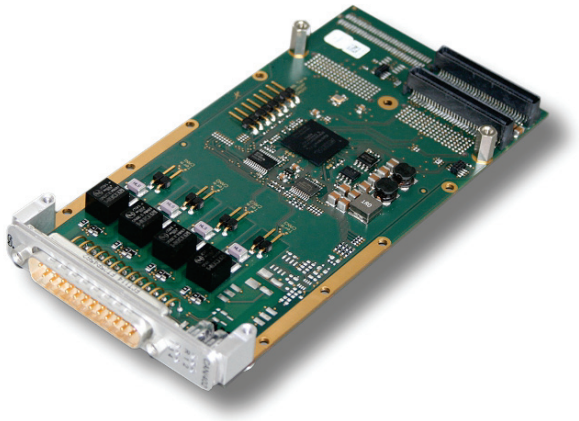
powerBridge Computer

Ehlbeek 15a
30938 Burgwedel
fon 05139-9980-0
fax 05139-9980-49

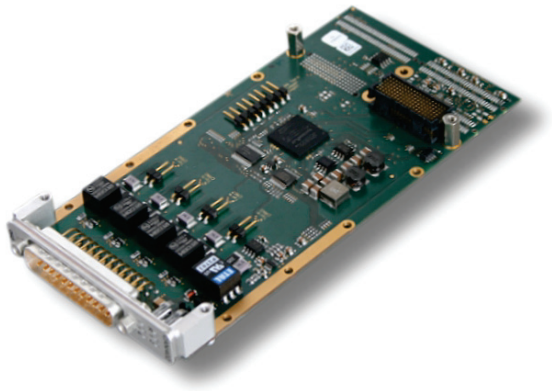
www.powerbridge.de
info@powerbridge.de

PMC-CAN/402-4-FD, XMC-CAN/402-4-FD

PMC or XMC Board with 4 CAN FD Interfaces and optional IRIG-B



PMC-CAN/402-4-FD



XMC-CAN/402-4-FD

Hardware Manual

to Products C.2018.68, C.2018.69
C.2028.68, C.2028.69, C.2028.78

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

N O T E

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esd electronics gmbh
Vahrenwalder Str. 207
30165 Hannover
Germany

Phone: +49-511-372 98-0
Fax: +49-511-372 98-68
E-Mail: info@esd.eu
Internet: www.esd.eu

This manual contains important information and instructions on safe and efficient handling of the PMC/XMC-CAN/402-4-FD. Carefully read this manual before commencing any work and follow the instructions.
The manual is a product component, please retain it for future use.

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Hardware version:	PCB 1.1

Document History

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

Rev.	Chapter	Changes versus previous version	Date
1.0	-	First English manual for PMC-CAN/402-4-FD and XMC-CAN/402-4-FD	2017-12-12
1.1	1.2, 6.7	Note on potential interoperability with enabled PCI Express Native Mode inserted (PMC-CAN/402-4-FD only)	2018-02-23
	10.	Chapter inserted:“Application Note to PMC-CAN/402”	
1.2	1.2	Note on CAN FD inserted	2018-12-21
	1.2, 6.7	Note on potential interoperability revised (PMC-CAN/402-4-FD only)	
	10.	Chapter revised, note on Linux operating systems added	
1.3	-	Note on conformity added under Safety Instructions	2019-06-18
	1.2	Description of esdACC and CAN FD supplemented	
	1.3	PMC-CAN/402-4-FD-T added, customization of temperature range deleted	
	10.2	Link to Linux-PCI kernel mailing list updated	
	11.	Declarations of Conformity updated	
	12.	PMC-CAN/402-4-FD-T added in Order Information	

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 PMC/XMC-CAN/402-4-FD follow the instructions below and read the manual carefully to protect yourself from injury and the PMC/XMC-CAN/402-4-FD from damage.
- The device is a built-in component. It is essential to ensure that the device is mounted in a way that cannot lead to endangering or injury of persons or damage to objects.
- Do not use damaged or defective cables to connect the PMC/XMC-CAN/402-4-FD and follow the CAN wiring hints in chapter: "Correct Wiring of Electrically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- Current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1).
- The PMC/XMC-CAN/402-4-FD 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 PMC/XMC-CAN/402-4-FD from dust, moisture and steam.
- Protect the PMC/XMC-CAN/402-4-FD from shocks and vibrations.
- The PMC/XMC-CAN/402-4-FD may become warm during normal use. Always allow adequate ventilation around the PMC/XMC-CAN/402-4-FD and use care when handling.
- Do not operate the PMC/XMC-CAN/402-4-FD adjacent to heat sources and do not expose it to unnecessary thermal radiation. Ensure an ambient temperature as specified in the technical data.

DANGER

Hazardous Voltage - **Risk of electric shock** due to unintentional contact with uninsulated live parts with high voltages inside of the system into which the PMC/XMC-CAN/402-4-FD is to be integrated.

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

→ Ensure the absence of voltage before starting any electrical work

NOTICE

Electrostatic discharges may cause damage to electronic components.

→ To avoid this, please discharge the static electricity from your body *before* you touch the PMC/XMC-CAN/402-4-FD.

→ Furthermore, you should prevent your clothes from touching the PMC/XMC-CAN/402-4-FD, because your clothes might be electrostatically charged as well.

Qualified Personnel

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

Conformity

The PMC/XMC-CAN/402-4-FD is an industrial product and meets the demands of the EU regulations and EMC standards printed in the conformity declaration at the end of this manual.

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

The PMC/XMC-CAN/402-4-FD is a sub-assembly intended for incorporation into an apparatus by a manufacturer. The manufacturer of the final system must decide, whether additional EMC or EMI protection requirements are necessary.

Intended Use

The intended use of the PMC-CAN/402-4-FD is the operation as PMC-CAN interface on a base board according to IEEE 1386.1-2001.
The intended use of the XMC-CAN/402-4-FD is the operation as XMC-CAN interface on a base board according to Vita 42.3.
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 PMC-CAN/402-4-FD is intended for installation in PMC slots according to IEEE 1386.1-2001. The XMC-CAN/402-4-FD is intended for installation in XMC slots according to Vita 42.3.
- The operation of the PMC/XMC-CAN/402-4-FD in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the PMC/XMC-CAN/402-4-FD for medical purposes is prohibited.

Service Note

The PMC/XMC-CAN/402-4-FD does not contain any parts that require maintenance by the user. The PMC/XMC-CAN/402-4-FD does not require any manual configuration of the hardware. Unauthorized intervention in the device voids warranty claims.

Disposal

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

Typographical Conventions

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

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

Number Representation

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

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

In this manual the PMC-CAN/402-4-FD and the XMC-CAN/402-4-FD and their order options with additional IRIG-B interface are described together as PMC/XMC-CAN/402-4-FD.
Differences of the boards are noted where they are described.

1.2 General Properties of the PMC/XMC-CAN/402-4-FD

The PMC/XMC-CAN/402-4-FD comes with four independent CAN FD interfaces according to ISO 11898-1:2015, which are driven by the ISO 16845:2004 certified esdACC (esd advanced CAN Core), implemented in an Intel® (formerly Altera®) FPGA.
For further information about esdACC see https://esd.eu/en/products/esdacc.

CAN FD
Due to the 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 qualities of the Classical CAN.
The PMC/XMC-CAN/402-4-FD is 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 PMC/XMC-CAN/402-4-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 PMC/XMC-CAN/402-4-FD has to communicate with the CAN nodes via Classical CAN frames, because Classical CAN controllers 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.

CAN Data Management
The FPGA supports bus mastering (firstparty 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.

Overview

Due to the usage of MSI (Message Signalled Interrupts) the PMC/XMC-CAN/402-4-FD can be operated for example in Hypervisor environments. It provides high resolution 64-bit hardware timestamps for CAN messages.

NOTICE (PMC-CAN/402-4-FD versions only)
PMC-CAN/402-4-FD boards which are equipped with the Pericom® PCI-to-PCI bridge PI7C9X111SL might have a potential interoperability problem in Microsoft Windows or in Linux operating systems. Read chapter “Application Note to PMC-CAN/402“ on page 40 for information about this.

Additional IRIG-B

The PMC/XMC-CAN/402-4-FD-IRIG-B comes with an additional IRIG-B interface, via the DSUB25 connector. The interface offers inputs for analog or RS-422 compatible IRIG-B coded signals at the front panel. Both are electrically isolated.
IRIG-B evaluation is controlled by an additional soft microcontroller implemented in the FPGA.

Extended Temperature Range

Optional the version PMC-CAN/402-4-FD-T of the PMC board is designed to be used in an extended temperature range (-40° C … +75° C)

Accessories

Adapter cables for the 25-pin DSUB connector in the front panel to 9-pin DSUB connectors for 4x CAN and optional IRIG-B (analog and RS-422 compatible) are available.

