



PMC-CAN/402, XMC-CAN/402

**PMC or XMC Board with 4 CAN FD Ports
and optional
IRIG-B or LIN and Digital I/O**



PMC-CAN/402-4-FD



XMC-CAN/402-4-FD-IRIG-B

Hardware Manual

For Products C.2018.68 - C.2018.71,
C.2028.68 - C.2028.71,
C.2028.78

Notes

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This manual contains important information and instructions on safe and efficient handling of the PMC/XMC-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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	<p>Note to CAN FD: For the following variants of the PMC/XMC-CAN/402 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:</p>		
	Product	Order No.	Increased bit rate available from batch number
	XMC-CAN/402-4-FD	C.2018.68	GC
	PMC-CAN/402-4-FD	C.2028.68	GE
	XMC-CAN/402-4-FD-IRIG-B	C.2018.69	No limitation with these variants! All boards are equipped with the CAN FD transceiver with increased bitrate (up to 8 Mbit/s).
	XMC-CAN/402-FD-LIN-DIO	C.2018.70	
	XMC-CAN/402-FD-LIN-DIO-T	C.2018.71	
	PMC-CAN/402-4-FD-IRIG-B	C.2028.69	
	PMC-CAN/402-FD-LIN-DIO	C.2028.70	
	PMC-CAN/402-FD-LIN-DIO-T	C.2028.71	
	PMC-CAN/402-4-FD-T	C.2028.78	

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
1.5	all	Name of LINIO-variants changed to PMC/XMC-CAN/402-LIN-DIO(-T)	2025-04-04
	2., 4.	Chapters revised	
	10.	Chapter Software licences added	
1.4		Document transferred to Word, all chapters revised	2024-02-01
	-	Safety Instructions edited	
	-	CAN FD bit rate increased to 8 Mbit/s. Note to limitation on page 3 added	
	1.1	Chapter revised	
	1.3.2, 1.4.2	New chapters: Description of PMC/XMC-LIN-DIO variant added	
	2.	Chapter revised, Description of LIN-DIO-variant and product label added	
	3.2	Description of Switchable Bus Termination (LIN-DIO variant only)	
	4., 5	Chapters revised	
	6.	Chapter revised and technical data of LIN and IO ports added	
	7.	Chapter revised and description of LIN-DIO-variant and associated cable	
	10.	"Application Note" revised, and links updated	
	11.	Declarations of Conformity updated	
12.	Order Information revised		

Technical details are subject to change without further notice.

Classification of Warning Messages and Safety Instructions

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



This is the safety alert symbol.

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

DANGER, WARNING, CAUTION

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



DANGER

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



WARNING

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



CAUTION

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

NOTICE

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



NOTICE

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



NOTICE

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

INFORMATION



INFORMATION

Notes to point out something important or useful.



Safety Instructions

- When working with the PMC/XMC-CAN/402 follow the instructions below and read the manual carefully to protect yourself from injury and the PMC/XMC-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 PMC/XMC-CAN/402 and follow the CAN wiring hints in chapter: "Correct Wiring of Galvanically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- The galvanic isolation of the PMC/XMC-CAN/402 has only functional tasks and is not a protection against hazardous electrical voltage.
- The PMC/XMC-CAN/402 may only be operated on supply circuits that provide sufficient protection against dangerous voltages.
- External circuits connected to the ports of the PMC/XMC-CAN/402 must be sufficiently protected against dangerous voltage.
- The user is responsible for compliance with the applicable national safety regulations.

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

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

Qualified Personnel

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

Conformity

The PMC/XMC-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 PMC/XMC-CAN/402 may cause radio interferences in which case the user may be required to take adequate measures.

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

Intended Use

The intended use of the 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-variants are intended for installation in PMC slots according to IEEE 1386.1-2001. The XMC-variants are intended for installation in XMC slots according to Vita™ 42.3.
- The operation of the PMC/XMC-CAN/402 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the PMC/XMC-CAN/402 for medical purposes is prohibited.

Service Note

The PMC/XMC-CAN/402 does not contain any parts that require maintenance by the user. The PMC/XMC-CAN/402 does not require any manual configuration of the. 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	<code>/dev/null</code> or <code><stdio.h></code>
Function names	<code>open()</code>
Programming constants	<code>NULL</code>
Programming data types	<code>uint32_t</code>
Variable names	<code>Count</code>

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1 Overview

1.1 About this Manual

This manual describes the hardware variants of the products PMC-CAN/402 and XMC-CAN/402. The hardware is largely identical. All variants of these products are collectively referred to as PMC/XMC-CAN/402.

Functional features, available options, and included components may differ depending on the selected PMC/XMC-CAN/402 variant. All specific differences between the PMC/XMC-CAN/402 variants are explicitly described in this manual, e.g. PMC or XMC or optional ports.

Products		4 CAN FD ports via DSUB25	Additional ports and features			
			IRIG-B	LIN	DIO	Extended Temp. Range
PMC	PMC-CAN/402-4-FD (C.2028.68)	✓	-	-		-
	PMC-CAN/402-4-FD-T (C.2028.78)					✓
	PMC-CAN/402-4-FD-IRIG-B (C.2028.69)		✓	-		-
	PMC-CAN/402-FD-LIN-DIO (C.2028.70)		-	✓	✓	-
	PMC-CAN/402-FD-LIN-DIO-T (C.2028.71)		-	✓	✓	✓
XMC	XMC-CAN/402-4-FD (C.2018.68)	✓	-	-		-
	XMC-CAN/402-4-FD-IRIG-B (C.2018.69)		✓	-		-
	XMC-CAN/402-FD-LIN-DIO (C.2018.70)		-	✓	✓	-
	XMC-CAN/402-FD-LIN-DIO-T (C.2018.71)		-	✓	✓	✓

1.2 General Properties of PMC/XMC-CAN/402

The PMC/XMC-CAN/402 comes with four independent CAN FD ports according to ISO 11898-1, which are driven by the ISO 16845:2004 certified esdACC (esd advanced CAN Controller), implemented in an 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 CAN classic (CAN CC).

The PMC/XMC-CAN/402 is fully backwards compatible with CAN CC and can also be used in CAN CC applications.

i	<p>INFORMATION</p> <p>Every CAN FD controller is backward compatible to the CAN CC protocol. CAN CC nodes and CAN FD nodes can communicate with each other as long as the CAN FD frame format remains unused!</p>
----------	--

You can insert for example the PMC/XMC-CAN/402 in your CAN classic application if you want to replace a CAN CC component. The CAN FD board automatically communicates like a CAN classic board (the existing program code can be used unchanged). The PMC/XMC-CAN/402 has to communicate with the CAN nodes via CAN CC frames, because CAN CC controllers do not tolerate CAN FD frames. All controllers must use the same CAN CC 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 CAN CC or with CAN FD. See NTCAN-API Manual Part 1: "Application Developers Manual" for further information.

**NOTICE**

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

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

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 (Message Signalled Interrupts) the PMC/XMC-CAN/402 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 variants 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 58 for information about this.

Additional IRIG-B Ports

The PMC-CAN/402-4-FD-IRIG-B and the XMC-CAN/402-4-FD-IRIG-B come with an additional IRIG-B port, via the DSUB25 connector. The IRIG-B port offers inputs for analog or RS-422 compatible IRIG-B coded signals at the front panel. Both are galvanically isolated.

IRIG-B evaluation is controlled by an additional soft microcontroller implemented in the FPGA.

Additional LIN and digital I/O Ports

The PMC-CAN/402-FD-LIN-DIO(-T) and the XMC-CAN/402-FD-LIN-DIO(-T) variants offer two additional LIN ports and 4 digital I/O ports, accessible via the DSUB25 connector in the front panel. The LIN ports are designed according to ISO 17987-4:2016. In addition to the CAN esdACC cores the FPGA carries two LIN IP cores for the control of the physical layers of the LIN ports. The digital I/O can be individually set as input (interrupt capable) or output. The I/O-voltage can be switched between 3.3V or 5V by software. Input latency (signal to interrupt) 1µs, with a minimum pulse width of 2 µs.

Extended Temperature Range

Optional the variant PMC-CAN/402-4-FD-T of the PMC board and the LIN-DIO-variants PMC-CAN/402-FD-LIN-DIO-T and XMC-CAN/402-FD-LIN-DIO-T are designed for usage 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) or optional LIN-DIO 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-FD Variants

1.3.1 Standard, Extended Temperature and IRIG-B Variants for PMC

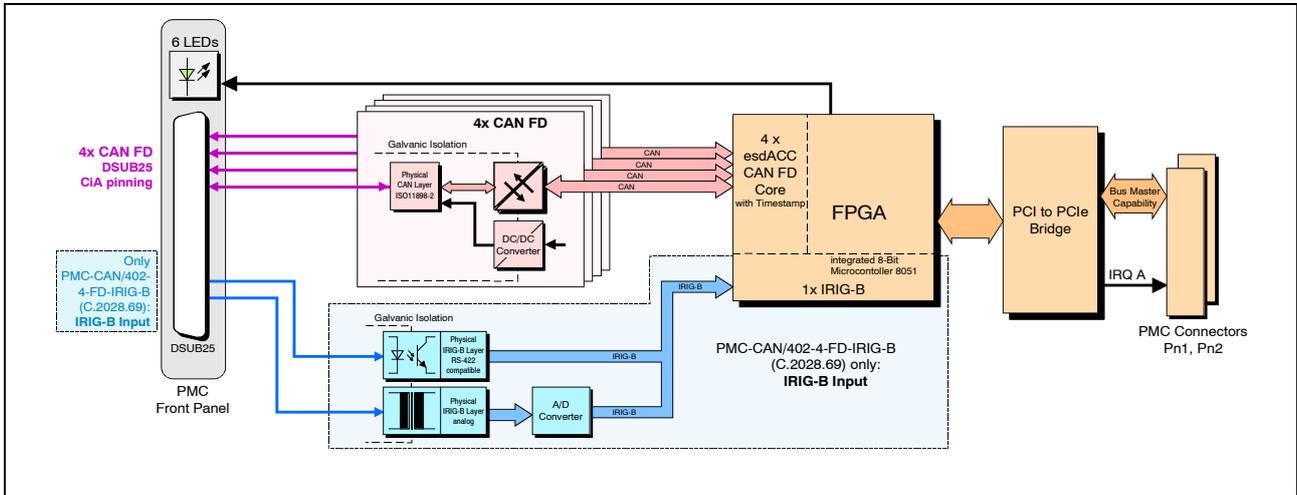


Figure 1: Block circuit diagram of PMC-CAN/402-4-FD and optional IRIG-B

Figure 1 shows the block circuit diagram of the standard variant PMC-CAN/402-4-FD, the PMC-CAN/402-4-FD-T for the extended temperature range and the PMC-CAN/402-4-FD-IRIG-B variant with additional IRIG-B ports.

Customized solutions are e.g.:

- Digital input (RS-422 compatible) for IRIG-B via PMC connector Pn4 (without galvanic isolation).
- Error simulation support
- All signals via Rear I/O

1.3.2 LIN and digital I/O Variants for PMC

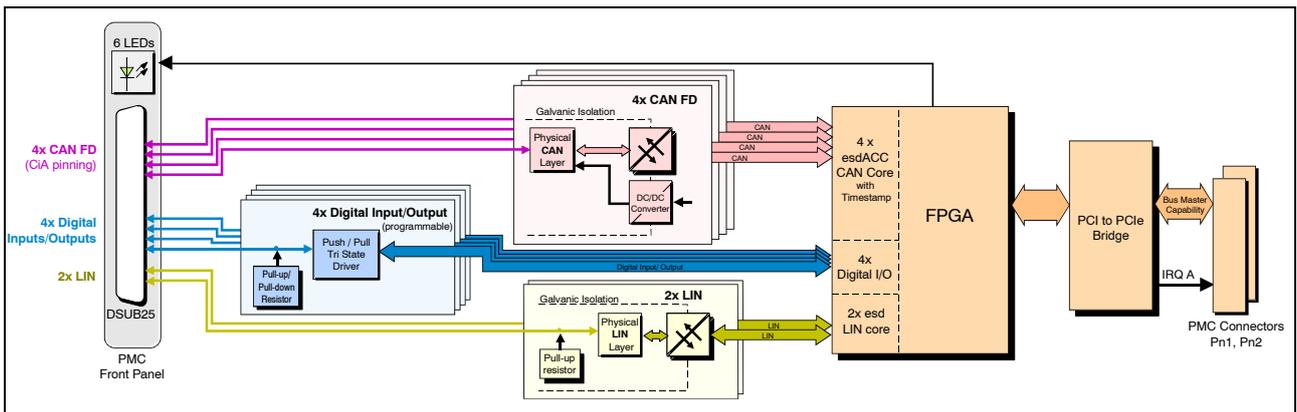


Figure 2: Block circuit diagram of PMC-CAN/402-FD-LIN-DIO

Figure 2 shows the block circuit diagram of the variant PMC-CAN/402-FD-LIN-DIO with additional LIN and digital IO ports. The block circuit diagram also applies to the PMC-CAN/402-FD-LIN-DIO-T for the extended temperature range.

