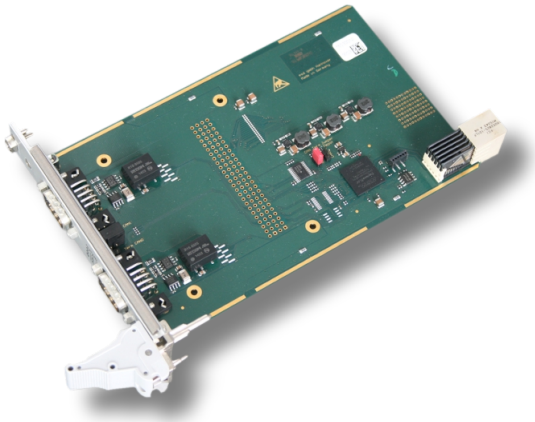
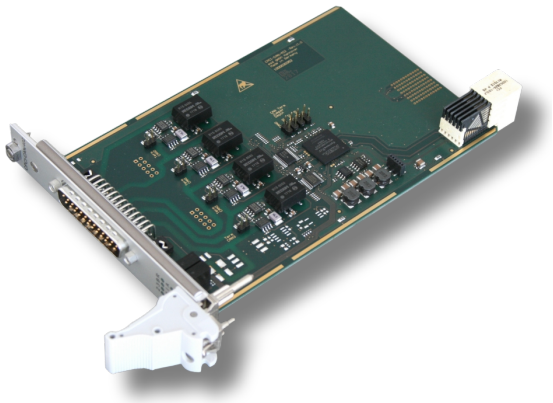
CPCIserial-CAN/402

CompactPCI® Serial (PCIe®) Board with up to 4 CAN FD and optional IRIG-B or 2 CAN Interfaces



CPCIserial-CAN/402-2(-FD)



CPCIserial-CAN/402-4-FD

Hardware Manual

to Products I.3001.64,
I.3001.68,
I.3001.69,
I.3001.88,
I.3001.04

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N O T E

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

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Hardware version.:	PCB 1.1			
	Note to CAN FD: For some CAN FD versions the transceiver for the increased CAN FD bit rate (up to 8 Mbit/s, formerly 5 Mbit/s) is only equipped from the batch number as described in the following table:			
	Product	Order No.	Increased bit rate available from batch number	
	CPCIserial-CAN/402-2-FD	I.3001.64	GB	(see chapter “Product Label” on page 16)
	CPCIserial-CAN/402-4-FD	I.3001.68	GB	
	CPCIserial-CAN/402-4-FD-IRIG-B	I.3001.69	GB	

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
1.3	1.	Description of CPCIserial-CAN/402-4-FD-IRIG-B version inserted, Figure 1 changed , CAN FD bit rate up to 8 Mbit/s for CAN FD product versions from batch number GB	2018-12-12
	2.2	Picture of 4 CAN FD version corrected	
	2.3	New chapter: “Product Label”	
	3.2	Chapter restructured, description of IRIG-B LED added	
	4.	Description of CPCIserial-CAN/402-4-FD-IRIG-B inserted	
	5.1, 5.5	Description of IRIG-B version added	
	5.4	CAN FD bit rate up to 8 Mbit/s	
	6.	Description of IRIB-B version and cable added	
	9.	Declarations of conformity updated	
	10.	Order Information	
1.4	1	Description of CPCIserial-CAN/402-4-FD-P3 added	2022-04-29
	2.3,	New chapter: Description of PCB	
	3.3	New chapter: Description of front panel, LEDs	
	4.	Notes on CPCIserial-CAN/402-4-FD-P3 inserted	
	5.1, 5.4	Description of CPCIserial-CAN/402-4-FD-P3 added	
	6.5	New chapter: Pin assignment P3	
	9.2	New Declaration of Conformity	
	10.1	CPCIserial-CAN/402-4-FD-P3 added	

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 CPCIserial-CAN/402 follow the instructions below and read the manual carefully to protect yourself from injury and the CPCIserial-CAN/402 from damage.
- The device is a built-in component. It is essential to ensure that the device is mounted in a way that cannot lead to endangering or injury of persons or damage to objects.
- Do not use damaged or defective cables to connect the CPCIserial-CAN/402 and follow the CAN wiring hints in chapter: "Correct Wiring of Electrically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- Current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1).
- The CPCIserial-CAN/402 may only be driven by current circuits, that are contact-protected. A power supply, that provides a safety extra-low voltage (SELV) according to EN 60950-1, complies with this conditions.

- The device has to be securely installed in the control cabinet before commissioning.
- Protect the CPCIserial-CAN/402 from dust, moisture and steam.
- Protect the CPCIserial-CAN/402 from shocks and vibrations.
- The CPCIserial-CAN/402 may become warm during normal use. Always allow adequate ventilation around the CPCIserial-CAN/402 and use care when handling.
- Do not operate the CPCIserial-CAN/402 adjacent to heat sources and do not expose it to unnecessary thermal radiation. Ensure an ambient temperature as specified in the technical data.

DANGER

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

→ Disconnect all hazardous voltages (mains voltage) before opening the system.

→ Ensure the absence of voltage before starting any electrical work

NOTICE

Electrostatic discharges may cause damage to electronic components.

→ To avoid this, please discharge the static electricity from your body *before* you touch the CPCIserial-CAN/402.

→ Furthermore, you should prevent your clothes from touching the CPCIserial-CAN/402, because your clothes might be electrostatically charged as well.

Qualified Personnel

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

Conformity

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

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

Intended Use

The intended use of the CPCIserial-CAN/402 is the operation as CompactPCI® Serial (PCIe®) Board with up to 4 CAN Interfaces in a CompactPCI Serial system.
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 CPCIserial-CAN/402 is intended for installation in a CompactPCI Serial system only.
- The operation of the CPCIserial-CAN/402 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CPCIserial-CAN/402 for medical purposes is prohibited.

Service Note

The CPCIserial-CAN/402 does not contain any parts that require maintenance by the user. The CPCIserial-CAN/402 does not require any manual configuration of the hardware, except for the configuration of 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.

Abbreviations

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

Table of contents

1. Overview

1.1 About this manual

This manual describes the hardware of the CPCIserial-CAN/402. The following versions of the product are described:

Versions with 4 CAN or CAN FD interfaces via DSUB25 connector:

- CPCIserial-CAN/402-4-FD: - 4 CAN FD interfaces
  (backwards compatible with Classical CAN)
- CPCIserial-CAN/402-4-FD-IRIG-B: - 4 CAN FD interfaces
  (backwards compatible with Classical CAN)
  - 1 IRIG-B interface

Verison with 4 CAN FD interfaces via P3:

- CPCIserial-CAN/402-4-FD-P3: - 4 CAN FD interfaces
  (backwards compatible with Classical CAN)
  and IRIG-B signals via Rear IO

Versions with 2 CAN or CAN FD interfaces via 2 DSUB9 connectors:

- CPCIserial-CAN/402-2-FD: 2 CAN FD interfaces
  (backwards compatible with Classical CAN),
- CPCIserial-CAN/402-2: 2 CAN interfaces (Classical CAN only)

All versions are described together as CPCIserial-CAN/402. Differences of the board versions are noted where they are described.

1.2 General Description

The CPCIserial-CAN/402 is a CompactPCI Serial board that is available with 2 or 4 CAN FD interfaces or 2 Classical CAN interfaces according to ISO 11898-1:2015.

CPCIserial-CAN/402-4-FD and CPCIserial-CAN/402-4-FD-IRIG-B

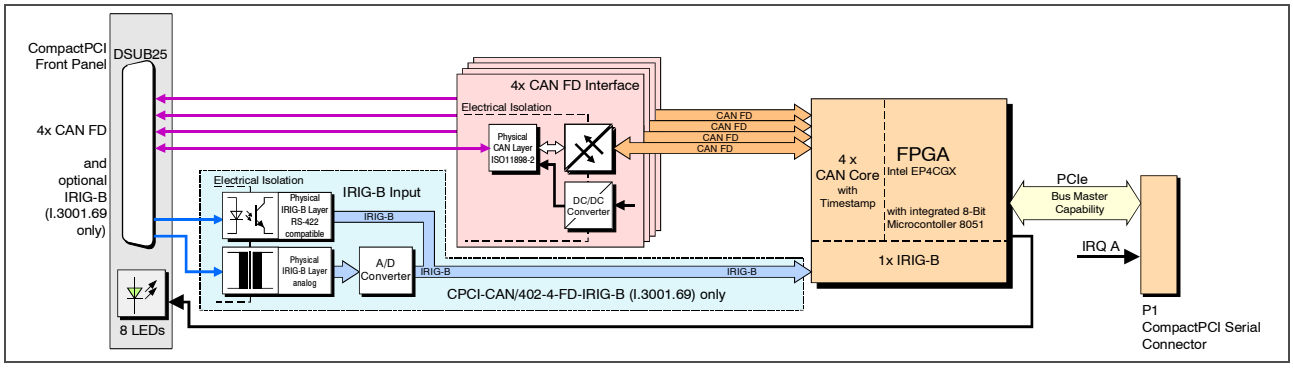


Figure 1: Block circuit diagram of CPCIserial-CAN/402-4-FD(-IRIG-B)

The CPCIserial-CAN/402-4-FD comes with four independent CAN FD interfaces via a 25-pole DSUB connector in the front panel.
The CPCIserial-CAN/402-4-FD-IRIG-B is designed as the CPCIserial-CAN/402-4-FD but provides an additional IRIG-B interface via the DSUB25 connector.
The IRIG-B interface offers inputs for analog or RS-422 IRIG-B coded signals. Both are electrically isolated. IRIG-B evaluation is controlled by an 8051 microcontroller integrated in the FPGA.

CPCIserial-CAN/402-4-FD-P3 - All signals via Rear I/O (P3)

The CPCIserial-CAN/402-4-FD-P3 comes without physical CAN layer and without connectors and LEDs in the front panel. The signal lines of the four independent CAN FD interfaces, the additional IRIG-B signals and 8 LED signal lines are routed to the P3 connector.