Customization

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

1.3 PMC-CAN/402-4-FD

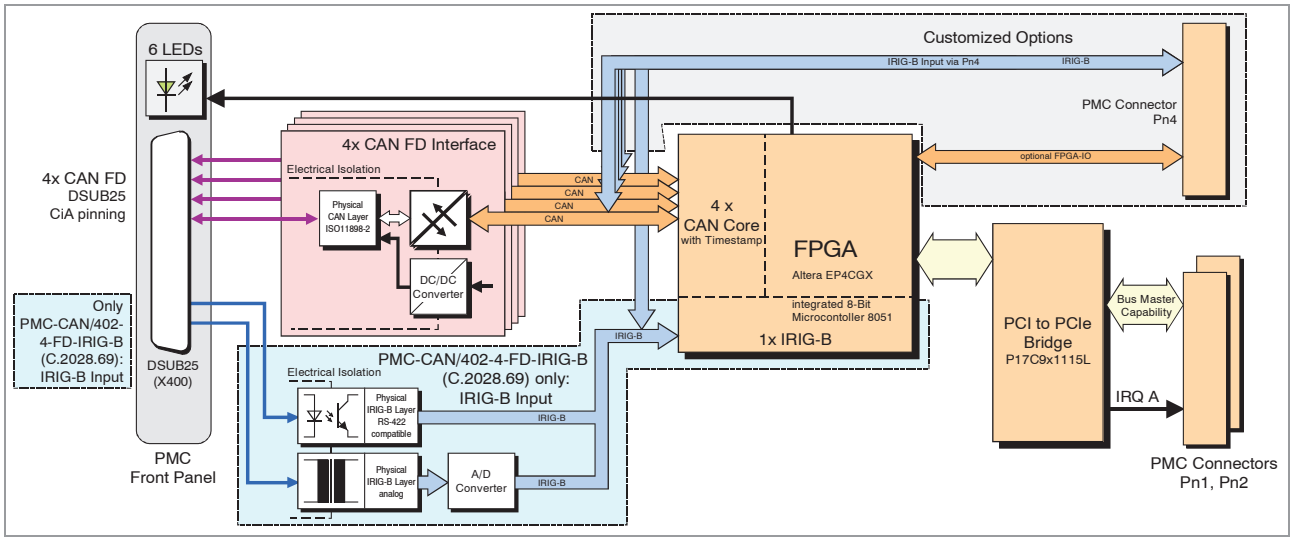


Figure 1: Block circuit diagram PMC-CAN/402-4-FD versions

Figure 1 shows the block circuit diagram of PMC-CAN/402-4-FD, PMC-CAN/402-4-FD-T and PMC-CAN/402-4-FD-IRIG-B

Customized solutions are e.g.:
- Digital input (RS-422 compatible) for IRIG-B via PMC connector Pn4 (without electrical isolation).
- Error simulation support
- All signals via Rear I/O

1.4 XMC-CAN/402-4-FD

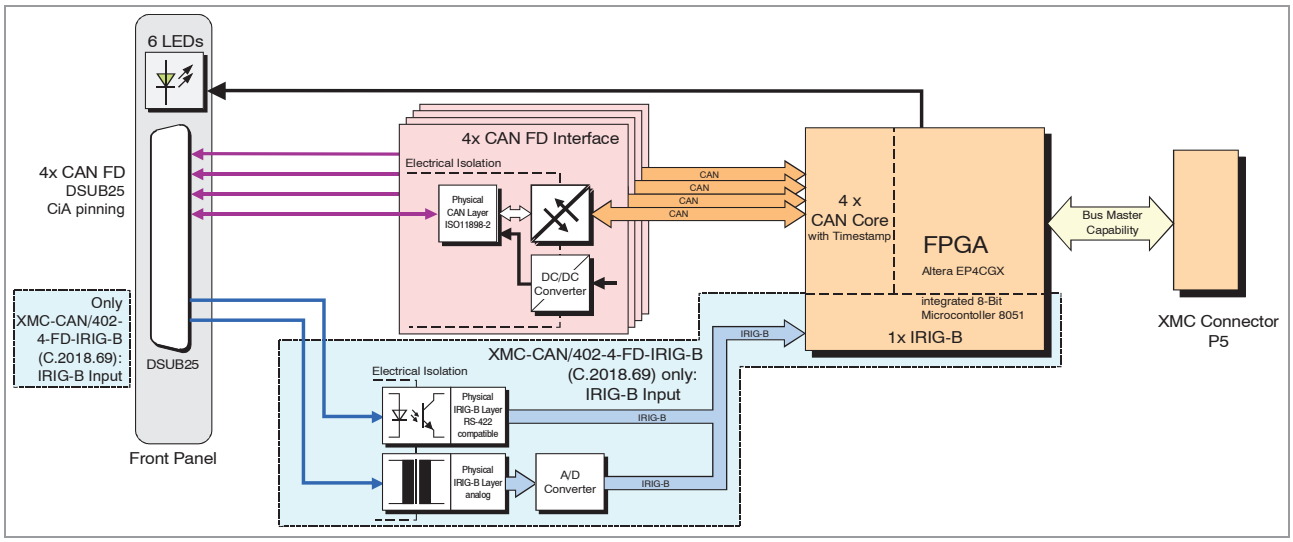


Figure 2: Block circuit diagram XMC-CAN/402-4-FD(-IRIG-B)

Figure 2 shows the block circuit diagram of XMC-CAN/402-4-FD and XMC-CAN/402-4-FD-IRIG-B.

Customized solutions are e.g.:
- Extended temperature range: -40° C … +75° C
- Digital input (RS-422 compatible) for IRIG-B via Rear I/O connector (without electrical isolation).
- Error simulation support
- All signals via Rear I/O

2. PCB-View with Connector and Jumper Positions

2.1 PMC-CAN/402-4-FD Versions

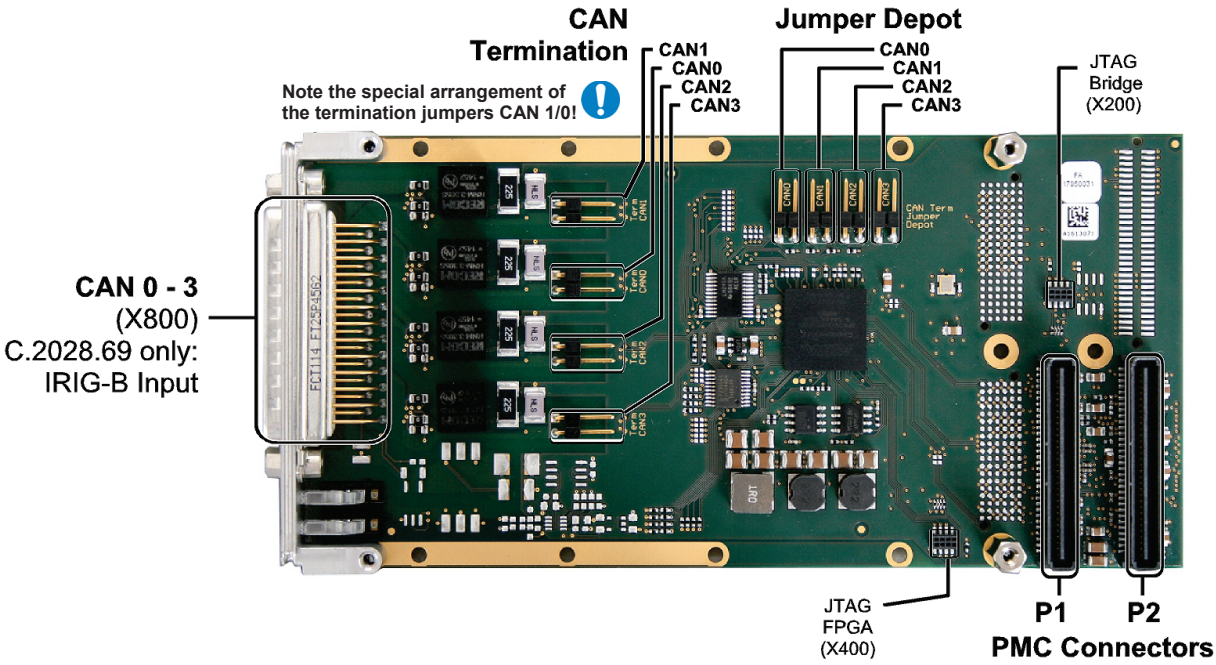


Figure 3: Top layer view of PMC-CAN/402-4-FD facing the carrier board

See also from page 21 for signal assignment of the connectors.

