PMC-CAN/331-3.3

PMC CAN Interface

PMC-CAN/331-3.3-2

Hardware Installation
and
Technical Data

to Product C.2039.01, C.2039.02

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N O T E

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This manual contains important information and instructions on safe and efficient handling of the PMC-CAN/331-3.3. 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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Document History

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

Rev.	Chapter	Changes versus previous version	Date
1.3	-	Safety Instructions revised	2015-12-04
	2.	Safety information revised	
	6.	Correct CAN Wiring with for double twisted pair cables	
	8.	EU Declaration of Conformity new	
	9.	Order Information revised	
-	-	-	-

Technical details are subject to change without further notice.

Classification of Warning Messages and Safety Instructions

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

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

DANGER, WARNING, CAUTION

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

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

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

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

NOTICE

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

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

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

INFORMATION

INFORMATION
Notes to point out something important or useful.

Safety Instructions

- When working with the PMC-CAN/331-3.3 follow the instructions below and read the manual carefully to protect yourself from injury and the PMC-CAN/331-3.3 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-CAN/331-3.3 and follow the CAN wiring hints in chapter: "Correct Wiring of Electrically Isolated CAN Networks".
- In case of damages to the device, which might affect safety, appropriate and immediate measures must be taken, that exclude an endangerment of persons and domestic animals and property.
- Current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1).
- The PMC-CAN/331-3.3 may only be driven by power supply current circuits, that are contact protected. A power supply, that provides a safety extra-low voltage (SELV) according to EN 60950-1, complies with this conditions.

- The device has to be securely installed in the control cabinet before commissioning.
- Protect the PMC-CAN/331-3.3 from dust, moisture and steam.
- Protect the PMC-CAN/331-3.3 from shocks and vibrations.
- The PMC-CAN/331-3.3 may become warm during normal use. Always allow adequate ventilation around the PMC-CAN/331-3.3 and use care when handling.
- Do not operate the PMC-CAN/331-3.3 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-CAN/331-3.3 is to be integrated.
→ Disconnect all hazardous voltages (mains voltage) before opening the system.
→ Ensure the absence of voltage before starting any electrical work

NOTICE
Electrostatic discharges may cause damage to electronic components.
To avoid this, perform the steps described on page 10 *before* you touch the PMC-CAN/331-3.3, in order to discharge the static electricity from your body.

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

Conformity
The PMC-CAN/331-3.3-2 meets the demands of the EU regulations and EMC standards printed in the conformity declaration at the end of this manual.

Intended Use
The intended use of the PMC-CAN/331-3.3 is the operation as PMC-CAN interface on a base board according to IEEE Std. 1386.1-2001.
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 operation of the PMC-CAN/331-3.3 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the PMC-CAN/331-3.3 for medical purposes is prohibited.

Service Note
The PMC-CAN/331-3.3 does not contain any parts that require maintenance by the user. The PMC-CAN/331-3.3 does not require any manual configuration of the hardware. Unauthorized intervention in the device voids warranty claims.

