CAN-M.2/402-2-FD

M.2 Card with 2 CAN FD Interfaces

Hardware Manual

to Product C.2074.64

esd electronics gmbh
Vahrenwalder Str. 207 • 30165 Hannover • Germany
http://www.esd.eu
Phone: +49 (0) 511 3 72 98-0 • Fax: +49 (0) 511 3 72 98-68

Notes

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esd electronics gmbh
Vahrenwalder Str. 207
30165 Hannover
Germany

Tel.: +49-511-37298-0
Fax: +49-511-37298-68
E-Mail: info@esd.eu
Internet: www.esd.eu

This manual contains important information and instructions on safe and efficient handling of the CAN-M.2/402-2-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.

Document Information

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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
1.0	-	First English manual	2020-08-27
-	-	-	

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-M.2/402-2-FD follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-M.2/402-2-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-M.2/402-2-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.
- Current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1).
- The CAN-M.2/402-2-FD may only be driven by power supply current circuits, that are contact protected. A power supply, that provides a safety extra-low voltage (SELV) according to EN 60950-1, complies with these conditions.

- The device has to be securely installed in the control cabinet before commissioning.
- Protect the CAN-M.2/402-2-FD from dust, moisture and steam.
- Protect the CAN-M.2/402-2-FD from shocks and vibrations.
- The CAN-M.2/402-2-FD may become warm during normal use. Always allow adequate ventilation around the CAN-M.2/402-2-FD and use care when handling.
- Do not operate the CAN-M.2/402-2-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-M.2/402-2-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.

→ To avoid this, please discharge the static electricity from your body before you touch the CAN-M.2/402-2-FD.
→ Furthermore, you should prevent your clothes from touching the CAN-M.2/402-2-FD, 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-M.2/402-2-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-M.2/402-2-FD may cause radio interferences in which case the user may be required to take adequate measures.

Intended Use

The intended use of the CAN-M.2/402-2-FD is the operation as CAN FD interface for Embedded 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-M.2/402-2-FD is intended for installation in an Embedded System or PC, with indoor use only.
- The operation of the CAN-M.2/402-2-FD in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-M.2/402-2-FD for medical purposes is prohibited.

Service Note

The CAN-M.2/402-2-FD does not contain any parts that require maintenance by the user. The CAN-M.2/402-2-FD does not require any manual configuration of the hardware. Unauthorized intervention in the device voids warranty claims

Disposal

Devices which have become defective in the long run have to be disposed in an appropriate way or have to be returned to the manufacturer for proper disposal. Please, make a contribution 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

List of Tables

List of Figures

1 Overview

1.1 Description of CAN-M.2/402-2-FD

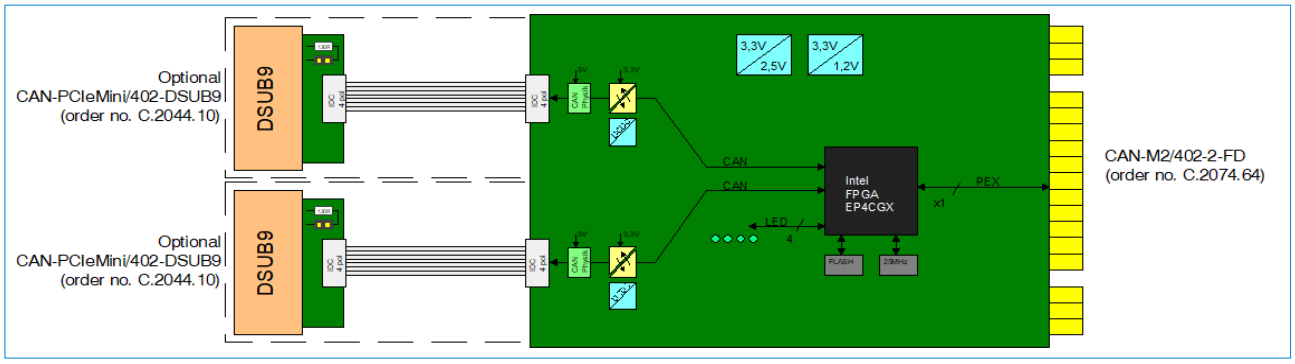


Figure 1: Block circuit diagram of CAN-M.2/402-2-FD

The CAN-M.2/402-2-FD is an M.2 Card, that features two electrically isolated CAN FD interfaces. The optional adapter CAN-PCIeMini/402-DSUB comes with a DSUB9 connector, selectable on-board CAN termination and an adapter cable.
CAN-M.2/402-2-FD is fully backwards compatible with CAN and can also be used in Classical CAN applications.

The independent CAN nets are driven by the ISO 16845:2004 certified esdACC (esd Advanced CAN Core) implemented in the Intel FPGA. The FPGA supports bus mastering (first-party DMA) to transfer data to the host memory. This results in a reduction of overall latency on servicing I/O transactions, in particular at higher data rates and a reduced host CPU load.
Due to the usage of MSI (Message Signaled Interrupts) the CAN-M.2/402-2-FD can be operated for example in Hypervisor environments.
The CAN-M.2/402-2-FD provides high resolution 64-bit hardware timestamps for CAN messages.

The CAN layer 2 (NTCAN-API) drivers for Windows® and Linux® are included in the scope of delivery. See “Order Information” on page 31 for availability of other drivers.