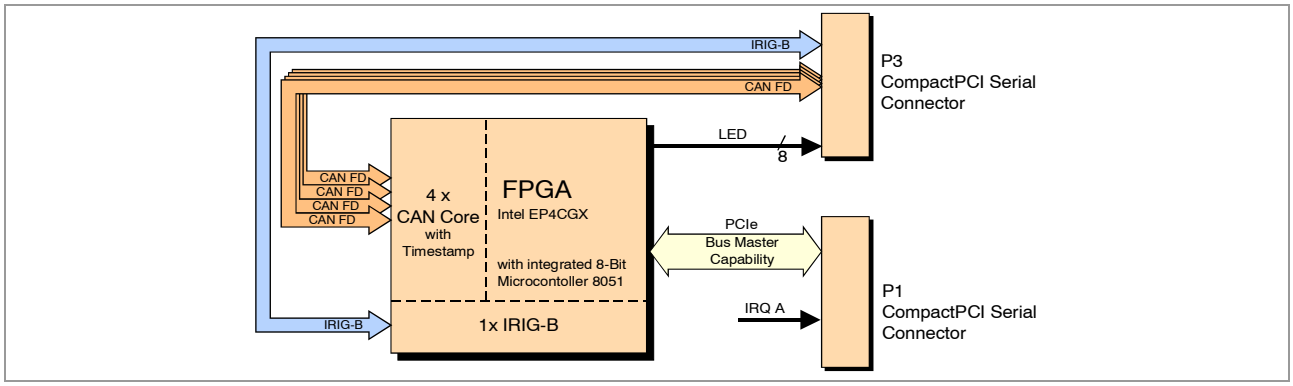


Figure 2: Block circuit diagram of CPCIserial-CAN/402-4-FD-P3

CPCIserial-CAN/402-2-FD

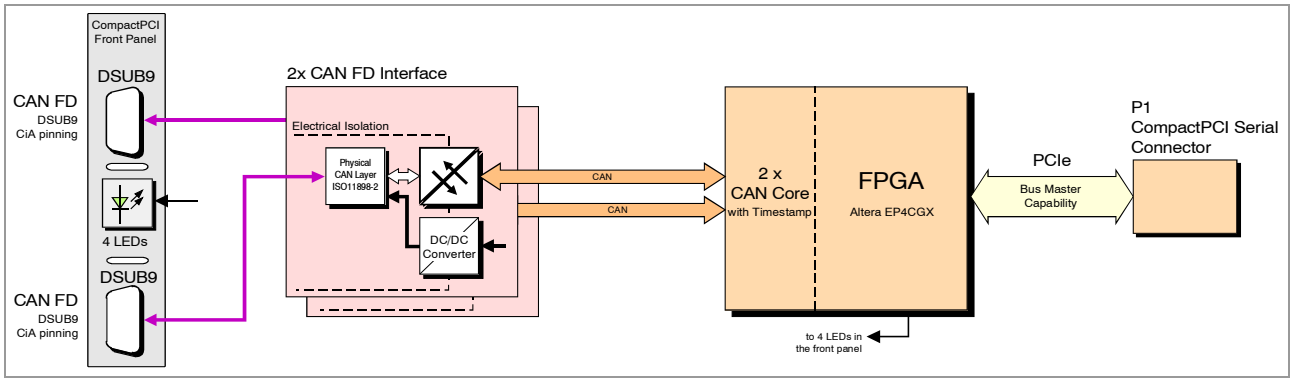


Figure 3: Block circuit diagram of CPCIserial-CAN/402-2-FD

The CPCIserial-CAN/402-2-FD provides two independent CAN FD interfaces which are accessible via two 9-pole DSUB connectors in the front panel. The CAN FD interfaces conform with ISO 11898-2 and support bit rates up to 8 Mbit/s.

CPCIserial-CAN/402-2

The hardware of the Classical CAN version CPCIserial-CAN/402-2 and the CAN FD version CPCIserial-CAN/402-2-FD is equal but both versions come with different CAN controllers in the FPGA images. The CPCIserial-CAN/402-2 can not be used in CAN FD applications, because Classical CAN controllers do not tolerate CAN FD frames!
The electrically isolated high-speed CAN interfaces are designed according to ISO 11898-2 and support bit rates up to 1 Mbit/s.

INFORMATION
The CPCIserial-CAN/402-2 is not recommended for new designs. (It can still be used in existing systems, e.g. if the drivers shall not be reinstalled.)
Please use the successor CPCIserial-CAN/402-2-FD or the CPCIserial-CAN/402-4-FD for new projects. The CAN FD versions can also be used for Classical CAN applications!

CAN FD
With a higher bit rate in the data phase in combination with the increase of efficiency by a higher number of user-data bytes, CAN FD offers a higher data throughput while maintaining the benefits of Classical CAN.
The Classical CAN version CPCIserial-CAN/402-2 can only be used in Classical CAN applications because its controller is not CAN FD capable.
The CAN FD versions CPCIserial-CAN/402-2-FD and CPCIserial-CAN/402-4-FD are fully backwards compatible with CAN and can also be used in Classical CAN applications.

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

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

INFORMATION
During the initialisation of the CAN controller of the CAN FD boards the application determines via software if the CAN FD boards communicate with Classical CAN or with CAN FD.
See NTCAN-API Manual Part 1: “Application Developers Manual” for further information.

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

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

esdACC
The CAN FD or CAN interfaces are driven by the ISO 16845:2004 certified esdACC (esd advanced CAN Core) implemented in an Intel® (formerly Altera®) FPGA.

CAN Data Management
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 the CPCIserial-CAN/402 can be operated for example in Hypervisor environments.
Furthermore the CPCIserial-CAN/402 provides high resolution 64-bit hardware timestamps for CAN messages.

CAN Termination
On-board CAN termination resistors can be individually set for each CAN channel via jumpers. Please note that on the CPCIserial-CAN/402-4-FD-P3 version the on-board resistors are not equipped. CAN termination resistors have to be set externally for this version.
The front panels of CPCIserial-CAN/402-2-FD and CPCIserial-CAN/402-2 come with two cut-outs, though which the position of the termination jumpers can be seen.

1.3 Customized Options

Customized options are for example:
- Extended temperature range: -40° C … +75° C
- Error simulation support

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

2. PCB-View with Connector and Jumper Positions

2.1 CPCIserial-CAN/402-2(-FD)

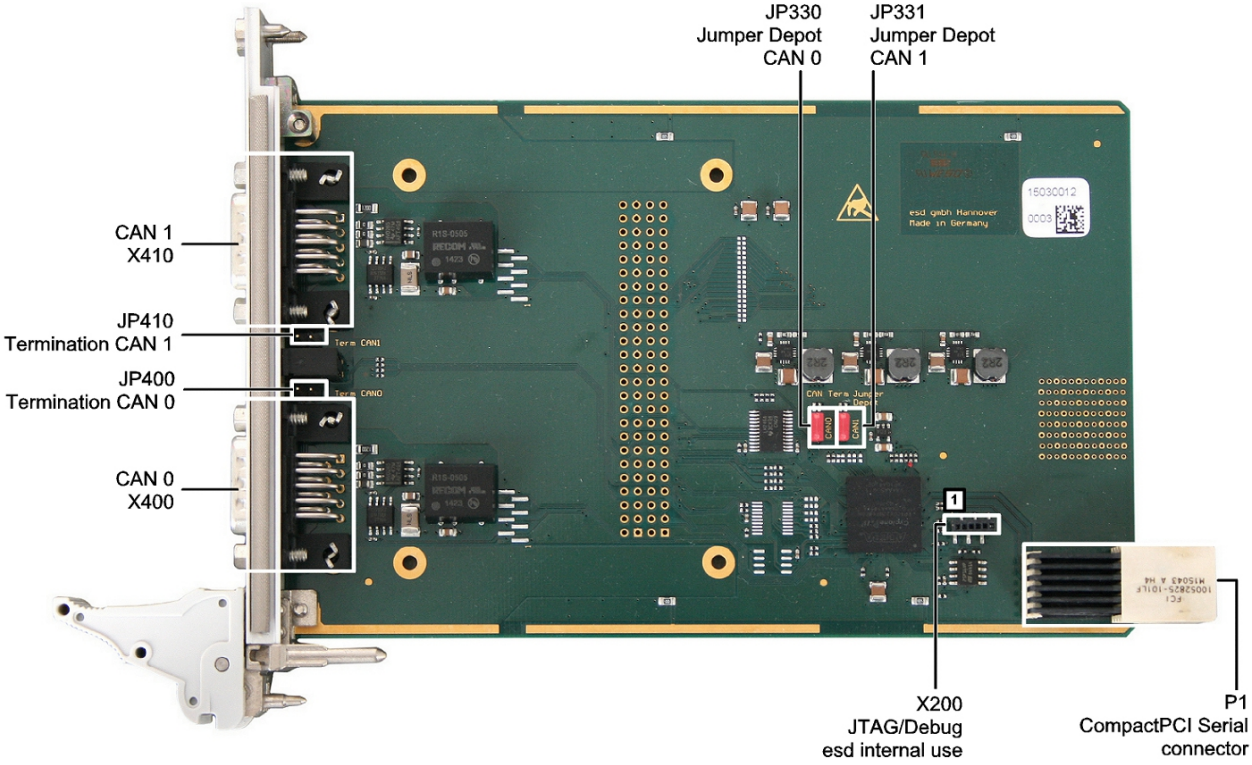


Figure 4: Top layer view of CPCIserial-CAN/402-2(-FD)

See also from page 28 for signal assignment of the connectors.

2.1.1 Jumpers for CAN Termination and Jumper Depot

An on-board termination resistor of 120Ω can be individually enabled for each CAN interface via jumpers (JP410, JP400). For the position of the jumper on the CPCIserial-CAN/402-2(-FD) see Figure 4.

Name	Jumper	Termination Jumper set	Termination Jumper not set	Jumper Depot
CAN1	JP410	Internal termination of CAN1	CAN1 has to be terminated externally	JP331
CAN0	JP400	Internal termination of CAN0	CAN0 has to be terminated externally	JP330

NOTICE
It is strongly recommended to keep the jumpers which are not used for CAN termination on the corresponding jumper depots CAN0 (JP330) or CAN1 (JP331)!
A jumper missing in the depot may erroneously lead to the assumption that the corresponding CAN interface is internally terminated

