bottom side of the CAN-PCIeMiniHS/402-4-FD. It is described using the example of the CAN-PCIeMiniHS/402-4-FD product label.

esd Product Label Example	esd Product Label shows	Example:
	- Data matrix code (top row)	-
	- esd order number	C.2054.68 (Order No. of CAN-PCIeMiniHS/402-4-FD)
	- Batch (first two letters) and serial number (following six digits)	GA000010 (GA 000010 Batch Serial number)
	- esd logo (www.esd.eu)	-

3 Connector Assignment and Adapter

3.1 CAN Connector

The CAN-PCIeMiniHS/402-4-FD comes with a wire-to-board connector for the connection of up to four CAN interfaces. It is equipped on the PCB top layer.

Device connector: 16-pin Wire-to-Board connector,
shrouded header (JST, SM16B-SURS-TF)

Pin Position:

1 . . . 16

Pin Assignment:

Pin	*Signal*
1	3.3V
2	GND
3	CAN1_Tx
4	CAN1_Rx
5	3.3V
6	GND
7	CAN3_Tx
8	CAN3_Rx
9	3.3V
10	GND
11	CAN2_Tx
12	CAN2_Rx
13	3.3V
14	GND
15	CAN0_Tx
16	CAN0_Rx

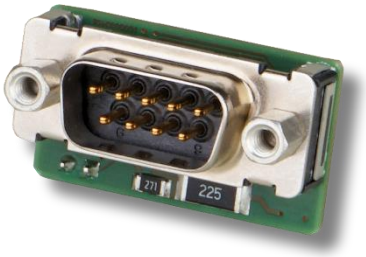
Signal Description:

CANx_Rx, CANx_Tx ...	CAN signals (TTL-level) of the CAN net x (x... 0, 1, 2, 3)
GND...	Reference potential (System GND)

NOTICE
esd grants the EU conformity of the product if the wiring is carried out with the adapter CAN-Mini/402-DSUB9-ISOL.

The 1-to-4 adapter cable is included in delivery of the CAN-PCIeMiniHS/402-4-FD. It comes with one 16-pin IDC receptacle (JST, 16SUR-32S) and four 4-pin IDC receptacles (JST, 04SUR-32S).

3.2 Optional Adapter CAN-Mini/402-DSUB9-ISOL



The optional adapters CAN-Mini/402-DSUB9-ISOL can be used to connect the individual CAN channels.
The adapter converts the TTL-level signals to CAN signal level, or vice versa.
It provides galvanic isolation of the CAN FD interface and is equipped with a DSUB9 plug on one side of the board, and the cable connector and a jumper for selectable CAN termination onboard on the other side of the board.

Figure 3: CAN-Mini/402-DSUB9-ISOL

The optional adapters CAN-Mini/402-DSUB9-ISOL have to be ordered separately as accessories, see “Order Information” on page 33.
The cable is contained in delivery of the CAN-PCIeMiniHS/402-4-FD.

NOTICE
Read chapter “Installing and Uninstalling Hardware” on page 16, before you start with the installation of the CAN-PCIeMiniHS/402-4-FD!

3.2.1 Adapter View

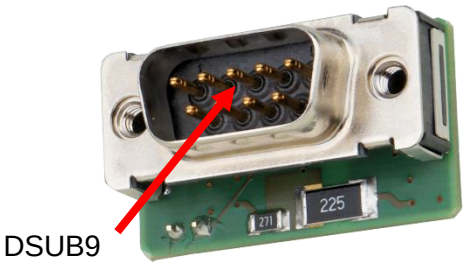


Figure 4: Top layer with DSUB9 connector

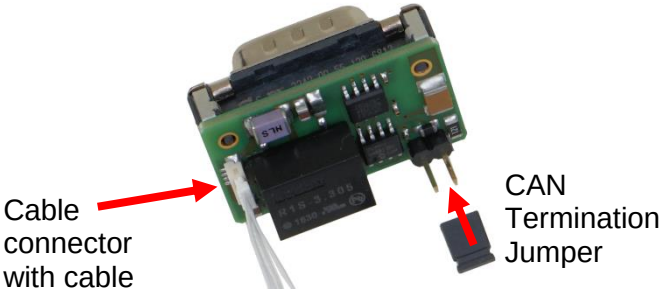


Figure 5: Bottom layer with jumper and cable connector

3.2.2 CAN Termination Jumper

With the jumper the CAN termination of the connected CAN interface can be set internally.
The jumpers are located on the bottom layers of the adapter boards (see **Figure 5**).