2.2 XMC-CAN/402-4-FD Versions

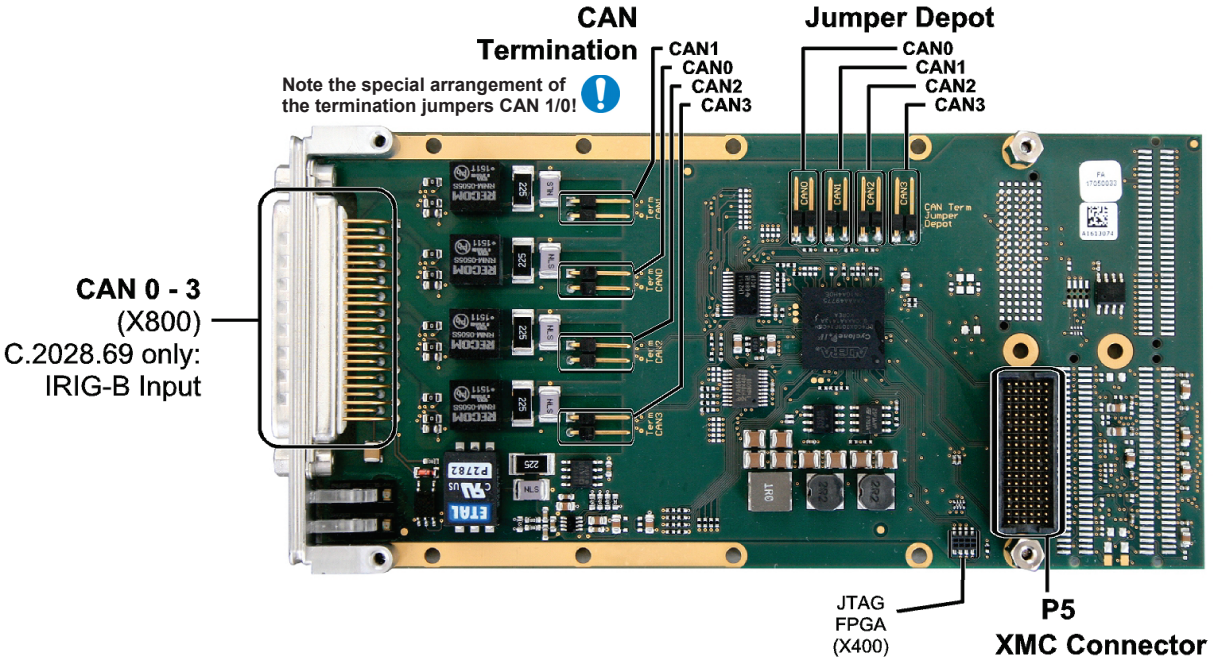


Figure 4: Top layer view of XMC-CAN/402-4-FD facing the carrier board

See also from page 21 for signal assignment of the connectors.

3. Jumper Configuration

3.1 CAN Termination

An on-board termination resistor of 120Ω can be individually enabled for each CAN interface via jumpers.
For the position of the jumpers and jumper depots on the PMC/XMC-CAN/402-4-FD see Figure 3 or 4 on page 12.

Name	Jumper	Jumper set	Jumper not set	Jumper Depot
CAN1	JP610	Internal termination of CAN1	CAN1 has to be terminated externally	JP531
CAN0	JP600	Internal termination of CAN0	CAN0 has to be terminated externally	JP530
CAN2	JP700	Internal termination of CAN3	CAN3 has to be terminated externally	JP532
CAN3	JP710	Internal termination of CAN2	CAN2 has to be terminated externally	JP533

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

4. LEDs

The PMC/XMC-CAN/402-4-FD is equipped with 6 green LEDs in the front panel.

INFORMATION
The IRIG-B option is only available on the the PMC/XMC-CAN/402-4-FD-IRIG-B boards (C.2028.69 and C.2018.69)

Figure 5: Front panel view of PMC/XMC-CAN/402-4-FD

Label	Function	**Indication** (LED on)
R	RUN	Board (FPGA) booted
I	IRIG-B	IRIG-B Link - PMC/XMC-CAN/402-4-FD-IRIG-B only, (C.2018. 69 and C.2028.69) flickering - no signal blinking - synchronisation is proceeding on - synchronised
	Reserved	Reserved - For the PMC/XMC-CAN/402-4-FD boards without IRIG-B option (C.2018.68 and C.2028.68) the LED is without function
1	CAN 0	blinking - Traffic on CAN 0
2	CAN 1	blinking - Traffic on CAN 1
3	CAN 2	blinking - Traffic on CAN 2
4	CAN 3	blinking - Traffic on CAN 3

Table 1: LED description

5. 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 PMC/XMC-CAN/402-4-FD is to be integrated.
→ Disconnect all hazardous voltages (mains voltage) before opening the system.
→ Ensure the absence of voltage before starting any electrical work

NOTICE
Electrostatic discharges may cause damage to electronic components.

→ To avoid this, please discharge the static electricity from your body *before* you touch the PMC/XMC-CAN/402-4-FD.
→ Furthermore, you should prevent your clothes from touching the PMC/XMC-CAN/402-4-FD, because your clothes might be electrostatically charged as well.

Procedure:

1. Switch off your computer and all connected peripheral devices (monitor, printer, etc.).
2. Discharge your body as described above.
3. Disconnect the computer 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. A conductive O-ring is contained in the product package of the PMC/XMC-CAN/402-4-FD module. Mount the conductive O-ring on the front panel of the PMC/XMC-CAN/402-4-FD to obtain EMC shielding.
6. Set the jumpers for the internal termination of the CAN interfaces according to your needs, as described in chapter “Jumper Configuration”, page 13
7. Remove the carrier board (if already installed) and plug the PMC/XMC-CAN/402-4-FD carefully on the carrier board. Pay attention that the PMC/XMC-CAN/402-4-FD module is correctly installed on the carrier board.
   Fix the PMC/XMC-CAN/402-4-FD with the screws on the carrier board. Use the four M 2.5 x 6 mm screws which are contained in the product package of the module.
8. Install the carrier board in your system.

9. Close the computer case again.
10. Connect the CAN interfaces and optionally the IRIG-B input via the DSUB25 connector in the front panel of the PMC/XMC-CAN/402-4-FD.

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 30.
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.
It is recommended to use the cable CAN/400-4-1C5 or CAN/400-4-1C4, as described in chapter 'Adapter Cables DSUB25 to DSUB9', page 22.
The conformity is granted when using this cables.

See also page 26 for notes on the IRIG-B wiring.

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

6. Technical Data

6.1 General Technical Data

Ambient temperature	Standard: 0...75°C, Extended temperature range: -40° C … +75° C (C.2028.78 only)
Humidity	90 %, non-condensing
Supply voltage	Nominal voltage: 3.3 VDC ±5% / $I_{3.3V\_MAX}$ = 1 A, $I_{3.3V\_TYPICAL}$ = 750 mA, Absolute maximum power: $P_{3.3V\_MAX}$ = 4W (4x CAN, 100% bus load)
Plug- and socket connectors	PMC-CAN/402-4-FD, PMC-CAN/402-4-FD-T, PMC-CAN/402-4-FD-IRIG-B: P1, (64-pin PMC connector) - PCI bus, P2, (64-pin PMC connector) - PCI bus, CAN 0-3, (DSUB25, X800) - CAN, IRIG-B (physical layers available) IRIG-B The IRIG-B option is only equipped on the PMC-CAN/402-4-FD-IRIG-B, order No.: C.2028.69 Only for test- and programming purposes: X200 (Samtec CLM104-02-F-D-BE) - JTAG Bridge X400 (Samtec CLM104-02-F-D-BE) - JTAG FPGA
	XMC-CAN/402-4-FD, XMC-CAN/402-4-FD-IRIG-B: P5, (Samtec: ASP-105885-01 connector) - PCI Express bus, CAN 0-3, (DSUB25, X800) - CAN, IRIG-B (physical layers available) IRIG-B The IRIG-B option is only equipped on the XMC-CAN/402-4-FD-IRIG-B, order No.: C.2018.69 Only for test- and programming purposes: X400 (Samtec CLM104-02-F-D-BE) - JTAG FPGA
Dimensions (width x height)	74.0 mm x 149.0 mm (single PMC size)
Weight	Approximately 100 g

Table 2: General technical data of the module

6.2 CAN FD Interface

Number of CAN FD interfaces	4x CAN FD interfaces (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 5 Mbit/s with the same CAN transceiver
Transceiver	4 x Microchip MCP2561FDE/SN
Bus termination	Terminating resistors (120Ω) can be set via jumpers for each individual CAN channel
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	1x 25-pin DSUB, male

Table 3: Data of the CAN FD interface

6.3 IRIG-B Interface

INFORMATION
The IRIG-B option is only equipped on the the PMC/XMC-CAN/402-4-FD-IRIG-B boards (C.2028.69 and C.2018.69)

Number	1 x analogue, 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 4: IRIG-B Inputs

6.4 PMC Interface

INFORMATION
The PMC interface is only equipped on the PMC boards PMC-CAN/402-4-FD (C.2028.68) and PMC-CAN/402-4-FD-IRIG-B (C.2028.69)

Number	1
Standard	PMC according to IEEE Std 1386.1-2001
PCI bus	PCI bus according to PCI Local Bus Specification 3.0, 32 bit 33/66 MHz, PCI bus master capability
Voltage	3.3 V, (5 V tolerant)
Connector	Via PMC P1, PMC P2

Table 5: Data of the PMC interface

6.5 XMC Interface

INFORMATION
The XMC interface is only equipped on the XMC boards XMC-CAN/402-4-FD (C.2018.68) and XMC-CAN/402-4-FD-IRIG-B (C.2018.69)

Number	1
Standard	XMC according to VITA 42.3
PCIe port	According to PCI Express Specification R1.0a, Link width 1x
Connector	Via XMC P5

Table 6: PCI bus data

6.6 Message-Signalled Interrupt Handling

The PMC/XMC-CAN/402-4-FD supports MSI. The equipped PCI-to-PCIe bridge is able to convert MSI's from the PCIe bus to “Hardware” Interrupt lines or to PCI MSI'.