1.4 XMC-CAN/402-FD Variants

1.4.1 Standard, Extended Temperature and IRIG-B Variants for XMC

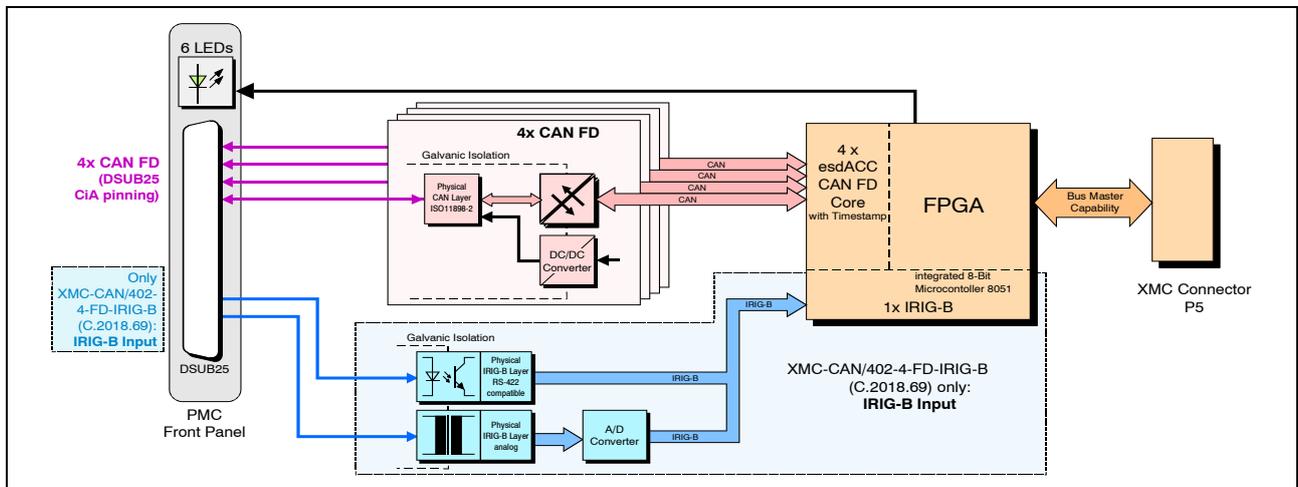


Figure 3: Block circuit diagram for XMC-CAN/402-4-FD(-IRIG-B)

Figure 3 shows the block circuit diagram of the standard variant XMC-CAN/402-4-FD and the XMC-CAN/402-4-FD-IRIG-B variant with additional IRIG-B port.

Customized solutions are e.g.:

- Extended temperature range: -40° C ... +75° C
- Digital input (RS-422 compatible) for IRIG-B via Rear IO connector (without galvanic isolation).
- Error simulation support
- All signals via Rear I/O

1.4.2 LIN and digital IO Variant for XMC

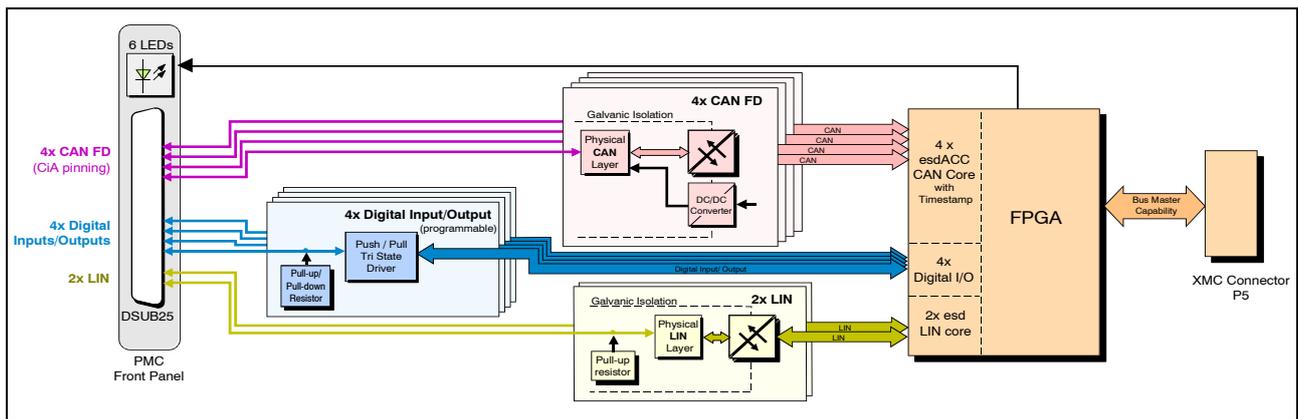


Figure 4: Block circuit diagram of XMC-CAN/402-FD-LIN-DIO

Figure 4 shows the block circuit diagram of the variant XMC-CAN/402-FD-LIN-DIO with additional LIN and digital IO Ports.

This also applies for the XMC-CAN/402-FD-LIN-DIO-T for the extended temperature range.

1.5 Glossary

Abbreviations

Abbreviation	Term
API	Application Programming Interface
CAN	Controller Area Network
CAN CC	CAN classic
CAN FD	CAN flexible data rate
CPU	Central Processing Unit
CiA	CAN in Automation
DCF	Device Configuration File
esd	esd electronics gmbh
HW	Hardware
IDC	Insulation Displacement Connector
I/O	Input/Output
n.a.	not applicable
OS	Operating System
PCI	Peripheral Component Interconnect
PCIe	PCI Express
SDK	Software Development Kit

2 PCB Views with Connectors and Label



NOTICE

Read chapter “Installing and Uninstalling Hardware” on page 22, before you start with the installation of the hardware!

See also page 32 for signal assignment of the CAN connectors.

2.1 PMC - Standard, -T and -IRIG-B Variants.

PMC Variants

PMC-CAN/402-4-FD

(Standard board),

PMC-CAN/402-4-FD-T

(Standard board for extended temperatures)

PMC-CAN/402-4-FD-IRIG-B

(Board with additional IRIG-B port):

The position of the CAN connector, the termination jumpers, the jumper depot and the PMC connectors is the same for all these variants and is described in Figure 5.

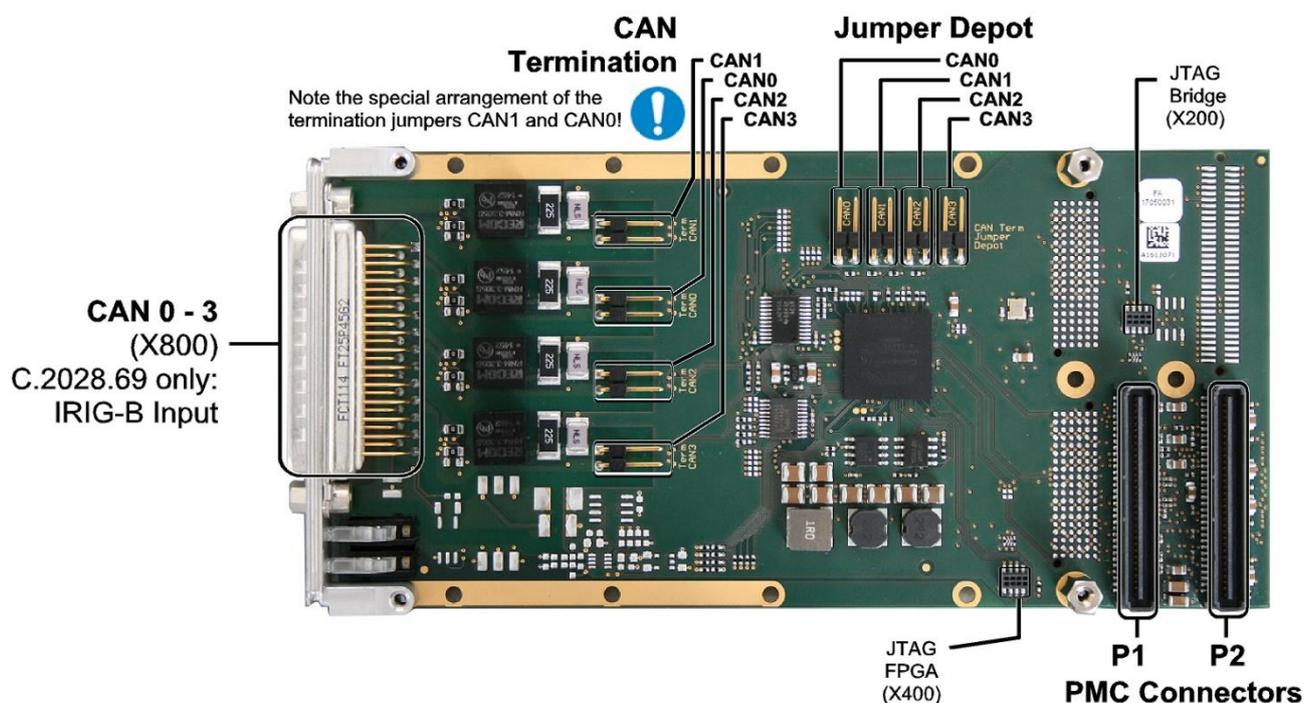


Figure 5: PCB top layer of PMC-CAN/402-4-FD (facing the carrier board)

2.2 XMC- Standard and IRIG-B Variant

XMC Variants

XMC-CAN/402-4-FD

(Standard board)

XMC-CAN/402-4-FD-IRIG-B

(Board with additional IRIG-B port):

The position of the CAN connector, the termination jumpers, the jumper depot and the XMC connector is the same for all these and is described in Figure 6.

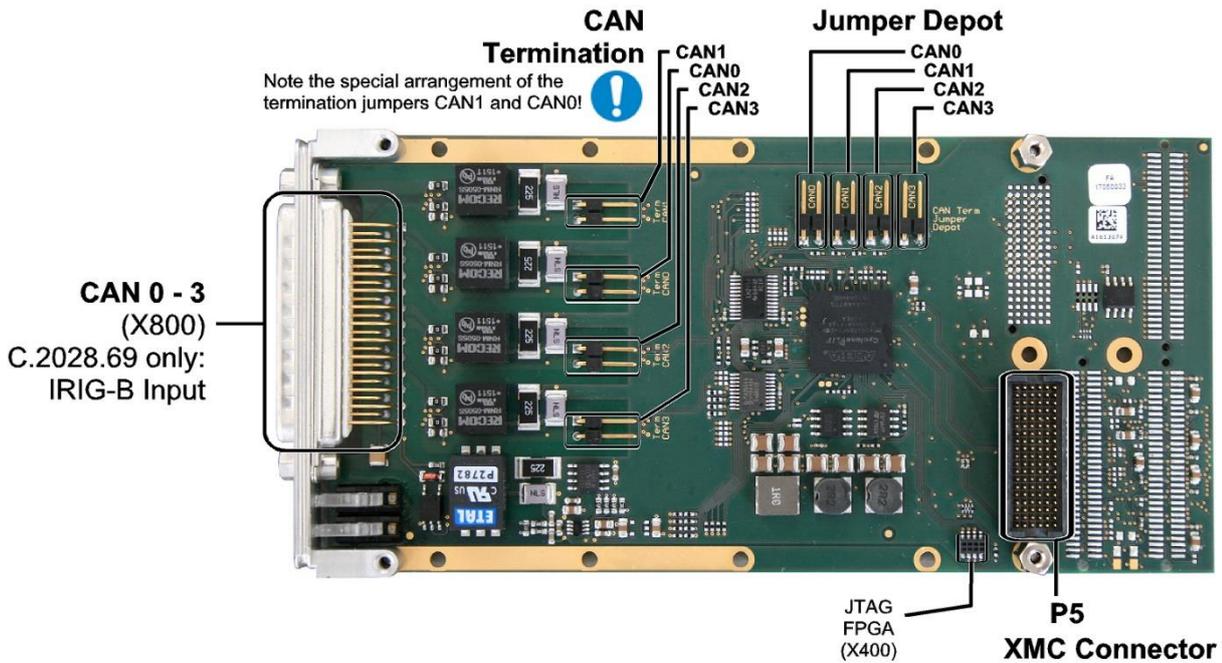


Figure 6: PCB top layer of XMC-CAN/402-4-FD-IRIG-B (facing the carrier board)

2.3 LIN-DIO Variants

In the PMC/XMC-CAN/402-LIN-DIO variants the jumper depot is not available.

PMC Variants

PMC-CAN/402-FD-LIN-DIO (Board with additional LIN and digital I/O ports),

PMC-CAN/402-FD-LIN-DIO-T (Board with additional LIN and digital I/O ports, and for extended temperatures):

The position of the CAN connector, the termination jumpers and the PMC connectors is the same for all these variants and is described in Figure 7.

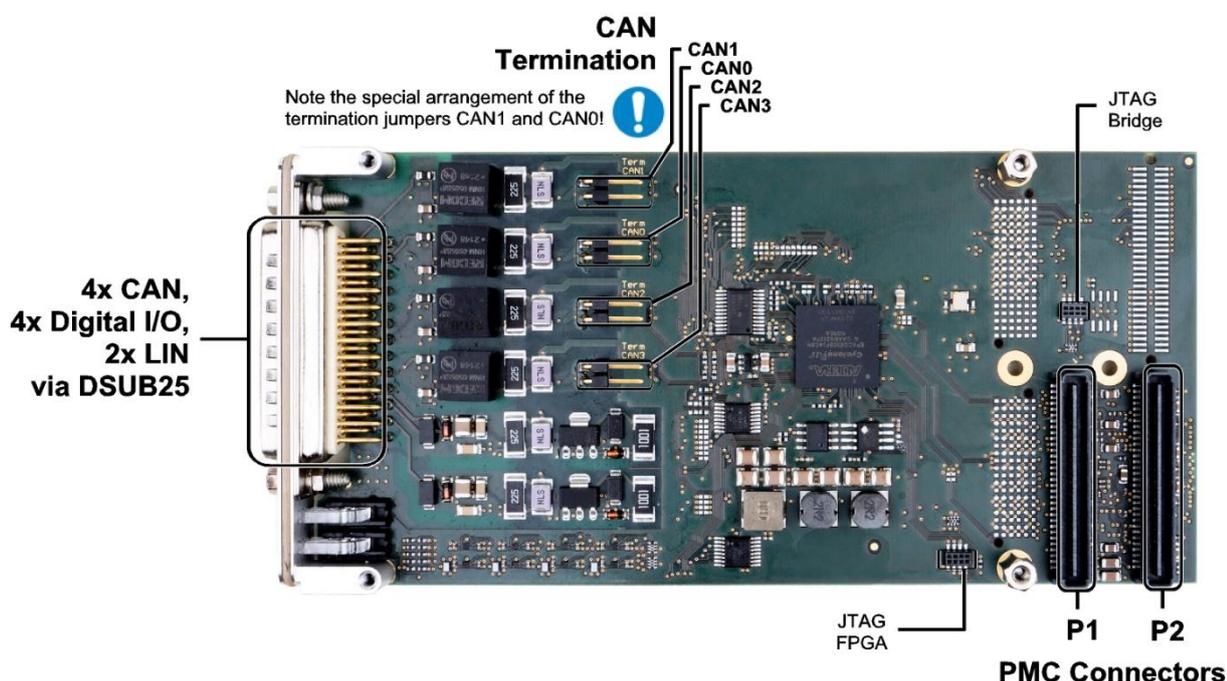


Figure 7: PCB top layer of PMC-CAN/402-FD-LIN-DIO (facing the carrier board)

XMC Variants

XMC-CAN/402-FD-LIN-DIO (Board with additional LIN and digital I/O ports),

XMC-CAN/402-FD-LIN-DIO-T (Board with additional LIN and digital I/O ports, and for extended temperatures):

The positions of the DSUB25 connector and the jumpers described in Figure 7 also apply accordingly to the XMC-CAN/4024-FD-LIN-DIO variants. The PMC connectors P1 and P2 are not equipped in the XMC variants, but the XMC connector P5 (see Figure 6).