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

1.2 Glossary

Abbreviations

Abbreviation	Term
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
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

2 PCB View with Connectors and LEDs

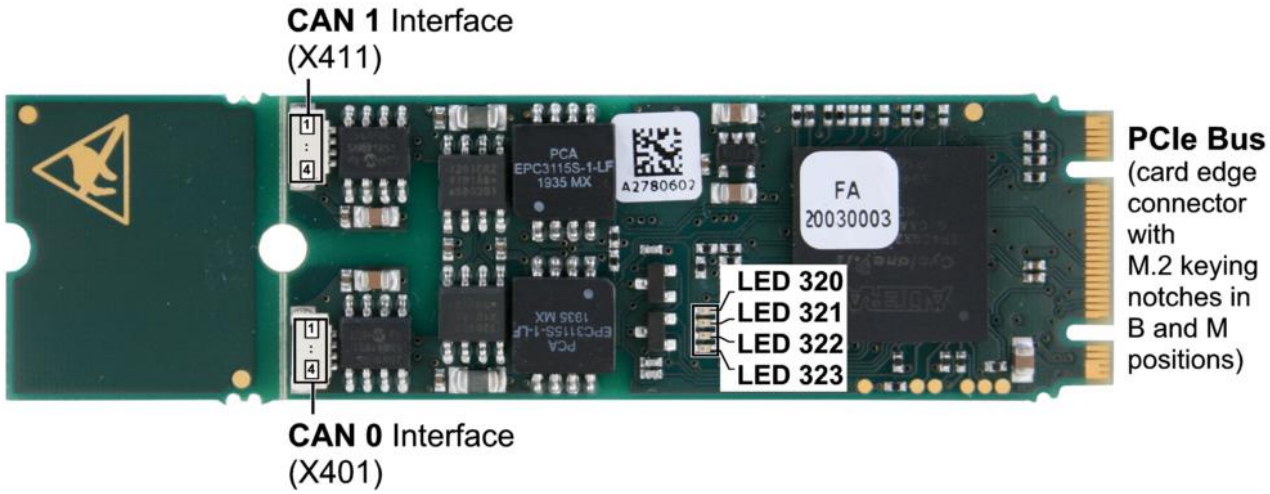


Figure 2: PCB view of CAN-M.2/402-2-FD

NOTICE
Read chapter “Hardware Installation” on page 15, before you start with the installation of the hardware!

2.1 LED Display

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

LED name in schematic diagram	Name	Indicator State	Description
LED320	Power	off	power supply voltage off / FPGA not booted
		on	power supply voltage on / FPGA ready
LED321	reserved	-	-
LED322	Traffic CAN1	off	no CAN bus connection and/or no CAN traffic on CAN1
		on	connected to CAN bus 1 and CAN traffic on CAN1
LED323	Traffic CAN0	off	no CAN bus connection and/or no CAN traffic on CAN0
		on	connected to CAN bus 0 and CAN traffic on CAN0

Table 1: LEDs

3 Connector Assignment

3.1 CAN Connector

The CAN-M.2/402-2-FDcomes with two CAN connectors equipped on the PCB top layer.

Device connector: 4-pin Wire-to-Board connector,
shrouded header (JST, SM04B-SURS-TF)

Pin Position:

1 2 3 4

Pin Assignment:

Pin	*Signal*
1	reserved
2	CANx_GND
3	CANx_H
4	CANx_L

Signal Description:

CANx_L, CANx_H ... CAN signals of the CAN net x (x... 0, 1)
CANx_GND... Reference potential of the local CAN physical layer of CAN net x (x... 0, 1)
reserved ... Reserved for future applications, do not connect!

4 DSUB Adapter and Adapter Cable

Figure 3: Adapter CAN-PCIeMini-402-DSUB9

With the adapter CAN-PCIeMini-402-DSUB9 you can connect the CAN interfaces of the CAN-M.2/402-2-FD via DSUB9 connectors.
The adapter CAN-PCIeMini-CAN/402-DSUB9 is not contained in the scope of delivery of the CAN-M.2/402-2-FD. See “Order Information” on page 31.
The adapter cable CAN-PCIeMini/402-Cable and two UNC 4-40 DSUB bolts are included in the scope of delivery of CAN-PCIeMini/402-DSUB. The bolts are intended to be used with a front panel!

NOTICE
Read chapter “Hardware Installation” on page 15, before you start with the installation of the CAN-M.2/402-2-FD!

4.1 Adapter View

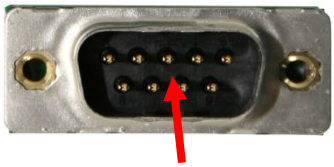


Figure 4: Top layer with DSUB9 connector

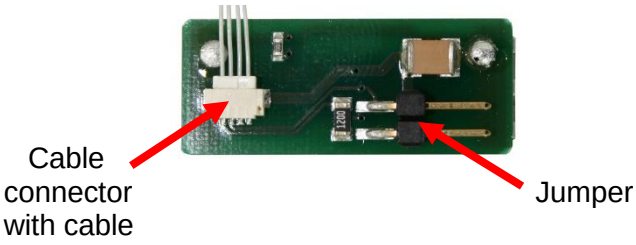


Figure 5: Bottom layer with jumper and cable connector

4.2 CAN Termination Jumper

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

JumperJP400	
Jumper set	Internal termination (120Ω) of the connected CAN net (CAN0 or CAN1)
Jumper not set	The connected CAN interface has to be terminated externally.

