CAN-USB/2

USB 2.0 Module with CAN Interface

Hardware Manual

For product C.2066.02,
C.2066.03

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Notes

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This manual contains important information and instructions on safe and efficient handling of the CAN-USB/2. Carefully read this manual before commencing any work and follow the instructions.
The manual is a product component, please retain it for future use.

The software used in the CAN-USB/2 is subject to the license terms of the respective authors or rights holders. CAN-USB/2 may only be used in accordance with these license terms!

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Hardware versions:	This manual applies to the CAN-USB/2 with hardware versions 1 and 2. Hardware version 2: CAN-USB/2 modules from serial number SN: JD012000 Hardware version 1: CAN-USB/2 modules up to serial number SN: JD011999. (See Product Label on page 13 for the serial number of your CAN-USB/2.)

Document History

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

Revision	Chapter	Changes versus previous version	Date
1.4	6	Updated chapter “Correctly Wiring electrically isolated CAN Networks“.	2013-03-06
	7	New Declaration of Conformity	
	8	Updated chapter “Order Information“	
1.5	3.	Note inserted to “Correctly Wiring electrically isolated CAN Networks“.	2015-05-26
	4.4.	Chapter “Serial Interface” deleted	
	6., 7.	Chapters revised	
	8.	New chapter “License”	
	9.	Chapter moved and Declaration of Conformity updated	
	10.	Chapter moved and revised	
1.6		Safety Instructions revised and Classification of Warning Messages and Safety instructions inserted	2019-06-17
	3.	Hardware Installation revised	
	4.	Weight corrected: 140g	
	5.1	Description of connector type corrected and description of Shied added	
	5.2	Description of connector type and signal description added	
	9.	EU Declaration of Conformity updated	
1.7		Safety Instructions and Notes revised	2023-11-10
	1. – 5.	Chapter revised, description of CAN-USB/2-DINrail inserted	
	8.	EU Declaration of Conformity updated	
	9.	Order Information revised	

Technical details are subject to change without further notice.

Classification of Warning Messages and Safety Instructions

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

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

DANGER, WARNING, CAUTION

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

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

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

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

NOTICE

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

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

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

INFORMATION

INFORMATION
Notes to point out something important or useful.

Safety Instructions

- When working with the CAN-USB/2 follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-USB/2 from damage.
- Do not use damaged or defective cables to connect the CAN-USB/2 and follow the CAN wiring hints in chapter: "Correct Wiring of Electrically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- The galvanic isolation of the CAN-USB/2 has only functional tasks and is not a protection against hazardous electrical voltage.
- The CAN-USB/2 is a device of protection class III according to DIN EN IEC 61010-2-201 and may only be operated on supply circuits that offer sufficient protection against dangerous voltages.
- External circuits connected to the interfaces of the CAN-USB/2 must be sufficiently protected against dangerous voltage.
- Compliance with the applicable national safety regulations is the responsibility of the user.

- Do not open the housing of the CAN-USB/2 .
- The CAN-USB/2 must be securely installed before commissioning.
- Never let liquids get inside CAN-USB/2. Otherwise, electric shocks or short circuits may result.
- Protect the CAN-USB/2 from dust, moisture, and steam.
- Protect the CAN-USB/2 from shocks and vibrations.
- The CAN-USB/2 may become warm during normal use. Always allow adequate ventilation around the CAN-USB/2 and use care when handling
- Do not operate the CAN-USB/2 adjacent to heat sources and do not expose it to unnecessary thermal radiation. Ensure an ambient temperature as specified in the technical data.

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-USB/2 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-USB/2 may cause radio interferences in which case the user may be required to take adequate measures.

Intended Use

The intended use of the CAN-USB/2 is the operation as a USB 2.0-CAN-Interface.
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-USB/2 is intended for indoor operation only.
- The operation of the CAN-USB/2 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-USB/2 for medical purposes is prohibited.

Service Note

The CAN-USB/2 does not contain any parts that require maintenance by the user. The CAN-USB/2 does not require any manual configuration of the hardware. 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*

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1 Overview

1.1 About this Manual

In this manual both variants of the module, the CAN-USB/2 and the CAN-USB/2-DINrail, are described together as CAN-USB/2. The hardware of the two variants is identical, except of the additional mounting rail holder equipped on the CAN-USB/2-DINrail only.
The differences of the module variants and hardware versions are noted accordingly where they are relevant.