2.2 CPCIserial-CAN/402-4-FD(-IRIG-B)

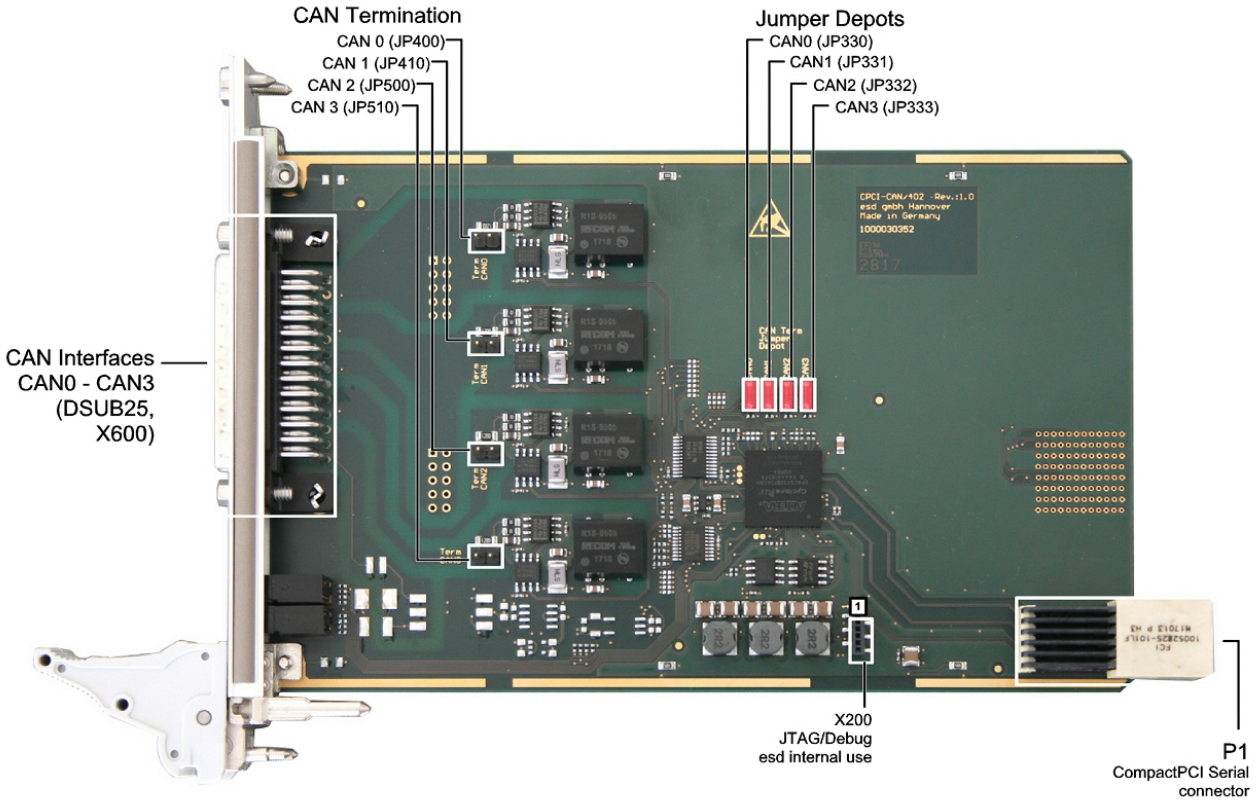


Figure 5: Top layer view of CPCIserial-CAN/402-4-FD

See also from page 28 for signal assignment of the connectors.
The CPCIserial-CAN/402-4-FD-IRIG-B is designed as the CPCIserial-CAN/402-4-FD but comes with an additional IRIG-B interface (via DSUB25 connector).

2.2.1 Jumpers for CAN Termination and Jumper Depot

An on-board termination resistor of 120Ω can be individually enabled for each CAN interface via the termination jumpers JP400-JP510.
For the position of the jumper on the CPCIserial-CAN/402-4-FD see Figure 5.

Name	Jumper	Termination Jumper set	Termination Jumper not set	Jumper Depot
CAN0	JP400	Internal termination of CAN0	CAN0 has to be terminated externally	JP330
CAN1	JP410	Internal termination of CAN1	CAN1 has to be terminated externally	JP331
CAN2	JP500	Internal termination of CAN3	CAN3 has to be terminated externally	JP332
CAN3	JP510	Internal termination of CAN2	CAN2 has to be terminated externally	JP333

NOTICE
It is strongly recommended to keep the jumpers which are not used for CAN termination on the corresponding jumper depots CAN0 - CAN3 (JP330-JP333)!
A jumper missing in the depot may erroneously lead to the assumption that the corresponding CAN interface is internally terminated

2.3 CPCIserial-CAN/402-4-FD-P3

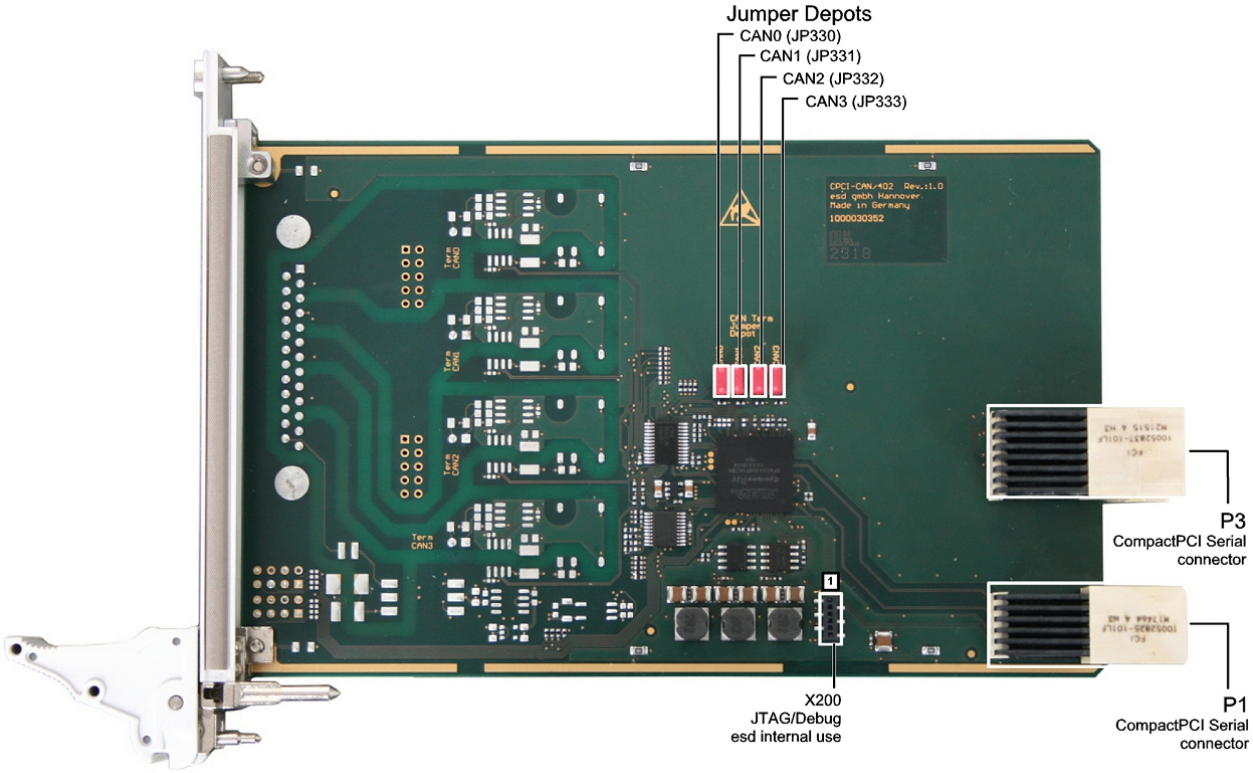


Figure 6: Top layer view of CPCIserial-CAN/402-4-FD-P3

In this version the CAN signal lines are routed via connector P3.
The physical CAN layer is not equipped. It must be connected to the TTL lines of the Rear IO by the customer. If you have any questions about this or would like more information, please do not hesitate to contact our support team.

See from page 28 for signal assignment of the connectors.

2.3.1 CAN Termination and Jumper Depot

CPCIserial-CAN/402-4-FD-P3 has no terminating resistors on the board. CAN0 - CAN3 must be terminated externally.

NOTICE
It is strongly recommended to keep the jumpers which are not used for CAN termination on the corresponding jumper depots CAN0 - CAN3 (JP330-JP333)!
A jumper missing in the depot may erroneously lead to the assumption that the corresponding CAN interface is internally terminated.

2.4 Product Label

esd Product label example

Figure 7: Example of product label (order of the items may deviate)

The esd product label is placed on the PCB and shows:

- **PN:** esd order number (Example: I.3001.68)
- **SN:** Batch and serial number (Example: Batch: GB Serial no.: 000111)

- CE label
- esd logo
- Product name (Example: CPCIserial-CAN/402-4-FD
- Data matrix code
- Fields for quality assurance (B, T, Q)

3. Front Panel View with Connectors and LEDs

3.1 CPCIserial-CAN/402-2(-FD)

The CPCIserial-CAN/402-2(-FD) comes with four green LEDs in the front panel.

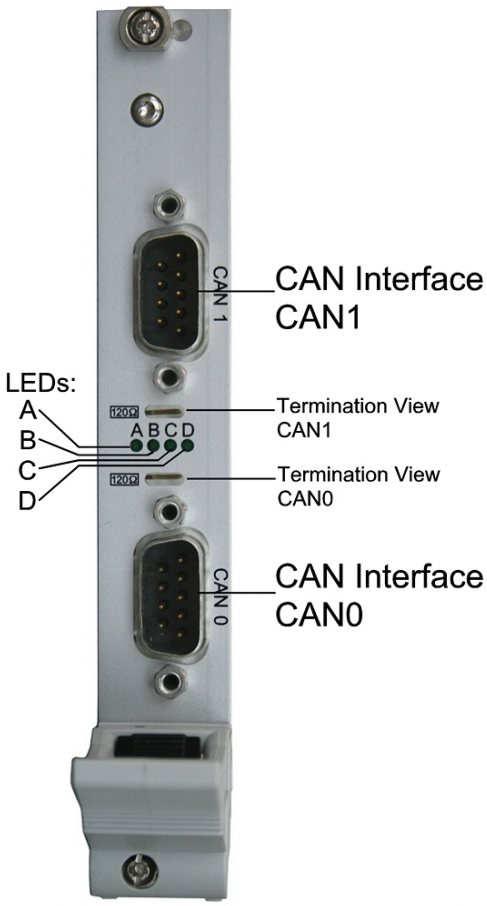


Figure 7: Position of Connectors and LEDs

LED	Function	Indicator State	Description	LED name in schematic diagram
D	Power	off	CPCIserial-CAN/402-2(-FD) is not ready, FPGA is not loaded	LED500D
		on	CPCIserial-CAN/402-2(-FD) is operational, FPGA is loaded	
C	reserved	-	-	LED500C
B	CAN 1 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 1	LED500B
		blinking	connected to CAN bus 1 and CAN traffic on CAN 1	
A	CAN 0 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 0	LED500A
		blinking	connected to CAN bus 0 and CAN traffic on CAN 0	

Table 1: Description of LEDs

3.2 CPCIserial-CAN/402-4-FD(-IRIG-B)

The CPCIserial-CAN/402-4-FD(-IRIG-B) is equipped with 8 green LEDs in the front panel.