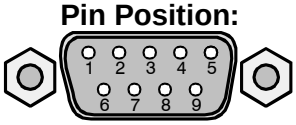
Table 2: Jumper

4.3 Connector Assignment of Adapter

4.3.1 CAN via DSUB9

Device connector: 9-pin DSUB connector, male

Pin Position:



Pin Assignment:

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

Signal Description:

CANx_L, CANx_H	CAN signal lines (x = 0 or 1, number of the connected CAN interface)
CANx_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!

4.3.2 CAN Cable Connector

The 4-pin Wire-to-Board connector, (JST, SM04B-SURS-TF) is equipped on the bottom layer of the adapter. The connector assignment of the CAN cable connector on the CAN-PCIeMini/402-DSUB9 is the same as for CAN-M.2/402-2-FD, see chapter “Connector Assignment”, page 12.

4.3.3 Adapter Cable

One adapter cable is included in delivery of the CAN-PCIeMini/402-DSUB9 adapter.
The cable can also be ordered separately as CAN-PCIeMini/402-Cable, see “Order Information”, page 31.
The twisted single-wire cable comes with two IDC receptacles (JST, 04SUR-32S).

Pin Position:

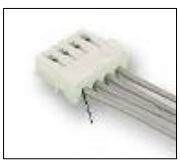


Figure 6: Adapter cable (detail)

Pin Assignment:

Pin	Signal
1	reserved
2	CANx_GND
3	CANx_H
4	CANx_L

5 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-M.2/402-2-FD 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 *before* you touch the CAN-M.2/402-2-FD.
→ Furthermore, you should prevent your clothes from touching the CAN-M.2/402-2-FD, 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. If applicable, connect the CAN-PCIeMini/402-DSUB9 adapters to the CAN-M.2/402-2-FD via the adapter cables.

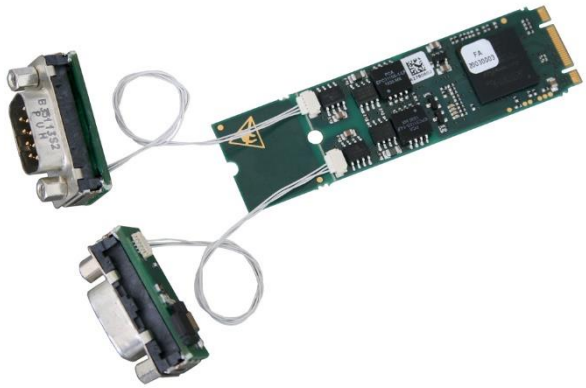


Figure 7: CAN-M.2/402-2-FD wit 2 adapters

Set or remove the CAN termination jumper on the adapter according to your needs.

4. Disconnect the system from the mains.
Make sure that no risk arises from the system into which the CAN-M.2/402-2-FD shall be inserted.

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.

5. Open the case if necessary.
6. Insert the CAN-M.2/402-2-FD board into the selected M.2 slot.
   Carefully push the board down into the slot.
7. If applicable mount the CAN-PCIeMini/402-DSUB9 adapters in your system. Use the enclosed bolts to fix the adapter.

NOTICE
The adapters are intended to be used with a front panel with 0,8 mm to 1,2 mm thickness! Don't mount the bolts into the DSUB without a front panel or additional spacers like washers, because otherwise the bolt threat might damage the DSUB.

8. Close the system's case again.

NOTICE
Please note that the CAN bus has to be terminated at both ends! esd offers special T-connectors and termination connectors for external termination. Additionally, the CAN_GND signal has to be connected to earth at exactly one point in the CAN network.
For details please read chapter “Correct Wiring of Electrically Isolated CAN Networks” from page 20

11. Connect the system to mains again (mains connector or safety fuse).
12. Switch on the system and the peripheral devices.
13. End of hardware installation.
14. Continue with the software installation as described in the manual ‘NTCAN-API, Installation Guide’ (see chapter “Manuals”, page 32).

6 Technical Data

6.1 General Technical Data

Power supply voltage	Nominal voltage: 3.3 V (Nominal current: $I_{3.3VMPMAX}$ = 320 mA, $I_{3.3VTYPICAL}$ = 270 mA)
Power consumption	Maximum: 3 W (with 2 CAN interfaces at 100% bus load)
Connectors	M.2: B & M-Key connector CAN: 2x Wire-to-board IDC connector, 4-pin; via adapter to: 1x 9-pin DSUB male per CAN channel
Temperature range	0°C ... 75°C ambient temperature
Humidity	Operation: max. 90%, non-condensing
Dimensions	22 mm x 80 mm x 4.4 mm (PCB is prepared for shortening to 22 mm x 60 mm x 4.4 mm by simply breaking off)
Weight	Board: approximately 8 g; Adapter: approximately 8 g each

Table 3: General Data of the module

6.2 Memory

FPGA	Intel EP4CGX22BF14C8N
Boot FLASH	Adesto AT25SF161-MHD-T

Table 4: Microprocessor and Memory

6.3 PCI Express Mini Interface

PCIe port	PCI Express Spec. R1.0a, Link width 1x
Form factor	2280, can be reduced to 2260 The component heights on the PCB top side exceed the requirements of the PCI Express M.2 specification. The maximum component height is 2.24 mm instead of 1.5 mm.