1.2 Description of CAN-USB/2

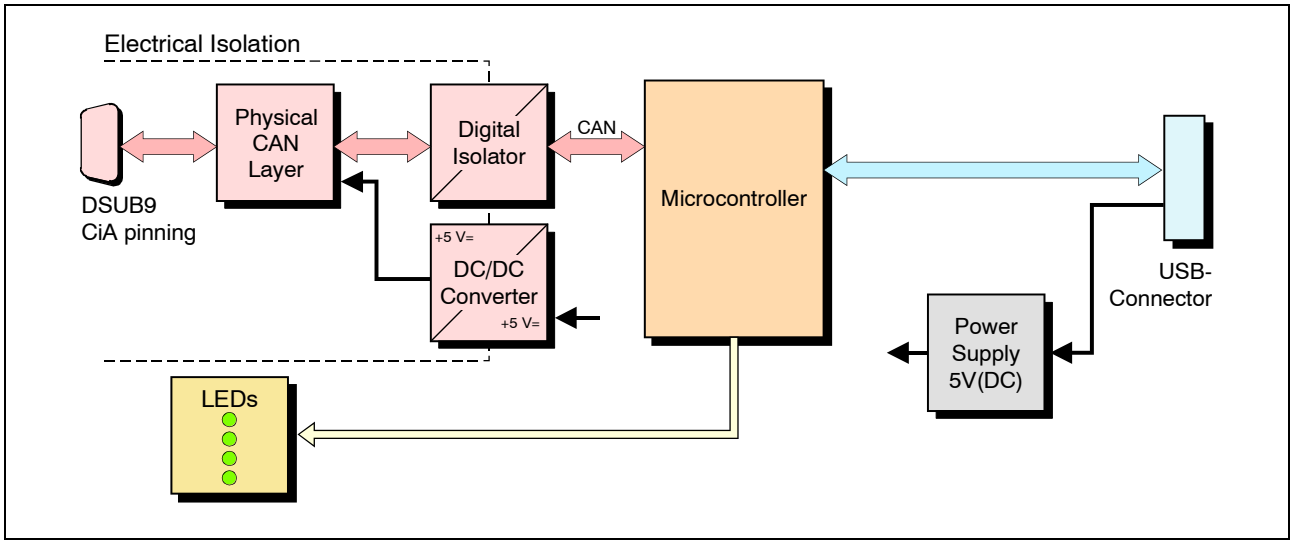


Figure 1: Block circuit diagram

The CAN-USB/2 module is a USB to CAN interface that uses an ARM® Cortex®-M7 based microcontroller for local CAN data management. The module supports the USB 2.0 Hi-Speed interface with data transfer rates of 480 Mbit/s.

The ISO 11898-compliant CAN interface allows a maximum data transfer rate of 1 Mbit/s. Like many other features of CAN interfaces, the bit rate can be set by means of software. The CAN interface and the other voltage potentials are electrically isolated by means of a digital isolator and DC/DC converters.

The supply voltage is fed via the USB bus.
The module is equipped with four green LEDs in the front panel which indicate the current module status.

The module is optionally available for DIN rail mounting according to IEC/EN 60715. The CAN-USB/2-DINrail is equipped with a mounting rail holder for snapping onto TS35 DIN rails.

Customized options are available for customized series 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 FD	Controller Area Network Flexible Data-Rate
CPU	Central Processing Unit
CiA	CAN in Automation
DSUB9	D-subminiature electrical connector with 9 positions
HW	Hardware
I/O	Input/Output
n.a.	not applicable
OS	Operating System
SDK	Software Development Kit
USB	Universal Serial Bus

2 Module Views, Connectors and LEDs

2.1 Module View

Figure 2: CAN-USB/2 front view

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

See also from page 20 for signal assignments of the CAN connector and the USB connector.

2.1.1 CAN-USB/2-DINrail

The mounting rail holder is only equipped on the back side of the CAN-USB/2-DINrail.

Figure 3: Module with mounting rail holder (CAN-USB/2-DINrail only)

Figure 4: CAN-USB/2-DINrail mounted on a mounting rail

2.2 Top View with USB Interface and Product Label

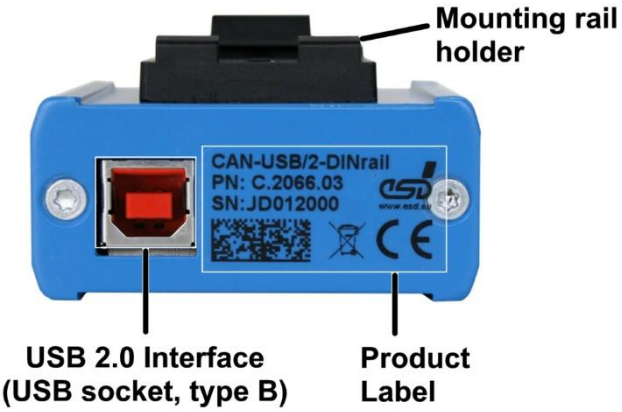


Figure 5: Top view of CAN-USB/2-DINrail module with USB Interface (Example)

The view applies accordingly also to the CAN-USB/2 module (V.2066.02) but without mounting rail holder. The CAN-USB/2 modules of hardware version 1 use a standard USB socket instead of the USB socket with high retention force.