The MSI enable bit in the capability pointer of the PCI-to-PCIe bridge is enabled. Usually this bit is modified during the plug-and-play run of the operating system and is set depending on the system configuration: Therefore it is not possible to affect the usage of MSI/Legacy IRQ directly.

6.7 Software Support

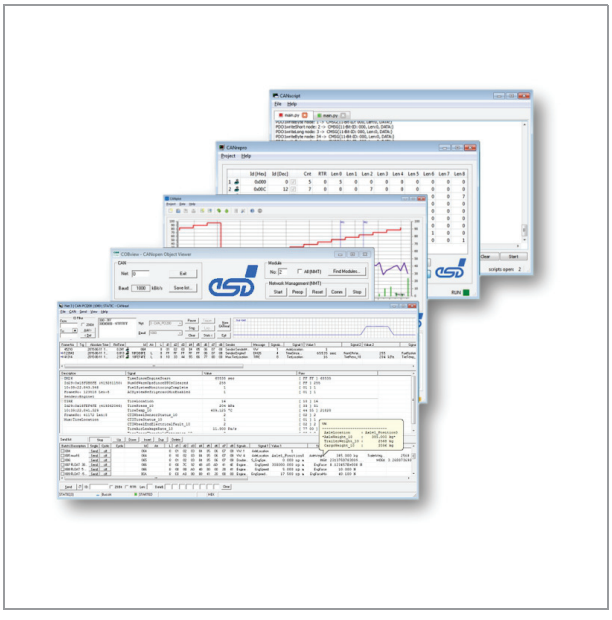
The CAN layer 2 (CAN-API) software installation and the software drivers are described in the manual:

“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

CAN layer 2 (CAN-API) software drivers are available for Windows®, QNX®, RTX64.
Higher layer protocols (CANopen, J1939, ARINC825) are only supported for Classical CAN applications on PMC/XMC-CAN/402-4-FD. See Order Information on page 45 for availability of the drivers. For detailed information about the driver availability for your operating system, please contact our sales team: sales@esd.eu.

NOTICE (PMC-CAN/402-4-FD versions only)
PMC-CAN/402-4-FD boards which are equipped with the Pericom® PCI-to-PCI bridge PI7C9X111SL might have potential interoperability problems in Microsoft Windows or Linux operating systems. Read chapter “Application Note to PMC-CAN/402“ on page 40 for information about this.

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



The following CAN Tools are available:

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

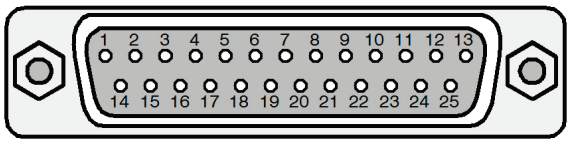
System Requirements:
- Windows 32 bit or 64 bit system
- 30 MB free HD drive space
- esd CAN driver installed

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

7. Connector Assignments

7.1 I/O Connector X800 (DSUB25 male) Pin Assignment

Device connector: 25-pin DSUB connector, male



Signal	Pin		Signal	
CAN1_L	1	14	CAN1_H	
CAN1_GND	2	15	-	
-	3	16	CAN2_L	
CAN2_H	4	17	CAN2_GND	
-	5	18	-	
CAN3_L	6	19	CAN3_H	
CAN3_GND	7	20	-	
-	8	21	CAN4_L	
CAN4_H	9	22	CAN4_GND	
-	10	23	-	
-	11	24	*IRIG-B_RX+*	Optional IRIG-B
IRIG-B_RX-	12	25	*IRIG-B_A+*	
IRIG-B_A-	13			

INFORMATION
The IRIG-B option is not equipped on the PMC/XMC-CAN/402-4-FD (order No.: C.2018.68 and C.2028.68). The IRIG-B signals do not apply for this version.
The signal assignment of the CAN signals are kept as shown above.

Name	Description	
CANx_L, CANx_H, CANx_GND	CAN signals of CAN node x (x= 1, 2, 3, 4). Physical layer according to ISO11898-2.	
-	Reserved - Do not use! (Spare Pin to increase creepage distance)	
PMC/XMC-CAN/402-4-FD-IRIG-B versions (C.2018.69, C.2028.68) only:		Optional IRIG-B
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 or CAN/400-4-1C4, as described in chapter 'Adapter Cables DSUB25 to DSUB9', page 22. The conformity is granted when using this cables.

7.1.1 Adapter Cables DSUB25 to DSUB9

esd offers the following two adapter cables (see also Order Information on page 45):
- 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 C.2018.68 and C.2028.68)
This adapter only connects the four CAN interfaces to the front panel connector X800. The cable comes with four DSUB9 male connectors 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.

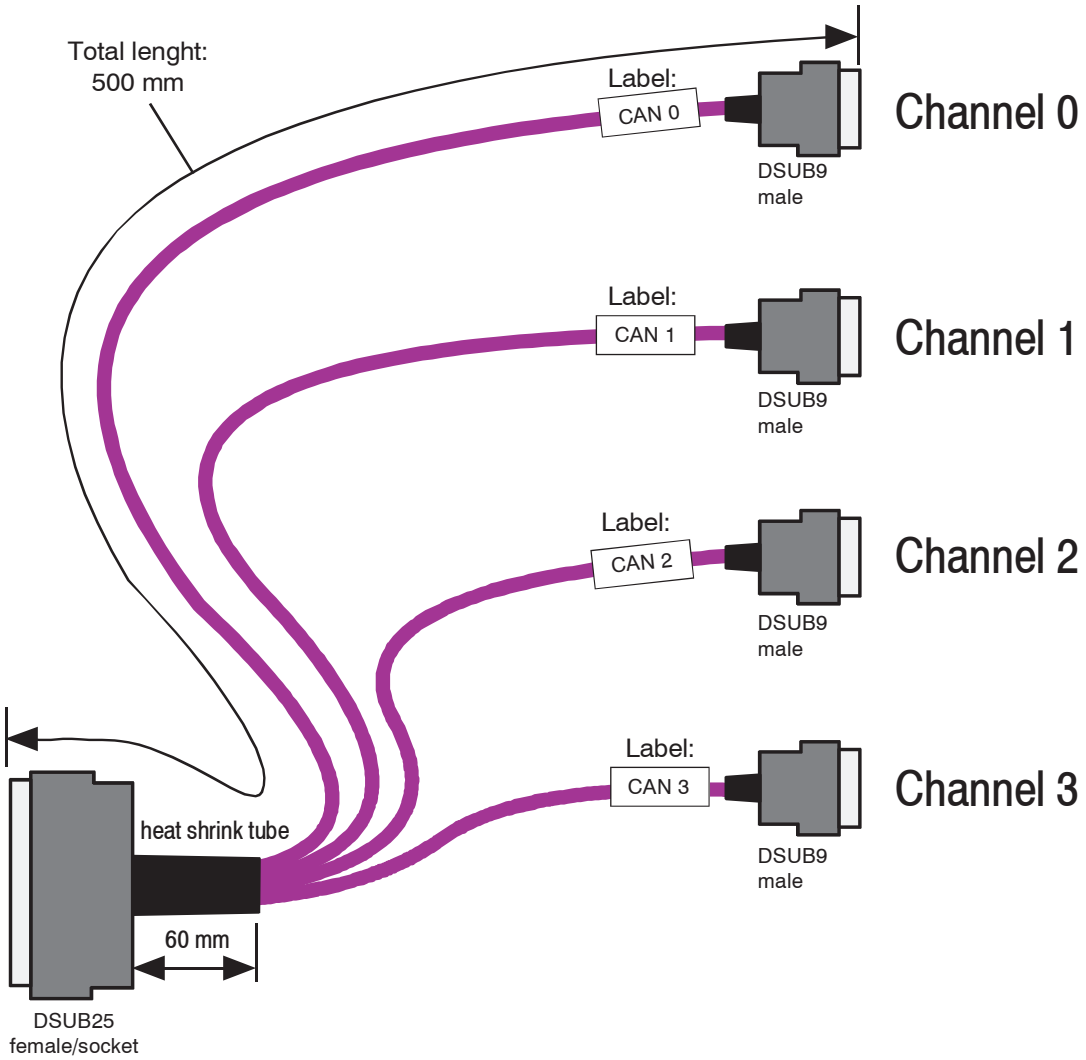


Figure 6: Adapter DSUB25 to 4x DSUB9

CAN/400-4-1C5 (to product C.2018.69 and C.2028.69, with IRIG-B option)
This adapter connects the four CAN interfaces and the IRIG-B inputs to the front panel connector X800. This cable offers four DSUB9 male connectors for the CAN interfaces (CAN0 -CAN3) and one DSUB9 female connector for the IRIG-B input.