Table 5: PCIe Mini interface

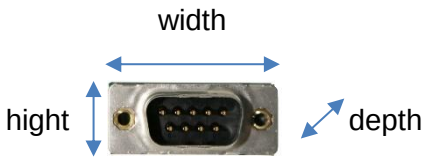
INFORMATION
The optional CAN-M.2-80/402-2-FD comes with a maximum component hight of 1.5 mm, as required in the M.2 specification. Form factor is 2280 only!
Contact our Sales Team (sales@esd.eu) for further information.

6.4 CAN Interfaces

Number of CAN interfaces	2
CAN controller	esdACC in EP4CGX Intel FPGA, acc. to ISO 11898-1 (CAN 2.0 A/B)
CAN protocol	According to ISO 11898-1
Physical CAN Layer	CAN FD transceiver conforms with ISO 11898-2:2016, and supports bit rates up to 8 Mbit/s
Electrical isolation	Separation by means of optocouplers and DC/DC-converters voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to Host/System Ground; CAN to CAN): 1kV DC @ 1s (I < 1 mA)
Bus termination	Terminating resistor can be switched on the optional CAN-PCIeMini/402-DSUB9 adapter, if required
Connector	Via adapter with DSUB9 connector

Table 6: Data of the CAN interface

6.5 CAN-PCIeMini/402-DSUB9 Adapter

Dimensions		width: 31.5 mm, hight: 13 mm, depth: 16.5 mm (10 mm behind front panel) (adapter only, without cables)

Weight	ca. 8 g
Cable length	150 mm
Connector	Adapter: 1x DSUB9 (male), 1x 4-pin Wire-to-Board connector, male (JST, SM04B-SURS-TF) Cable: 2x IDE receptacles (JST, 04SUR-32S to JST, 04SUR-32S)
Bolts	2x DSUB bolts (UNC 4-40 x 5 mm hex nuts with UNC 4-40 x 6 mm thread)

Table 7: Technical data of the DSUB9 adapter

NOTICE
The adapter is intended to be used with a front panel with 0,8 mm to 1,2 mm thickness! Don't mount the bolts into the DSUB without a front panel or additional spacers like washers, because otherwise the bolt threat might damage the DSUB.

6.6 Software Support

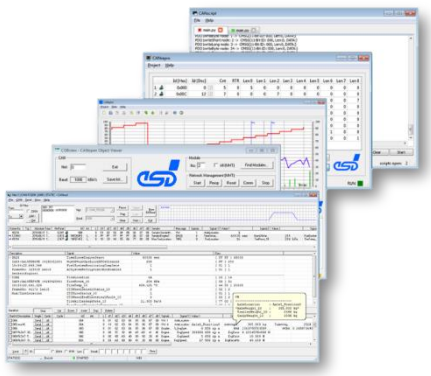
Device drivers for Windows® and Linux® are included in delivery. Drivers for real-time operating systems, are available for QNX® and RTX64®.
Higher layer protocols (CANopen®, J1939, ARINC825) are supported for Classical CAN applications on CAN-PCIe/402-FD only. See Order Information on page 31 for availability of the drivers.
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 and
"NTCAN-API Part 2: Installation, Configuration and Firmware Update" Installation Guide

(esd-order No.: C.2001.21)

CAN Tools for Classical CAN
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.

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), e.g. regarding electromagnetic compatibility, security distances, cable cross-section or material, have to be observed.

7.1 Standards concerning CAN Wiring

The flexibility in CAN network design is one of the key strengths of the various extensions and additional standards like e.g. CANopen, ARINC825, DeviceNet and NMEA2000 that have been built on the original ISO 11898-2 CAN standard. In using this flexibility comes the responsibility of good network design and balancing these tradeoffs.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO 11898. They have made system level tradeoffs for data rate, cable length, and parasitic loading of the bus.

However, for CAN network design margin must be given for signal loss across the complete system and cabling, parasitic loadings, network imbalances, ground offsets against earth potential and signal integrity. **Therefore, the practical maximum number of nodes, bus length and stub length are typically much lower.**

esd has concentrated her recommendations concerning CAN wiring on the specifications of the ISO 11898-2. Thus, this wiring hints forgoes to describe the special features of the derived standards CANopen, ARINC825, DeviceNet and NMEA2000.

The consistent compliance to ISO 11898-2 offers significant advantages:

- Durable operation due to well proven design specifications
- Minimizing potential failures due to sufficient margin to physical limits
- Trouble-free maintenance during future network modifications or during fault diagnostics due to lack of exceptions

Of course, reliable networks can be designed according 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 cable type with a wave impedance of about 120 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) has to be used. The voltage drop over the wire has to be considered.
2	For light industrial environment use at least a two-wire CAN cable. Connect • the two twisted wires to the data signals (CAN_H, CAN_L) and • the cable shield to the reference potential (CAN_GND).
3	The reference potential CAN_GND has to be connected to the functional earth (FE) at exactly **one** point.
4	A CAN net must not branch (exception: short cable stubs) and has to 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.