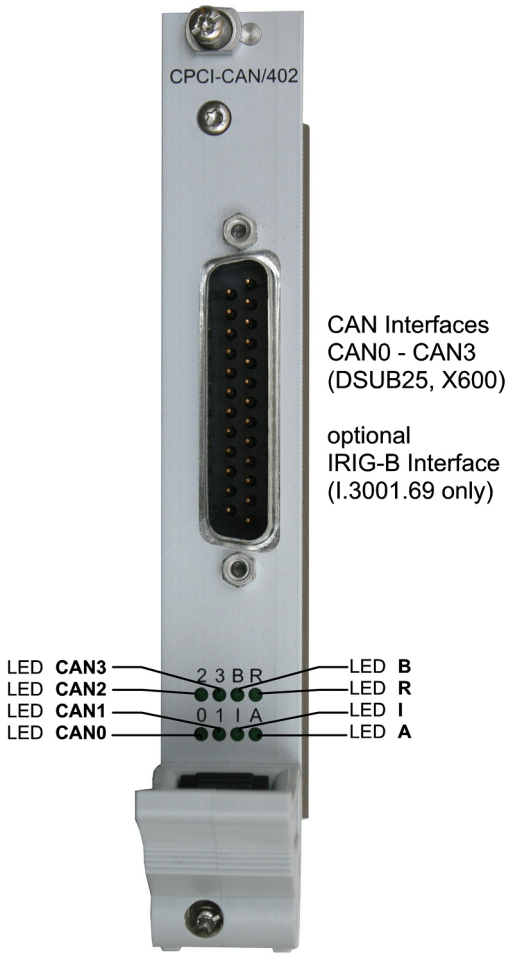


Figure 8: Front panel view of CPCIserial-CAN/402-4-FD(-IRIG-B)

3.2.1 CAN-LEDs

Label	Function	Indicator State	**Indication** (LED on)
0	CAN 0 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 0
		blinking	connected to CAN bus 0 and CAN traffic on CAN 0
1	CAN 1 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 1
		blinking	connected to CAN bus 1 and CAN traffic on CAN 1
2	CAN 2 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 2
		blinking	connected to CAN bus 2 and CAN traffic on CAN 2
3	CAN 3 Traffic	off	no CAN bus connection and/or no CAN traffic on CAN 3
		blinking	connected to CAN bus 3 and CAN traffic on CAN 3

Table 2: Description of CAN LED 0, 1, 2, 3

3.2.2 LEDs R, A, B

Label	Function	Indicator State	**Indication** (LED on)
R	READY	off	CPCIserial-CAN/402-4-FD is not ready, FPGA is not loaded
		on	CPCIserial-CAN/402-4-FD is operational, FPGA is loaded
A	Reserved	-	-
B	Reserved	-	-

Table 3: Description of LED **R, A, B**

3.2.3 IRIG-B LED I

CPCIs-CAN/402-4-FD-IRIG-B (I.3001. 69) only:			
Label	**Function**	**Indicator State**	**Indication** (LED on)
I	IRIG-B Link	flickering	- no signal
		blinking	- synchronisation is proceeding
		on	- synchronised

CPCI-CAN/402-4-FD (I.3001.68) only:			
Label	**Function**	**Indicator State**	**Indication** (LED on)
I	Reserved	-	For the CPCIs-CAN/402-4-FD board without IRIG-B option the LED is without function

Table 4: Descriptions of LED **I**

3.3 CPCIserial-CAN/402-4-FD-P3

3.3.1 Frontpanel

The CPCIserial-CAN/402-4-FD-P3 has neither front panel connectors nor LEDs.

Figure 9: Front panel view of CPCIserial-CAN/402-4-FD-P3

3.3.2 LEDs

The LED signal lines are routed to the CPCIserial connector P3. The display functions correspond to those described in chapter 3.2.1 CAN-LEDs, 3.2.2 LEDs R, A, B and 3.2.3 IRIG-B LED I.

4. Hardware Installation

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

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 CPCIserial-CAN/402 is to be integrated.
→ Disconnect all hazardous voltages (mains voltage) before opening the system.
→ Ensure the absence of voltage before starting any electrical work

NOTICE
Electrostatic discharges may cause damage to electronic components.

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

Procedure:

1. Switch off your system and all connected peripheral devices (monitor, printer, etc.). Switch off the connected CAN devices.
2. Discharge your body as described above.
3. Disconnect the system from the mains.

   DANGER
   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.
4. Open the case.
5. Set the internal termination jumpers of the CAN interfaces according to your needs, as described for CPCIserial-CAN/402-2(-FD) on page 13
   and for CPCIserial-CAN/402-4-FD(-IRIG-B) on page 14.
   CPCIserial-CAN/402-4-FD-P3 has no internal termination jumpers.
6. Insert the CPCIserial-CAN/402 board into the selected CompactPCI Serial slot.
   Carefully push the board until it snaps into place.
7. Attach the CPCIserial-CAN/402 board.

8. Connect the CAN interfaces via the connectors in the front panel :

CPCIserial-CAN/402-2(-FD):	Connect CAN0 to the lower DSUB9 connector (X400). Connect CAN1 to the upper DSUB9 connector (X410). See page 17 for the position of the connectors in the front panel.
CPCIserial-CAN/402-4-FD:	Connect CAN0 - CAN3 to the DSUB25 connector (X600). See page 18 for the position of the connector in the front panel. You can use the cable CAN/400-4-1C4 by esd (see order information, page 49) as adapter from the DSUB25 connector to 4 DSUB9 connectors.
CPCIserial-CAN/402-4-FD-IRIG-B:	Connect CAN0 - CAN3 and the IRIG-B signals to the DSUB25 connector (X600). See page 18 for the position of the connector in the front panel. You can use the cable CAN/400-4-1C5 by esd (see order information, page 49) as adapter from the DSUB25 connector to 4 DSUB9 connectors.
CPCIserial-CAN/402-4-FD-P3:	This versions has no front panel connectors. The CAN signals are routet via the backplane connector P3. Ensure that EMC directives are followed when the CPCIserial-CAN/402-4-FD-P3 is externally wired.

9. Close the system's case again.

10. **NOTICE**
Please note that the CAN bus has to be terminated at both ends!

If the integrated CAN termination of the CAN interface is not set via the jumpers, the interface has to be terminated externally, read chapter “Correct Wiring of Electrically Isolated CAN Networks“, from page 37.
For external termination esd offers suitable termination connectors for the CAN bus.
Additionally the CAN_GND signal has to be connected to earth at exactly one point.
A CAN participant with electrical connection to earth potential acts as an earth connection.

NOTICE
To ensure the EC Conformity shielded cables have to be used.
In an adapter cable FE (functional earth) shall be connected to the cable shield.

CPCIserial-CAN/402-4-FD: It is recommended to use the cable CAN/400-4-1C4. The CE conformity is granted when using this cable.

CPCIserial-CAN/402-4-FD-IRIG-B: It is recommended to use the cable CAN/400-4-1C5. The CE conformity is granted when using this cable.

For further information about the adapter cables read chapter “Adapter Cables DSUB25 to DSUB9”, page 31

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. Set the interface properties in your operating system. Refer to the documentation of the operating system.

5. Technical Data

5.1 General Technical Data

Power supply voltage	Via CompactPCI Serial bus: nominal voltage: 12 V ±5% according to CPCI-S.0 Specification Absolute maximum power at 12V, 4x CAN ($I_{max.12V}$ = 250 m A): $P_{max:12V}$ = 3 W	
Connectors	P1	(X100, AirMax VS®, 10052825-101LF, Type A Peripheral Slot) - CompactPCI Serial P1
	CPCIserial-CAN/402-2(-FD) only:	
	CAN0 CAN1	(9-pin DSUB, plug, X400) - CAN Interface CAN0 (9-pin DSUB, plug, X410) - CAN Interface CAN1
	CPCIserial-CAN/402-4-FD(-IRIG-B) only:	
	CAN0 - CAN3, IRIG-B	(25-pin DSUB, plug, X600) - CAN Interfaces CAN0 - CAN3 - the IRIG-B option is only equipped on CPCIserial-CAN/402-4-FD-IRIG-B (order No. I.3001.68)
	CPCIserial-CAN/402-4-FD-P3 only:	
	P3	(X100, AirMax VS®, 10052825-101LF, Type A Peripheral Slot) - CompactPCI Serial P3
	Only for test- and programming purposes:	
	X200	JTAG/Debug interface
Temperature range	Operation: 0...+75 °C ambient temperature Storage: -40 °C … +85 °C	
Humidity	max. 90%, non-condensing	
Dimensions	PCB: Front panel:	100 mm x 160 mm without front panel according to CPCI-S0 R1.0 Specification 3U/4HP compliant to IEEE 1101
Weight	ca. 150 g	
Conformity	EN 61000-6-2, EN 61000-6-4, EMC, RoHS, CE	

Table 5: General data of the module

5.2 CompactPCI Serial Interface

Interface	PICMG® CPCI-S.0 Rev. 1.0 supporting PCI Express interface lines according to PCI Express Specification R1.0a, Link width 1x
Connector	P1 Connector (Type A), Peripheral Slot

Table 6: Data of the CompactPCI Serial interface

5.3 Classical CAN Interface

Number of CAN interfaces	CPCIserial-CAN/402-2: 2x high-speed CAN interfaces (CAN0, CAN1)
CAN controller	esdACC in EP4CGX Intel FPGA, according to ISO11898-1 (CAN 2.0A/2.0B)
Physical Layer	Physical layer according to ISO 11898-2, CAN bit rate up to 1 Mbit/s
Bus termination	Terminating resistors can be set between CAN-H and CAN_L via jumpers, resistance: 120 Ω ±5%, 250 mW
Electrical isolation	Electrical isolation via digital isolator and DC/DC-converters is possible: voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to host/system ground; CAN to CAN): 1000V DC @ 1s (I < 1 mA)
Connector	CPCIserial-CAN/402-2: 2x 9-pin DSUB, plug

Table 7: Data of the CAN interfaces

5.4 CAN FD Interface

Number of CAN FD interfaces	CPCIserial-CAN/402-2-FD: 2x CAN FD (CAN0, CAN1) CPCIserial-CAN/402-4-FD-Versions: 4x CAN FD (CAN0 - CAN3)
CAN controller	esdACC in EP4CGX Intel FPGA, according to ISO11898-1:2015
Physical Layer	Physical layer according to ISO 11898-2, CAN bit rates from 10 kbit/s up to 8 Mbit/s with the same CAN transceiver
	INFORMATION Please note that the increased CAN FD bit rate (up to 8 Mbit/s, formerly 5 Mbit/s) is only ensured for products with batch numbers as specified in the table “Hardware” on page 3.
Bus termination	Terminating resistors can be set between CAN-H and CAN_L via jumpers, resistance: 120 Ω ±5%, 250 mW CPCIserial-CAN/402-4-FD-P3 only: In this version the terminating resistors are not equipped and must be set externally!
Electrical isolation	Electrical isolation via digital isolator and DC/DC-converters is possible: voltage over CAN isolation (CAN to slot bracket/EARTH; CAN to host/system ground; CAN to CAN): 1000V DC @ 1s (I < 1 mA) CPCIserial-CAN/402-4-FD-P3 only: No electrical isolation.
Connector	CPCIserial-CAN/402-2-FD: 2x 9-pin DSUB, plug CPCIserial-CAN/402-4-FD(-IRIG-B): 1x 25-pin DSUB, plug CPCIserial-CAN/402-4-FD-P3: CompactPCI serial connector P3

Table 8: Data of the CAN FD interfaces (CAN FD versions only)

INFORMATION
The CAN FD interfaces can also be used as CAN interfaces in Classical CAN applications.