2.4 Product Label

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

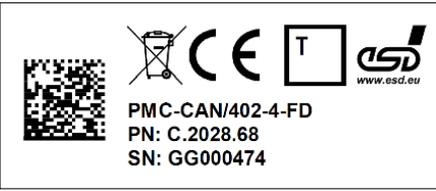
<p>esd Product label example</p>	<p>The esd product label is placed on the PCB and shows:</p>	<p>Example:</p>
 <p>PMc-CAN/402-4-FD PN: C.2028.68 SN: GG000474</p>	<p>Icons in top row from left to right:</p> <ul style="list-style-type: none"> - Data matrix code - Crossed-out dustbin (disposal) - CE label (CE) - Field for quality assurance (T) - esd logo (www.esd.eu) 	<p>-</p>
	<p>Below top row:</p> <ul style="list-style-type: none"> - Product name - PN: esd order number - SN: Batch (first two letters) and serial number (following six digits) 	<p>PMc-CAN/402-4-FD C.2028.68 SN: GG000474 (GG 000474 Batch Serial number)</p>
<p>Figure 8: Example of product label (order of the items may deviate)</p>		

Table 1: Product label

3 Jumper Configuration

An on-board termination resistor of 120Ω can be individually enabled for each CAN port via jumpers. In addition, a jumper depot is available on the PMC/XMC-CAN/402 cards (see section 3.1) except for the PMC/XMC-CAN/402-LIN-DIO variants (see section 3.2).

3.1 CAN Termination via Jumper Depot

	<p>NOTICE The jumper depot is not equipped on the PMC/XMC-CAN/402-LIN-DIO variants, see 3.2. The CAN termination of all other variants is described in this chapter.</p>
---	---

For the position of the jumpers and jumper depots on the XMC-CAN/402-4-FD(-IRIG-B) see Figure 6 on page 16, and for the PMC-CAN/402-4-FD(-T, -IRIG-B) see Figure 5 on page 15.

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

	<p>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 port.</p>
---	--

Table 2: CAN termination

3.2 Switchable Bus Termination (LIN-DIO-Variants only)

For the position of the jumpers on the PMC/XMC-CAN/402-LIN-DIO variants see Figure 7 on page 17. The jumper depots are not equipped on the PMC/XMC-CAN/402-LIN-DIO variants. On delivery the jumpers are not set. If the jumpers are not set on the PMC/XMC-CAN/402-LIN-DIO variants, the CAN termination can also be enabled or disabled via software. Please refer to the NTCAN API Manual Part 1 for more information about using the software function 'Switchable Bus Termination'. In delivery state the CAN termination is switched off by default.

Name	Jumper	Jumper set	Jumper not set	Jumper Depot
CAN1	JP610	Internal termination of CAN1	The individual CAN bus must be terminated externally or CAN termination can be switched by software.	-
CAN0	JP600	Internal termination of CAN0		-
CAN2	JP700	Internal termination of CAN3		-
CAN3	JP710	Internal termination of CAN2		-

	<p>NOTICE Please note that the software can only deactivate the CAN termination that is set via software. The CAN termination set via the jumpers cannot be deactivated by software! Furthermore, a CAN termination set by software will not remain active if the PMC/XMC-CAN/402-LIN-DIO is switched off or reset! It is recommended to use the jumper if the bus termination is to be set permanently.</p>
---	---

Table 3: CAN termination of LIN-DIO variant

4 LEDs

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

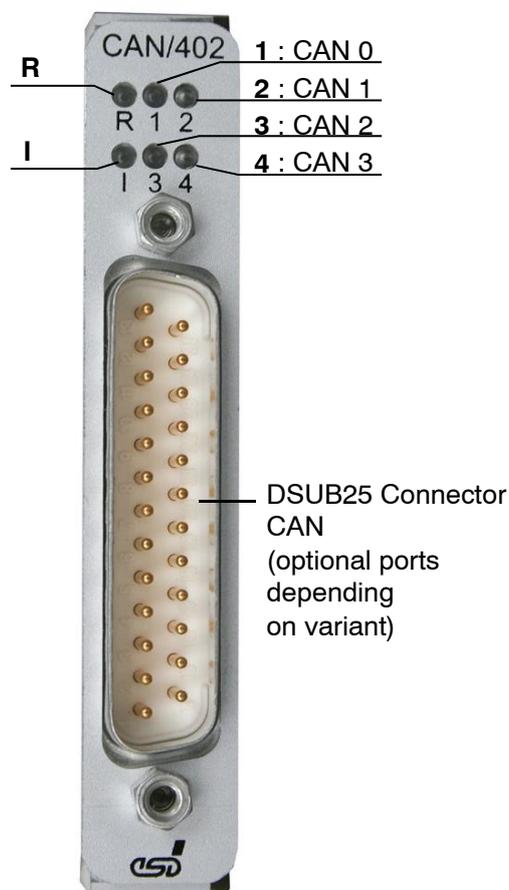


Figure 8: Front panel view of PMC/XMC-CAN/402

4.1 CAN LEDs (1 -4)

Label	Function	Indication (LED on)
1	CAN 0	blinking - Connected to CAN 0 and data transfer on CAN 0
2	CAN 1	blinking - Connected to CAN 1 and data transfer on CAN 1
3	CAN 2	blinking - Connected to CAN 2 and data transfer on CAN 2
4	CAN 3	blinking - Connected to CAN 3 and data transfer on CAN 3

Table 4: Description of CAN LEDs

4.2 Status LEDs (R, I, or optional A, B)

The name and indication of these LEDs differ for the different PMC/XMC-CAN/402 variants.

PMC/XMC-CAN/402 Standard Variants and Extended Temperature Variant		(C.2018.68, C.2028.68, C.2028.78) only:
Label	Function	Indication (LED on)
R	RUN	Board (FPGA) booted
I	Reserved	Reserved the LED is without function

Table 5: LEDs R, I of standard variants

PMC/XMC-CAN/402-IRIG-B Variants		(C.2018.69, C.2028.69) only:
Label	Function	Indication (LED on)
R	RUN	Board (FPGA) booted
I	IRIG-B	IRIG-B Link
		flickering - no signal
		blinking - synchronisation is proceeding
		on - synchronised

Table 6: LEDs R, I of IRIG-B variants

PMC/XMC-CAN/402-LIN-DIO Variants		(C.2018.70, C.2018.71, C.2028.70, C.2028.71) only
Label	Function	Indication (LED on)
R	LIN0	Data transfer on LIN0
I	LIN1	Data transfer on LIN1

Table 7: LEDs R, I of LIN-DIO-variants

5 Installing and Uninstalling Hardware



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 is to be integrated.

- The PMC/XMC-CAN/402 may only be operated on supply circuits that provide sufficient protection against dangerous voltages.
- External circuits connected to the ports of the PMC/XMC-CAN/402 must be sufficiently protected against dangerous voltage.
- The user is responsible for compliance with the applicable national safety regulations.
- Disconnect all hazardous voltages (mains voltage) before opening the system. Never carry out work while power supply voltage is switched on!
- Ensure the absence of voltage before starting any electrical work.



NOTICE

Electrostatic discharges may cause damage to electronic components.

- Take the appropriate precautions for handling electrostatic discharge sensitive devices.
- Discharge the static electricity from your body *before* you touch the PMC/XMC-CAN/402.
- Furthermore, you should prevent your clothes from touching the PMC/XMC-CAN/402, because your clothes might be electrostatically charged as well.

5.1 Preparation

Procedure for Installation and Uninstallation:

1. Switch off your computer and all connected peripheral devices (monitor, printer, etc.). Switch off the connected CAN devices.
2. Discharge your body as described above.
3. Disconnect the computer from the mains.
Make sure that no risk arises from the system into which the PMC/XMC-CAN/402 shall be inserted.
Read the manual of the system (PC) used and follow the instructions of the system's manufacturer.



WARNING

Hazardous Voltage

Risk of electric shock due to unintentional contact with uninsulated live parts with high voltages.

- Disconnect all hazardous voltages (mains voltage) before opening the system.
- If the system does not have a flexible mains cable, but is directly connected to mains, disconnect the power supply via the safety fuse and make sure that the fuse cannot switch on again unintentionally (i.e., with caution label).
- Ensure the absence of voltage before starting any electrical work.
- Cover or block off adjacent live parts.

4. Open the case if necessary.

To install the PMC/XMC-CAN/402, continue as described in chapter 5.2 'Installing the Hardware'.
To uninstall the PMC/XMC-CAN/402, continue as described in chapter 5.3 'Uninstalling the Hardware'

5.2 Installing the Hardware

1. Read and follow the safety instructions at the beginning of chapter 5 and execute step 1 to 4 of the preparation procedure as described in chapter 5.1 if not already done.
2. A conductive O-ring is contained in the product package of the PMC/XMC-CAN/402 module. Mount the conductive O-ring on the front panel of the PMC/XMC-CAN/402 to obtain EMC shielding.
3. Set the jumpers for the internal termination of the CAN ports according to your needs, as described in chapter "Jumper Configuration", page 19.
4. Remove the carrier board (if already installed) and plug the PMC/XMC-CAN/402 carefully on the carrier board. Pay attention that the PMC/XMC-CAN/402 module is correctly installed on the carrier board.
Fix the PMC/XMC-CAN/402 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.
5. Install the carrier board in your computer.
Carefully push the board down until it snaps into place. Fix the carrier board.
6. Close the computer case again.
7. Connect the CAN ports and optionally the IRIG-B input or the LIN and IO ports via the DSUB25 connector in the front panel of the PMC/XMC-CAN/402.



NOTICE

To ensure the EC Conformity shielded cables must be used.
In an adapter cable FE (functional earth) shall be connected to the cable shield.
It is recommended to use the cables as described in chapters "Adapter Cables for Standard and IRIG-B Variants" on page 34 and "Adapter Cable for LIN-DIO Variants" on page 40. The conformity is granted when using these cables.



NOTICE

Please note that the CAN bus must be terminated at both ends!

If the integrated CAN termination of the CAN port is not set via the jumpers or software (PMC/XMC-CAN/402-LIN-DIO variants only), CAN has to be terminated externally, read chapter "Correct Wiring of Galvanically Isolated CAN Networks", from page 47.

For external CAN termination esd offers suitable termination connectors for the CAN bus. Additionally, the CAN_GND signal must be connected to earth at exactly one point in the CAN network.

A CAN participant with electrical connection to earth potential acts as an earth connection.

See also page 38 for notes on the IRIG-B wiring if you use the PMC/XMC-CAN/402-IRIG-B.

8. Connect the computer to mains again (mains connector or safety fuse).
9. Before you switch on the supply voltage, check that all plug connectors are correctly seated. Switch on the computer and the peripheral devices.
10. End of hardware installation.
11. Set the port properties in your operating system. Refer to the documentation of the operating system.

5.3 Uninstalling the Hardware

1. Read and follow the safety instructions at the beginning of chapter 5 and execute step 1 to 4 of the preparation procedure as described in chapter 5.1 if not already done.
2. Make sure that all connected interfaces and power supply are switched off.
3. Disconnect the PMC/XMC-CAN/402 from the connected interfaces.
4. Loosen the fastening of the carrier board and pull it out of the slot carefully.
5. Loosen the fastening of the PMC/XMC-CAN/402 and pull it carefully from the carrier board.
6. If necessary, close the housing of the computer again.