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

Table of contents

1. Overview

1.1 Description of the Module

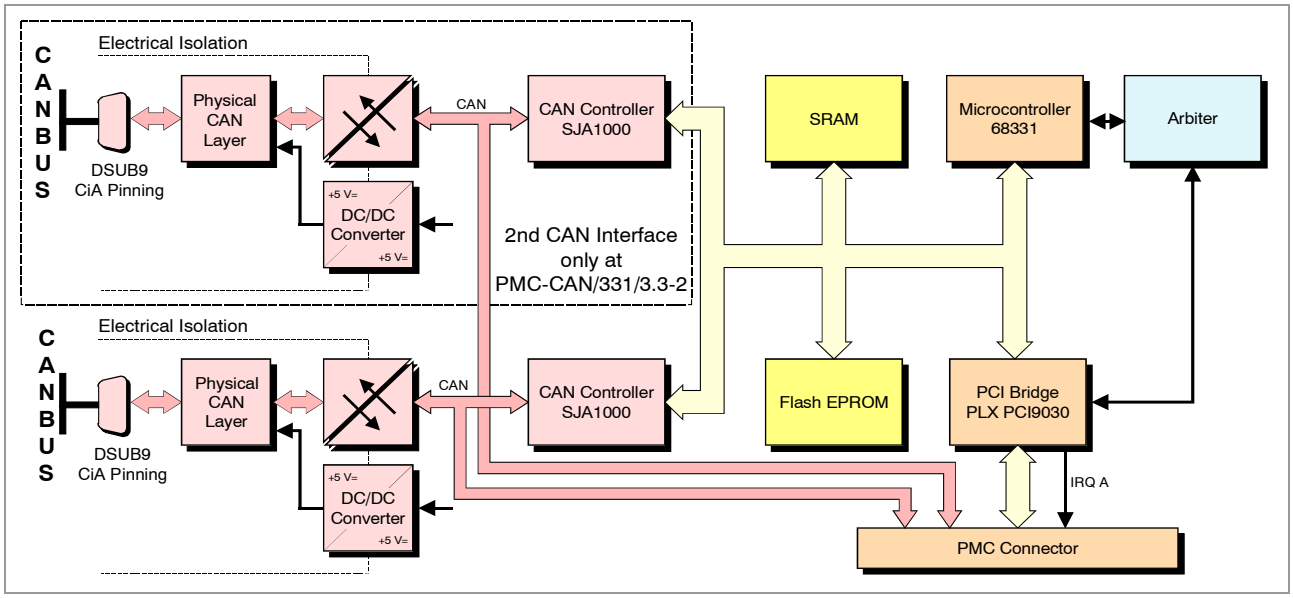


Figure 1: Block circuit diagram of PMC-CAN/331-3.3

The module PMC-CAN/331/3.3 uses a 68331 micro controller, which cares for the local CAN data management. The CAN data is stored in the local SRAM. Security and consistency of data is guaranteed up to 1 Mbit/s.

The ISO11898-compliant CAN interfaces allow a maximum data-transfer rate of 1 Mbit/s. Among many other features of the CAN interfaces, the bit rate can be set by software.

The CAN interfaces are electrically isolated from the other potentials and from each other by means of optocouplers and DC/DC-converters.

1.2 PCB View with Connectors

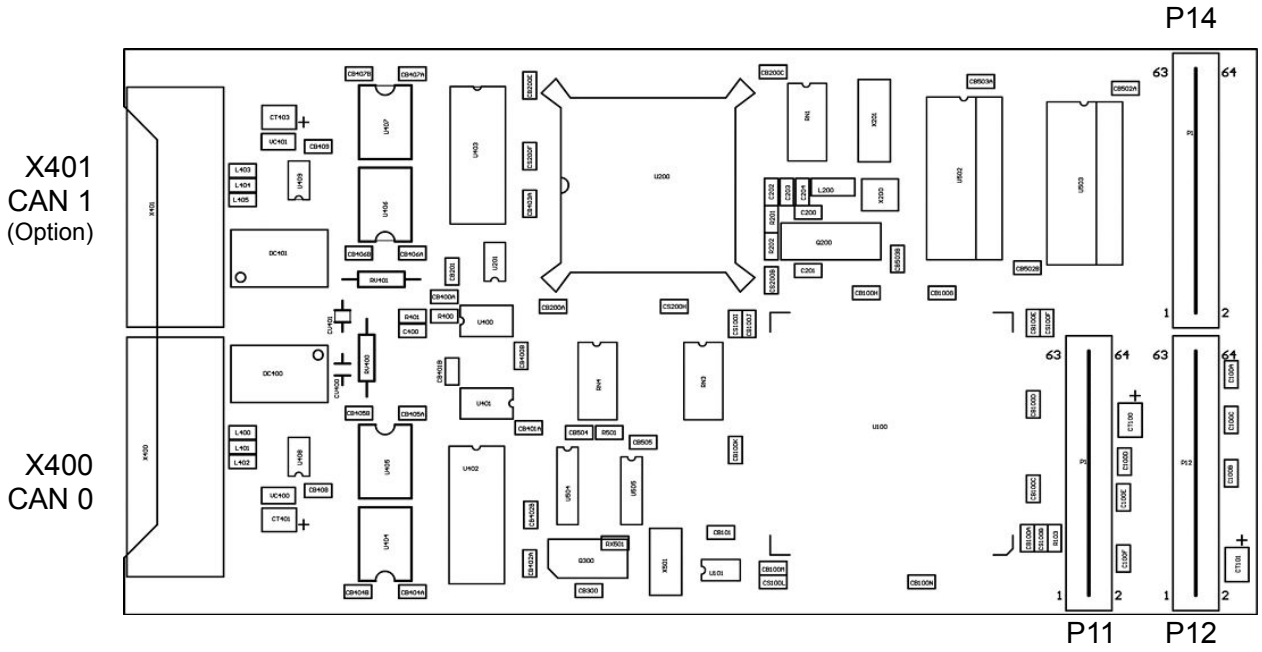


Figure 2: View of PCB layer and connectors facing the carrier board (PMC-CAN/331-3.3-2)