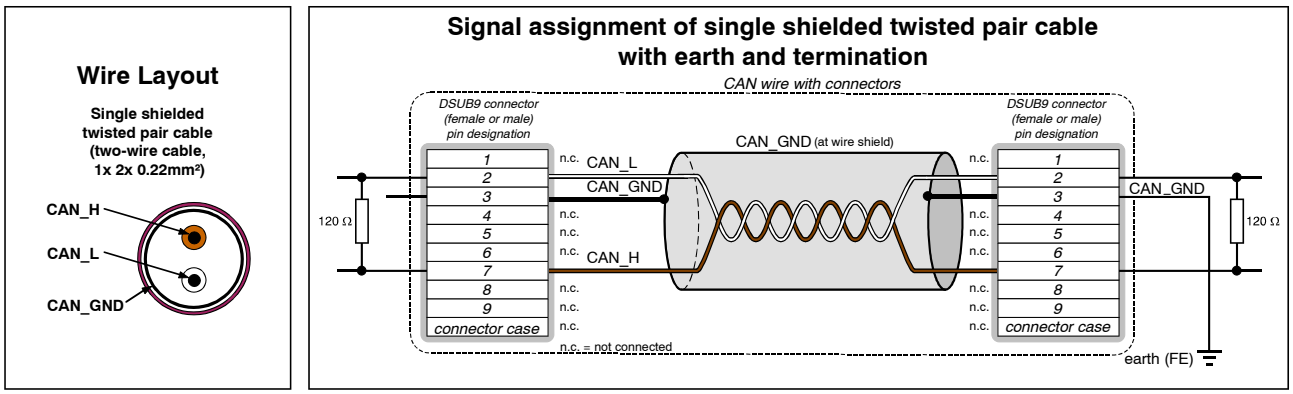


Figure 8: CAN wiring for light industrial environment

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.

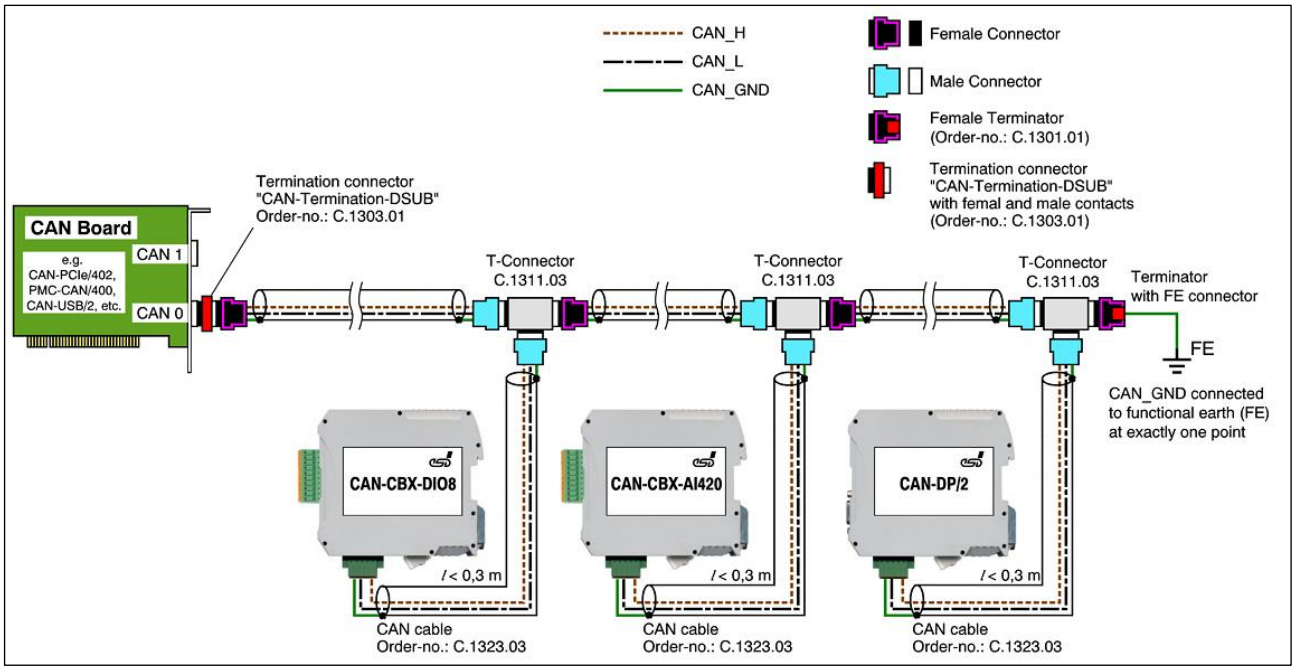


Figure 9: Example for proper wiring with single shielded single twisted pair wires

7.2.3 Branching

- In principle the CAN bus has to be realized in a line. The participants 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 is unavoidable, take care that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by the usage of repeaters.

7.2.4 Termination

- A termination resistor has to be connected at both ends of the CAN bus.
  If an integrated CAN termination resistor which is equipped at the CAN interface at the end of the bus is connected, this one has to be used for termination instead of an external CAN termination plug.
- 9-pin DSUB-termination connectors with integrated termination resistor and male and female contacts are available from esd (order no. C.1303.01).
- DSUB termination connectors with male contacts (order no. C.1302.01) or female contacts (order no. C.1301.01) and additional functional earth contact are available, if CAN termination and grounding of CAN_GND is required.