2.3 Product Label

The product label is stuck on the top of the CAN-USB/2, see Figure 5.
It is described using the example of the CAN-USB/2-DINrail product label.

esd Product label example	The esd product label is placed on the top and shows:	Example:
	**- Product name**	**CAN-USB/2-DINrail**
	- PN: esd order number	**C.2066.03**
	- SN: Batch (first two letters) and Serial number (six digits)	**SN: JD012000 (JD 012000 Batch Serial number)**
	- esd logo (www.esd.eu)	
	Icons in the bottom row from left to right: - Data matrix code - Crossed-out dustbin (disposal) - CE label (CE)	

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

2.4 Bottom View with CAN Connector and LEDs

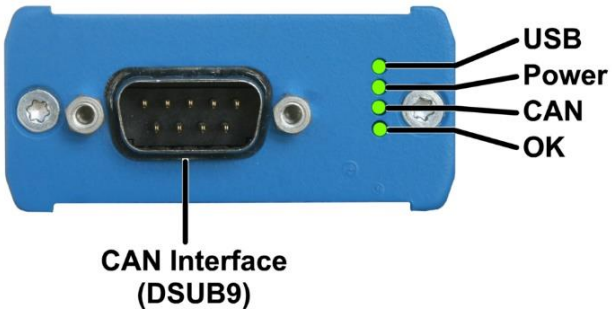


Figure 6: Module view with CAN connector and LEDs

2.5 LED Description

LED		Description (See Figure 6 for the position of the LEDs)
NAME	**Status**	
USB	on	USB module is enumerated, driver is loaded
	off	Driver is not loaded
Power	on	Module is in operation, the 5 V power supply is applied to the module
CAN	on	Activity, data is received or sent on the CAN bus in the last 200 ms. The LED remains on for a period of 200 ms after the last activity on the CAN bus.
	off	No activity on the CAN bus for at least 200 ms.
OK	on	CAN interface is initialized, bit rates are set
	off	Bit rate not set
	fast flashing (approx. 10 Hz)	CAN interface is initialized and in mode “Listen Only”, the bit rate is already set
	slow flashing (approx. 1 Hz)	CAN interface is initialized and in mode “Automatic Baud rate Detection” (from firmware version 1.0.0.4 and CAN driver version 2.5.2 on)

Table 1: Description of LEDs

3 Hardware Installation

To put the CAN-USB/2 into operation, please follow the installation notes.

Step	Procedure	See Page
	NOTICE **Carefully read the safety instructions at the beginning of this document before you start with the hardware installation!**	5
	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-USB/2 is to be integrated. → The CAN-USB/2 is a device of protection class III according to DIN EN IEC 61010-2-201 and may only be operated on supply circuits that offer sufficient protection against dangerous voltages. → External circuits connected to the interfaces of the CAN-USB/2 must be sufficiently protected against dangerous voltages. → Compliance with the applicable national safety regulations is the responsibility of the user.	
To install, continue as described from steps 1. to 3. To uninstall, continue from step 4.		
1.	CAN-USB/2-DINrail only: Optionally, you can mount the CAN-USB/2-DINrail on a mounting rail by snapping the module's mounting rail holder onto it (see **Figure 3** and **Figure 4**).	12
2.	Connect the CAN bus via the DSUB9 connector of the CAN-USB/2 as described in chapter "Correctly Wiring Electrically Isolated CAN Networks". Please note that 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.	22
3.	Connect the USB interface of the CAN-USB/2-module via USB bus to your PC. Use the supplied USB cable for this purpose. The module is powered via USB.	13
To uninstall the CAN-USB/2 continue as described below.		
4.	Make sure that all connected interfaces are switched off. Disconnect the CAN-USB/2 from the connected interfaces (CAN, USB). If applicable, loosen the fastening of the CAN-USB/2-DINrail and carefully pull the CAN-USB/2 from the mounting rail.	

INFORMATION
Access is supported via esd's NTCAN API.
The software installation is described in the second part of the CAN-API documentation called 'NTCAN-API, Part 2: Installation Guide'.