6 Technical Data

6.1 General Technical Data

Ambient temperature	Standard temperature range: 0...75° C PMC/XMC-CAN/402-4-FD PMC/XMC-CAN/402-4-FD-IRIG-B, PMC/XMC-CAN/402-LIN-DIO only
	Extended temperature range: -40° C ... +75° C PMC-CAN/402-4-FD-T PMC/XMC-CAN/402-LIN-DIO-T only
Humidity	90 %, non-condensing
Supply voltage	Nominal voltage: 3.3 VDC ±5% / PMC/XMC-CAN/402-4-FD(-T): I _{3.3V_MAX} = 1 A, I _{3.3V_TYPICAL} = 750 mA PMC/XMC-CAN/402-LIN-DIO: I _{3.3V_MAX} = < approx. 1.5 A, I _{3.3V_TYPICAL} = 800 mA
IP protection class	IP20
Dimensions (Width x height)	149 mm x 74 mm x 10 mm (length x width x height) (Single PMC size)
Weight	Approximately 100 g

Table 8: General technical data of the module

6.2 Connectors

Name	Function	Type	Durability	Variants
P1	PCI bus	64-pin PMC connector	100 mating cycles	PMC only
P2	PCI bus	64-pin PMC connector	100 mating cycles	
P5	PCI Express bus	Samtec VITA 42.3 XMC Standard Connectors 114 pos., 6 rows, pin contacts	10 mating cycles	XMC only
X800	CAN0 – CAN3, optional IRIG-B, optional LIN, DIO	DSUB25, pin contacts, Quality class 2	200 mating cycles	All
Only for test- and programming purposes:				
X200	JTAG Bridge	Samtec CLM104-02-F-D-BE	100 mating cycles	PMC only
X400	JTAG FPGA	Samtec CLM104-02-F-D-BE	100 mating cycles	All

Table 9: Connectors

6.3 CAN FD Ports

Number of CAN FD ports	4 CAN FD ports (CAN0 - CAN3)
CAN controller	esdACC in FPGA, according to ISO11898-1
Physical Layer	Physical layer according to ISO 11898-2, CAN FD bit rates from 10 kbit/s up to 8 Mbit/s with the same CAN transceiver
Bus termination	Terminating resistors (120Ω) can be set via jumpers for each individual CAN channel, see chapter 3 on page 19. PMC/XMC-CAN/402-LIN-DIO variants only: The CAN termination can be switched by software, see chapter 3.2 on page 19.
Galvanic isolation	Galvanic 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	DSUB25, pin-contacts

Table 10: Data of the CAN FD port

6.4 PMC Port

	<p>INFORMATION The PMC port is only equipped on the PMC variants (C.2028.xx)!</p>
---	--

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 11: Data of the PMC port

6.5 XMC Port



INFORMATION

The XMC port is only equipped on the XMC variants (C.2018.xx)!

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 12: Data of the XMC port

6.6 Message-Signalled Interrupt Handling

The PMC/XMC-CAN/402 supports MSI. The equipped PCI-to-PCIe bridge can 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 Optional Ports

6.7.1 IRIG-B Port



INFORMATION

The IRIG-B port is only equipped on the IRIG-B variants:
 XMC-CAN/402-4-FD-IRIG-B (C.2018.69)
 PMC-CAN/402-4-FD-IRIG-B (C.2028.69).

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

Table 13: Data of the IRIG-B port

6.7.2 LIN Port

	<p>INFORMATION</p> <p>The LIN port is only equipped on the LIN-DIO variants: XMC-CAN/402-FD-LIN-DIO (C.2018.70), XMC-CAN/402-FD-LIN-DIO-T (C.2018.71), PMC-CAN/402-FD-LIN-DIO (C.2028.70), PMC-CAN/402-FD-LIN-DIO-T (C.2028.71)</p>
---	--

Number	2
Specification	LIN Specifications up to variants 2.2A
LIN Controller	DLIN IP-Core
Physical LIN Layer	<p>LIN port according to ISO 17987-4:2016 Bit rates supported from 1000 Bit/s up to 20 kBit/s, Automatic bit rate detection and resynchronisation,</p> <p>The EN Pin can be switched by the FPGA, Switchable commander pull-up resistor</p>
Galvanic isolation	<p>Via digital isolator and external power supply from the LIN bus connector (24V)</p>
	<div style="display: flex; align-items: center;">  <p>NOTICE Functional insulation only!</p> </div> <p>Dielectric strength of insulation (LIN to slot bracket/EARTH; LIN to Host/System Ground; LIN to LIN): 1kV DC @ 1s (I < 1 mA)</p>
Bus termination	Switchable commander pull-up resistors (1K) (Activation via software)
Connector	DSUB25 in the front panel

Table 14: Data of the LIN port

6.7.3 Digital I/O Port

i	<p>INFORMATION</p> <p>The digital I/O port is only equipped on the LIN-DIO variants: XMC-CAN/402-FD-LIN-DIO (C.2018.70), XMC-CAN/402-FD-LIN-DIO-T (C.2018.71), PMC-CAN/402-FD-LIN-DIO (C.2028.70), PMC-CAN/402-FD-LIN-DIO-T (C.2028.71),</p>
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Number	4 digital I/O channels
I/O configuration	Each channel individually configurable as input or output. Direction switching is done via FPGA pins.
Schematic diagram of the I/O circuitry	
Control	The control and configuration of the I/Os is done via the NTCAN API. States of the I/Os as well as their configuration are mapped as register model.
Input resistance	4.7 kΩ per channel individually switchable as pullup or pulldown.
Galvanic isolation	None
Output level	<p>The output voltage of the drivers is individually switchable between nominal 3.3V and 5V. The switching is controlled via the I²C bus.</p> <p>$V_{OH} (@ I_{OH} = -24 \text{ mA} \ \& \ V_{CC} = V_{CC3,3MIN} = 3.0 \text{ V}) = 2.4 \text{ V}$ $V_{OH} (@ I_{OH} = -32 \text{ mA} \ \& \ V_{CC} = V_{CC5,0MIN} = 4.5 \text{ V}) = 3.8 \text{ V}$ $V_{OL} (@ I_{OL} = 24 \text{ mA} \ \& \ V_{CC} = V_{CC3,3MIN} = 3.0 \text{ V}) = 0.55 \text{ V}$ $V_{OL} (@ I_{OL} = 32 \text{ mA} \ \& \ V_{CC} = V_{CC5,0MIN} = 4.5 \text{ V}) = 0.55 \text{ V}$</p>
Input level	<p>The input switching thresholds depend on the driver voltage (nominally 3.3V / 5.0V)</p> <p>$V_{IH} (@ V_{CC} \text{ between } 3.0 \text{ V} - 3.6 \text{ V}) = 2.0 \text{ V}$ $V_{IH} (@ V_{CC} \text{ between } 4.5 \text{ V} - 5.5 \text{ V}) = 0.7 \times V_{CC}$ $V_{IL} (@ V_{CC} \text{ between } 3.0 \text{ V} - 3.6 \text{ V}) = 0.8 \text{ V}$ $V_{IL} (@ V_{CC} \text{ between } 4.5 \text{ V} - 5.5 \text{ V}) = 0.3 \times V_{CC}$</p>
Output current	<p>±24 mA @ nominal 3.3 V driver voltage ±32 mA @ nominal 5.0 V driver voltage</p>

Technical Data

Switching speed of the driver	<p>@ V_{CC} between 3.0 V - 3.6 V</p> <p>Level change (high to low; low to high): t_{PLH} = max. 5.8 ns; t_{PHL} = max. 5.0 ns</p> <p>Direction change (IN to OUT; OUT to IN): t_{PHZ} = max. 8.8 ns; t_{PHL} = max. 7.1 ns</p> <p>@ V_{CC} between 4.5V - 5.5V</p> <p>Level change (high to low; low to high): t_{PLH} = max. 4.4 ns; t_{PHL} = max. 4.0 ns</p> <p>Direction change (IN to OUT; OUT to IN): t_{PHZ} = max. 6.8 ns; t_{PHL} = max. 4.9 ns</p>
Protection circuits	Overvoltage protection via TVS diodes
Interrupts	<p>The triggering of interrupts (IRQ) can be programmed for the I/Os configured as inputs.</p> <p>The setting options for the detection of the signal states are: no IRQs / rising signal edge / falling signal edge / both signal edges.</p>
Connector	DSUB25 in the front panel

Table 15: Data of the digital I/O port

6.8 Software Support

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

Additional CAN object licences for the real-time operating systems such as QNX®, RTX64®, VxWorks® and INtime® are available. Higher layer protocols (CANopen®, J1939, ARINC825) are supported for CAN CC applications. See Order Information from page 63 for availability of the drivers.

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

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

“NTCAN Part 1: C/C++ Software Design Guide” Application Developers Manual and
 “NTCAN Part 2: Installation, Configuration and Firmware Update” Installation Guide.

The manuals can be downloaded free of charge from our website via the product page of the PMC/XMC-CAN/402 or the CAN-SDK page: <https://esd.eu/produkte/can-sdk>

For the PMC/XMC-CAN/402-LIN-DIO variants an additional NTLIN Application Developers Manual is available and can be downloaded free of charge from our website.

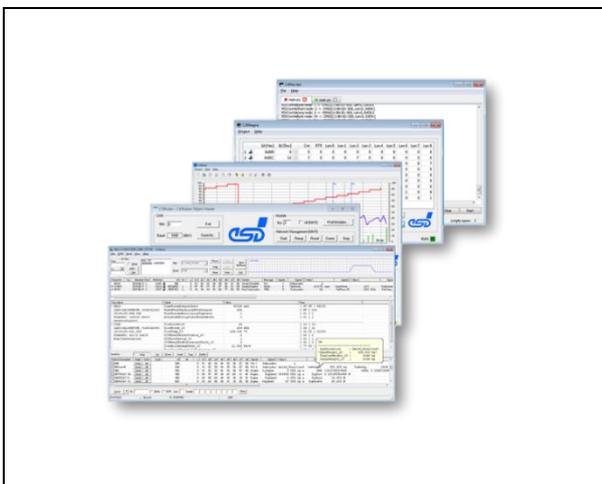


NOTICE (PMC-CAN/402-4-FD variants only)
 PMC-CAN/402-4-FD boards which are equipped with the Pericom® PCI-to-PCI bridge PI7C9X111SL might have potential interoperability problems in Microsoft Windows or Linux operating systems. Read chapter “Application Note to PMC-CAN/402“ on page 58 for information 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
- 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 Standard and optional IRIG-B Variants

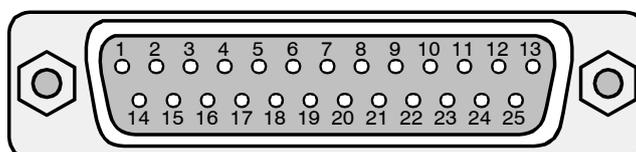
This chapter describes the pin assignment of the DSUB25 connector of the PMC/XMC-CAN/402 standard variants (C.2018.68, C.2028.68, C.2028.78) and the IRIG-B variants (C.2018.69, C.2028.69) and the associated cables.

See from page 39 for the pin assignment of the DSUB25 connector of PMC/XMC-CAN/402-LIN-DIO variants.

7.1.1 DSUB25 Connector

Device connector: DSUB25 connector with pin contacts

Pin Position:



Pin Assignment				Variant
Signal	Pin		Signal	
CAN0_L	1	14	CAN0_H	All Standard and IRIG-B variants only: C.2018.68, C.2018.69, C.2028.68, C.2028.69, C.2028.78
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	-	Standard variants only: C.2018.68, C.2028.68, C.2028.78
-	11	24	-	
-	12	25	-	
-	13	-	-	
-	10	23	-	IRIG-B variants only: C.2018.69, C.2028.69
-	11	24	IRIG-B_RX+	
IRIG-B_RX-	12	25	IRIG-B_A+	
IRIG-B_A-	13	-	-	

The pin assignment of the CAN signals on pins 1 - 9 and pins 14 - 22 is identical for all standard and IRIG-B variants.

The pins 10 -13 and 23 – 25 are only used for the additional IRIG-B ports of the optional IRIG-B variants.

The connector housing is connected to Shield potential.

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

PMC/XMC-CAN/402-4-FD-IRIG-B variants only (C.2018.69, C.2028.69):

IRIG-B_RX+, IRIG-B_RX-	IRIG-B input. Physical layer RS-422 compatible.	Optional IRIG-B
IRIG-B_A+, IRIG-B_A-	IRIG-B analog input.	



NOTICE

To ensure the EU Conformity shielded cables must be used.

In an adapter cable FE (functional earth) shall be connected to the cable shield.

It is recommended to use the CAN cables, as described in chapter "Adapter Cables for Standard and IRIG-B Variants" from page 34.

The conformity is granted when using these cables.