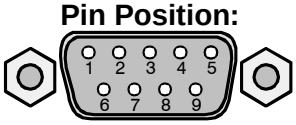
JumperJP400	
Jumper set	Internal termination (120Ω) of the connected CAN net
Jumper not set	No internal termination of the connected CAN interface. It must be terminated externally.

Table 2: Jumper

3.2.3 CAN Interface via DSUB9

Device connector: DSUB9 connector, pin-contacts

Pin Position:



Pin Assignment:

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

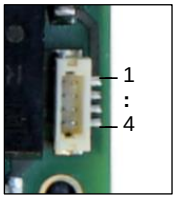
Signal Description:

CANx_L, CANx_H	CAN signal lines of the connected CAN interface x (x = 0, 1, 2 or 3)
CAN_GND	Reference potential of the local CAN physical layer
Shield	Shielding (connected with the case of the 9-pin DSUB connector)
Reserved	Reserved for future applications, do not connect!

3.2.4 CAN TTL-Level Signals via Cable Connector

The 4-pin Wire-to-Board connector, (JST, BM04B-SURS-TF) is equipped on the bottom layer of the adapter, see Figure 5.

Pin Position:



Pin Assignment:

Pin	Signal
1	3.3V
2	GND
3	CANx_Tx
4	CANx_Rx

Signal Description:

CANx_Rx, CANx_Tx ...	CAN signals (TTL-level) of the CAN net x (x... 0, 1, 2, 3)
GND...	Reference potential (System GND)

4 Installing and Uninstalling Hardware

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-PCIeMiniHS/402-4-FD shall be integrated.

→ The CAN-PCIeMiniHS/402-4-FD may only be operated on supply circuits that provide sufficient protection against dangerous voltages.
→ External circuits connected to the interfaces of the CAN-PCIeMiniHS/402-4-FD must be sufficiently protected against dangerous voltage.
→ The user is responsible for compliance with the applicable national safety regulations.
→ 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.

→ Take the appropriate precautions for handling electrostatic discharge sensitive devices.
→ Discharge the static electricity from your body before touching the CAN-PCIeMiniHS/402-4-FD.
→ Transport and store the CAN-PCIeMiniHS/402-4-FD only in an electrostatically safe bag, as when delivered.

4.1 Preparation

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. If applicable, connect the CAN-Mini/402-DSUB9-ISOL adapters to the CAN-PCIeMiniHS/402-4-FD via the cable, see Figure 6.

Figure 6: CAN-PCIeMiniHS/402-4-FD with 4 adapters

4. Set or remove the CAN termination jumpers on the adapter boards according to your needs see Figure 5, page 14.

5. Disconnect the system from the mains.
   Make sure that no risk arises from the system into which the CAN-PCIeMiniHS/402-4-FD shall be inserted.
   Read the manual of the system used and follow the instructions of the system manufacturer.

   WARNING
   Hazardous Voltage - Risk of electric shock due to unintentional contact with uninsulated live parts with high voltages.

   → 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 (i.e. with caution label).
   → Ensure the absence of voltage before starting any electrical work.
   → Cover or block off adjacent live parts.

6. Open the case if necessary.

To install CAN-PCIeMiniHS/402-4-FD, continue as described in chapter 4.2 ‘Installing the Hardware’. To uninstall, continue as described in chapter 4.3 ‘Uninstalling the Hardware’ .

4.2 Installing the Hardware

1. Read and follow the safety instructions at the beginning of chapter 4 and execute steps 4 of the preparation procedure as described in chapter 4.1 if not already done.
2. Select a free PCIe Mini or Mini Half-Size slot. Please note that an adapter may be required when using a PCIE Mini slot. Insert the board into the selected slot and gently push the board into the slot.
3. If applicable, mount the CAN-Mini/402-DSUB9-ISOL adapter in your system. Use the enclosed bolts to fix the DSUB9 adapters, for example in a front panel.