4 Technical Data

4.1 General Technical Data

Power supply voltage	Via USB 2.0 bus: Nominal voltage: $U_{NOMINAL}$ = 4.4 V_{DC} - 5.25 V_{DC}
Current consumption	Maximum: $I_{MAXIMUM}$ = 250 mA, Typical: $I_{TYPICAL}$ = 150 mA
Protection circuits	Reverse polarity protected connector, protection against transient disturbances on the input voltage
Temperature range	Operation: 0°C ... +50 °C ambient temperature Storage: -40°C ... +70 °C Transport: -40°C ... +70 °C
Humidity	Max. 90%, non-condensing
Protection class	IP40
Housing	Tube case, Aluminium continuous casting
Form factor / Case dimensions	55 mm x 54 mm x 25 mm (Without connectors and mounting rail holder)
Weight	CAN-USB/2: ca. 80 g CAN-USB-DINrail: 85 g

Table 2: General Data of the module

NOTICE
Please note that the current consumption of the module of 250 mA must be supplied (high-powered bus-powered device). The maximum current consumption of 250 mA has to be guaranteed also if a hub is used. Therefore, it is highly recommended to use a self-powered hub.

4.2 Connectors accessible from Outside

Name	Function, Interfaces	Type
CAN	CAN interfaces	DSUB9 connector, pin contacts
USB	USB 2.0 interface	USB 2.0 socket, type B, high retention force The USB socket with high retention force is only equipped on CAN-USB/2 modules from serial number SN: JD012000 (HW-version 2), see 2.3. Before that, up to serial number SN: JD011999 (HW-version 1), standard USB 2.0 sockets type B were installed

Table 3: Connectors, accessible from outside

4.3 CAN Interface

Number of CAN interfaces	1
CAN controller	Integrated in CPU
CAN protocol	According to ISO 11898-1 (11- and 29- bit identifiers are supported)
Physical CAN Layer	CAN interface according to ISO 11898-2, Transmission rate programmable from 10 kbit/s up to 1 Mbit/s
Electrical isolation	Separation by means of optocoupler and DC/DC-converter, Voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to Host/System Ground;): 1kV DC @ 1s (I < 1 mA)
Bus termination	Terminating resistor has to be set externally if required
Connector	DSUB9 according to CiA® Specification CiA 303-1

Table 4: Data of the CAN interface

4.4 USB Interface

Number	1
Specifiation	USB Specification Rev. 2.0, bit
Physical layer	USB controller and the physical layer for USB are integrated in the CPU
Galvanic isolation	None
Bit rate	Max. 480 Mbit/s,

Table 5: USB interface

4.5 Software Support

Available software drivers for Windows® 10/11 are included in delivery or can be downloaded from the product page of the CAN-USB/2 on our website: https://esd.eu/en/products/can-usb-2

Support of Linux® (kernel ≥ 5.19) via Linux CAN (SocketCAN) and NTCAN wrapper library, as well as other operating systems are available on request.
The firmware can be updated from the PC. Updates are available on the esd website.
Libraries for the higher layer protocols CANopen and J1939 are available for Classical CAN applications with CAN-USB/2 .

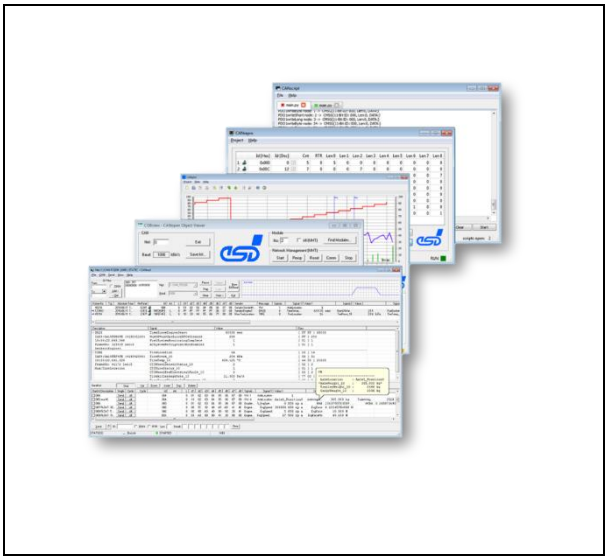
For detailed information about the availability of the driver for your operating system, please contact our sales team: (sales@esd.eu).

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

"NTCAN-API Part 1: Structure, Function and C/C++ API" Application Developers Manual and
"NTCAN-API Part 2: Installation, Configuration and Firmware Update" Installation Guide

The manuals can be downloaded free of charge from our website via the product page of the CAN-USB/2 or the CAN-SDK page: https://esd.eu/produkte/can-sdk

CAN Tools
esd offers additional free-of-charge tools for Windows, that support the efficient setup and analysis of CAN applications and networks.
The CAN Tools can be used for 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
- 40 MB free HD drive space
- esd CAN driver installed

The CAN Tools are included in the CAN-CD as part of the esd Software Development Kit (CAN SDK) of the NTCAN-API.
The CAN SDK can also be downloaded free-of-charge from the esd website.