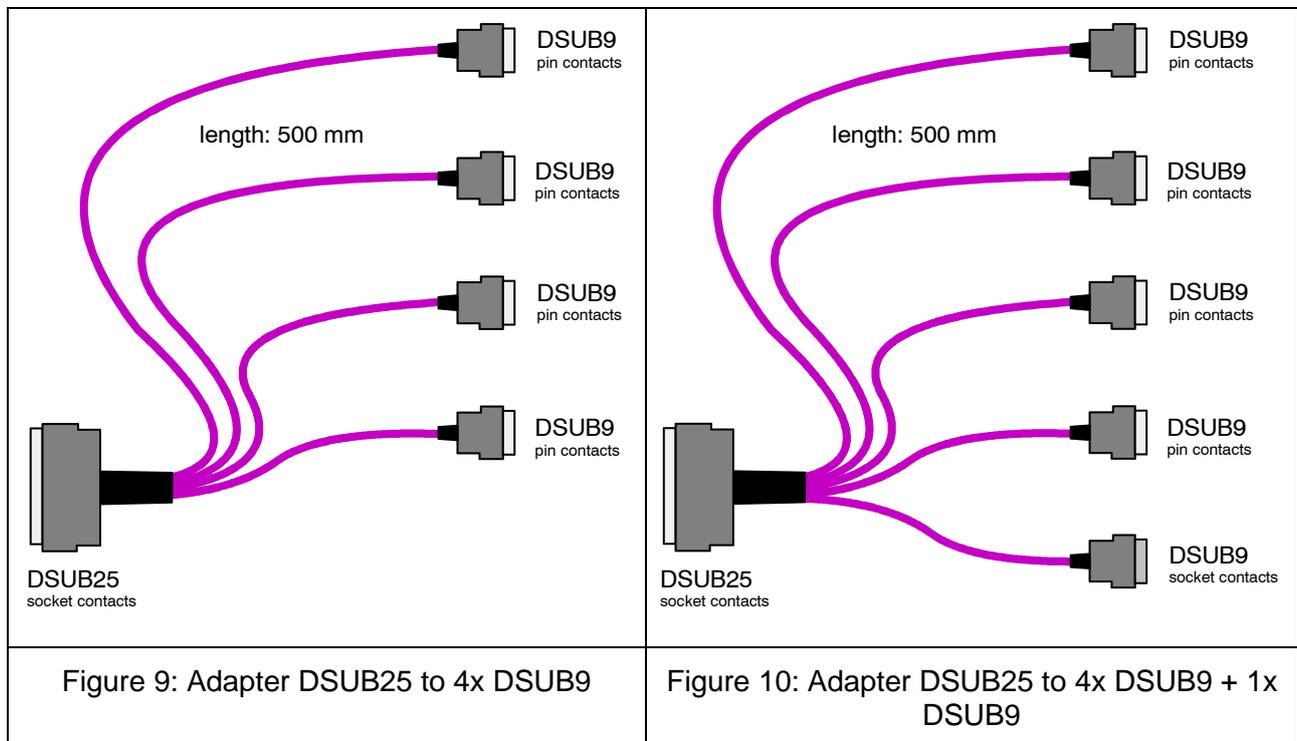
Connector Assignments

7.1.2 Adapter Cables for Standard and IRIG-B Variants

	<p>NOTICE</p> <p>To ensure the EU Conformity shielded cables must be used. In this adapter cables FE (functional earth) is connected to the cable shield.</p>
---	--

esd offers the following adapter cables (see also Order Information on page 63):

Cable	Use with
<p>CAN/400-4-1C4 1xDSUB25-to-4xDSUB9 (order no. C.2047.19)</p> <p>Cable to for the Standard Products (4x DSUB9) This adapter only connects the four CAN ports to the DSUB25 front panel connector X800. The cable comes with four DSUB9 connectors with pin contacts for the four CAN ports (CAN0 -CAN3), see Figure 9.</p>	<p>Standard variants:</p> <p>C.2018.68, C.2028.68, C.2028.78 only!</p>
<p>CAN/400-4-1C5 1xDSUB25-to-5xDSUB9 (order no. C.2047.18)</p> <p>Cables for the IRIG-B variants (4x DSUB9 +1x DSUB9) This adapter connects the four CAN ports and the optional IRIG-B inputs to the DSUB25 front panel connector X800. This cable comes with four DSUB9 connectors with pin contacts for the CAN ports (CAN0 -CAN3) and an additional DSUB9 connector with socket contacts for the IRIG-B input, see Figure 10.</p>	<p>IRIG-B variants:</p> <p>C.2018.69, C.2028.69 only!</p>



Adapter DSUB25 to 4x DSUB9 (pin contacts) and optional DSUB9 (socket contacts)

DSUB25 Connector		Cable	DSUB9 Connector		Signal Name	
Connector Type	Pin No.	Port	Connector Type	Pin No.		
DSUB25 connector, socket-contacts	1	CAN0	DSUB9, pin contacts	2	CAN0_L	
	14			7	CAN0_H	
	2			3	CAN0_GND	
	Connector housing			Shield	Connector housing	FE
	16	CAN1	DSUB9, pin contacts	2	CAN1_L	
	4			7	CAN1_H	
	17			3	CAN1_GND	
	Connector housing			Shield	Connector housing	FE
	6	CAN2	DSUB9, pin contacts	2	CAN2_L	
	19			7	CAN2_H	
	7			3	CAN2_GND	
	Connector housing			Shield	Connector housing	FE
	-					
	21	CAN3	DSUB9, pin contacts	2	CAN3_L	
	9			7	CAN3_H	
	22			3	CAN3_GND	
	Connector housing			Shield	Connector housing	FE
CAN/400-4-1C5 1xDSUB25-to-5xDSUB9 (order no. C.2047.18) only:						
24	IRIG-B	DSUB9, socket contacts	9	IRIG-B_Rx+		
12			4	IRIG-B_Rx-		
25			1	IRIG-B_A+		
13			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 Figure 11 and Figure 12, on page 38 for a description of the wiring of the analog and digital IRIG-B ports.

Connector Assignments

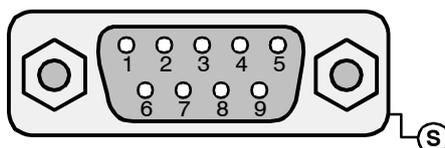
7.1.2.1 CAN Port via DSUB9 (Pin Contacts)

Four DSUB9 connectors for the CAN0 - CAN3 ports 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: DSUB9 connector, pin contacts

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:

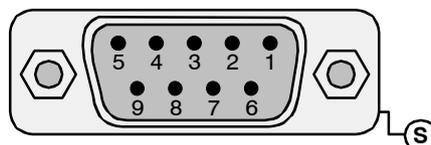
Name	Description
-	Reserved - Do not use! This pin is not connected at the module.
CANx_L, CANx_H, CANx_GND	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

7.1.2.2 IRIG-B Input via DSUB9 (Socket Contacts)

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

Device connector: DSUB9 connector, socket contacts

Pin Position:



Pin Assignment:

Signal	Pin	Signal
IRIG-B_A+	1	
-	2	-
-	3	-
IRIG-B_Rx-	4	IRIG-B_A-
-	5	-IRIG-B_Rx+
FE	S (Shield)	

Signal Description:

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 38 for a description of the wiring of the analog and digital IRIG-B ports.

Connector Assignments

7.1.2.3 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 connector (socket contacts)

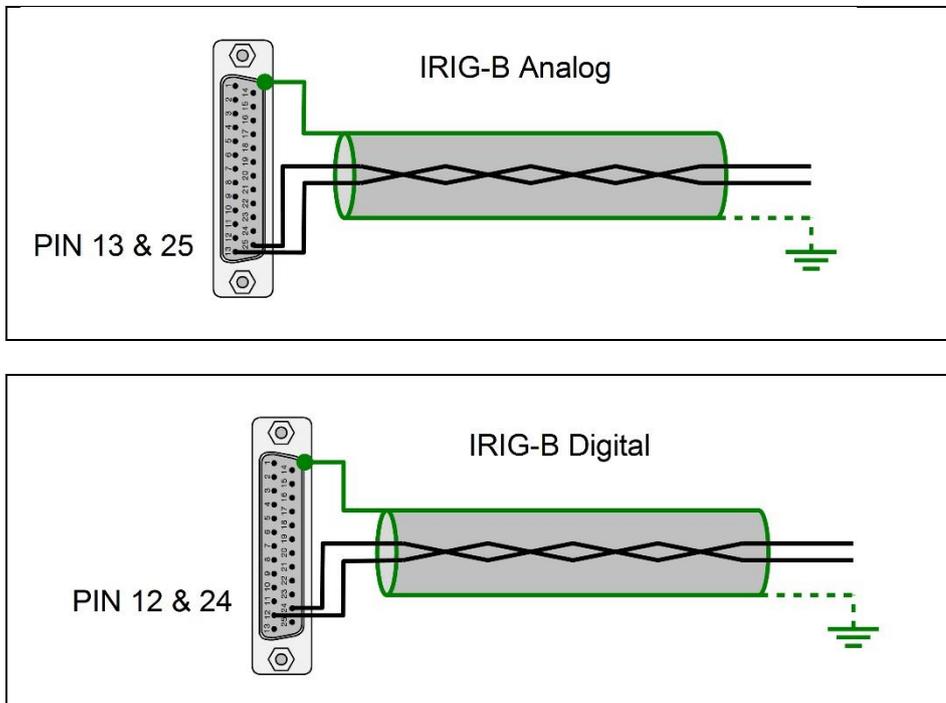


Figure 11: Analog and digital IRIG-B wiring guidelines at DSUB25

Analog and digital IRIG-B at DSUB9 connector (socket contacts)

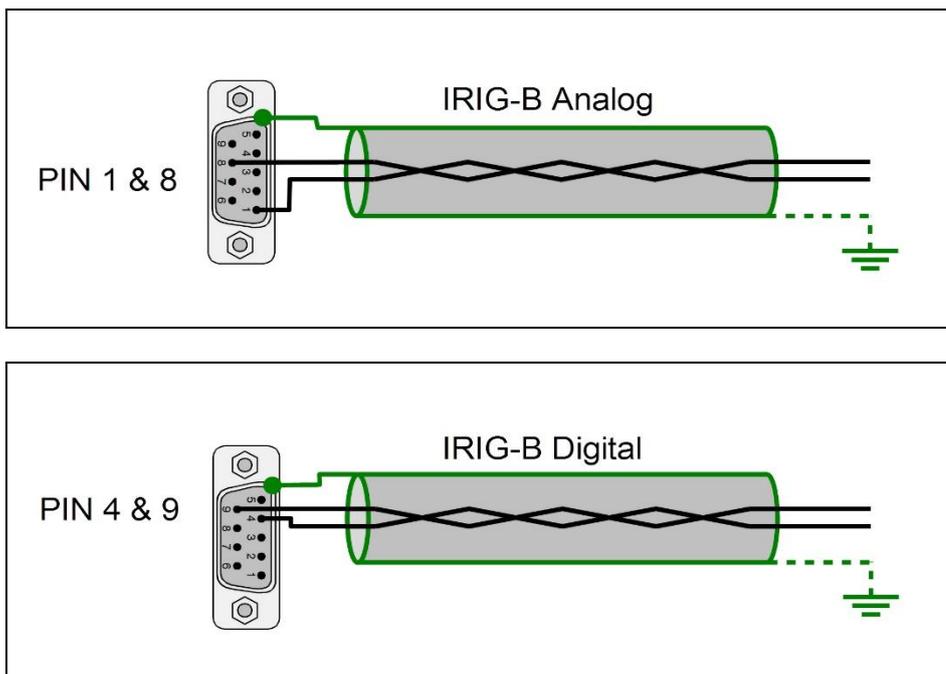


Figure 12: Analog and digital IRIG-B wiring guidelines at DSUB9

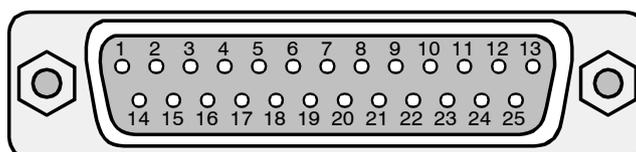
7.2 LIN-DIO Variants

This chapter describes the pin assignment of the DSUB25 connector of PMC/XMC-CAN/402-LIN-DIO variants (C.2018.70, C.2018.71, C.2028.70, C.2028.71) and the associated cable.

7.2.1 DSUB25 Connector

Device connector: DSUB25 connector with pin contacts

Pin Position:



Pin Assignment				Variant
Signal	Pin		Signal	
CAN0_L	1	14	CAN0_H	Optional LIN-DIO, C.2018.70 C.2018.71 C.2028.70 C.2028.71 only
CAN0_GND	2	15	-	
-	3	16	CAN1_L	
CAN1_H	4	17	CAN1_GND	
GPIO0	5	18	GPIO1	
CAN2_L	6	19	CAN2_H	
CAN2_GND	7	20	GPIO2	
GPIO3	8	21	CAN3_L	
CAN3_H	9	22	CAN3_GND	
LIN0_BUS_Line	10	23	LIN0_24V	
LIN0_GND	11	24	LIN1_BUS_Line	
LIN1_24V	12	25	LIN1_GND	
GND	13	-	-	

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

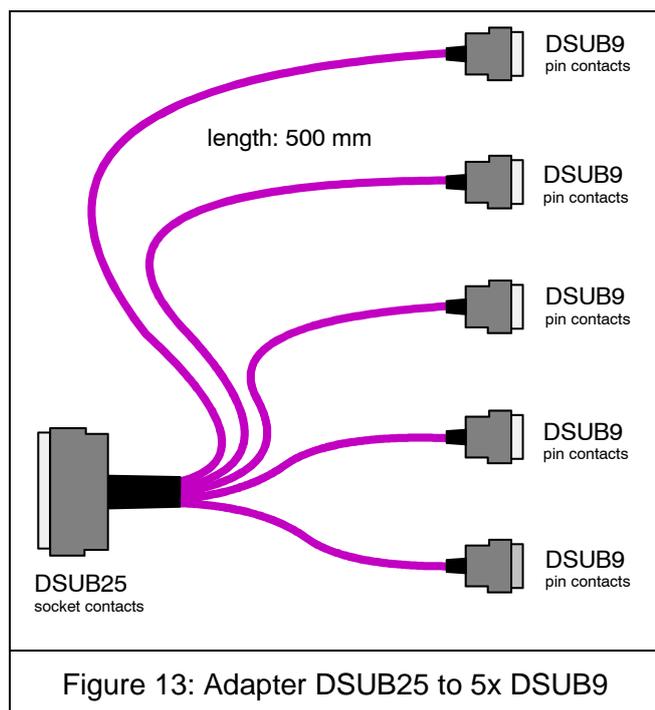
Optional LIN-DIO		
LINx_Bus_Line	Signal line of LINx (x = 0, 1)	Optional LIN
LINx_24V	24 V supply voltages of LINx (x =0, 1)	
LINx_GND	Reference potentials of LINx (x = 0, 1)	
GPIOy	Signal line of I/Oy (y = 0, 1, 2, 3)	Optional GPIOs
GND	Reference potential for GPIO signals	



NOTICE

To ensure the EU Conformity shielded cables must be used. In an adapter cable FE (functional earth) shall be connected to the cable shield. It is recommended to use the CAN cable CAN Cable 1xDSUB25-to5xDSUB9_LIN-DIO, which is described in the following chapter: "Adapter Cable for LIN-DIO Variants". The conformity is granted when using this cable.