NOTICE
To avoid damage to the CAN-Mini/402-DSUB9-ISOL adapter, please note that the thread of the bolts reaching into the body of the DSUB should not be longer than 6 mm!

4. Close the system's case again.
5. Connect the CAN bus.
   Please note:
   - The CAN bus must be terminated at both ends! esd offers special T-connectors and termination connectors for external termination. Additionally, the CAN_GND signal must be connected to earth at exactly one point in the CAN network.
   - If you use the CAN-PCIeMiniHS/402-4-FD without the CAN-Mini/402-DSUB9-ISOL adapters, the CAN signals are not galvanically isolated and are TTL-level only!
   - If you use the CAN-PCIeMiniHS/402-4-FD with the CAN-Mini/402-DSUB9-ISOL adapters the CAN interfaces might be already terminated, depending on the CAN termination jumper settings on the adapter boards.
     For further details, please read chapter 6 “Correct Wiring Electrically Isolated CAN Networks” from page 22.
6. Connect the system to mains again (mains connector or safety fuse).
7. Before you switch on the supply voltage, check that all plug connectors are correctly seated.

Switch on the system and the peripheral devices.

8. End of hardware installation.
9. Continue with the software installation as described in the manual ‘NTCAN-API, Installation Guide’ (see chapter “Manuals”, page 34).

4.3 Uninstalling the Hardware

1. Read and follow the safety instructions at the beginning of chapter 4 and execute steps 4 of the preparation procedure as described in chapter 4.1 if not already done.
2. Make sure that all connected interfaces and power supply are switched off.
3. Disconnect the CAN-PCIeMiniHS/402-4-FD and the adapter from the connected interfaces.
4. Loosen the fastening of the CAN-PCIeMiniHS/402-4-FD and of the adapter.
5. Carefully pull the CAN-PCIeMiniHS/402-4-FD and the adapter out of the slot.
6. If necessary, close the housing cover again.

5 Technical Data

5.1 General Technical Data

Power supply voltage	Nominal voltage: 3.3 V DC (Nominal current: $I_{3.3VMPMAX}$ = 300 mA, $I_{3.3VTYPICAL}$ = 220 mA)
Temperature range	CAN-PCIeMiniHS/402-4-FD (C.2054.68): Ambient temperature (Standard range): 0°C ... 75°C CAN-PCIeMiniHS/402-4-FD-T (C.2054.69): Ambient temperature (Extended range): -40°C ... 85°C
Humidity	Operation: max. 90%, non-condensing
Dimensions	26,8 mm x 30 mm x 5 mm
Weight	Board: approximately 10 g; Adapter: each approximately 10 g

Table 3: General Data of the module

5.2 Connectors

Name	Function, Interfaces	Type
CAN	CAN interfaces CAN0 - CAN3	1x Wire-to-board connector JST SM16B-SURS-TF, shrouded header (16-pos.), side entry type, (4x CAN FD); Optional adapters with DSUB9 connectors (pin contacts) can be connected (1 adapter per CAN channel) via the 1-4 adapter cable
PCIeMiniHS	Mini PCI Express interface	Mini PCIe card edge connector according to (1)

5.3 PCI Express Mini Half-Size Interface

PCIe port	PCI Express Spec. R1.0a, Link width 1x
Form factor	According to PCI Express Mini Card Electromechanical Specification, Revision 1.2, half size

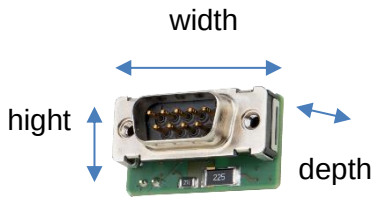
Table 4: PCIe Mini HS interface

5.4 CAN FD Interfaces

Number of CAN interfaces	4 CAN interfaces with TTL level; The TTL-level signals can be converted to CAN signal level via the optional bidirectional adapter CAN-Mini/402-DSUB9-ISOL
CAN controller	esdACC integrated in FPGA, acc. to ISO 11898-1 (CAN 2.0 A/B)
CAN protocol	According to ISO 11898-1
Physical CAN Layer	CAN FD transceiver on optional adapter conforms with ISO 11898-2, CAN FD bit rates: up to 8 Mbit/s CAN CC bit rates: 10 kbit/s up to 1 Mbit/s
Galvanic isolation	None Galvanic isolation via optional adapters
Bus termination	None, Terminating resistor can be switched via the optional adapter, if required
Cable	1-to-4 cable, included in the scope of delivery 1x IDE receptacle 16 positions (JST, 16SUR-32S) to 4x IDE receptacles 4 positions (JST, 04SUR-32S) Length: 150 mm
Connector	1x Wire-to-board connector, 16 positions Via adapter to DSUB9 connector