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 cable type with a wave impedance of about 120 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) has to be used. The voltage drop over the wire has to be considered.
2	For heavy industrial environment use a four-wire CAN cable. Connect • two twisted wires to the data signals (CAN_H, CAN_L) and • the other two twisted wires to the reference potential (CAN_GND) and • the cable shield to functional earth (FE) at least at one point.
3	The reference potential CAN_GND has to be connected to the functional earth (FE) at exactly **one** point.
4	A CAN bus line must not branch (exception: short cable stubs) and has to 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 can not be avoided, double shielded cables are recommended.

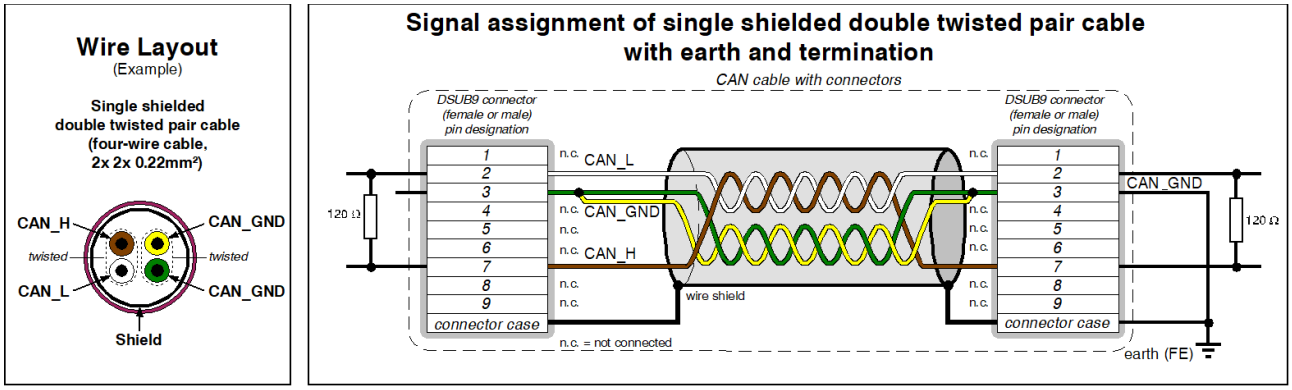


Figure 10: CAN wiring for heavy industrial environment

7.3.2 Device Cabling

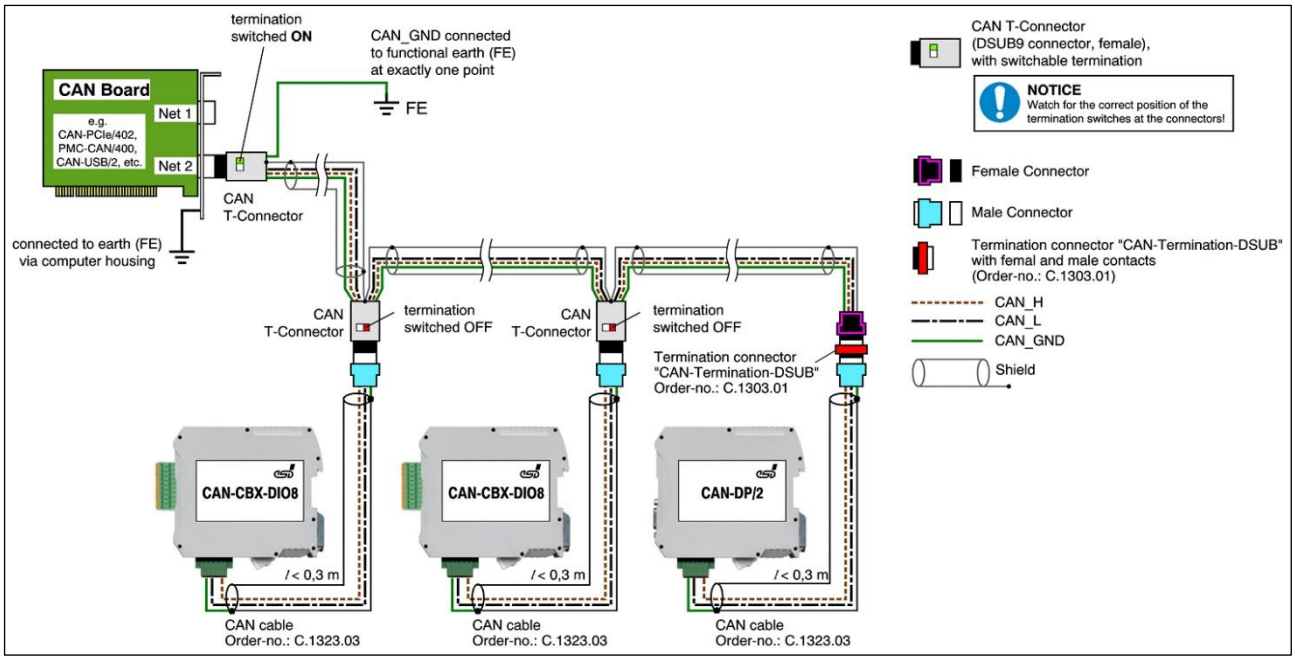


Figure 11: Example of proper wiring with single shielded double twisted pair cables

7.3.3 Branching

- In principle the CAN bus has to be realized in a line. The participants are connected to the main CAN bus line via short cable stubs. This is normally realised by so called T-connectors. When using esd's CAN-T-Connector (order no.: C.1311.03) it should be noted that the shield potential of the conductive DSUB housing is not looped through this T-Connector type. Thus, the shielding is interrupted. Therefore, you have to take adequate measures to connect the shield potentials, as described in the manual of the CAN-T-Connector. For further information on this read 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, e.g. the DSUB9 connector from ERNI (ERBIC CAN BUS MAX, order no.:154039).
- If a mixed application of single twisted and double twisted cables is unavoidable, take care that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by the usage of repeaters.