7.2.2 Adapter Cable for LIN-DIO Variants



esd offers the following adapter cable (see also Order Information on page 63):

Cable	Use with
<p>CAN Cable 1xDSUB25-to5xDSUB9_LIN-DIO (order no. C.2047.17) Cables for the LIN-DIO variants (5x DSUB9 connectors with pin contacts) This adapter connects the four CAN ports and the optional LIN and IO ports to the DSUB25 front panel connector X800. It comes with: 2 DSUB9 connectors for CAN and LIN (CAN0 + LIN0, CAN1 + LIN1) 2 DSUB9 connectors for CAN only (CAN2, CAN3) 1 DSUB9 connector for the digital Ios (GPIO0-3) See Figure 13.</p>	<p>LIN-DIO variants: C.2018.70, C.2018.71, C.2028.70, C.2018.71 only!</p>



NOTICE

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

Adapter DSUB25 to 5x DSUB9 (pin contacts)

DSUB25 Connector		Cable	DSUB9 Connector		Signal Name
Connector Type	Pin No.	Port	Connector Type	Pin No.	
DSUB25 plug, socket- contacts	1	CAN0, LIN0	DSUB9 plug, pin contacts	2	CAN0_L
	2			3	CAN0_GND
	10			4	LIN0_BUS_Line
	11			5	LIN0_GND
	14			7	CAN0_H
	23			9	LIN0_24V
	Connector housing			shield	Connector housing
	16	CAN1, LIN1	DSUB9 plug, pin contacts	2	CAN1_L
	17			3	CAN1_GND
	24			4	LIN1_BUS_Line
	25			5	LIN1_GND
	4			7	CAN1_H
	12			9	LIN1_24V
	Connector housing			shield	Connector housing
	6	CAN2	DSUB9 plug, pin contacts	2	CAN2_L
	7			3	CAN2_GND
	19			7	CAN2_H
	Connector housing			shield	Connector housing
	21	CAN3	DSUB9 plug, pin contacts	2	CAN3_L
	22			3	CAN3_GND
	9			7	CAN3_H
	Connector housing			shield	Connector housing
	5	Digital IO 0 - 3	DSUB9 plug, pin contacts	1	GPIO0
	18			2	GPIO1
	13			6	GND
	20			7	GPIO2
	8			8	GPIO3
	Connector housing			shield	Connector housing

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

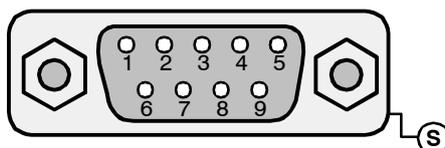
Connector Assignments

7.2.2.1 CAN and LIN Ports via DSUB9 Connectors (Pin Contacts)

The cable comes with four DSUB9 connectors each for one of the CAN ports CAN0- CAN3. The signals for the LIN0 port are also connected via the DSUB9 connector for CAN0, and signals for the LIN1 port are also connected via the DSUB9 connector for CAN1. The DSUB9 connectors for CAN2 and CAN3 are CAN only.

Device connector: DSUB9 connector, pin contact

Pin Position:



Pin Assignment:

Signal	Pin	Signal
-	1	-
CANx_L	2	CANx_H
CANx_GND	3	-
LINx_BUS_Line*	4	LINx_24V*
LINx_GND*	5	-
FE	S (Shield)	

* LIN0 with CAN0 and LIN1 with CAN1 only!

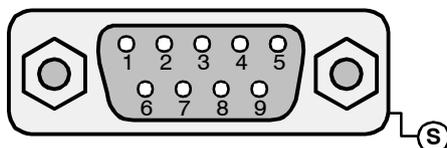
Signal Description:

Name	Description
-	Reserved - Do not use!
CANx_L, CANx_H, CANx_GND	CAN signals of CAN node x (x= 0, 1, 2, 3). Physical layer according to ISO11898-2.
LINx_Bus_Line	Signal line of LINx (x = 0, 1)
LINx_24V	24 V supply voltages of LINx (x =0, 1)
LINx_GND	Reference potentials of LINx (x = 0, 1)
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

7.2.2.2 Digital IO Ports via DSUB9 Connector (Pin Contacts)

Device connector: DSUB9 connector, pin contact

Pin Position:



Pin Assignment:

Signal	Pin	Signal
GPIO0	1	
		6
GPIO1	2	GPIO2
		7
-	3	GPIO3
		8
-	4	
		9
-	5	
FE	S (Shield)	

Signal Description:

Name	Description
-	Reserved - Do not use!
GPIO0 GPIO1 GPIO2 GPIO3	Signal lines of the digital input/output channels 0 -3
GND	Reference potential of the digital inputs/outputs
FE	Functional earth (FE) is connected to the housing of the DSUB9 connector and to the shield of the cable

7.3 PMC Connectors

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

i	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)
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7.3.1 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.

7.3.2 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.

7.4 XMC Connector

The XMC connectors P5 provides the PCI port 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).

7.4.1 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	VPWR	9								
GND	10	GND	10	n.c.	10	GND	10	GND	10	I ² C_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	I ² C_GA1	12	GND	12	GND	12	GND	12
n.c.	13	VPWR	13								
GND	14	GND	14	I ² C_GA2	14	GND	14	GND	14	I ² C.4.SDA	14
n.c.	15	VPWR	15								
GND	16	GND	16	I ² C_WE	16	GND	16	GND	16	I ² C.4.SCL	16
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 Galvanically Isolated CAN Networks



NOTICE

This chapter applies to CAN networks with bit rates up to 1 Mbit/s.

If you work with higher bit rates, as for example used for CAN FD, the information given in this chapter must be examined for applicability in each individual case.

For further information refer to the CiA® CAN FD guidelines and recommendations (<https://www.can-cia.org/>).

For the CAN wiring all applicable rules and regulations (EU, DIN), such as regarding electromagnetic compatibility, security distances, cable cross-section or material, must be observed.

8.1 CAN Wiring Standards

The flexibility in CAN network design is a major strength of the various extensions based on the original CAN standard ISO 11898-2, such as CANopen®, ARINC825, DeviceNet® and NMEA2000. However, taking advantage of this flexibility absolutely requires a network design that considers the interactions of all network parameters.

In some cases, the CAN organizations have adapted the scope of CAN in their specifications to enable applications outside the ISO 11898 standard. They have imposed system-level restrictions on data rate, line length and parasitic bus loads.

However, when designing CAN networks, a margin must always be planned for signal losses over the entire system and cabling, parasitic loads, network imbalances, potential differences against earth potential, and signal integrities. **Therefore, the maximum achievable number of nodes, bus lengths and stub lengths may differ from the theoretically possible number!**

esd has limited its recommendations for CAN wiring to the specifications of ISO 11898-2.

A description of the special features of the derived specifications CANopen, ARINC825, DeviceNet, and NMEA2000 is omitted here.

The consistent compliance with the ISO 11898-2 standard offers significant advantages:

- Reliable operation due to proven design specifications
- Minimization of error sources due to sufficient distance to the physical limits.
- Easy maintenance because there are no "special cases" to consider for future network modifications and troubleshooting.

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

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 suitable cable type with a wave impedance of about $120 \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22 \text{ mm}^2$) must be used. The voltage drop over the wire must be considered.
2	For light industrial environment use at least a two-wire CAN cable, the wires of which must be assigned as follows: <ul style="list-style-type: none"> • Two twisted wires must be assigned to the data signals (CAN_H, CAN_L). • The cable shield must be connected to the reference potential (CAN_GND).
3	The reference potential CAN_GND must be connected to the functional earth (FE) at exactly one point.
4	A CAN bus line must not branch (exception: short cable stubs) and must be terminated with the characteristic impedance of the line (generally $120 \Omega \pm 10\%$) at both ends (between the signals CAN_L and CAN_H and not at CAN_GND).
5	Keep cable stubs as short as possible ($l < 0.3 \text{ m}$).
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.

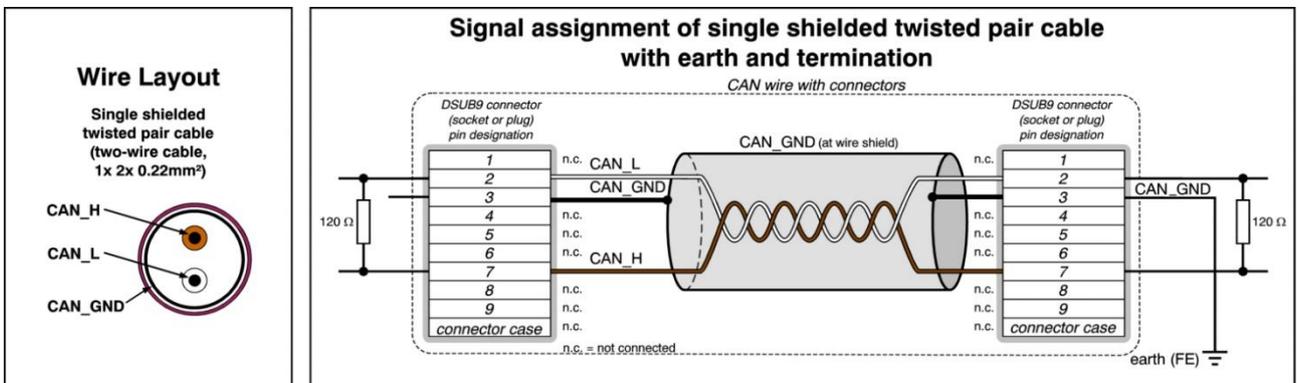


Figure 14: CAN wiring for light industrial environment

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 these devices are located at the end of the CAN network, the CAN terminator “CAN-Termination-DSUB9” can be used.

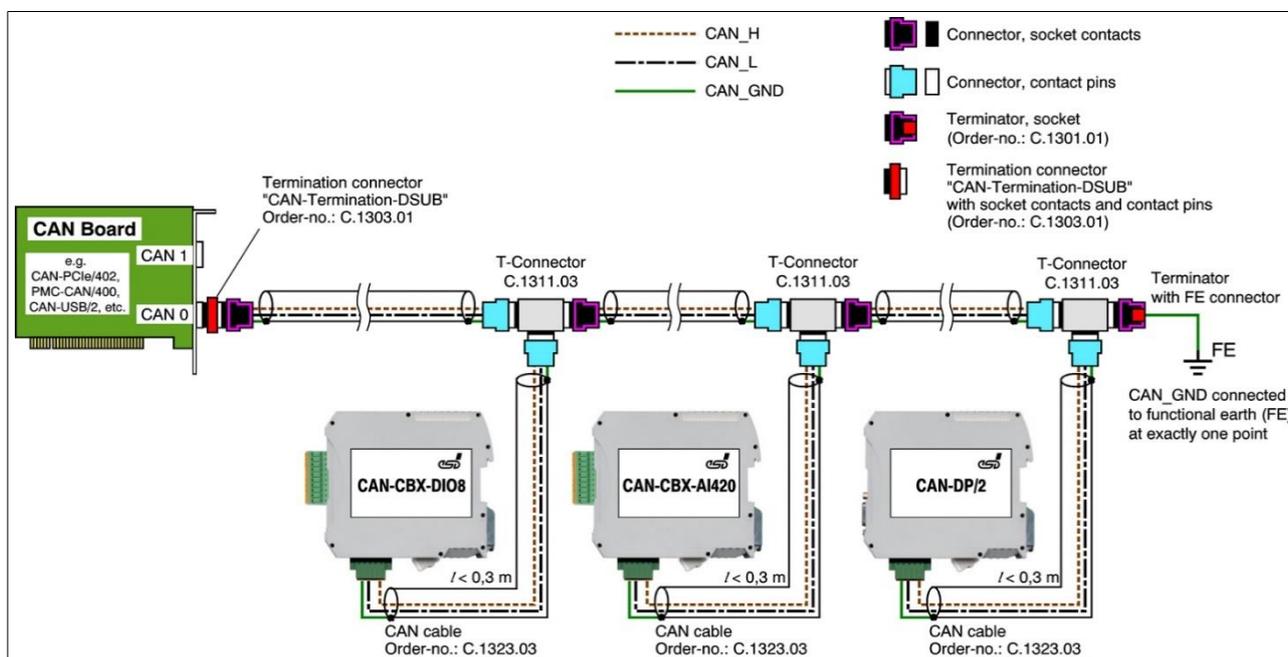


Figure 15: Example for proper wiring with single shielded single twisted pair wires

8.2.3 Branching

- In principle the CAN bus must be realized in a line. The nodes are connected to the main CAN bus line via short cable stubs. This is normally realised by so called T-connectors. esd offers the CAN-T-Connector (Order No.: C.1311.03)
- If a mixed application of single twisted and double twisted cables cannot be avoided, ensure that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by using repeaters.

8.2.4 Termination Resistor

- A termination resistor must be connected at both ends of the CAN bus. If an integrated CAN termination resistor is connected to the CAN interface at the end of the CAN bus, this integrated termination must be used instead of an external CAN termination resistor.
- 9-pole DSUB-termination connectors with integrated termination resistor and pin contacts and socket contacts are available from esd (order no. C.1303.01).
- For termination of the CAN bus and grounding of the CAN_GND, DSUB terminators with pin contacts (order no. C.1302.01) or socket contacts (order no. C.1301.01) and with additional functional earth contact are available.