Adapter DSUB25 to 4x DSUB9 (male) and optional DSUB9 (female)

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, male	2	CAN0_L
	14		brown		7	CAN0_H
	2		green		3	CAN0_GND
	Connector housing		shield		Connector housing	FE
	16	CAN1	white	DSUB9 plug, male	2	CAN1_L
	4		brown		7	CAN1_H
	17		green		3	CAN1_GND
	Connector housing		shield		Connector housing	FE
	6	CAN2	white	DSUB9 plug, male	2	CAN2_L
	19		brown		7	CAN2_H
	7		green		3	CAN2_GND
	Connector housing		shield		Connector housing	FE
						-
	21	CAN3	white	DSUB9 plug, male	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, female	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.

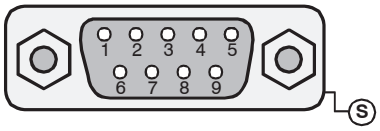
See also Figures 7 and 8, on page 26 for a description of the wiring of the analog and digital IRIG-B interfaces.

7.1.1.1 CAN Interfaces via DSUB9

Four DSUB9 male connectors 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, male

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:

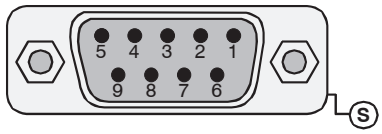
Name	Description
-	Reserved - Do not use! This pin is not connected at the module.
CANx_L, CANx_H, CANx_GND	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

7.1.1.2 IRIG-B Input via DSUB9

One DSUB9 female connector for the IRIG-B interfaces is equipped on the cable:
- CAN/400-4-1C5 1xDSUB25-to-5xDSUB9 (order no. C.2047.18)

Device connector: 9-pin DSUB connector, female

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 8, on page 26 for a description of the wiring of the analog and digital IRIG-B interfaces.

7.1.1.3 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 (female)

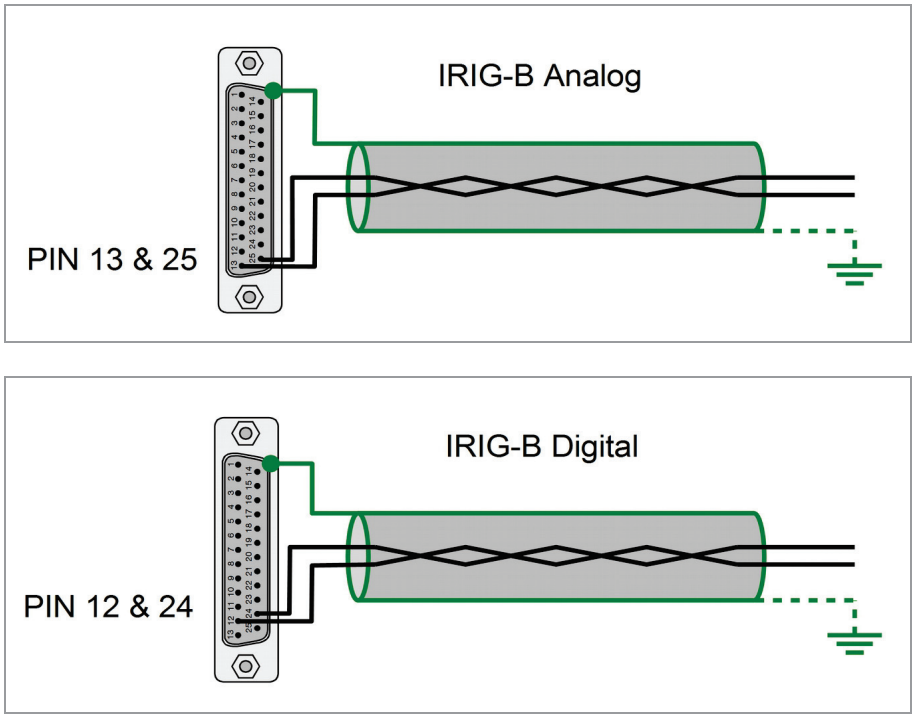


Figure 7: Analog and digital IRIG-B wiring guidelines at DSUB25

Analog and digital IRIG-B at DSUB9 (female)

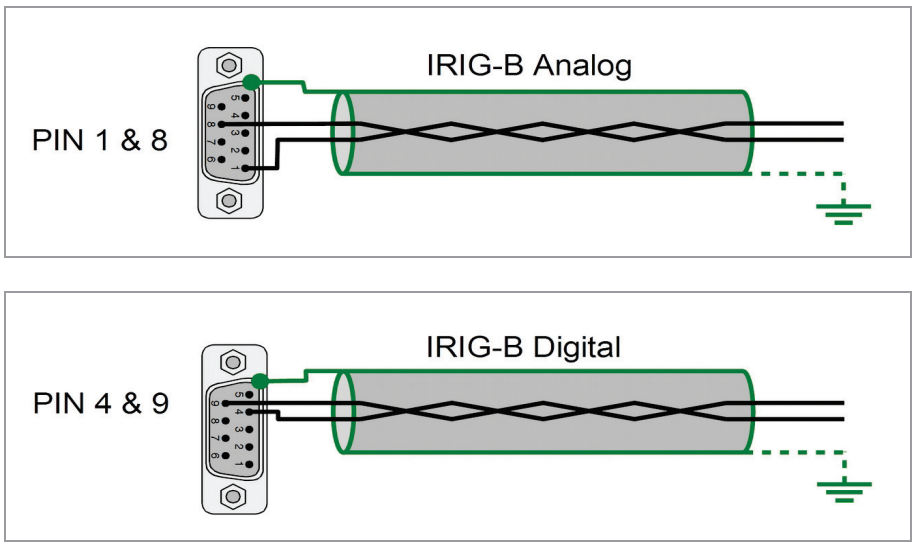


Figure 8: IRIG_B wiring guidelines at DSUB9

7.2 PMC Connectors

The PMC connectors P1 and P2 provide the PCI interface and power supply connection.

INFORMATION
The PMC connectors P1 and P2 are only equipped on the PMC boards PMC-CAN/402-4-FD (C.2028.68) and PMC-CAN/402-4-FD-IRIG-B (C.2028.69)

7.2.1 PMC Connector P1

P1

Signal	Pin		Signal
TCK	1	2	-12V
GND	3	4	INTA#
INTB#	5	6	INTC#
GND (BMODE1#)	7	8	+5V
INTD#	9	10	n.c. (reserved)
GND	11	12	+3.3VAUX
PCI-CLK	13	14	GND
GND	15	16	GNT#
REQ#	17	18	+5V
VIO	19	20	AD[31]
AD[28]	21	22	AD[27]
AD[25]	23	24	GND
GND	25	26	C/BE3#
AD[22]	27	28	AD[21]
AD[19]	29	30	+5V
VIO	31	32	AD[17]
FRAME#	33	34	GND
GND	35	36	IRDY#
DEVSEL#	37	38	+5V
GND (XCAP)	39	40	LOCK#
n.c. (SDONE#)	41	42	n.c. (SBO)
PAR	43	44	GND
VIO	45	46	AD[15]
AD[12]	47	48	AD[11]
AD[09]	49	50	+5V
GND	51	52	C/BE0#
AD[06]	53	54	AD[05]
AD[04]	55	56	GND
VIO	57	58	AD[03]
AD[02]	59	60	AD[01]
AD[00]	61	62	+5V
GND	63	64	n.c. (REQ64#)

For signal description please refer to the PCI Local Bus Specification 2.2.

7.2.2 PMC Connector P2

P2

Signal	Pin		Signal
+12V	1	2	TRST#
TMS	3	4	TDO (bridged to TDI)
TDI (bridged to TDO)	5	6	GND
GND	7	8	n.c. (reserved)
n.c. (reserved)	9	10	n.c. (reserved)
n.c. (MODE2#)	11	12	+3.3V
PCI-RST#	13	14	n.c. (BMODE3#)
+3.3V	15	16	n.c. (BMODE4#)
PME#	17	18	GND
AD[30]	19	20	AD[29]
GND	21	22	AD[26]
AD[24]	23	24	+3.3V
IDSEL	25	26	AD[23]
+3.3V	27	28	AD[20]
AD[18]	29	30	GND
AD[16]	31	32	C/BE2#
GND	33	34	n.c (IDSELB)
TRDY#	35	36	+3.3V
GND	37	38	STOP#
PERR#	39	40	GND
+3.3V	41	42	SERR#
C/BE1#	43	44	GND
AD[14]	45	46	AD[13]
M66EN	47	48	AD[10]
AD[08]	49	50	+3.3V
AD[07]	51	52	n.c. (REQB#)
+3.3V	53	54	n.c. (GNTB#)
n.c. (reserved)	55	56	GND
n.c. (reserved)	57	58	n.c. (EREADY)
GND	59	60	n.c. (RESETOUT#)
n.c. (ACK64#)	61	62	+3.3V
GND	63	64	n.c. (MONARCH#)

For signal description please refer to the PCI Local Bus Specification 2.2.