4.6 Licenses

The software used for the CAN-USB/2 from esd and from third parties is subject to licenses.

- The CAN-USB/2 uses the open source FreeRTOS™ operating system.
  For the full license text see FreeRTOS, Amazon.com, Inc., Licence Details:
  https://www.freertos.org/a00114.html#license_comparison

  This also includes the MIT open source license.
  You can also download the text of the MIT License from our homepage: MIT License text

- CMSIS End User License Agreement, For the full text of the End user licence agreement for the cortex microcontroller software interface standard (CMSIS) deliverables see:
  https://www.keil.com/Content/eula/cmsiseula.html

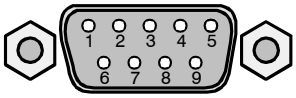
NOTICE
You must accept these license conditions before using the device!

5 Connector Assignments

5.1 CAN (DSUB9)

Device connector: 9-pin DSUB connector, pin contacts
Connector pin-assignment according to CiA® 106 recommendations.

Pin Position:



Pin Assignment:

Signal	Pin		Signal
CAN_GND	6	1	Reserved
		2	CAN_L
CAN_H	7	3	CAN_GND
Reserved	8	4	Reserved
Reserved	9	5	Shield

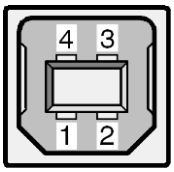
Signal Description:

CAN_L, CAN_H …	CAN signal lines
CAN_GND …	Reference potential of the local CAN physical layer
Shield …	Shielding (connected with the case of the 9-pin DSUB connector and with the case of CAN-USB/2)
Reserved …	Reserved for future applications, do not connect!

5.2 USB Socket

Device connector: USB 2.0 connector, receptacle, type-B
The high-retention force option is only equipped on CAN-USB/2 modules from serial number JD012000 (HW-version 2).

Pin Position:



Pin Assignment:

Pin	Signal
1	V_{BUS}
2	D-
3	D+
4	GND
-	Shield

Signal Description:

V_{BUS} ...	+5 V power supply voltage
D+, D-...	USB signal lines Data+, Data-
GND...	Reference potential
Shield	Shielding (connected with the case of the USB connector and with the case of the CAN-USB/2)

NOTICE
As USB 2.0 device, the CAN-USB/2 can be connected to USB ports that comply with USB standards at least from USB 1.1!
Please note that at least USB 2.0 is required for USB high-speed operation.

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.

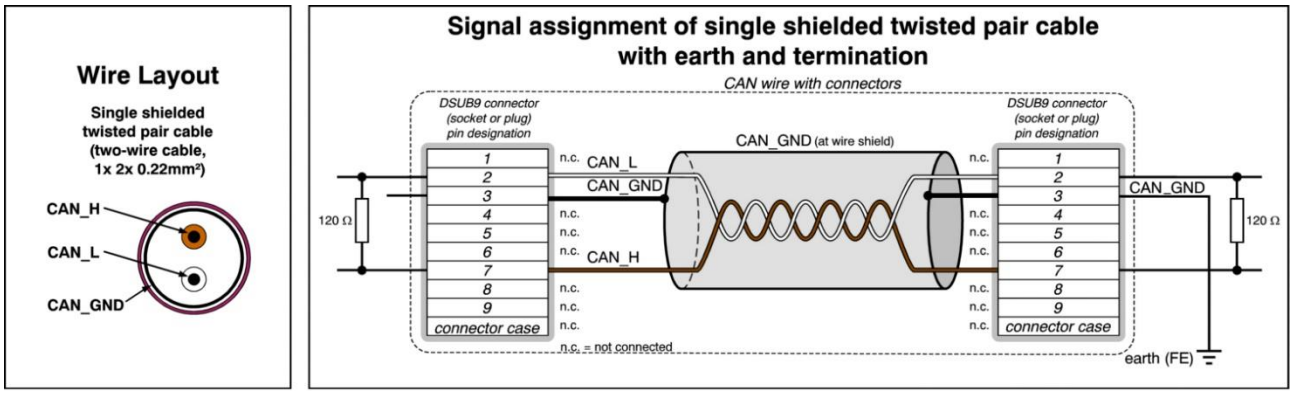


Figure 7: CAN wiring for light industrial environment

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.