Table 5: Data of the CAN interface

5.4.1 CAN-Mini/402-DSUB9-ISOL Adapter

Description	Adapter for 1 CAN interface of CAN-PCIeMiniHS/402-4-FD	
Dimensions Adapter board		width: 31.5 mm, hight: 18 mm, depth: 22,5 mm (10 mm behind front panel) (adapter only, without cable)

Weight	ca. 10 g
Connector	Adapter board with 1x DSUB9 (pin contacts) 1x Wire-to-Board connector 4 positions, pin contacts (JST, SM04B-SURS-TF)
Bolts	2x bolts are needed per adapter board (use e.g. UNC 4-40 x 5 mm hex nuts with UNC 4-40 x 6 mm thread)

Table 6: Technical data of the DSUB9 adapter

NOTICE
To avoid damage to the CAN-Mini/402-DSUB9-ISOL adapter, please note that the thread of the bolts reaching into the body of the DSUB should not be longer than 6 mm!

5.5 Software Support

CAN layer 2 (CAN-API) device drivers for Windows® and Linux® are included in delivery of the CAN-PCIeMiniHS/402-4-FD boards. They can also be downloaded from the CAN-PCIeMiniHS/402-4-FD product page on our website: https://esd.eu/

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 CAN CC applications.
See Order Information from page 33 for availability of the drivers.

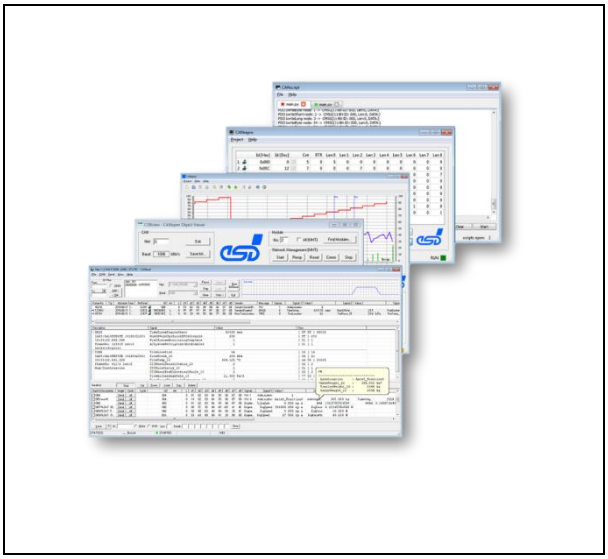
Drivers for other operating systems are available on request. For detailed information about the driver availability for your operating system, please contact our sales team: sales@esd.eu

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

"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-PCIeMiniHS/402-4-FD or the CAN-SDK page: https://esd.eu/produkte/can-sdk

CAN Tools for CAN Classic
esd offers additional free-of-charge tools which support efficient setup and analysis of CAN CC 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 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.

6.1 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!**

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

6.2.1 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 6.3 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 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) 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: • 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 Ω ±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 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.