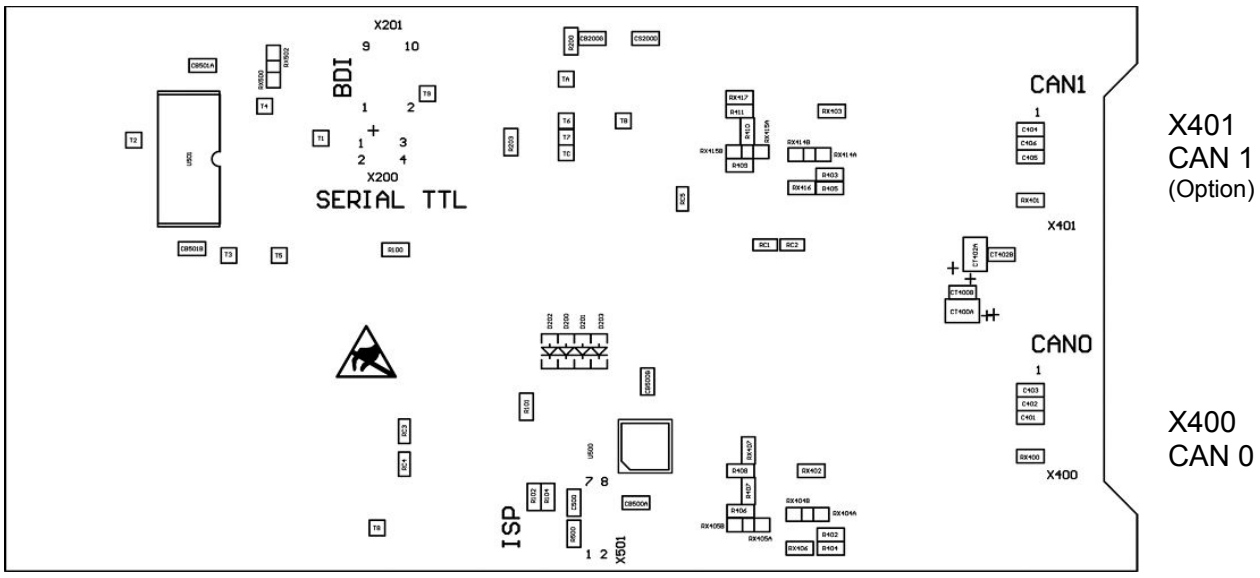


Figure 3: View of PCB layer not facing the carrier board with position of the configuration resistors

In PMC-CAN/331-3.3-1 version only CAN 0 is available via connector X400. The CAN1 connector X401 is not equipped.

2. Hardware Installation

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

DANGER
Hazardous Voltage - **Risk of electric shock** due to unintentional contact with uninsulated live parts with high voltages inside of the computer into which the PMC-CAN/331-3.3 is to be integrated.
→ Disconnect all hazardous voltages (mains voltage) before opening the computer.
→ Ensure the absence of voltage before starting any electrical work.

NOTICE
Electrostatic discharges may cause damage to electronic components.
In order to avoid this please follow the instructions below before touching the CAN module:

→ Switch off the power supply of your computer but leave it connected to mains to make sure that the computer case remains earthed.

→ Then touch the metal case of the computer to discharge your static electricity.

→ Furthermore, you should prevent your clothes from touching the PMC-CAN/331-3.3, because your clothes might be electrostatically charged as well.

The PMC-CAN/331/3.3 module can be used on various carrier boards, therefore, the carrier system will generally be called ‘computer’, below.

Procedure:

1. Switch off your computer and all connected peripheral devices (monitor, printer, etc.). Switch off the connected CAN devices of the network the CAN module is to be connected to.
2. Discharge your body as described above.
3. Disconnect the power supply of the computer from the mains.

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

   → Disconnect all hazardous voltages (mains voltage) before opening the computer.
   → If the computer 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
4. Open the case.
5. Plug the PMC-CAN/331/3.3 module onto a suitable carrier board.
   Connect module and carrier board by means of screws. Use the four M2.5 x 6 mm screws which are contained in the product package of the module.
6. Install the carrier board into your system.
7. Close the computer case.