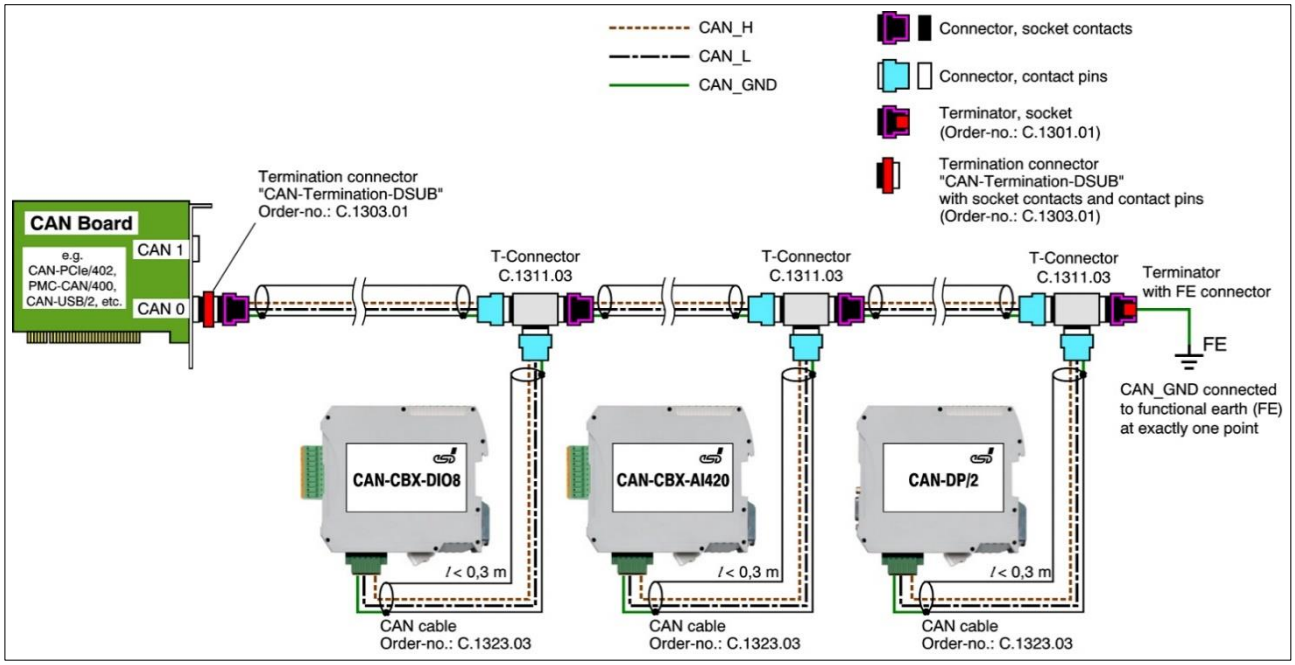


Figure 8: Example for proper wiring with single shielded single twisted pair wires

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.