5.5 IRIG-B Interface

INFORMATION
The IRIG-B option is only equipped on the the CPCIserial-CAN/402-4-FD-IRIG-B (I.3001.69)

Number	1 x analog, 1 x digital
Design	IRIG-B Input according to standard 200-87 in format B122 (analog) and B003 (digital), both electrically isolated
Controller	8051 microprocessor, integrated in the FPGA
Connector	DSUB25 in the front panel

Table 9: IRIG-B Inputs

5.6 Software Support

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

The CAN layer 2 (NTCAN-API) drivers for Windows and Linux are included in the scope of delivery of the CPCIserial-CAN/402 boards.
Additional CAN layer 2 (NTCAN-API) drivers for Realtime OS can be ordered separately.
Higher layer protocols (CANopen, J1939, ARINC825) are only supported for Classical CAN applications.

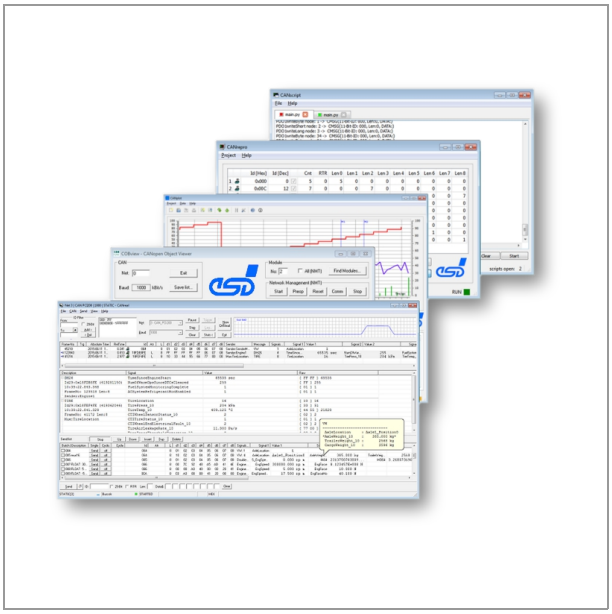
CPCIserial-CAN/402-4-FD, CPCIserial-CAN/402-4-FD-IRIG-B, CPCIserial-CAN/402-2-FD:
See Order Information on page 51 for availability of the drivers.

CPCIserial-CAN/402-2: See Order Information on page 49 for availability of the drivers.

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

5.6.1 CAN Tools

esd offers additional free-of-charge tools for Windows which support efficient setup and analysis of Classical CAN applications and networks.
The CAN Tools are operational with all esd PC-CAN interfaces (e.g. PCIe, USB, EtherCAN/2 ...)



The following CAN Tools are available:

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

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

As part of the esd software development kit (CAN SDK) of the NTCAN-API the CAN Tools are included in delivery of the CAN-CD.
The CAN SDK can also be downloaded free-of-charge from the esd website.

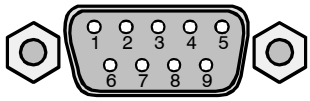
6. Connector Assignments

6.1 CPCIserial-CAN/402-2(-FD): CAN0, CAN1 via DSUB9

The two CAN connectors CAN0 (X400) and CAN1 (X410) in the front panels of the CPCIserial-CAN/402-2-FD and the CPCIserial-CAN/402-2 have the same pin assignment, each for the corresponding CAN interface.

Device connector: 9-pin DSUB connector, plug

Pin Position:



Pin Assignment:

Signal	Pin		Signal
		1	reserved
CAN GND	6	2	CAN L
CAN H	7	3	CAN GND
reserved	8	4	reserved
reserved	9	5	Shield

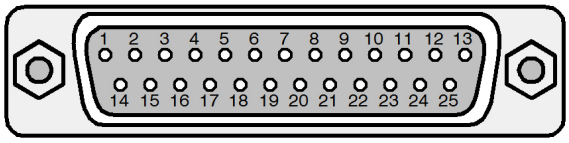
Signal Description:

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)
reserved ...	reserved, do not connect!

6.2 CPCIserial-CAN/402-4-FD: CAN0-3 via DSUB25

Device connector: 25-pin DSUB connector, plug

Pin Position:



Pin Assignment:

Signal	Pin		Signal
CAN0_L	1	14	CAN0_H
CAN0_GND	2	15	-
-	3	16	CAN1_L
CAN1_H	4	17	CAN1_GND
-	5	18	-
CAN2_L	6	19	CAN2_H
CAN2_GND	7	20	-
-	8	21	CAN3_L
CAN3_H	9	22	CAN3_GND
-	10	23	-
-	11	24	-
-	12	25	-
-	13		

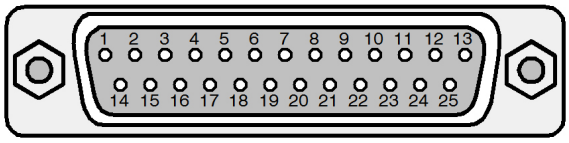
Name	Description
CANx_L, CANx_H	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
CANx_GND	Reference potential of the local CAN physical layer x
-	Reserved - Do not use! (Spare Pin to increase creepage distance)

NOTICE
To ensure the EC Conformity shielded cables have to be used. In an adapter cable FE (functional earth) shall be connected to the cable shield. It is recommended to use the cable CAN/400-4-1C4, as described in chapter 'Adapter Cables DSUB25 to DSUB9', page 31. The conformity is granted when using this cables.

6.3 CPCIserial-CAN/402-4-FD-IRIG-B: CAN0-3, IRIG-B via DSUB25

Device connector: 25-pin DSUB connector, plug

Pin Position:



Pin Assignment:

Signal	Pin		Signal	
CAN0_L	1	14	CAN0_H	
CAN0_GND	2	15	-	
-	3	16	CAN1_L	
CAN1_H	4	17	CAN1_GND	
-	5	18	-	
CAN2_L	6	19	CAN2_H	
CAN2_GND	7	20	-	
-	8	21	CAN3_L	
CAN3_H	9	22	CAN3_GND	
-	10	23	-	
-	11	24	*IRIG-B_RX+*	Optional IRIG-B (I.3001.69 only)
IRIG-B_RX-	12	25	*IRIG-B_A+*	
IRIG-B_A-	13			

INFORMATION
The IRIG-B option is only equipped on the CPCIserial-CAN/402-4-FD-IRIG-B (order No.: I.3001.69). The IRIG-B signals do not apply for the other versions. The pins 12, 13, 24 and 25 are reserved there. The signal assignment of the CAN signals are kept as shown above.

Name	Description
CANx_L, CANx_H	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
CANx_GND	Reference potential of the local CAN physical layer x
-	Reserved - Do not use! (Spare Pin to increase creepage distance)
IRIG-B_RX+, IRIG-B_RX-	IRIG-B input. Physical layer RS-422 compatible.
IRIG-B_A+, IRIG-B_A-	IRIG-B analog input.

NOTICE
To ensure the EC Conformity shielded cables have to be used. In an adapter cable FE (functional earth) shall be connected to the cable shield. It is recommended to use the cable CAN/400-4-1C5, as described in chapter 'Adapter Cables DSUB25 to DSUB9', page 31. The conformity is granted when using this cables.

6.4 Adapter Cables DSUB25 to DSUB9

esd offers the following two adapter cables (see also Order Information on page 49):
- CAN/400-4-1C4 1xDSUB25-to-4xDSUB9 (order no. C.2047.19)
- CAN/400-4-1C5 1xDSUB25-to-5xDSUB9 (order no. C.2047.18)

CAN/400-4-1C4 (to product I.3001.68)
This adapter only connects the four CAN interfaces to the DSUB25 front panel connector. The cable comes with four DSUB9 plugs for the CAN interfaces (CAN0 -CAN3).

NOTICE
To ensure the EC Conformity shielded cables have to be used. In this adapter cables FE (functional earth) is connected to the cable shield.

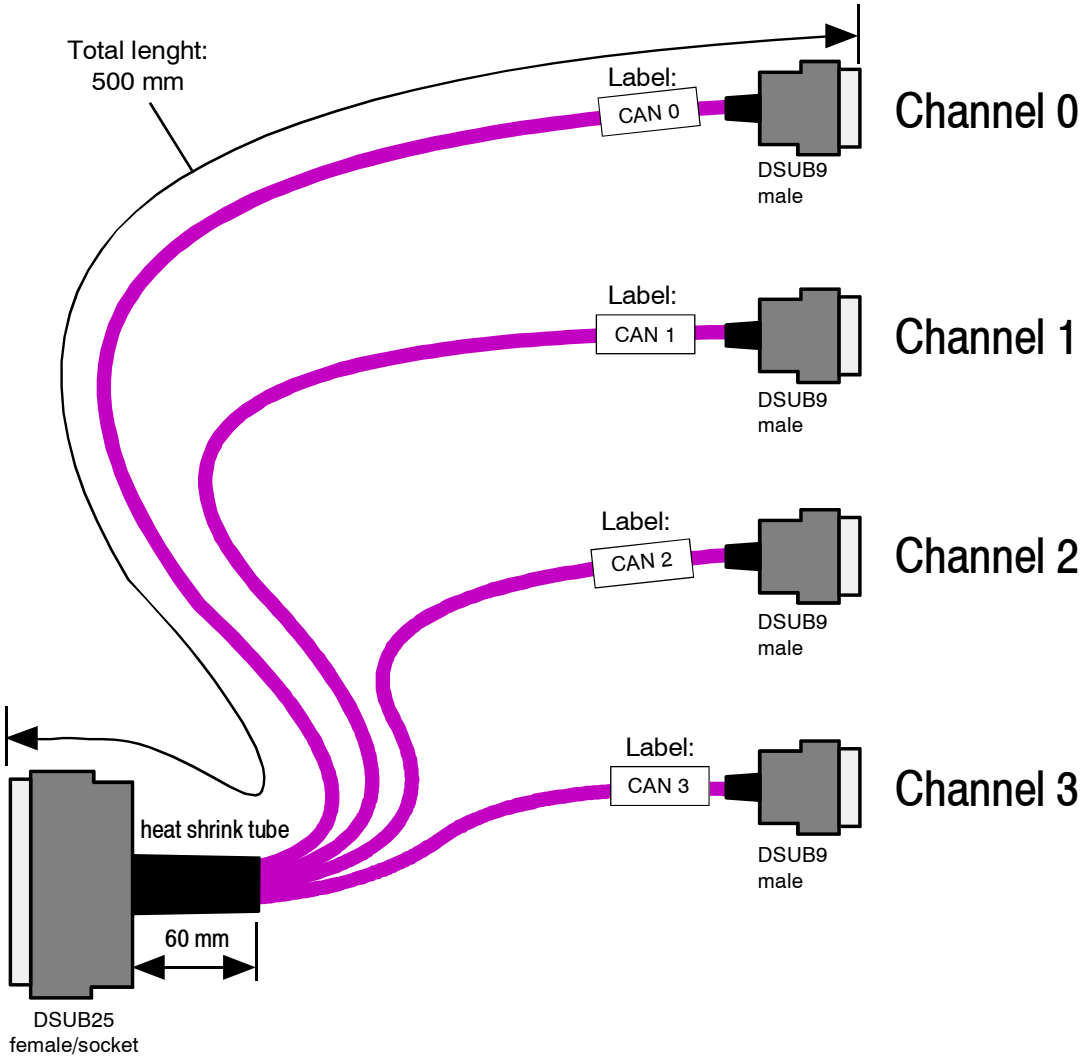


Figure 10: Adapter DSUB25 to 4x DSUB9 (C.2047.19)

CAN/400-4-1C5 (to product I.3001.69, with IRIG-B option)
This adapter is designed as CAN/400-4-1C4 with 4 DSUB9 plugs for the CAN interfaces (CAN0 -CAN3) but comes with an additional DSUB9 socket for the IRIG-B inputs.