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 suitable cable type with a wave impedance of about $120\ \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22\ \text{mm}^2$) must be used. The voltage drop over the wire must be considered.
2	For heavy industrial environment use a four-wire CAN cable, the wires of which must be assigned as follows: <ul style="list-style-type: none"> • Two twisted wires must be assigned to the data signals (CAN_H, CAN_L) and • The other two twisted wires must be assigned to the reference potential (CAN_GND). • The cable shield must be connected to functional earth (FE) at least at one point.
3	The reference potential CAN_GND must be connected to the functional earth (FE) at exactly one point.
4	A CAN bus line must not branch (exception: short cable stubs) and must be terminated with the characteristic impedance of the line (generally $120\ \Omega \pm 10\%$) at both ends (between the signals CAN_L and CAN_H and not to CAN_GND).
5	Keep cable stubs as short as possible ($l < 0.3\ \text{m}$).
6	Select a working combination of bit rate and cable length.
7	Keep away CAN cables from disturbing sources. If this cannot be avoided, double shielded cables are recommended.

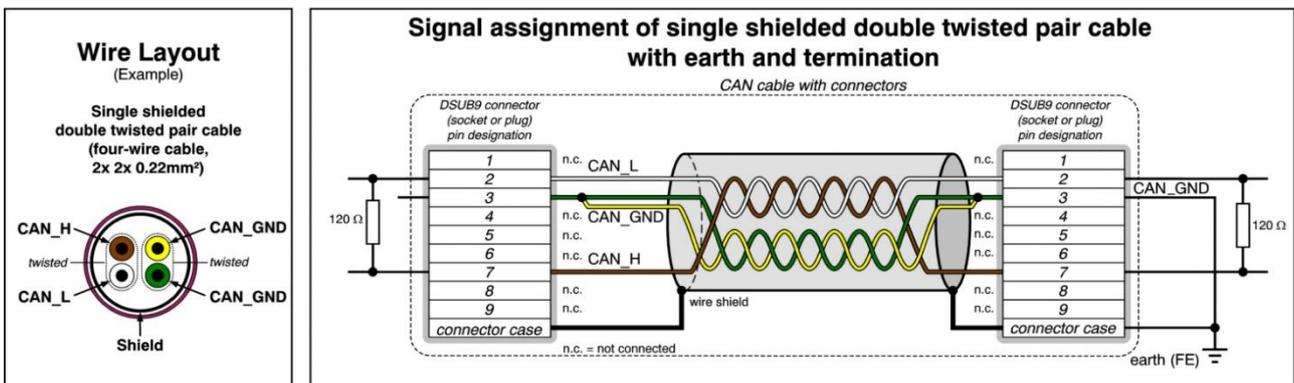


Figure 16: CAN wiring for heavy industrial environment

8.3.2 Device Cabling

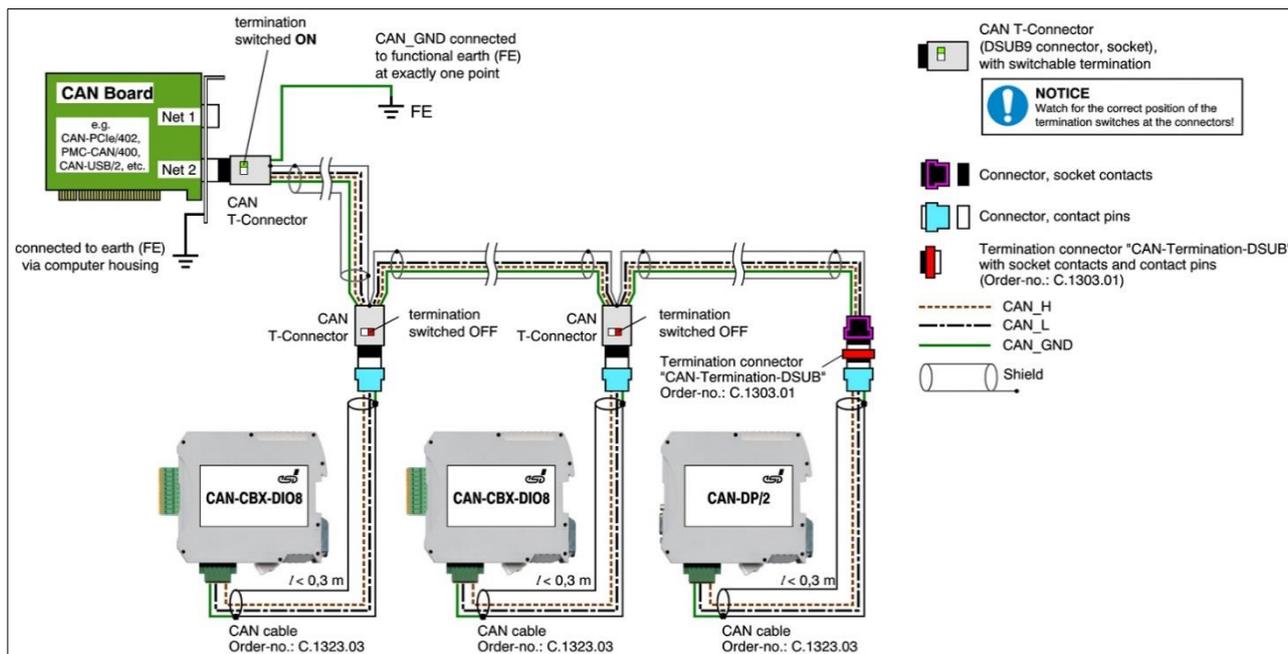


Figure 17: Example of proper wiring with single shielded double twisted pair cables

8.3.3 Branching

- In principle, the CAN bus must be realized in a line. The nodes are connected to the main CAN bus line via short cable stubs. This is usually realised via so called T-connectors. When using esd's CAN-T-Connector (order no.: C.1311.03) in heavy industrial environment and with four-wire twisted cables, it must be noted that the shield potential of the conductive DSUB housing is not looped through this type of T-connector. This interrupts the shielding. Therefore, you must take appropriate measures to connect the shield potentials, as described in the manual of the CAN-T-Connector. For further information on this, please refer to the CAN-T-Connector Manual (order no.: C.1311.21). Alternatively, a T-connector can be used, in which the shield potential is looped through, for example the DSUB9 connector from ERNI (ERBIC CAN BUS MAX, order no.:154039).
- If a mixed application of single twisted and double twisted cables cannot be avoided, ensure that the CAN_GND line is not interrupted!
- Deviations from the bus structure can be realized by using repeaters.

8.3.4 Termination Resistor

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

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 done for example at a termination connector (e.g. order no. C.1302.01 or C.1301.01).

8.5 Bus Length

The bus length of a CAN network must be adapted to the set bit rate. The maximum values result from the fact that the time required for a bit to be transmitted in the bus system is shorter the higher the transmission rate is. However, as the line length increases, so does the time it takes for a bit to reach the other end of the bus. It should be noted that the signal is not only transmitted, but the receiver must also respond to the transmitter within a certain time. The transmitter, in turn, must detect any change in bus level from the receiver(s). Delay times on the line, the transceiver, the controller, oscillator tolerances and the set sampling time must be considered.

In the following table you will find guide values for the achievable bus lengths at certain bit rates.

Bit Rate [kbit/s]	Theoretical values of reachable wire length with esd interface l_{max} [m]	CiA recommendations (07/95) for reachable wire lengths l_{min} [m]	Standard values of the cross-section according to CiA 303-1 [mm ²]
1000	37	25	0.25 to 0.34
800	59	50	0.34 to 0.6
666. $\bar{6}$	80	-	
500	130	100	
333. $\bar{3}$	180	-	
250	270	250	
166	420	-	0.5 to 0.6
125	570	500	
100	710	650	0.75 to 0.8
83. $\bar{3}$	850	-	
66. $\bar{6}$	1000	-	
50	1400	1000	
33. $\bar{3}$	2000	-	not defined in CiA 303-1
20	3600	2500	
12.5	5400	-	
10	7300	5000	

Table 16: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

Optical couplers are delaying the CAN signals. esd modules typically achieve a wire length of 37 m at 1 Mbit/s within a proper terminated CAN network without impedance disturbances, such as those caused by cable stubs > 0.3 m.



NOTICE

Please note that the cables, connectors, and termination resistors used in CANopen networks shall meet the requirements defined in ISO 11898-2.

In addition, further recommendations of the CiA, like standard values of the cross section, depending on the cable length, are described in the CiA recommendation CiA 303-1 (see CiA 303 CANopen Recommendation - Part 1: “Cabling and connector pin assignment,” Version 1.9.0, Table 2). Recommendations for pin-assignment of the connectors are described in CiA 106: “Connector pin-assignment recommendations”.

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 mm ²) Order No.: 93 022 016 (UL appr.)
	BUS-Schleppflex-PUR-C (1x 2x 0.25 mm ²) 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 mm ²) Order No.: 93 022 026 (UL appr.)
	BUS-Schleppflex-PUR-C (2x 2x 0.25 mm ²) 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 finding and eliminating the most common problems and errors when setting up CAN bus networks and CAN-based systems.

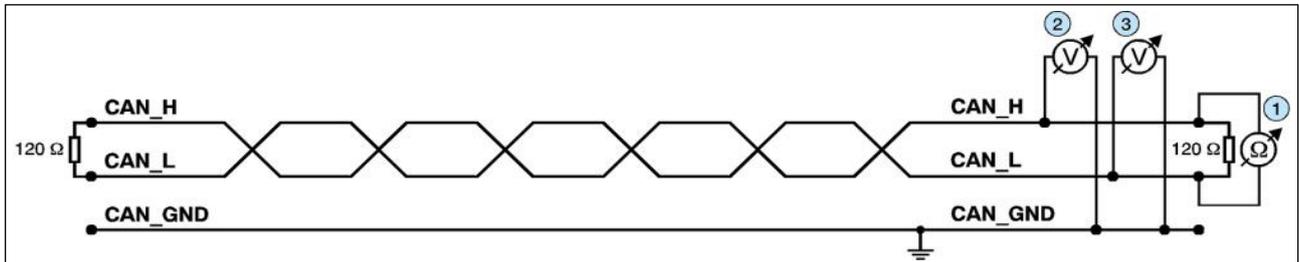


Figure 18: Simplified diagram of a CAN network

Termination

The bus termination is used to match impedance of a node to the impedance of the bus line used. If the impedance is mismatched, the transmitted signal is not completely absorbed by the load and will be partially reflected back into the transmission line.

If the impedances of the sources, transmission lines and loads are equal, the reflections are avoided. This test measures the total resistance of the two CAN data lines and the connected terminating resistors.

To test this, please proceed as follows:

1. Switch off the supply voltages of all connected CAN nodes.
2. Measure the DC resistance between CAN_H and CAN_L at one end of the network, measuring point ① (see figure above).

Expected result:

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

Possible causes of error:

- If the determined value is below 50 Ω, please make sure that:
 - There is no **short circuit** between CAN_H and CAN_L wiring.
 - **No more than two** terminating resistors are connected.
 - The transceivers of the individual nodes are not defective.
- If the determined value is higher than 70 Ω, please make sure that:
 - All CAN_H and CAN_L lines are correctly connected.
 - Two terminating resistors of 120 Ω each are connected to your CAN network (one at each end).

9.1 Electrical Grounding

The CAN_GND of the CAN network should be connected to the functional earth potential (FE) at only **one** point. This test indicates whether the CAN_GND is grounded at one or more points.

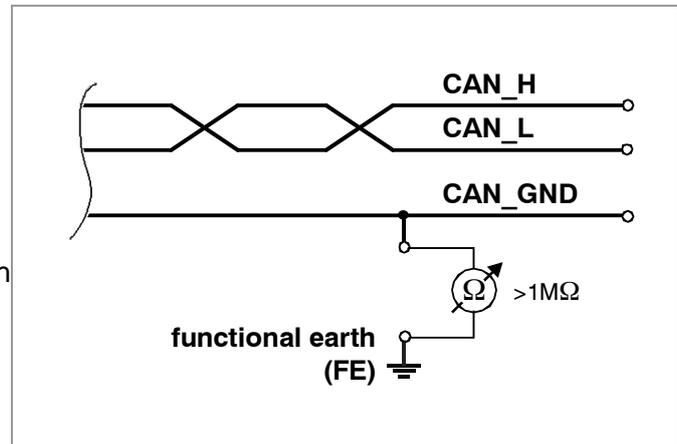
Please note that this test can only be performed with electrically isolated CAN nodes.

To test this, please proceed as follows:

1. Disconnect the CAN_GND from the earth potential (FE).
2. Measure the DC resistance between CAN_GND and earth potential (see figure on the right).

Do not forget to reconnect CAN_GND to earth potential after the test!

Figure 19: Simplified schematic diagram of ground test measurement



Expected result:

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

9.2 Short Circuit in CAN Wiring

A CAN bus might possibly still be able to transmit data even if CAN_GND and CAN_L are short-circuited. However, this will usually cause the error rate to rise sharply. Ensure that there is no short circuit between CAN_GND and CAN_L!

9.3 Correct Voltage Levels on CAN_H and CAN_L

Each node contains a CAN transceiver that outputs differential signals. When the network communication is idle the CAN_H and CAN_L voltages are approximately 2.5 V measured to CAN_GND. Defective transceivers can cause the idle voltages to vary and disrupt network communication.

To test for defective transceivers, please proceed as follows:

1. Switch on all supply voltages.
2. Terminate all network communication.
3. Measure the DC voltage between CAN_H and CAN_GND, measuring point ②. (See “Simplified diagram of a CAN network” on previous page).
4. Measure the DC voltage between CAN_L and CAN_GND, measuring point ③. (See “Simplified diagram of a CAN network” on previous page).

Expected result:

The measured voltage should be between 2.0 V and 3.0 V.