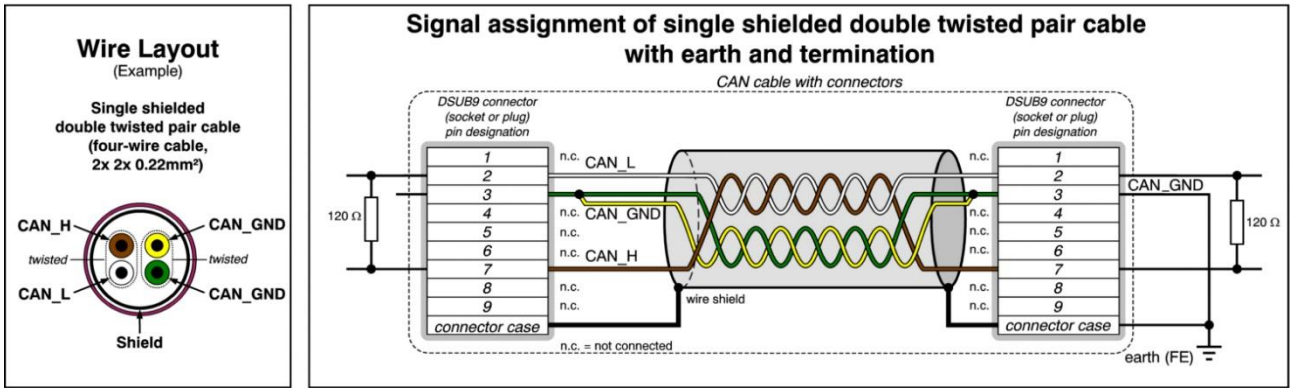


Figure 9: CAN wiring for heavy industrial environment

6.3.2 Device Cabling

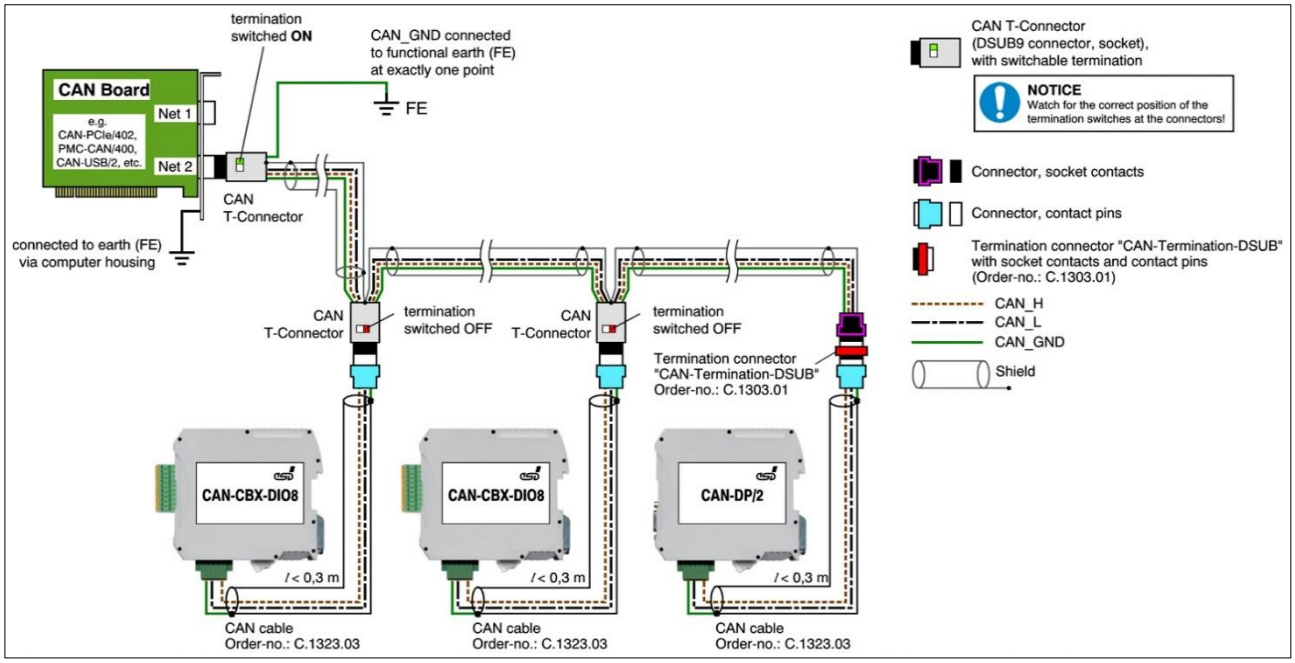


Figure 10: Example of proper wiring with single shielded double twisted pair cables

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 6: 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.

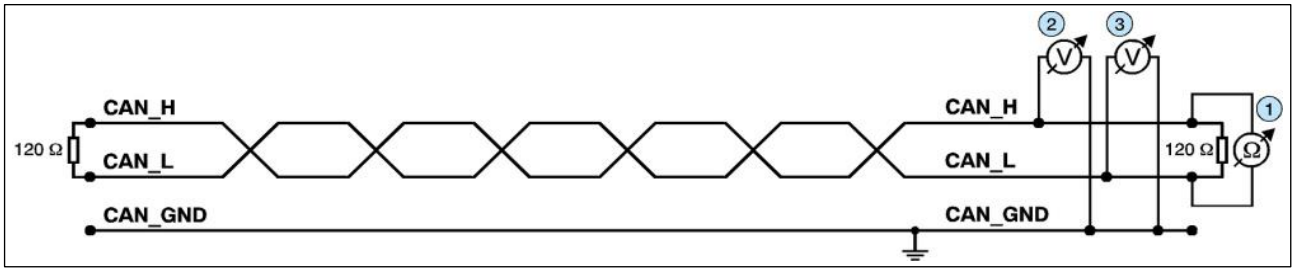


Figure 11: Simplified diagram of a CAN network

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!

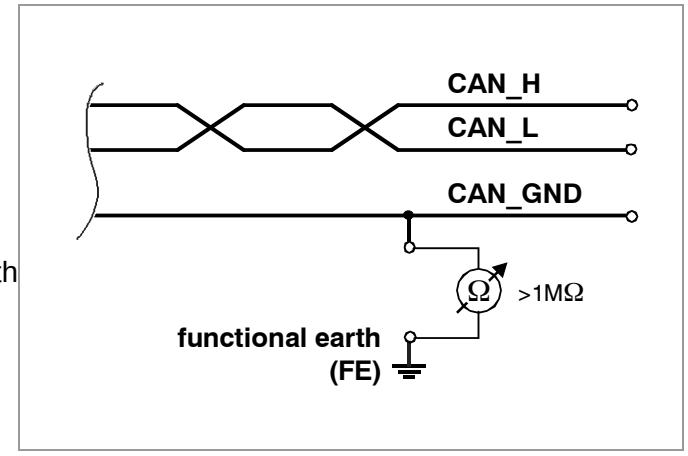


Figure 12: Simplified schematic diagram of ground test measurement

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.)