Adapter DSUB25 to 4x DSUB9 (plug) and optional DSUB9 (socket, C.2047.18 only)

DSUB25 Connector		Cable		DSUB9 Connnector		Signal Name
Connector Type	Pin No.	Interface	Wire (internal)	Connector Type	Pin No.	
DSUB25 socket, female						
	1	CAN0	white	DSUB9 plug, pin contacts	2	CAN0_L
	14		brown		7	CAN0_H
	2		green		3	CAN0_GND
	Connector housing		shield		Connector housing	FE
	16	CAN1	white	DSUB9 plug, pin contacts	2	CAN1_L
	4		brown		7	CAN1_H
	17		green		3	CAN1_GND
	Connector housing		shield		Connector housing	FE
	6	CAN2	white	DSUB9 plug, pin contacts	2	CAN2_L
	19		brown		7	CAN2_H
	7		green		3	CAN2_GND
	Connector housing		shield		Connector housing	FE
						-
	21	CAN3	white	DSUB9 plug, pin contacts	2	CAN3_L
	9		brown		7	CAN3_H
	22		green		3	CAN3_GND
	Connector housing		shield		Connector housing	FE
	CAN/400-4-1C5 (order no.: C.2047.18, with IRIG-B) only:					
	24	IRIG-B	white	DSUB9 socket, socket contacts	9	IRIG-B_Rx+
	12		brown		4	IRIG-B_Rx-
	25		green		1	IRIG-B_A+
	13		yellow		8	IRIG-B_A-
	Connector housing		shield		Connector housing	FE

CANx-GND are isolated from each other. They are not tied together by the adapter cable.

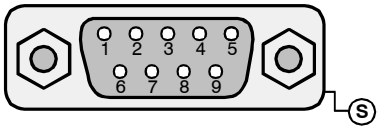
See also Figures 11 and 12, on page 35 for a description of the wiring of the analog and digital IRIG-B interfaces.

6.4.1 CAN Interfaces via DSUB9 Plugs

Four DSUB9 plugs for the CAN0 - CAN3 interfaces are equipped on the cables:
- CAN/400-4-1C4 1xDSUB25-to-4xDSUB9 (order no. C.2047.19)
- CAN/400-4-1C5 1xDSUB25-to-5xDSUB9 (order no. C.2047.18)

Device connector: 9-pin DSUB connector, pin contact

Pin Position:



Pin Assignment:

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

FE	S (Shield)

Signal Description:

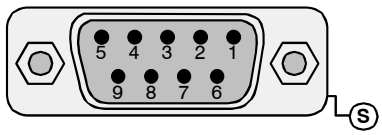
Name	Description
-	Reserved - Do not use! This pin is not connected at the module.
CANx_L, CANx_H, CANx_GND	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

6.4.2 IRIG-B Input via DSUB9 Socket

The cable **CAN/400-4-1C5 1xDSUB25-to-5xDSUB9** (order no. C.2047.18) comes with an additional DSUB9 socket for the IRIG-B interfaces.

Device connector: 9-pin DSUB, socket contacts

Pin Position:



Pin Assignment:

Signal	Pin		Signal
IRIG-B A+	1	6	-
-	2	7	-
-	3	8	IRIG-B A-
IRIG-B Rx-	4	9	IRIG-B Rx+
-	5		

FE	S (Shield)

Name	Description
-	Reserved - Do not use! This pin is not connected at the module.
IRIG-B A+/-	Analogue IRIG-B input acc. to standard 200-87, format B122
IRIG-B_RX+/-	Digital IRIG-B input acc. to standard 200-87, format B003
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

See also Figure 12, on page 35 for a description of the wiring of the analog and digital IRIG-B interfaces.

6.4.2.1 IRIG-B Wiring at CAN/400-4-1C5

In the adapter CAN/400-4-1C5 (order no. C.2047.18) for the IRIG-B wiring a shielded twisted pair cable is used. FE (functional earth) is connected to the cable shield in this cable as described in the following figures.

Analog and digital IRIG-B at DSUB25 socket

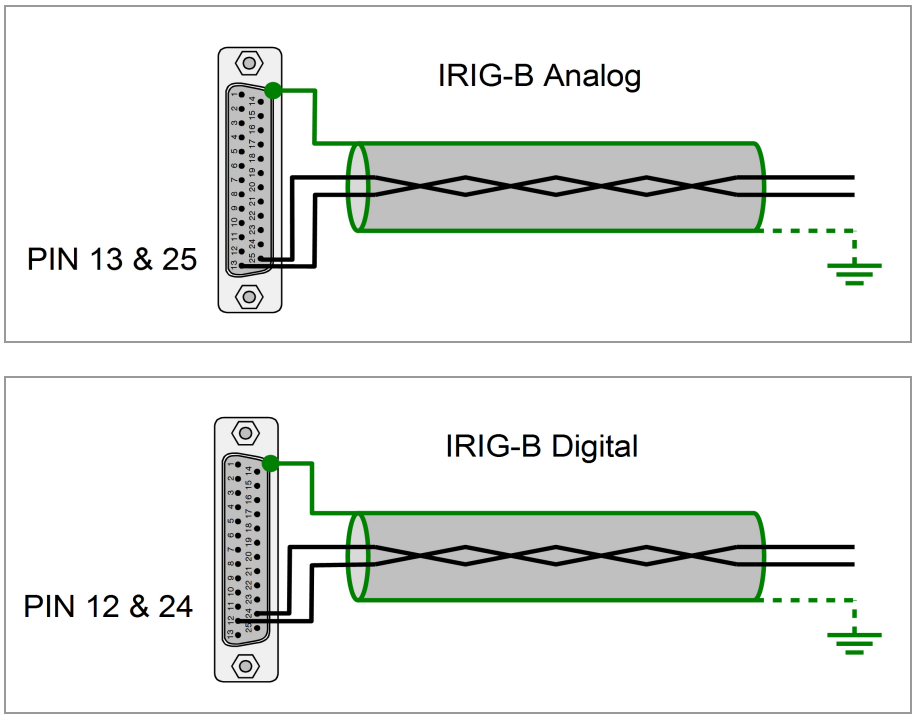


Figure 11: Analog and digital IRIG-B wiring guidelines at DSUB25

Analog and digital IRIG-B at DSUB9 socket

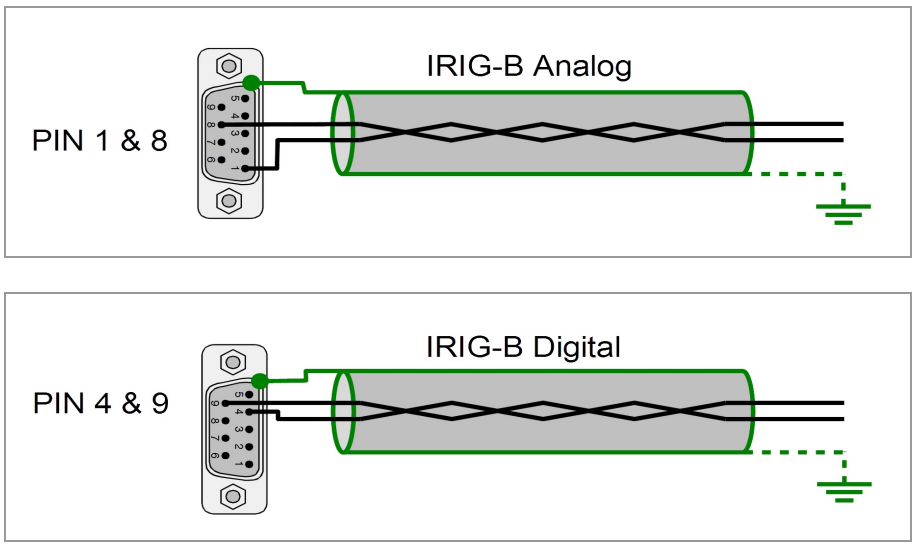


Figure 12: IRIG_B wiring guidelines at DSUB9

6.5 CPCIserial-CAN/402-4-FD-P3: CAN0-3 via P3

Signal	PIN on P3	Direction	Function	Voltage Level
CAN0_Tx	K6	Output	CAN Transmit	3,3V LVTTL
CAN0_Rx	L6	Input	CAN Receive	3,3V LVTTL
CAN1_Tx	J5	Output	CAN Transmit	3,3V LVTTL
CAN1_Rx	K5	Input	CAN Receive	3,3V LVTTL
CAN2_Tx	J7	Output	CAN Transmit	3,3V LVTTL
CAN2_Rx	K7	Input	CAN Receive	3,3V LVTTL
CAN3_Tx	K8	Output	CAN Transmit	3,3V LVTTL
CAN3_Rx	L8	Input	CAN Receive	3,3V LVTTL
CAN0_LED	K2	Output	Traffic LED CAN0	3,3V LVTTL
CAN1_LED	K1	Output	Traffic LED CAN1	3,3V LVTTL
CAN2_LED	I8	Output	Traffic LED CAN2	3,3V LVTTL
CAN3_LED	K3	Output	Traffic LED CAN3	3,3V LVTTL
IRIG_LED	L2	Output	Status LED IRIG	3,3V LVTTL
READY_LED	J1	Output	Card Ready LED	3,3V LVTTL
RESERVED (LED)	H4	Output	Reserved LED	3,3V LVTTL
RESERVED (LED)	I4	Output	Reserved LED	3,3V LVTTL
IRIG_PULSE	H8	Input	IRIG-B Digital Input	3,3V LVTTL
IRIG_SCLK	J3	Output	IRIG-B Analog ADC Clock	3,3V LVTTL
IRIG_CS#	K4	Output	IRIG-B Analog ADC Chip Select	3,3V LVTTL
IRIG_DAT	L4	Input	IRIG-B Analog ADC Data	3,3V LVTTL

Signal	PINs on P3
GND	C5, F5, I5, L5, A6, D6, G6, J6, C7, F7, I7, L7, A8, D8, G8, J8, I1, L1, A2, D2, G2, J2, C3, F3, I3, L3, A4, D4, G4, J4
5V	B8, C8, E8, F8
3,3V	A1, B1, D1, E1, G1, H1

NOTICE
To ensure the EC Conformity the user must ensure that EMC directives are followed when the CPCIserial-CAN/402-4-FD-P3 is externally wired.