CAN Troubleshooting Guide

Possible causes of error:

- If the voltage is lower than 2.0 V or higher than 3.0 V, it is possible that one or more nodes have defective transceivers.
 - If the voltage is lower than 2.0 V, please check the connections of the CAN_H and CAN_L lines.
- To find a node with a defective transceiver within a network, please check individually the resistances of the CAN transceivers of the nodes (see next section).

9.4 CAN Transceiver Resistance Test

CAN transceivers have circuits that control CAN_H and CAN_L. Experience shows that electrical damage can increase the leakage current in these circuits.

To measure the current leakage through the CAN circuits, please use an ohmmeter and proceed as follows:

1. Switch **off** the node ④ and **disconnect** it from the CAN network.
(See figure below.)
2. Measure the DC resistance between CAN_H and CAN_GND, measuring point ⑤
(See figure below.)
3. Measure the DC resistance between CAN_L and CAN_GND, measuring point ⑥
(See figure below.)

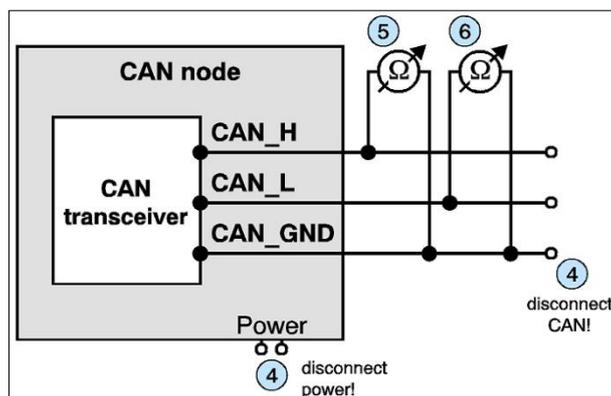


Figure 20: Measuring the internal resistance of CAN transceivers

Expected result:

The measured resistance should be greater than 10 k Ω for each measurement.

Possible causes of error:

- If the resistance is significantly lower, the CAN transceiver may be defective.
- Another indication of a defective CAN transceiver is a very high deviation of the two measured input resistances (>> 200 %).

9.5 Support by esd

If you have followed the troubleshooting steps in this troubleshooting guide and still cannot find a solution to your problem, our support team can help.

Please contact our support by email to support@esd.eu or by phone +49-511-37298-130.

10 Software Licenses



NOTICE

The software from esd and from third parties used in the IRIG-B variants PMC/XMC-CAN/402-4-FD-IRIG-B is subject to the license terms of the respective authors or rights holders. The IRIG-B variants PMC/XMC-CAN/402-4-FD-IRIG-B may only be used in accordance with these license terms!

By using the IRIG-B variants PMC/XMC-CAN/402-4-FD-IRIG-B you agree to the terms of these software licenses.

You can download the license terms from our website, see the following chapters.

10.1 3rd Party Software License Terms

License Name	Identifier (from SPDX License List)
GNU Lesser General Public License v3.0 only	LGPL-3.0

Table 17: License and Identifier

- The IRIG-B variants PMC-CAN/402-4-FD-IRIG-B and XMC-CAN/402-4-FD-IRIG-B use the Oregano Systems 8051 IP Core. The 8051 IP Core is subject to the 3rd Party Software License Terms of GNU LGPL-3.0, see Table 17.

10.1.1 Open-Source Software Copy

You may obtain a copy of the source code, if and as required under the license by sending a mail

You may obtain a copy of the source code, if and as required under the license by sending a mail to oss-compliance@esd.eu

You may also obtain a copy of the source code, if and as required under the license, by sending a check or money of EUR 25.00 to:

esd electronics gmbh
Vahrenwalder Str. 207
30165 Hannover, Germany

11 Application Note to PMC-CAN/402

Potential Interoperability with Windows or Linux OS

	INFORMATION This chapter is to alert users to potential interoperability problems that affect esd PMC-CAN/402-4-FD boards which are equipped with the Pericom® PCI-to-PCI bridge PI7C9X111SL.
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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	C.2028.68
PMC-CAN/402-4-FD-IRIG-B	C.2028.69
PMC-CAN/402-LIN-DIO	C.2028.70
PMC-CAN/402-LIN-DIO-T	C.2028.71
PMC-CAN/402-4-FD-T	C.2028.78

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

11.1 Windows Operating System

Potential Interoperability Problem with enabled PCI Express Native Control Mode

Background and Information

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 mandatory features which are not implemented in the bridge of the PMC-CAN/402-FD boards. This may prevent the start of the default PCI-to-PCI bridge driver (Code 10).

This problem occurs for example 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.

Necessary Changes in Application

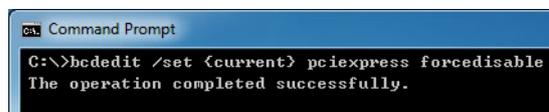
Solution: Disabling PCI Express Native Control Feature in Windows

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: <code>bcdedit /deletevalue {current} pciexpress</code> or <code>bcdedit /set {current} pciexpress default</code>
---	--

Weblinks for further information:

- About `BCDEdit /set` command: <https://learn.microsoft.com/en-us/windows-hardware/drivers/devtest/bcdedit--set>
- About PCI Express Native Control: [https://learn.microsoft.com/en-us/previous-versions/windows/hardware/design/dn631753\(v=vs.85\)](https://learn.microsoft.com/en-us/previous-versions/windows/hardware/design/dn631753(v=vs.85))
- PCI-SIG website: <https://pcisig.com/>

11.2 Linux Operating System

Potential Interoperability Problem caused by Active State Power Management Reconfiguration

Background and Information

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
10: ff ff
20: ff ff
30: ff ff
```

Necessary changes in application

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.

The mentioned patch hit the Linux mainline kernel with version 5.2.0.

The patch also has been backported to the following mainline stable kernels:

- 5.1.5
- 5.0.19
- 4.19.46
- 4.9.179
- 3.16.74

12 Declaration of Conformity

12.1 XMC-CAN/402-4-FD

EU-KONFORMITÄTSERKLÄRUNG EU DECLARATION OF CONFORMITY



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

esd erklärt, dass das Produkt
esd declares, that the product

XMC-CAN/402-4-FD
XMC-CAN/402-4-FD-IRIG-B
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9
CAN/400-5-1C4 1xDSUB25-to-5xDSUB9

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

C.2018.68
C.2018.69
C.2047.19
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
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*This declaration loses its validity if the product is not used or run according to the manufacturer's
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Funktion / Title *QM-Beauftragter / QM Representative*
Datum / Date Hannover, 2019-04-05

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12.2 PMC-CAN/402-4-FD Standard and -IRIG-B Variants

EU-KONFORMITÄTSERKLÄRUNG EU DECLARATION OF CONFORMITY



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

esd erklärt, dass das Produkt
esd declares, that the product

PMC-CAN/402-4-FD
PMC-CAN/402-4-FD-IRIG-B
PMC-CAN/402-4-FD-T
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9
CAN/400-5-1C4 1xDSUB25-to-5xDSUB9

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

C.2028.68,
C.2028.69,
C.2028.78
C.2047.19
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

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Datum / Date Hannover, 2019-04-12

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12.3 PMC-CAN/402-FD-LIN-DIO Variants

EU-KONFORMITÄTSERKLÄRUNG EU DECLARATION OF CONFORMITY



Adresse **esd electronics gmbh**
Address **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-FD-LIN-DIO
PMC-CAN/402-FD-LIN-DIO-T

C.2028.70
C.2028.71

XMC-CAN/402-FD-LIN-DIO
XMC-CAN/402-FD-LIN-DIO-T

C.2018.70
C.2018.71

CAN Cable LIN-DIO DSUB25-to-5xDSUB9

C.2047.17

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.

EMVP No.: 0227-202305

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2014/30/EU

Das Produkt entspricht den EU-Richtlinien „RoHS“
The product conforms to the EU Directives 'RoHS'

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This declaration loses its validity if the product is not used or run according to the manufacturer's documentation or if non-compliant modifications are made.

Name / Name T. Bielert
Funktion / Title QM-Beauftragter / QM Representative
Datum / Date Hannover, 2024-04-23

A handwritten signature in blue ink, appearing to read 'T. Bielert', is written over a horizontal line.

Rechtsgültige Unterschrift / authorized signature

13 Order Information

13.1 Hardware

Type	Properties	Order No.
XMC Variants		
XMC-CAN/402-4-FD	CAN port board for XMC, 4 CAN 2.0A/B-ports with esd Advanced CAN IP-Core (esdACC) CAN-FD capable according to ISO 11898-1 Physical Layer according to ISO 11898-2, High-speed CAN, galvanically isolated 1x DSUB25 connector (pin contacts) 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 port	C.2018.69
XMC-CAN/402-FD-LIN-DIO	As C.2018.68 but with additional ports: 2x LIN; ISO 17898-1:2015; <= 20 kbit/s 4x Digital In/Out; 3,3V; 5V tolerant, electronically switchable CAN termination	C.2018.70
XMC-CAN/402-FD-LIN-DIO-T	As C.2018.70 but for extended temperature range: -40° C ... +75° C	C.2018.71
PMC Variants		
PMC-CAN/402-4-FD	CAN port board for PMC, 4 CAN 2.0A/B ports with esd Advanced CAN IP-Core (esdACC) CAN-FD capable according to ISO 11898-1:2015 Physical Layer according to ISO 11898-2, High-speed CAN, galvanically isolated, 1x DSUB25 connector (pin contacts) 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-T	As C.2028.68 but for extended temperature range: -40° C ... +75° C	C.2028.78
PMC-CAN/402-4-FD-IRIG-B	As C.2028.68 but with additional IRIG-B port	C.2028.69
PMC-CAN/402-FD-LIN-DIO	As C.2028.68 but with additional ports: 2x LIN; ISO 17898-1:2015; <= 20 kbit/s 4x Digital In/Out; 3,3V; 5V tolerant, electronically switchable CAN termination	C.2028.70
PMC-CAN/402-FD-LIN-DIO-T	As C.2028.70 but for extended temperature range: -40° C ... +75° C	C.2028.71

Order Information

Type	Properties	Order No.
Accessories		
CAN/400-4-1C4 1xDSUB25-to-4xDSUB9	Adapter cable DSUB25 (socket contacts) to 4x DSUB9 (pin contacts) for CAN, length: 0.5 m, to product: C.2018.68, C.2028.68, C.2028.78	C.2047.19
CAN/400-4-1C5 1xDSUB25-to-5xDSUB9	Adapter cable DSUB25 (socket contacts) to 4x DSUB9 pin contacts (CAN ports) and 1x DSUB9 socket contacts (IRIG-B port), length: 0.5 m, to product: C.2018.69, C.2028.69	C.2047.18
CAN Cable LIN DIO DSUB25-to-5xDSUB9	Adapter cable DSUB25 (socket contacts) to 5x DSUB9 (pin contacts) for CAN and LIN and digital IOs length: 0.5 m, to product: C.2018.70, C.2018.71, C.2028.70, C.2028.71	C.2047.17

Table 18: Order information hardware

13.2 Software

Type	Order No.
Device drivers for Windows and Linux on CD-ROM to PMC/XMC-CAN/402 are included in delivery.	
Additional CAN object licences including CD-ROM with CAN driver:	
CAN-DRV-LCD CDROM+Lizenz QNX Object Licence and CD-ROM for QNX 6.x and 7.x	C.1101.32
CAN-DRV-LCD CDROM+Lizenz RTX Object Licence and CD-ROM for RTX64	C.1101.35
CAN-DRV-LCD CDROM+Lizenz VxWorks Object Licence and CD-ROM for VxWorks	C.1101.55
CAN-DRV-LCD CDROM+Lizenz INtime Object Licence and CD-ROM for INtime 6 and 7	C.1101.65
Higher-Layer Protocols including CD-ROM for CAN CC Applications:	
CANopen-Software Stack Windows/Linux Single user runtime license for CANopen Software Stack for Windows and Linux	C.1101.06
CANopen-LCD CDROM + Lizenz QNX Single user runtime license for CANopen Software Stack for QNX	C.1101.17
CANopen-LCD CDROM + Lizenz RTX Single user runtime license for CANopen Software Stack for RTX/RTX64	C.1101.16
CANopen-LCD CDROM + Lizenz VxWorks Single user runtime license for CANopen Software Stack for VxWorks	C.1101.18
J1939 Stack for Windows (Object) Single-user runtime license for J1939 Software Stack and J1939 Device Simulator & Monitor	C.1130.10
J1939 Stack for Linux (Object) Single-user runtime license for Linux Software Stack	C.1130.11
J1939 Stack for RTX (Object) Single-user runtime license for RTX/RTX64 Software Stack	C.1130.12
ARINC 825-LCD Windows/Linux/LabVIEW Licence and CD for Windows, Linux and LabVIEW (Windows)	C.1140.06
ARINC 825-LCD QNX Licence and CD for QNX	C.1140.17
ARINC 825-LCD RTX Licence and CD for RTX/RTX64	C.1140.16
ARINC 825-LCD VxWorks Licence and CD for VxWorks	C.1140.18
For detailed information about the driver availability for your special operating system, please contact our sales team.	

Table 19: Order information software

13.3 Manuals

PDF Manuals

For the availability of the manuals see Table 20 below.

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

Manuals		Order No.
XMC-CAN/402-4-FD-ME	Hardware manual to PMC/XMC-CAN/402 in English, this manual	C.2018.21
PMC-CAN/402-4-FD-ME		C.2028.21
CAN-API-ME	NTCAN-API Manual Part1: Application Developers Manual NTCAN-API Manual Part 2: Installation Guide	C.2001.21
NTLIN-API-ME	LIN Application Developers Manual	C.2007.21

Table 20: 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.