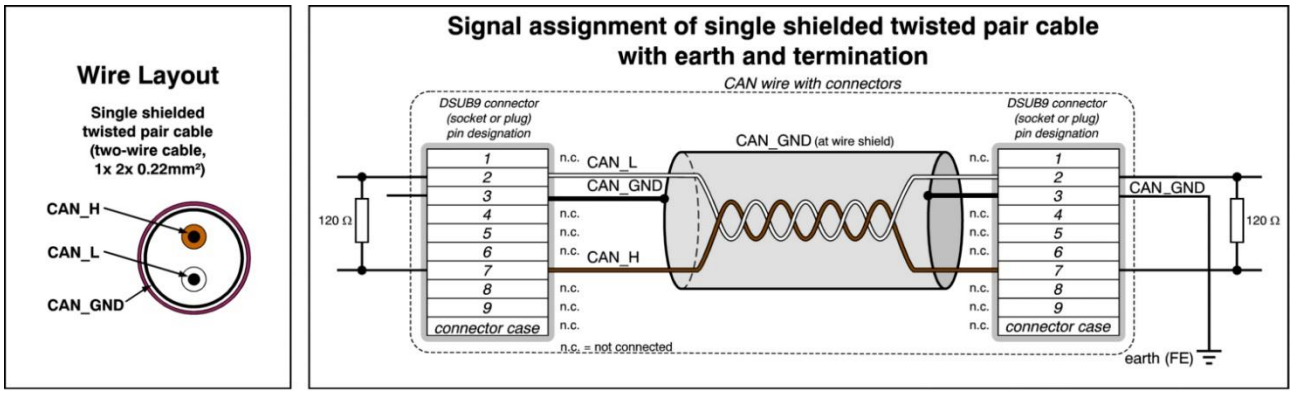


Figure 7: CAN wiring for light industrial environment

6.2.2 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.

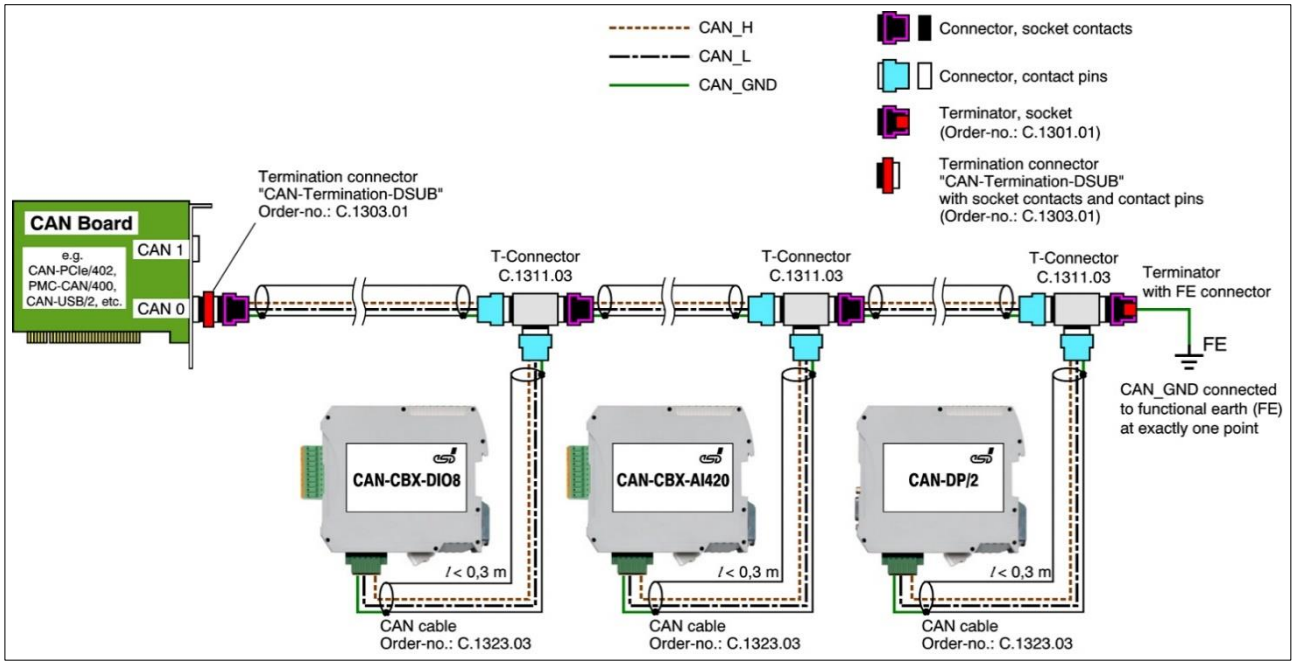


Figure 8: Example for proper wiring with single shielded single twisted pair wires

6.2.3 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.

6.2.4 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.

6.3 Heavy Industrial Environment (Double Twisted Pair Cable)

6.3.1 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 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) 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: • 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 Ω ±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 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.