7.3 XMC Connector

The XMC connectors P5 provides the PCI interface and power supply connection.

INFORMATION
The XMC connector P5 is only equipped on the XMC boards XMC-CAN/402-4-FD (C.2018.68) and XMC-CAN/402-4-FD-IRIG-B (C.2018.69)

7.3.1 XMC Connector P5

Signal / PIN Row A		Signal / PIN Row B		Signal / PIN Row C		Signal / PIN Row D		Signal / PIN Row E		Signal / PIN Row F	
PCIe_Tx_L0p	1	PCIe_Tx_L0n	1	3.3V	1	n.c.	1	n.c.	1	VPWR	1
GND	2	GND	2	n.c.	2	GND	2	GND	2	LC_PRST#	2
n.c.	3	n.c.	3	3.3V	3	n.c.	3	n.c.	3	VPWR	3
GND	4	GND	4	n.c.	4	GND	4	GND	4	n.c.	4
n.c.	5	n.c.	5	3.3V	5	n.c.	5	n.c.	5	VPWR	5
GND	6	GND	6	n.c.	6	GND	6	GND	6	+X12V	6
n.c.	7	n.c.	7	3.3V	7	n.c.	7	n.c.	7	VPWR	7
GND	8	GND	8	n.c.	8	GND	8	GND	8	-X12V	8
n.c.	9	n.c.	9	n.c.	9	n.c.	9	n.c.	9	VPWR	9
GND	10	GND	10	n.c.	10	GND	10	GND	10	I²C_GA0	10
PCIe_Rx_L0p	11	PCIe_Rx_L0n	11	n.c.	11	n.c.	11	n.c.	11	VPWR	11
GND	12	GND	12	I²C_GA1	12	GND	12	GND	12	GND	12
n.c.	13	n.c.	13	n.c.	13	n.c.	13	n.c.	13	VPWR	13
GND	14	GND	14	I²C_GA2	14	GND	14	GND	14	I²C.4.SDA	14
n.c.	15	n.c.	15	n.c.	15	n.c.	15	n.c.	15	VPWR	15
GND	16	GND	16	I²C_WE	16	GND	16	GND	16	I²C.4.SCL	16
n.c.	17	n.c.	17	n.c.	17	n.c.	17	n.c.	17	n.c.	17
GND	18	GND	18	n.c.	18	GND	18	GND	18	n.c.	18
PEX_XMC_CLK_IN_p	19	PEX_XMC_CLK_IN_n	19	n.c.	19	WAKE#	19	NONET1	19	n.c.	19

n.c. … not connected

8. 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.

8.1 Standards concerning CAN Wiring

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

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

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

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

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

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

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

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

8.2.1 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 8.3. 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.

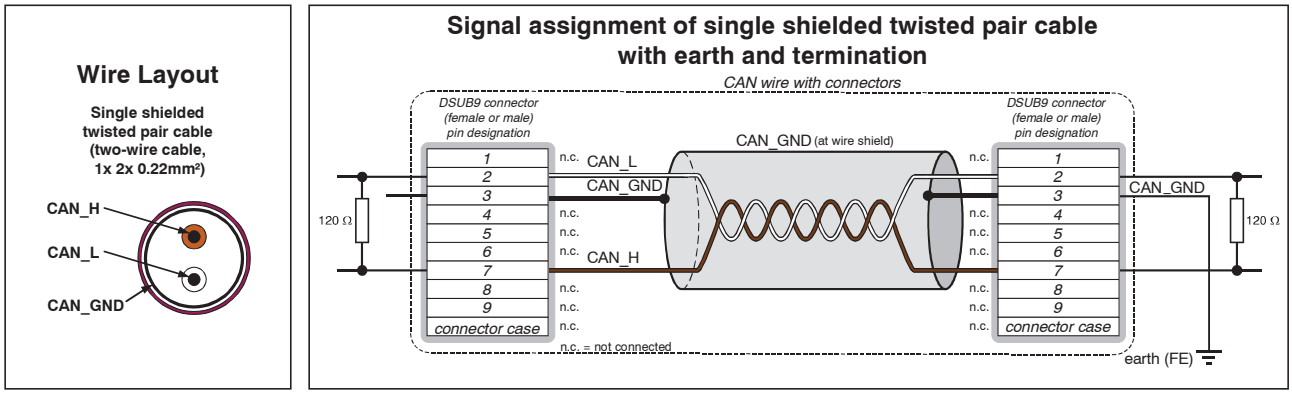


Figure 9: CAN wiring for light industrial environment

8.2.2 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.

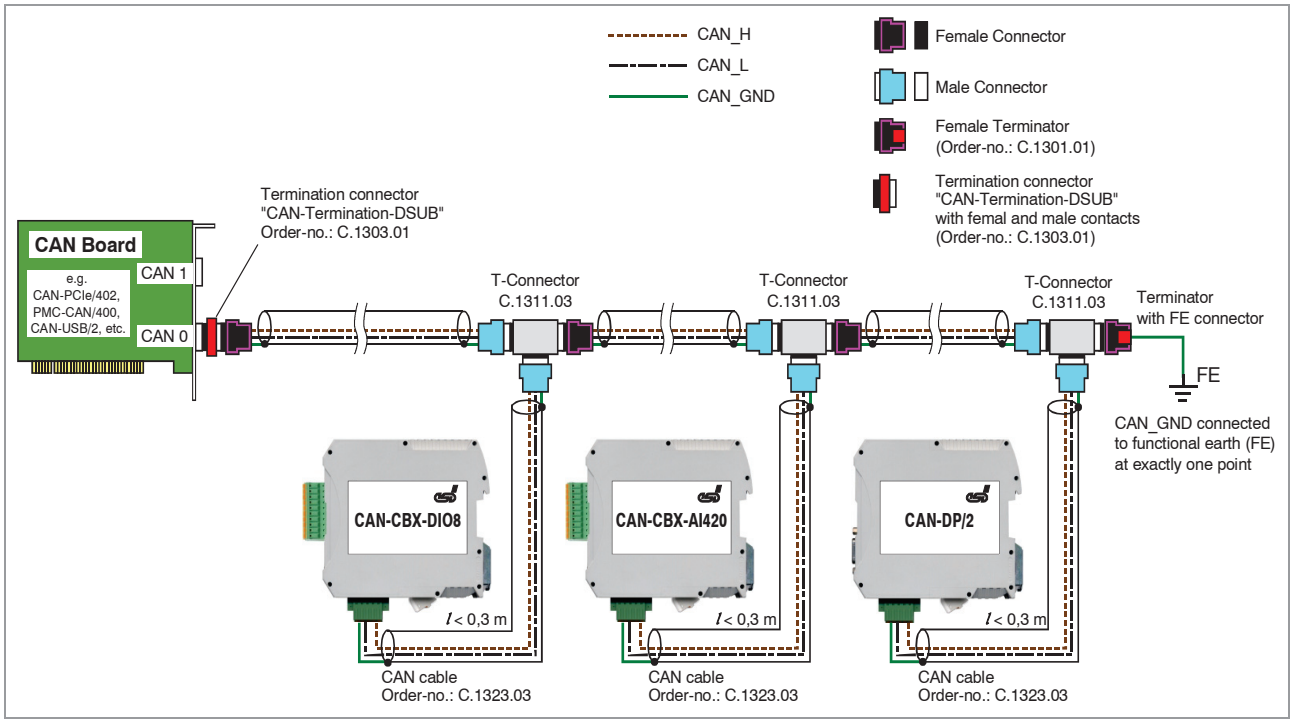


Figure 10: Example for proper wiring with single shielded single twisted pair wires

8.2.3 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.

8.2.4 Termination

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

8.3 Heavy Industrial Environment (*Double* Twisted Pair Cable)

8.3.1 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.