8. Connect the CAN wire.

NOTICE
To sustain the compliance with directive 2004/108/EC, it is necessary to use four-wire twisted pair CAN cables.

Please note that the CAN line must be terminated at both ends.
Additionally, the CAN_GND must be connected to earth at exactly one point in the CAN network. Use the special T- connectors and terminator connectors offered by esd.
A CAN device whose CAN interface is not electrically isolated acts as an earth connection like the CAN_GND.
Please pay attention to the notes on correctly wiring of CAN networks (see from page 25)!

The first CAN interface (CAN network 0) is connected via the DSUB connector (X400) and the second CAN interface (CAN network 1) is connected via the DSUB connector (X401).

9. Connect the computer to mains again (mains connector or safety fuse).
10. Switch on the computer, the peripheral devices and the other CAN devices again.
11. End of hardware installation.

Continue with the software installation as described in the manual ‘NTCAN-API, Installation Guide’.

3. Technical Data

3.1 General Technical Data

<table>
<tr><td>Ambient temperature</td><td>0...50°C</td></tr>
<tr><td>Humidity</td><td>90 %, non-condensing</td></tr>
<tr><td>Power Supply</td><td>via PMC-connector

5 V ±5%
and
3.3 V ±5%

current consumption (at 20 °C):

<table>
<tr><td>Product</td><td colspan="2">Max. Current Consumption [mA]</td><td colspan="2">Typical Current Consumption (without any CAN traffic) [mA]</td></tr>
<tr><td>PMC-CAN/ 331/3.3-1 (1x CAN)</td><td>$I_{3.3V\_MAX}$ < 150</td><td>I_{5V_MAX} < 300</td><td>$I_{3.3V\_IDLE}$ = 100</td><td>I_{5V_IDLE} = 200</td></tr>
<tr><td>PMC-CAN/331/3.3-2 (2x CAN)</td><td>$I_{3.3V\_MAX}$ < 150</td><td>I_{5V_MAX} < 400</td><td>$I_{3.3V\_IDLE}$ = 100</td><td>I_{5V_IDLE} = 290</td></tr>
</table>
</td></tr>
<tr><td>Connectors</td><td>P11 (64-pole PMC-connector) - PCI-signals
P12 (64-pole PMC-connector) - PCI-signals
P14 (64-pole PMC-connector) - CAN-TTL-signals (optional)
X400 (DSUB9/male) - first CAN interface (network 0)
X401 (DSUB9/male) - optional second CAN interface (network 1)

The following connectors are only equipped for programming and service:
X200 (4-pole female con.) - CPU-interface (serial, TTL)
X201 (10-pole male con.) - BDM-interface
X501 (8-pole male con.) - ISP-programming</td></tr>
<tr><td>Dimensions</td><td>148.33 mm x 74.04 mm</td></tr>
<tr><td>Installation</td><td>by means of four screws M2.5 x 6 mm and spacing bolts (contained in the product package)</td></tr>
<tr><td>Weight</td><td>100 g</td></tr>
</table>

Table 1: General technical data of the module

3.2 PCI-Bus

Host bus	PCI bus according to PCI Local Bus Specification 2.1
PCI data bus	32 bit
Controller	PLX PCI9030
Interrupt	Interrupt Signal A
Signalling voltage	Compatible to PMC systems with 3.3 V or 5 V signalling voltage

Table 2: PCI bus data

INFORMATION
The PMC-CAN/331/3.3 module accepts signal voltage levels of 3.3 V or 5 V, but POWER always has to be supplied for **3.3V AND 5V** as well!