7.3.4 Termination

- A termination resistor has to be connected at both ends of the CAN bus.
  If an integrated CAN termination resistor which is equipped at the CAN interface at the end of the bus is connected, this one has to be used for termination instead of an external CAN termination plug.
- 9-pin DSUB-termination connectors with integrated termination resistor and male and female contacts are available from esd (order no. C.1303.01).
- 9-pin DSUB-connectors with integrated switchable termination resistor can be ordered e.g. from ERNI (ERBIC CAN BUS MAX, female 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 made e.g. at a termination connector (e.g. order no. C.1302.01 or C.1301.01).

7.5 Bus Length

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).

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
800 666.$\overline{6}$ 500 333.$\overline{3}$ 250	59 80 130 180 270	50 - 100 - 250	0.34 to 0.6
166 125	420 570	- 500	0.5 to 0.6
100 83.$\overline{3}$ 66.$\overline{6}$ 50	710 850 1000 1400	650 - - 1000	0.75 to 0.8
33.$\overline{3}$ 20 12.5 10	2000 3600 5400 7300	- 2500 - 5000	not defined in CiA 303-1

Table 8: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

- Optical couplers are delaying the CAN signals. esd modules typically reach a wire length of 37 m at 1 Mbit/s within a proper terminated CAN network without impedance disturbances like e.g. caused by cable stubs > 0.3 m.

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 find and eliminate the most frequent hardware-error causes in the wiring of CAN networks.

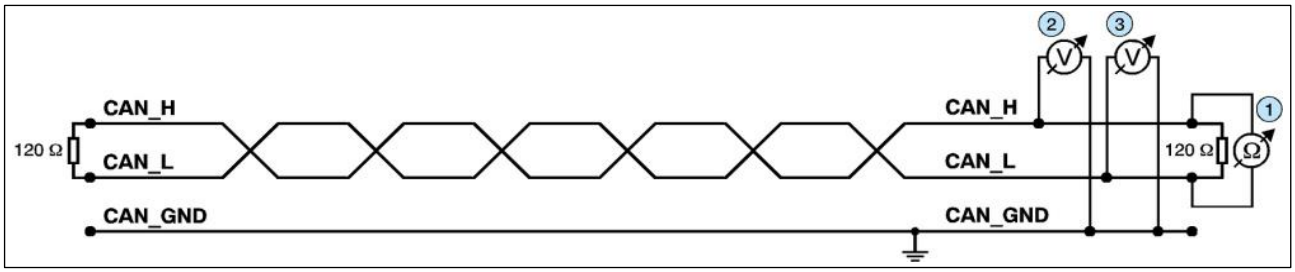


Figure 12: Simplified diagram of a CAN network

8.1 Termination

The termination is used to match impedance of a node to the impedance of the transmission line being used. When impedance is mismatched, the transmitted signal is not completely absorbed by the load and a portion is reflected back into the transmission line. If the source, transmission line and load impedance are equal these reflections are avoided. This test measures the series resistance of the CAN data pair conductors and the attached terminating resistors.

To test it, please

1. Turn off all power supplies of the attached CAN nodes.
2. Measure the DC resistance between CAN_H and CAN_L at one end of the network ① (see figure above).

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

If the value is below 50 Ω, please make sure that:
- there is no **short circuit** between CAN_H and CAN_L wiring
- there are **not more than two** terminating resistors connected
- the nodes do not have faulty transceivers.

If the value is higher than 70 Ω, please make sure that:
- there are no open circuits in CAN_H or CAN_L wiring
- your bus system has two terminating resistors (one at each end) and that they are 120 Ω each.

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 will check if the CAN_GND is grounded in several places.
To test it, please

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).
3. Reconnect CAN_GND to earth potential.

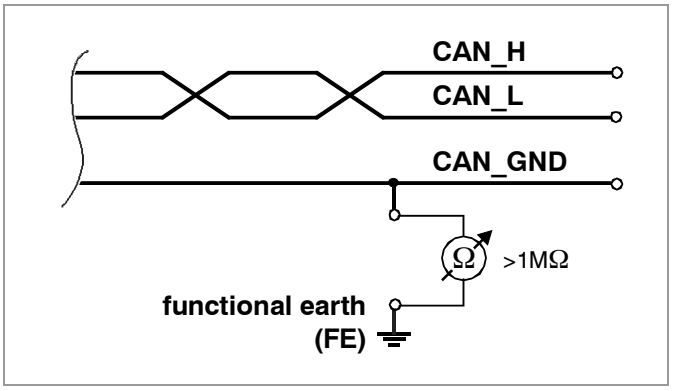


Figure 13: Simplified schematic diagram of ground test measurement

The measured resistance should be higher than 1 MΩ. If it is lower, 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 if there is a short circuit between CAN_GND and CAN_L, but generally the error rate will increase strongly. Make sure that there is no short circuit between CAN_GND and CAN_L!