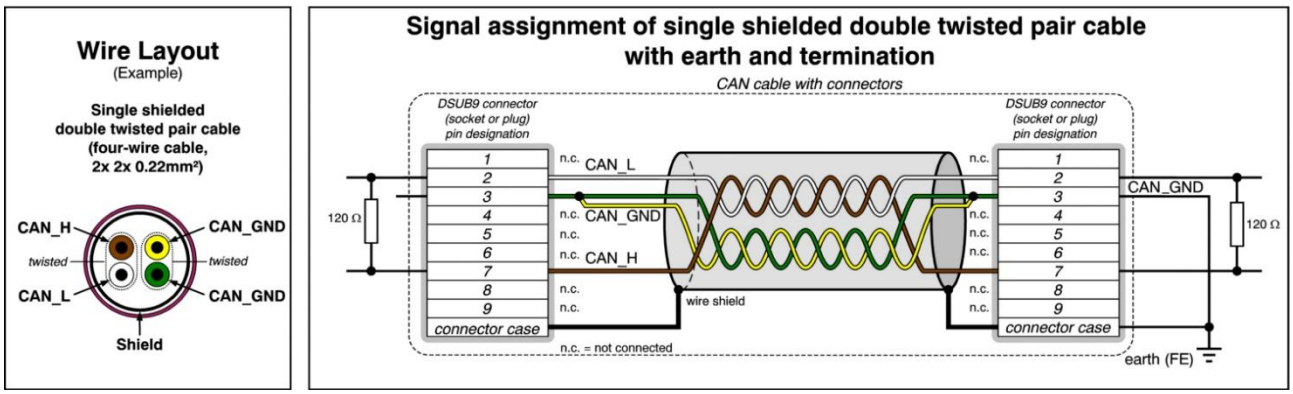


Figure 9: CAN wiring for heavy industrial environment

6.3.2 Device Cabling

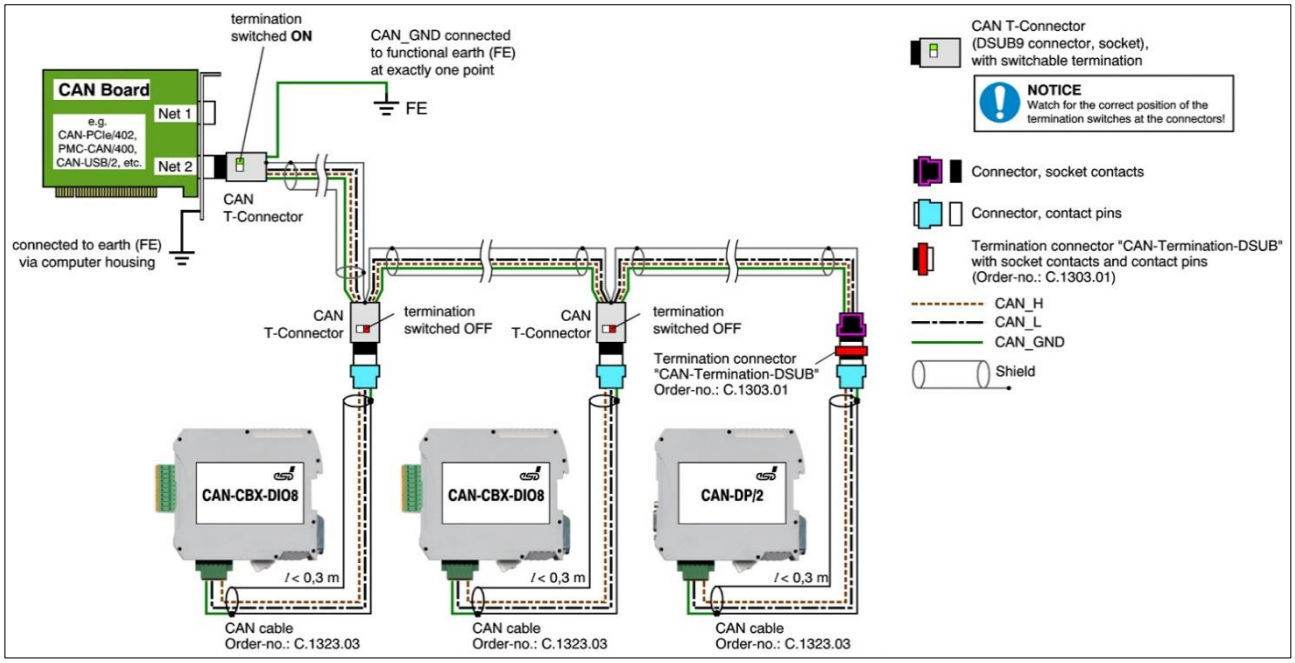


Figure 10: Example of proper wiring with single shielded double twisted pair cables

6.3.3 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.

6.3.4 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).

6.4 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).

6.5 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 [mm²]
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 7: 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 ”.

6.6 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.

6.6.1 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.)

6.6.2 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**.