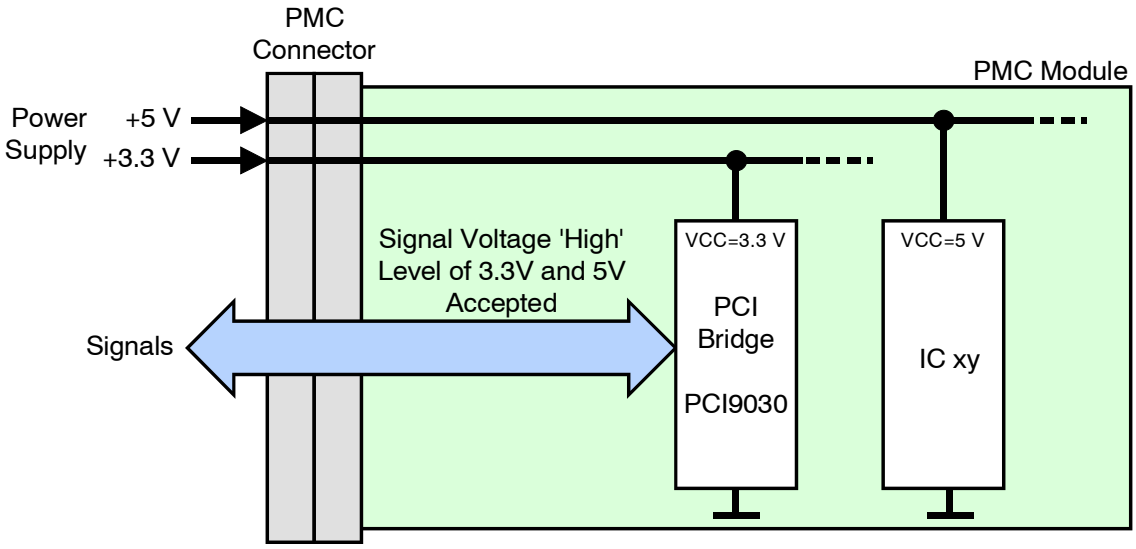


Figure 4: Power supply voltage and signal level voltage requirements at PMC-CAN/331/3.3

3.3 CAN Interface

Number	1, optionally 2 CAN interfaces
CAN controller	SJA1000
CAN protocol	ISO 11898-1
Physical interface	physical layer in accordance with ISO 11898-2, transfer rate programmable from 10 Kbit/s to 1 Mbit/s
Bus termination	has to be set externally
Wiring	use single shielded double twisted pair cable acc. to ISO 11898-2, 2x2x 0.22 mm², to sustain the compliance with directive 2004/30/EC
Electrical insulation of the CAN interface from other units	both possible CAN interfaces are electrically isolated from each other and from the PCI-bus potentials by means of optocouplers and DC/DC-converters
DeviceNet option	CAN-ADA-DN (Order No.: C.2012.25) external adapter board with pluggable screw terminal, optocouplers and CAN driver in accordance with DeviceNet specification 'DeviceNet Communication Model and Protocol, Rel. 2.0'; 1 DeviceNet interface, signals of the second DeviceNet interface can be connected through.
Option: ISO-11898 Transceiver Module	external adapter boards with CAN interface, DSUB9 connector, electrical isolation via optocouplers and DC/DC-converter, physical layer according to ISO11898-2, transmission rate programmable from 10 Kbit/s to 1 Mbit/s. - CAN-ADA-ISO11898 (Order No.: C.2012.26): 1 CAN interface, signals of the second CAN interface can be connected through, connection of the CAN-TTL-level signals via 10-pole ODU-connector - CAN-PHYSLAY-HSP (Order No.: C.1201.01): 1 CAN interface, connection of the CAN-TTL-level signals to the adapter board via 8-pole connection strip or via wires directly connected with the board.

Table 3: Data of the CAN interface

3.4 Software Support

Software drivers are available for Linux®, LynxOS, Solaris®, SGI-IRIX6.5, AIX®, RTOS-UH, VxWorks®, QNX® and Windows® systems. The firmware can be loaded from the PC into the Flash EPROM.

INFORMATION

The CAN layer 2 (NTCAN-API) software installation and the software drivers are described in the NTCAN-API manual (esd-order No.: C.2001.21):

“NTCAN-API Part 1: Application Developers manual” and
“NTCAN-API Part 2: Installation Guide”

CANopen® and DeviceNet™ software packages are available for RTOS-UH, VxWorks, Windows or UNIX® systems.

4. Configuration Resistors

By changing the resistors equipped, the assignment of the local CAN interface and the PMC-connector P14 can be changed. In order to do this, existing resistors have to be removed and new ones have to be equipped.

NOTICE
Any intervention in the device by unauthorized persons voids warranty claims!
It is therefore recommended to send the PMC-CAN/331-3.3 to esd for the change of the resistors. The changes can be made by esd for your expense. Please contact our support.

4.1 Comparison of Different Signal Assignments

Signal assignment 1 (component equipment 1 / =default equipment):
In the default version of PMC-CAN/331/3.3 the CAN signals of the CAN controller are assigned to the local ISO11898-interface (DSUB9). Only the GND-signals are assigned to P14.

Signal assignment 2 (component equipment 2):
Alternatively, the unidirectional CAN signals of the controllers can be assigned to the connector P14. Assigning the signals to P14 and the DSUB-connectors at the same time is not permitted.