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 to the specifications of CANopen, ARINC825, DeviceNet and NMEA2000, **however it must be observed that it is strictly not recommended to mix the wiring guidelines of the various specifications!**

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

7.2.1 General Rules

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

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

1	A 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.

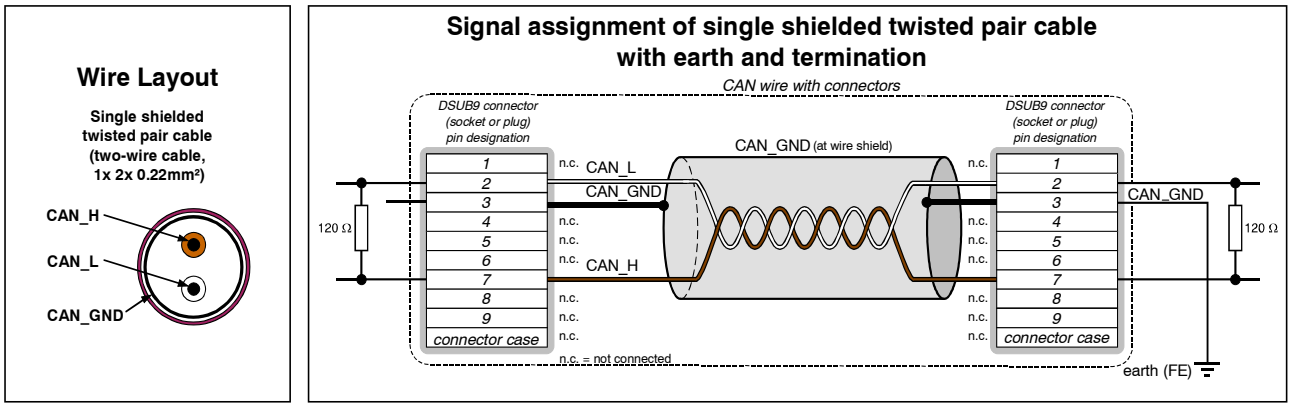


Figure 13: CAN wiring for light industrial environment

7.2.2 Cabling

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

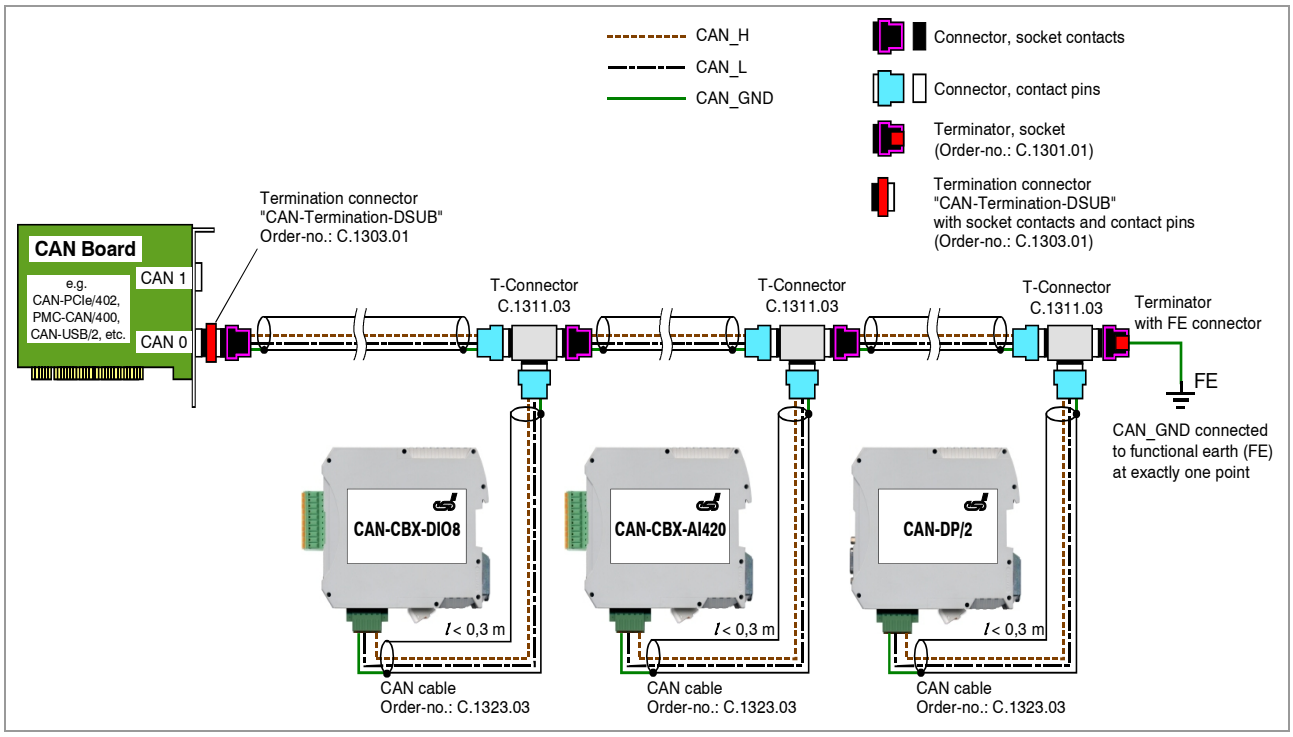


Figure 14: Example for proper wiring with single shielded single twisted pair wires

7.2.3 Branching

- In principle the CAN bus 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 pin contacts and socket contacts are available from esd (order no. C.1303.01).
- DSUB termination connectors with pin contacts (order no. C.1302.01) or socket 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.

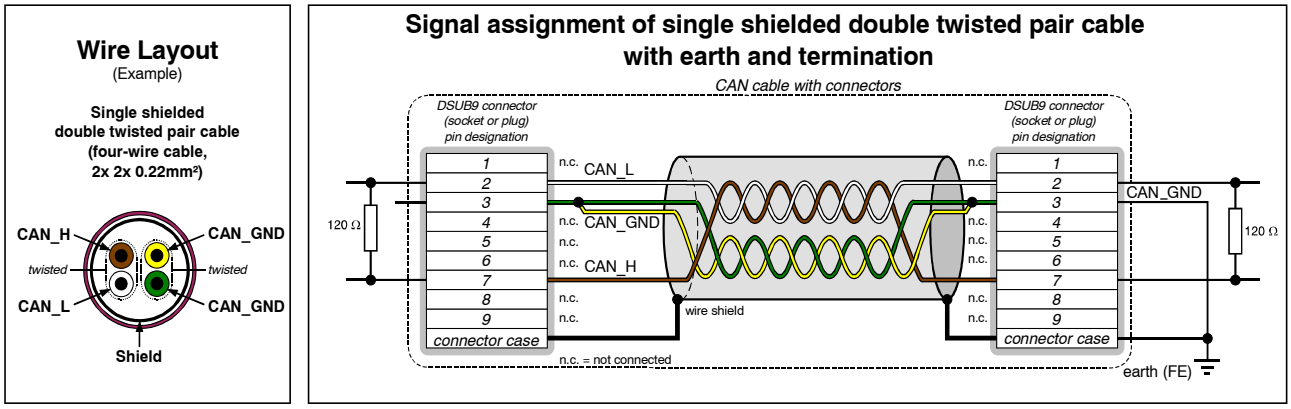


Figure 15: CAN wiring for heavy industrial environment

7.3.2 Device Cabling

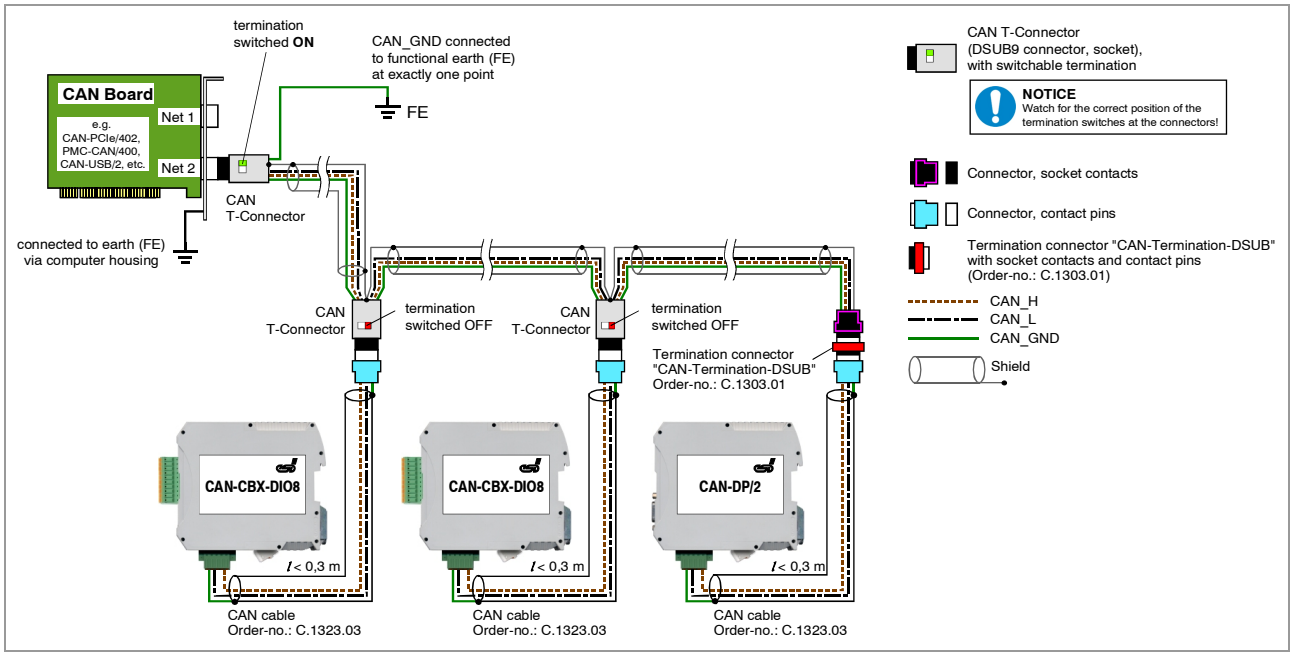


Figure 16: Example of proper wiring with single shielded double twisted pair cables

7.3.3 Branching

- In principle the CAN bus 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 pin contacts and socket 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, socket contacts, order no.:154039).