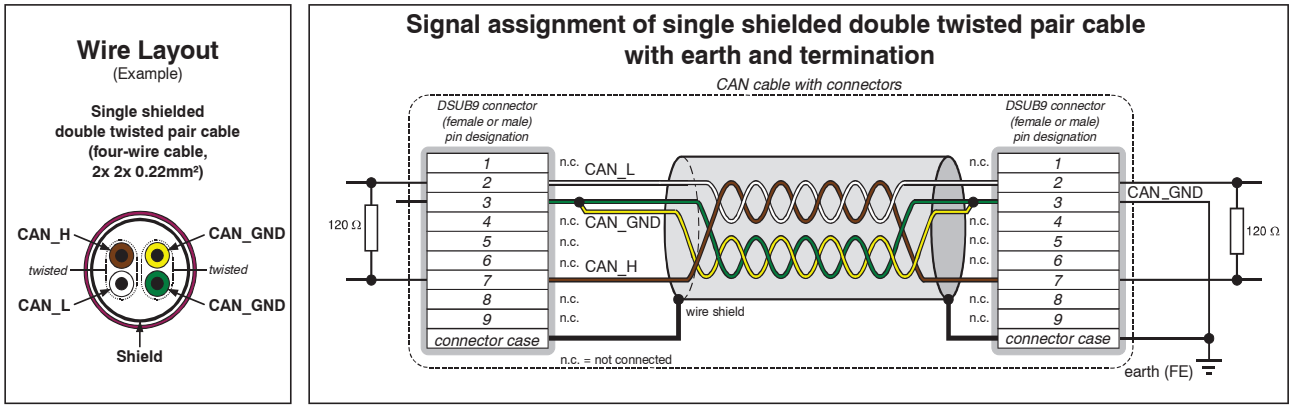


Figure 11: CAN wiring for heavy industrial environment

8.3.2 Device Cabling

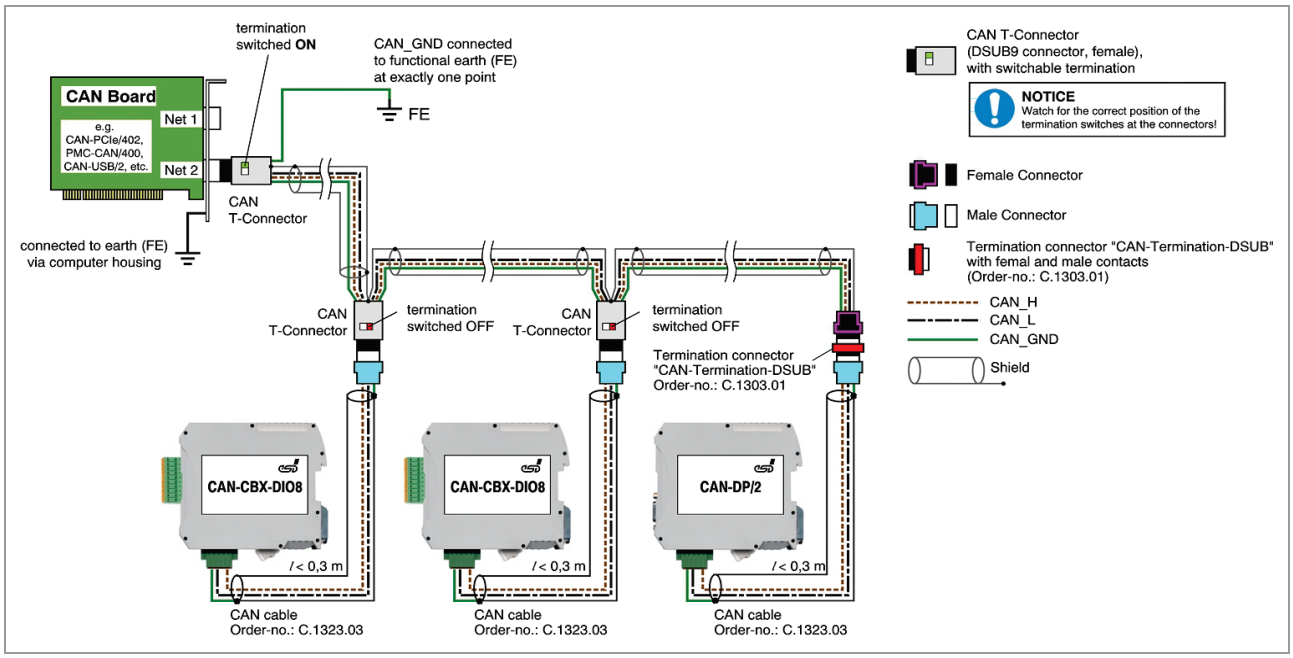


Figure 12: Example of proper wiring with single shielded double twisted pair cables

8.3.3 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.

8.3.4 Termination

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

8.4 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).

8.5 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	59	50	0,34 to 0,6
666,6̄	80	-	
500	130	100	
333,3̄	180	-	
250	270	250	
166	420	-	0,5 to 0,6
125	570	500	
100	710	650	0,75 to 0,8
83,3̄	850	-	
66,6̄	1000	-	
50	1400	1000	
33,3̄	2000	-	not defined in CiA 303-1
20	3600	2500	
12,5	5400	-	
10	7300	5000	

Table 7: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

- Optical couplers are delaying the CAN signals. esd modules typically 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.

8.6 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.

8.6.1 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.)

8.6.2 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**.

9. 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.

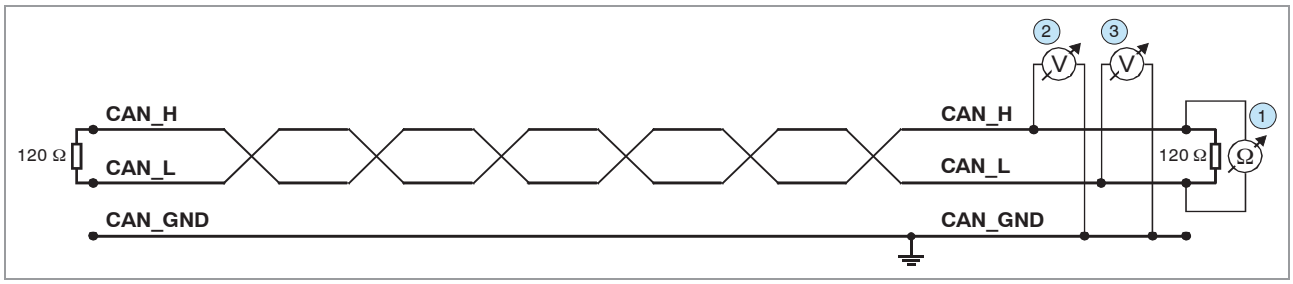


Figure 13: Simplified diagram of a CAN network

9.1 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.

9.2 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.

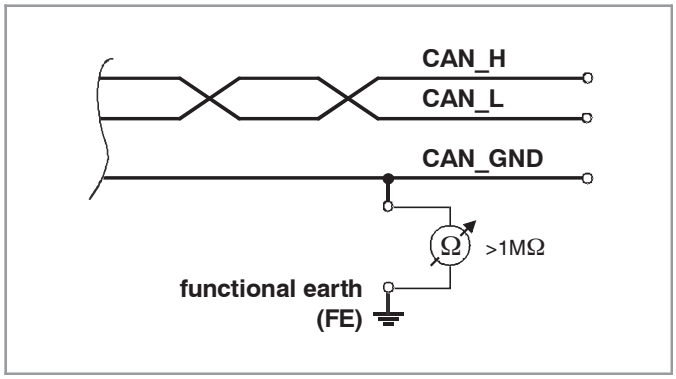


Figure 14: Simplified schematic diagram of ground test measurement

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

9.3 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!

9.4 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.

9.5 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 %).

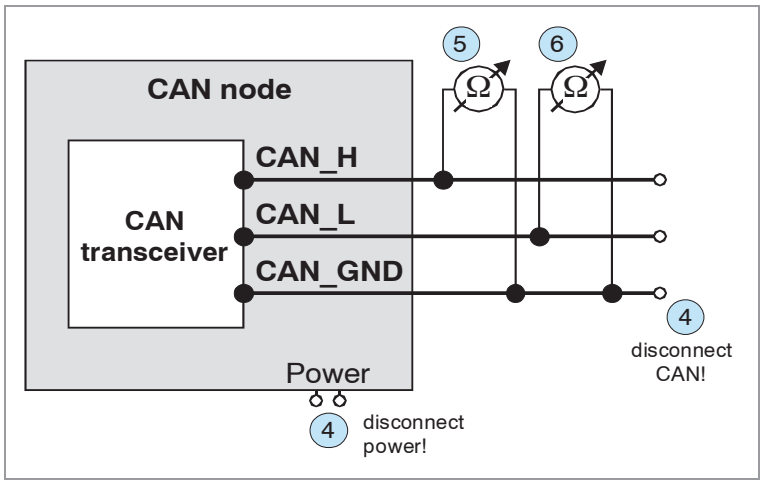


Figure 15: Measuring the internal resistance of CAN transceivers

9.6 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 **+40-511-37298-130**.

10. Application Note to PMC-CAN/402

Potential Interoperability with Windows or Linux OS

INFORMATION
This chapter is to alert users to a potential interoperability problems that affect esd **PMC**-CAN/402-4-FD boards which are equipped with the Pericom® PCI-to-PCI bridge PI7C9X111SL.

Depending on the host computer system the following PMC-CAN/402-4-FD articles may be affected:

Article	Order no.
PMC-CAN/402-4-FD PMC-CAN/402-4-FD-IRIG-B	C.2028.68, C.2028.69

The XMC-CAN/402-4-FD versions are not affected!

10.1 Windows Operating System

Potential Interoperability Problem with enabled PCI Express Native Control Mode

Problem Description
Microsoft Windows operating systems including Windows Vista, Windows Server 2008, and later versions include a feature called “PCI Express Native Control”. Many current motherboards offer support for the PCI Express Native Control feature in their BIOS.