8.4 CAN_H/CAN_L-Voltage

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. Faulty transceivers can cause the idle voltages to vary and disrupt network communication.

To test for faulty transceivers, please

1. Turn on all supplies.
2. Stop all network communication.
3. Measure the DC voltage between CAN_H and CAN_GND ② (see figure at previous page).
4. Measure the DC voltage between CAN_L and CAN_GND ③ (see figure at previous page).

Normally the voltage should be between 2.0 V and 3.0 V.

If it is lower than 2.0 V or higher than 3.0 V, it is possible that one or more nodes have faulty transceivers. For a voltage lower than 2.0 V please check CAN_H and CAN_L conductors for continuity.

To find the node with a faulty transceiver within a network please test the CAN transceiver resistance (see below) of the nodes.

8.5 CAN Transceiver Resistance Test

CAN transceivers have circuits that control CAN_H and CAN_L. Experience has shown that electrical damage of the circuits may increase the leakage current in these circuits.

To measure the current leakage through the CAN circuits, please use a resistance measuring device and:

1. Switch **off** the node and **disconnect** it from the network ④
   (see figure below).

2. Measure the DC resistance between CAN_H and CAN_GND ⑤
   (see figure below).

3. Measure the DC resistance between CAN_L and CAN_GND ⑥
   (see figure below).

The measured resistance has to be about 500 kΩ for each signal. If it is much lower, the CAN transceiver it is probably faulty.
Another indication for a faulty transceiver is a very high deviation between the two measured input resistances (>> 200 %).

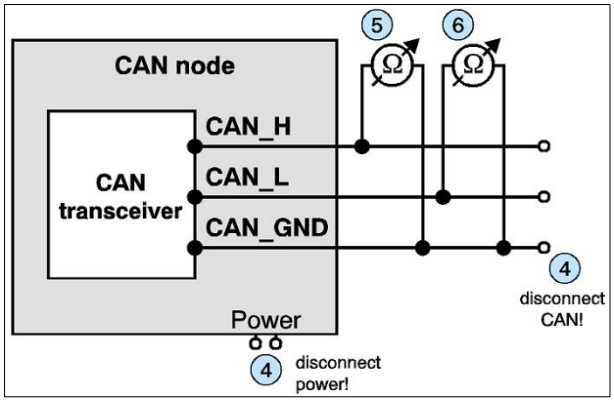


Figure 14: Measuring the internal resistance of CAN transceivers

8.6 Support by esd

If you have executed the fault diagnostic steps of this troubleshooting guide and you even can not find a solution for your problem our support department will be able to assist.
Please contact our support via email at **support@esd.eu** or by phone **+49-511-37298-130**.

9 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
CAN-M.2/402-2-FD

Typ, Modell, Artikel-Nr.
Type, Model, Article No.
C.2074.64

die Anforderungen der Normen
fulfills the requirements of the standards
EN 61000-6-2:2005,
EN 61000-6-3:2007/A1:2011

gemäß folgendem Prüfberichte erfüllt.
according to test certificate.
H-K00-0760-20

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, 2020-07-22

Rechtsgültige Unterschrift / *authorized signature*

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10 Order Information

10.1 Hardware

Type	Properties	Order No.
CAN-M.2/402-2-FD	Active CAN Interface Board for M.2 slot with PCIexpress Mini, 3.3V - type 2260 respectively 2280 - 2,24 mm maximum component height - B & M keying - 2 CAN interfaces with esd Advanced CAN IP-Core (esdACC) - CAN FD capable according to ISO 11898-1:2015 - Physical Layer according ISO 11898, electrically isolated - 3x LEDs for CAN- and board status Drivers, tools and documentation for Windows & Linux on CD-ROM	C.2074.64
CAN-M.2-80/402-2-FD	As C.2074.64 but: - type 2280 only - 1,5 mm maximum component height	C.2074.74
Accessories:		
CAN-PCIeMini/402-DSUB9	Adapter with 1x DSUB9 connector (male), 1x 4-pin Wire-to-Board connector (SM04B-SURS-TF), 2x DSUB bolts CAN-PCIeMini/402-Cable (C.2044.14) included	C.2044.10
CAN-PCIeMini/402-Cable	Adapter Cable, 4 positions, length: 150 mm, wire size: 32AWG (for SM04B-SUR-TF to SM04B-SUR-TF, JST),	C.2044.14

Table 9: Order information hardware

10.2 Software for CAN-M.2/402-2-FD

Type		Order No.
CAN layer 2 software drivers for Windows and Linux on CD-ROM to CAN-M.2/402-2-FD (C.2074.64) 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 4.x and 6.x	C.1101.32
CAN-DRV-LCD CDROM+Lizenz RTX	Object Licence and CD-ROM for RTX64	C.1101.35
Higher-Layer Protocols including CD-ROM for Classical CAN Applications:		
CANopen-LCD Windows/Linux	These drivers are available for **Classical CAN 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 10: Order information software

10.3 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-M.2/402-2-FD-ME	Hardware manual in English	C.2074.21
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 11: 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.