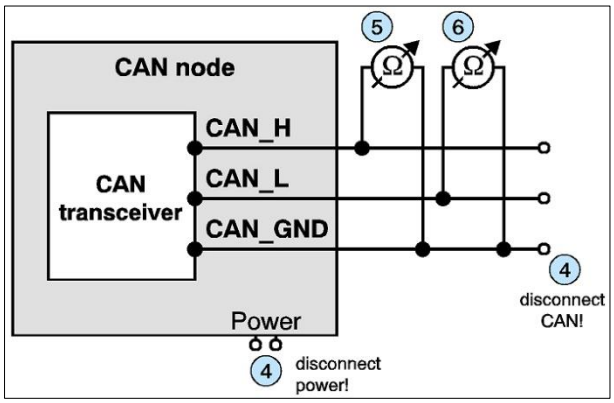


Figure 13: Measuring the internal resistance of CAN transceivers

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 die Produkte *esd declares, that the products*	Typ, Modell, Artikel-Nr. *Type, Model, Article No.*
CAN-USB/2	**C.2066.02**
CAN-USB/2-DINrail	**C.2066.03**
die Anforderungen der Normen *fulfill the requirements of the standards*	**EN 61000-6-2:2005,** **EN 61000-6-4:2007/A1:2011** (up to S/N JD011999) **EN 61000-6-3:2007/A1:2011** (from S/N JD012000)
gemäß folgender Prüfberichte erfüllen. *according to test certificates.*	**H-K00-0272-06 + H-Z01-0272-13** (up to S/N JD011999) **H-K00-0762-20** (from S/N JD012000)
Die Produkte entsprechen damit der EU-Richtlinie „EMV" *Therefore, the products conform to the EU Directive 'EMC'*	**2014/30/EU**
Die Produkte entsprechen den EU-Richtlinien „RoHS" *The products conform to the EU Directives 'RoHS'*	**2011/65/EU, 2015/863/EU**

Diese Erklärung verliert ihre Gültigkeit, wenn die Produkte nicht den Herstellerunterlagen entsprechend eingesetzt und betrieben wird oder die Produkte abweichend modifiziert werden.
This declaration loses its validity if the products are 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, 2023-09-29

Rechtsgültige Unterschrift / *authorized signature*

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9 Order Information

Type	Properties	Order No.
CAN-USB/2	Intelligent CAN FD interface for the USB port in a compact and robust aluminum housing. Supports USB 2.0 High-Speed with up to 480 Mbit/s and CAN with physical layer according to ISO 11898-2 with optical isolation and a CAN data rate of up to 1 Mbit/s. The module is powered via USB. Drivers and tools for Windows are included. Support for Linux is provided via SocketCAN.	C.2066.02
CAN-USB/2-DINrail	Intelligent CAN FD interface for the USB port in a compact and robust aluminum housing for DIN rail mounting. Supports USB 2.0 High-Speed with up to 480 Mbit/s and CAN with physical layer according to ISO 11898-2 with optical isolation and a CAN data rate of up to 1 Mbit/s. The module is powered via USB. Drivers and tools for Windows are included. Support for Linux is provided via SocketCAN.	C.2066.03
Software		
CANopen Software Stack Windows/Linux	CANopen® object license for Linux and Windows incl. CD-ROM	C.1101.06
J1939 Stack for Windows (Object)	Single-user runtime license for J1939 Software Stack and J1939 Device Simulator & Monitor for use with esd CAN hardware and NTCAN API., delivered as Windows object code	C.1130.10
J1939 Stack for Linux (Object)	Single-user runtime license for J1939 Software Stack for use with esd CAN hardware and NTCAN API. Provided as Linux object code for easy integration into a system.	C.1130.11
For detailed information about the driver availability for your special operating system, please contact our sales team.		

Table 7: Order information software for CAN-USB/2-FD

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

Manuals		Order No.
CAN-USB/2-ME	Hardware manual in English	C.2066.21
CAN-API-ME	NTCAN-API manual Part 1: Application Developers Manual NTCAN-API manual Part 2: Driver Installation Guide	C.2001.21
CANopen-ME	CANopen Software Stack, manuals in English	C.2002.21
J1939 Stack ME	J1939 Stack software manual in English	C.1130.21

Table 8: 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.