If this feature is enabled by Windows, it enforces additional features which are not implemented in the bridge of the PMC-CAN/402-4-FD. This may prevent the start of the default PCI-to-PCI bridge driver (Code 10). This problem occurs e.g. on most ACER PC Windows systems.

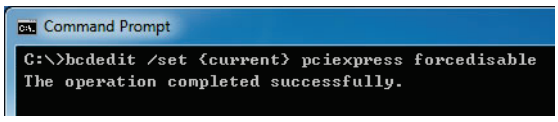
Based on our information Pericom does not plan to revise the silicon of the PCI-to-PCI bridge to be compatible with the Windows-supplied bridge driver.

Solution: Disabling PCI Express Native Control Feature in Windows
The PCI Express Native Control can be switched off by commands in the command prompt window with administrator rights.

Use the command `BCDEdit /set`

to set a boot entry option value in the Windows boot configuration data store (BCD):

1. Boot the Windows system.
2. Open the command prompt window with administrator rights (right-click to `C:\Windows\System32\cmd.exe` and select “*Run as Administrator*”).
3. Enter the command: `bcdedit /set {current} pciexpress forcedisable`



4. Restart your computer.

NOTICE
If you disable the PCI Express Native mode this may cause loss of other system features, such as Hot Plug, which requires the PCI Express Native mode (see link to MSDN for more details).

To restore the previous state type the following commands:
`bcdedit /deletevalue {current} pciexpress`
or
`bcdedit /set {current} pciexpress default`

Links to further Information

- About `BCDEdit /set` command:
  https://msdn.microsoft.com/en-us/library/windows/hardware/ff542202%28v=vs.85%29.aspx?ppud=4
- About PCI Express Native Control:
  https://msdn.microsoft.com/en-us/library/windows/hardware/dn631753%28v=vs.85%29.aspx
- ACPI website: http://www.acpi.info
- PCI-SIG website: http://pcisig.com

10.2 Linux Operating System

Potential Interoperability Problem caused by Active State Power Management Reconfiguration

Problem Description
Recent Linux kernels try to reconfigure and optimize the Active State Power Management settings of PCI Express links. In the course of the reconfiguration the kernel triggers an erratum of the PCI-to-PCIe reverse bridge PI7C9X111SL that is used on the shown products. Caused by this erratum the PCIe link stays in the link retraining state and is not usable.

This can be diagnosed by looking at the lspci output for the PCIe device behind the Pericom bridge that looks like this in the failure case:

```
root@host# lspci -s 3:0.0 -v -x
03:00.0 CANBUS: ESD Electronic System Design GmbH Device 0402 (rev ff) (prog-if ff)
        !!! Unknown header type 7f
00: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
10: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
20: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
30: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
```

Solution: Booting the System with the additional Kernel Parameter "pcie_aspm=off"
As a workaround you may boot the system with the additional kernel parameter "pcie_aspm=off" which will disable ASPM reconfiguration for the whole machine.
If you are able to build your Linux kernel yourself you may apply this patch to introduce a workaround for this Pericom reverse bridge.

```
--- drivers/pci/pcie/aspm-orig.c        2018-04-01 23:20:27.000000000 +0200
+++ drivers/pci/pcie/aspm.c     2018-11-07 14:08:58.301927694 +0100
@@ -218,6 +218,7 @@
        child = list_entry(linkbus->devices.next, struct pci_dev, bus_list);
        BUG_ON(!pci_is_pcie(child));

+
        /* Check downstream component if bit Slot Clock Configuration is 1 */
        pcie_capability_read_word(child, PCI_EXP_LNKSTA, &reg16);
        if (!(reg16 & PCI_EXP_LNKSTA_SLC))
@@ -251,6 +252,16 @@
        /* Retrain link */
        reg16 |= PCI_EXP_LNKCTL_RL;
        pcie_capability_write_word(parent, PCI_EXP_LNKCTL, reg16);
+       if (0x12d8 == parent->vendor && 0xe111 == parent->device) {
+            /*
+             * Due to an erratum in the Pericom PI7C9X111SLB bridge in
+             * reverse mode the retrain link bit needs to be cleared
+             * manually to allow the link training to succeed.
+             */
+            pci_info(parent,"PI7C9X111SLB workaround: Clear PCI_EXP_LNKCTL_RL again.\n");
+            reg16 &= ~PCI_EXP_LNKCTL_RL;
+            pcie_capability_write_word(parent, PCI_EXP_LNKCTL, reg16);
+       }

        /* Wait for link training end. Break out after waiting for timeout */
        start_jiffies = jiffies;
```

An equivalent patch was submitted to the Linux-PCI kernel mailing list (see https://lore.kernel.org/linux-pci/20190406143031.GB200379@google.com/T/ but it will take some time until it will show up in the production kernels of Linux distributions.

11. Declaration of Conformity

11.1 PMC-CAN/402-4-FD

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.*
PMC-CAN/402-4-FD	**C.2028.68,**
PMC-CAN/402-4-FD-IRIG-B	**C.2028.69,**
PMC-CAN/402-4-FD-T	**C.2028.78**
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 61000-6-3:2007/A1:2011**
gemäß folgendem Prüfbericht erfüllt. *according to test certificate.*	**H-K00-0676-17**
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, 2019-04-12

Rechtsgültige Unterschrift / *authorized signature*

I:\Texte\Doku\MANUALS\PMC-XMC\PMC_XMC-CAN402-4-FD\PMC-CAN402-4-FD_Konformitaet\PMC-CAN402-4-FD_Konformitaetserklaerung_2019-04-12.odt

11.2 XMC-CAN/402-4-FD

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.*
XMC-CAN/402-4-FD	**C.2018.68**
XMC-CAN/402-4-FD-IRIG-B	**C.2018.69**
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 61000-6-3:2007/A1:2011

gemäß folgendem Prüfbericht erfüllt.
according to test certificate.
H-K00-0676-17

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, 2019-04-05

T. Bie

Rechtsgültige Unterschrift / *authorized signature*

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12. Order Information

12.1 Hardware

Type	Properties	Order No.
XMC-CAN/402-4-FD	CAN interface board for XMC, 4 CAN 2.0A/B-interfaces with esd Advanced CAN IP-Core (esdACC) CAN-FD capable according to ISO 11898-1:2015 Physical Layer according ISO 11898-2, High-speed CAN, electrically isolated 1x DSUB25 connector 6x LEDs for CAN and board status Drivers, tools and documentation for Windows & Linux on CD-ROM	C.2018.68
XMC-CAN/402-4-FD-IRIG-B	as C.2018.68 but with additional IRIG-B interface	C.2018.69
PMC-CAN/402-4-FD	CAN interface board for PMC, 4 CAN 2.0A/B interfaces with esd Advanced CAN IP-Core (esdACC) CAN-FD capable according to ISO 11898-1:2015 Physical Layer according ISO 11898-2, High-speed CAN, electrically isolated, 1x DSUB25 connector 6x LEDs for CAN and board status Drivers, tools and documentation for Windows & Linux on CD-ROM	C.2028.68
PMC-CAN/402-4-FD-IRIG-B	as C.2028.68 but with additional IRIG-B interface	C.2028.69
PMC-CAN/402-4-FD-T	as C.2028.68 but for extended temperature range: -40° C … +75° C	C.2028.78
Accessories		
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9	Adapter cable DSUB25 female to 4x DSUB9 male (4x CAN), length: 0.5 m, to product: C.2018.68, C.2028.68	C.2047.19
CAN/400-4-1C5 1xDSUB25-to-5xDSUB9	Adapter cable DSUB25 female to 4x DSUB9 male and 1x DSUB9 female (4x CAN + 1x IRIG-B interface), length: 0.5 m, to product: C.2018.69, C.2028.69	C.2047.18

12.2 Software

Software		Order No.
CAN layer 2 drivers for Windows are included in delivery of PMC/XMC-CAN/402-4-FD-FD free of charge. Additional CAN-layer 2 object licences including CD-ROM: CAN-DRV-LCD QNX CAN-DRV-LCD RTX (RTX64)		 C.1101.32 C.1101.35
Higher layer protocols including CD-ROM (Classical CAN): CANopen-DRV-LCD Windows/Linux CANopen-DRV-LCD QNX CANopen-DRV-LCD RTX (RTX64) J1939 stack for Windows J1939 stack for Linux ARINC 825-LCD Windows/Linux ARINC 825-LCD QNX ARINC 825-LCD RTX (RTX)	These drivers are available for **Classical CAN operation only!**	 C.1101.06 C.1101.17 C.1101.16 C.1130.10 C.1130.11 C.1140.06 C.1140.17 C.1140.16

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

Table 8: Order information additional software for PMC/XMC-CAN/402-4-FD-FD

12.3 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.
PMC/XMC-CAN/402-4-FD-ME	Hardware manual in English for XMC-CAN/402-4-FD and PMC-CAN/402-4-FD	C.2018.21
CAN-API-ME	NTCAN API manual Part 1: Application Developers Manual NTCAN API manual Part 2: Installation Guide	C.2001.21

Table 9: 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.