7.4 Electrical Grounding

- For CAN devices with electrical isolation the CAN_GND must be connected between the CAN devices.
- CAN_GND should be connected to the earth potential (FE) at **exactly one** point of the network.
- Each *CAN interface with electrical connection to earth potential* acts as a grounding point. For this reason it is recommended not to connect more than one *CAN device with electrical connection to earth potential.*
- Grounding can be 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 ISO11898-2.
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 1.8.0, 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
800 666,6̄ 500 333,3̄ 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 83,3̄ 66,6̄ 50	710 850 1000 1400	650 - - 1000	0,75 to 0,8
33,3̄ 20 12,5 10	2000 3600 5400 7300	- 2500 - 5000	not defined in CiA 303-1

Table 10: 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.

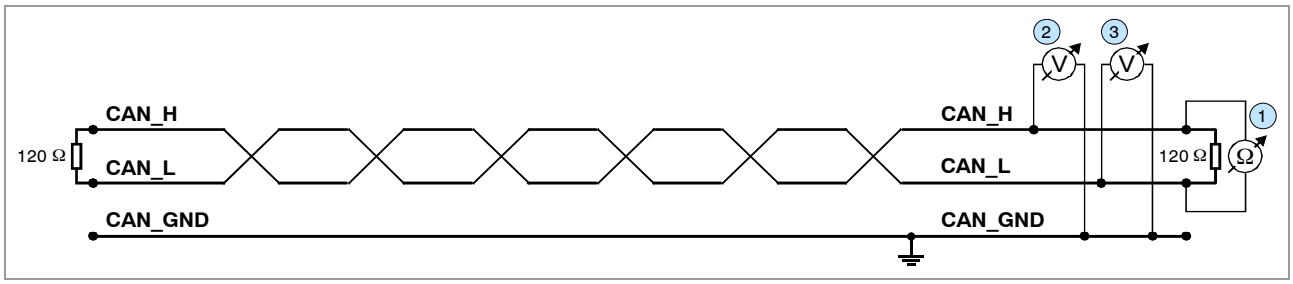


Figure 17: Simplified diagram of a CAN network

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.

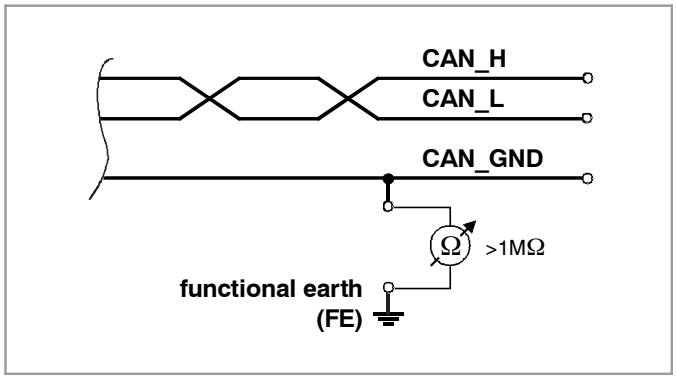


Figure 18: Simplified schematic diagram of ground test measurement

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 %).

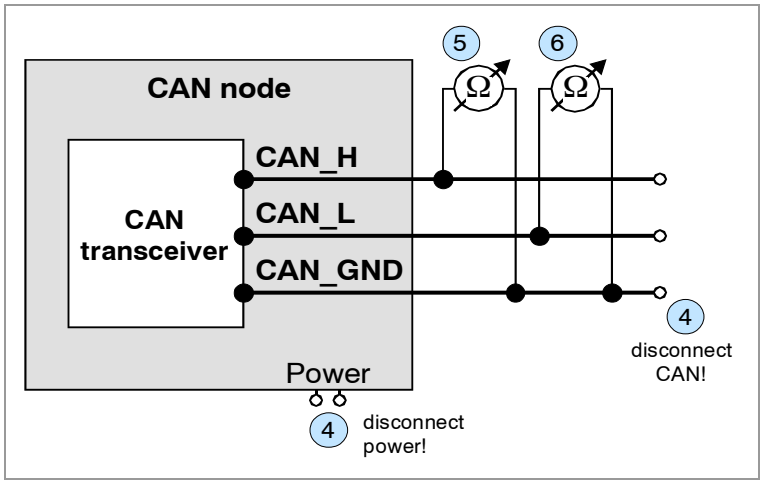


Figure 19: Measuring the internal resistance of CAN transceivers

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

9.1 CPCIserial-CAN/402-2-FD and CPCIserial-CAN/402-2

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. *Type, Model, Article No.*
CPCIserial-CAN/402-2 **CPCIserial-CAN/402-2-FD**	**I.3001.04** **I.3001.64**
die Anforderungen der Normen *fulfills the requirements of the standards*	**EN 61000-6-2:2005,** **EN 61000-6-4:2007/A1:2011**
gemäß folgendem Prüfbericht erfüllt. *according to test certificate.*	**H-K00-0582-15**
Das Produkt entspricht damit der EU-Richtlinie „EMV" *Therefore the product conforms to the EU Directive 'EMC'*	**2014/30/EU**
Das Produkt entspricht der EU-Richtlinie „RoHS" *The product conforms to the EU Directive '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
Datum / *Date* Hannover, 2019-03-07

Rechtsgültige Unterschrift / *authorized signature*

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9.2 CPCIserial-CAN/402-4-FD Versions

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. *Type, Model, Article No.*
CPCIserial-CAN/402-4-FD	**I.3001.68**
CPCIserial-CAN/402-4-FD-IRIG-B	**I.3001.69**
CPCIserial-CAN/402-4-FD-P3	**I.3001.88**
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9	**C.2047.19**
CAN/400-5-1C4 1xDSUB25-to-5xDSUB9	**C.2047.18**
die Anforderungen der Normen *fulfills the requirements of the standards*	**EN 61000-6-2:2005,** **EN 61000-6-4:2007/A1:2011**
gemäß folgendem Prüfbericht erfüllt. *according to test certificate.*	**H-K00-0682-17**
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, 2022-04-05

Rechtsgültige Unterschrift / *authorized signature*

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10. Order Information

10.1 Hardware

Type	Properties	Order No.
CPCIserial-CAN/402-2-FD	3U/4HP CompactPCI Serial (CPCI-S.0) interface card, 2 x CAN FD at front via 2x DSUB9 and with esd Advanced CAN Core (esdACC) incl. Driver CD for Windows/Linux	I.3001.64
CPCIserial-CAN/402-4-FD	3U/4HP CompactPCI Serial (CPCI-S.0) interface card, 4 x CAN FD at front via 1x DSUB25 and with esd Advanced CAN Core (esdACC) incl. Driver CD for Windows/Linux	I.3001.68
CPCIserial-CAN/402-4-FD-IRIG-B	3U/4HP CompactPCI Serial (CPCI-S.0) interface card, with 4x CAN FD and 1x IRIG-B at front via 1x DSUB25, with esd Advanced CAN Core (esdACC) incl. Driver CD for Windows/Linux	I.3001.69
CPCIserial-CAN/402-4-FD-P3	esd Advanced CAN Core (esdACC) based CompactPCI Serial (CPCI-S.0, 3U/4HP) interface board with 4x CAN FD via P3 connector to backplane incl. driver for Windows & Linux	I.3001.88
CPCIserial-CAN/402-2	3U/4HP CompactPCI Serial (CPCI-S.0) interface card, 2 x CAN at front via 2x DSUB9 and with esd Advanced CAN Core (esdACC) incl. Driver CD for Windows/Linux	I.3001.04
Accessories		
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9	Adapter cable DSUB25 socket to 4x DSUB9 plug (4x CAN), length: 0.5 m, to product: I.3001.68	C.2047.19
CAN/400-4-1C5 1x DSUB25-to-5x DSUB9	Adapter cable DSUB25 socket to 4x DSUB9 plug (4x CAN) and 1x DSUB9 socket (IRIG-B), length: 0.5 m, to product: I.3001.69	C.2047.18

Table 11: Order information hardware

10.2 Software for CPCIserial-CAN/402-2

Type		Order No.
CAN layer 2 software drivers for Windows and Linux on CD-ROM to CPCIserial-CAN/402-2 (I.3001.04) 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 RTX and RTX64	C.1101.35
CAN-DRV-LCD CDROM+Lizenz VxWorks	Object Licence and CD-ROM for VxWorks 5.x and 6.x	C.1101.55
CAN-DRV-LCD On Time RTOS-32	Object Licence and CD-ROM for On Time RTOS-32	C.1101.45
Higher-Layer Protocols including CD-ROM (Classical CAN Applications only):		
CANopen-LCD Windows/Linux	CANopen Object Driver Licence + CD-ROM for Windows / Linux	C.1101.06
CANopen-LCD QNX	CANopen Object Driver Licence + CD-ROM for QNX	C.1101.17
CANopen-LCD RTX	CANopen Object Driver Licence + CD-ROM for RTX	C.1101.16
CANopen-LCD VxWorks	CANopen Object Driver Licence + CD-ROM for VxWorks	C.1101.18
J1939 Stack for Windows (Object)	J1939 Stack for esd CAN Hardware, Windows Object Code, incl. J1939 Simulation Tool	C.1130.10
J1939 Stack for Linux (Object)	J1939 Stack for esd CAN Hardware, Linux Object Code	C.1130.11
J1939 Stack for RTX (Object)	J1939 Stack for esd CAN Hardware, RTX Object Code	C.1130.12
ARINC 825-LCD Windows/Linux/LabVIEW	Licence and CD for esdACC based CAN-Boards for Windows/ Linux/ LabVIEW, incl. Object Driver Licence	C.1140.06
ARINC 825-LCD QNX	Licence and CD for esdACC based CAN-Boards for QNX, incl. Object Driver Licence	C.1140.17
ARINC 825-LCD RTX	Licence and CD for esdACC based CAN-Boards for RTX, incl. Object Driver Licence	C.1140.16
ARINC 825-LCD VxWorks	Licence and CD for esdACC based CAN-Boards for VxWorks, incl. Object Driver Licence	C.1140.18
For detailed information about the driver availability for your special operating system, please contact our sales team.		

Table 12: Order information software for CPCIserial-CAN/402-2

10.3 Software for CPCIserial-CAN/402-FD

Type		Order No.
CAN layer 2 software drivers for Windows and Linux on CD-ROM to CPCIserial-CAN/402-2-FD (I.3001.64) and CPCIserial-CAN/402-4-FD (I.3001.68) 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
Higher-Layer Protocols including CD-ROM for Classical CAN Applications:		
CANopen-LCD Windows/Linux	These drivers are available for **Classical CAN operation 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 13: Order information software for CAN FD versions

10.4 Manuals

PDF Manuals
For availability of English manuals see table below.
Please download the manuals as PDF documents from our esd website www.esd.eu for free.

Manuals		Order No.
CPCIserial-CAN/402-ME	Hardware manual in English for CPCIserial-CAN/402-2 and CPCIserial-CAN/402-4-FD	I.3001.21
CAN-API-ME	NTCAN API manual Part 1: Application Developers Manual NTCAN API manual Part 2: Installation Guide	C.2001.21

Table 14: 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.