7 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.

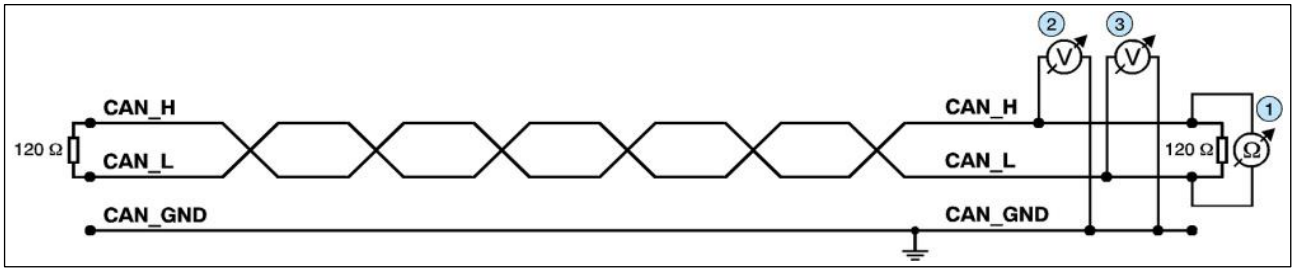


Figure 11: Simplified diagram of a CAN network

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).

7.1 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!

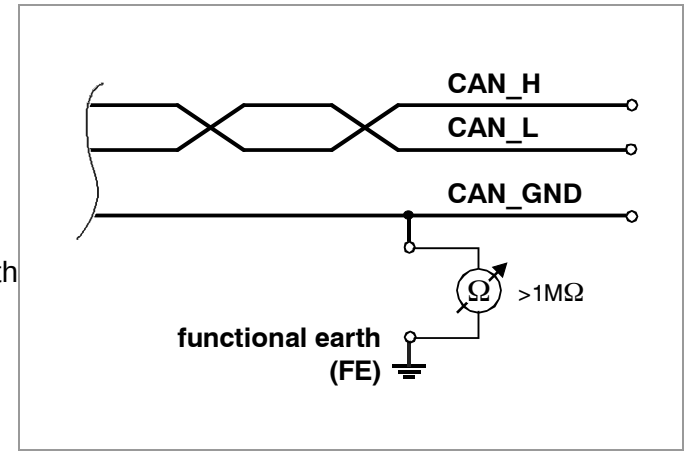


Figure 12: Simplified schematic diagram of ground test measurement

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.

7.2 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!

7.3 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).

7.4 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.)

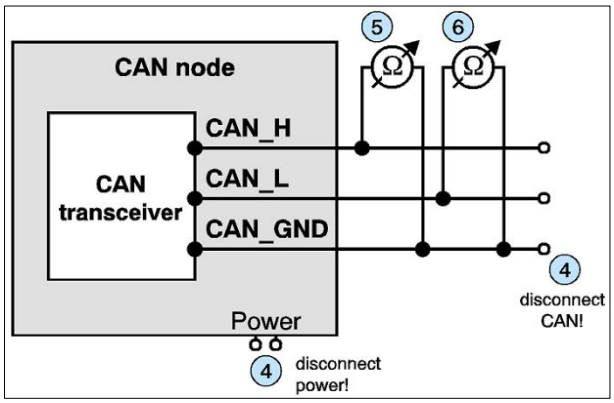


Figure 13: Measuring the internal resistance of CAN transceivers

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 %).

7.5 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.**

8 Declaration of Conformity

EU-KONFORMITÄTSERKLÄRUNG
EU DECLARATION OF CONFORMITY

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

esd erklärt, dass das Produkt *esd declares, that the product*	Typ, Modell, *Artikel-Nr.*	Mit Adapter, *with adapter*	Type, Model, *Article No.*
CAN-PCIeMiniHS/402-4-FD	C.2054.68	CAN-Mini/402-DSUB9-ISOL	C.2054.10
CAN-PCIeMiniHS/402-4-FD-T	C.2054.69	CAN-Mini/402-DSUB9-ISOL	C.2054.10

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.
EMVP No.: 0241-202310

Das Produkt entspricht damit der EU-Richtlinie „EMV"
Therefore the product conforms to the EU Directive 'EMC'
2014/30/EU

Das Produkt entspricht den EU-Richtlinien „RoHS"
The product conforms 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, 2024-01-26

Rechtsgültige Unterschrift / *authorized signature*

I:\Texte\Doku\MANUALS\CAN\PCI-Express\CAN-PCIeMiniHS402\Konformitaetserklaerung\CAN-PCIeMiniHS402-4-FD_EU-Declaration_of_Conformity_2023-11-21.docx

9 Order Information

9.1 Hardware

Type	Properties	Order No.
CAN-PCIeMiniHS/402-4-FD	Active CAN FD interface card with 4 interfaces for PCI Express Mini in half-size format. Galvanic isolation via optional plug adapter CAN FD interfaces based on esd Advanced CAN Core (esdACC) according to ISO 11898-1. Standard temperature range (0 °C … +75 °C) Display of CAN status via four LEDs. 1-to-4 adapter cable included Drivers, tools and documentation for Windows & Linux on CD and connection cable included. Adapters must be ordered separately	C.2054.68
CAN-PCIeMiniHS/402-4-FD-T	As C.2054.68 but for use in extended temperature range (-40 °C … +85 °C)	C.2054.69
Accessories:		
CAN-Mini/402-DSUB9-ISOL	1x DSUB9 adapter for CAN-PCIeMiniHS/402-4-FD boards. Converts CAN TTL-level signals to CAN signal level Galvanic isolation of CAN; The CAN terminating resistor can be switched via a jumper. Order one adapter per interface.	C.2054.10

Table 8: Order information hardware

9.2 Software

Type		Order No.
CAN layer 2 software drivers for Windows and Linux on CD-ROM to CAN-PCIeMiniHS/402-4-FD (C.2054.64) are included in delivery. Additional CAN layer 2 object licences including CD-ROM:		
CAN-DRV-LCD CDROM+Lizenz QNX	Object Licence and CD-ROM for QNX 6.x and 7.x	C.1101.32
CAN-DRV-LCD CDROM+Lizenz RTX	Object Licence and CD-ROM for RTX64	C.1101.35
CAN-DRV-LCD CDROM+Lizenz VxWorks	Object Licence and CD-ROM for VxWorks	C.1101.55
CAN-DRV-LCD CDROM+Lizenz INtime	Object Licence and CD-ROM for INtime 6 and 7	C.1101.65
Higher-Layer Protocols including CD-ROM for l CAN Classic Applications:		
CANopen-LCD Windows/Linux	These drivers are available for **CAN CC Applications** only!	C.1101.06
CANopen-LCD QNX		C.1101.17
CANopen-LCD RTX		C.1101.16
J1939 Stack for Windows (Object)		C.1130.10
J1939 Stack for Linux (Object)		C.1130.11
ARINC 825-LCD Windows/Linux/LabVIEW		C.1140.06
ARINC 825-LCD QNX		C.1140.17
ARINC 825-LCD RTX		C.1140.16
For detailed information about the driver availability for your special operating system, please contact our sales team.		

Table 9: Order information software

9.3 Manuals

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-PCIeMiniHS/402-4-FD-ME	Hardware manual in English	C.2054.21
CAN-API-ME	NTCAN-API: Application Developers Manual NTCAN-API: Driver Installation Guide	C.2001.21
CANopen-ME	CANopen Manuals in English	C.2002.21

Table 10: 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.