Signal assignment 3 (component equipment 3):
Another alternative is to assign the connector P14 with differential CAN signals of the controllers. For this matter the controller has to be especially configured, because it drives the ports unidirectional in standard configuration.

4.2 Signal Assignments

4.2.1 Signal Assignment 1: Unidirectional Signals to Local CAN Interface

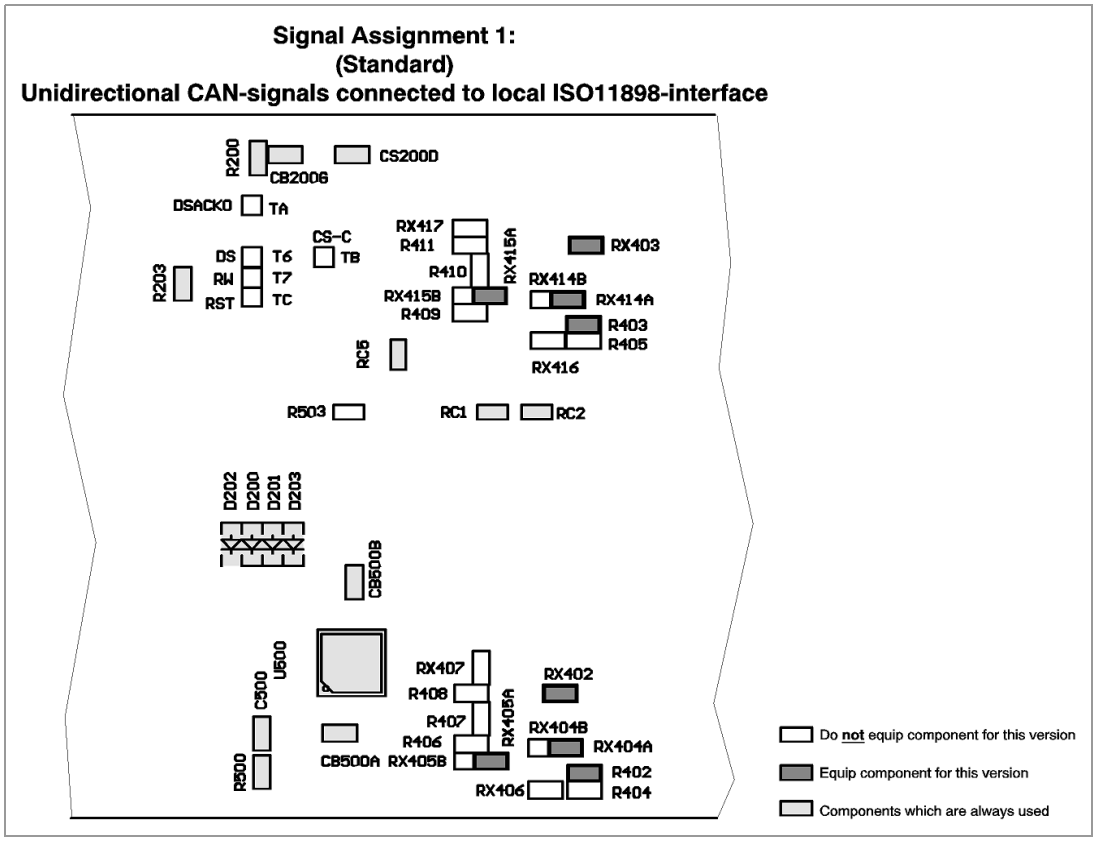


Figure 5: Component equipment version 1 (default)

Resistor values:			
CAN Net 1		*CAN Net 0*	
R403 = 10 kΩ		R402 = 10 kΩ	
RX403 = 0 Ω		RX402 = 0 Ω	
R405 = n.e.		R404 = n.e.	
R409 = n.e.		RX404A = 0 Ω,	RX404B = n.e.
R410 = n.e.		RX405A = 0 Ω,	RX404B = n.e.
R411 = n.e.		R406 = n.e.	
RX414A = 0 Ω,	RX414B = n.e.	RX406 = n.e.	
RX415A = 0 Ω,	RX415B = n.e.	R407 = n.e.	
RX416 = n.e.		RX407 = n.e.	
RX417 = n.e.		R408 = n.e.	

n.e. ... component not equipped

4.2.2 Signal Assignment 2: Unidirectional Signals to P14

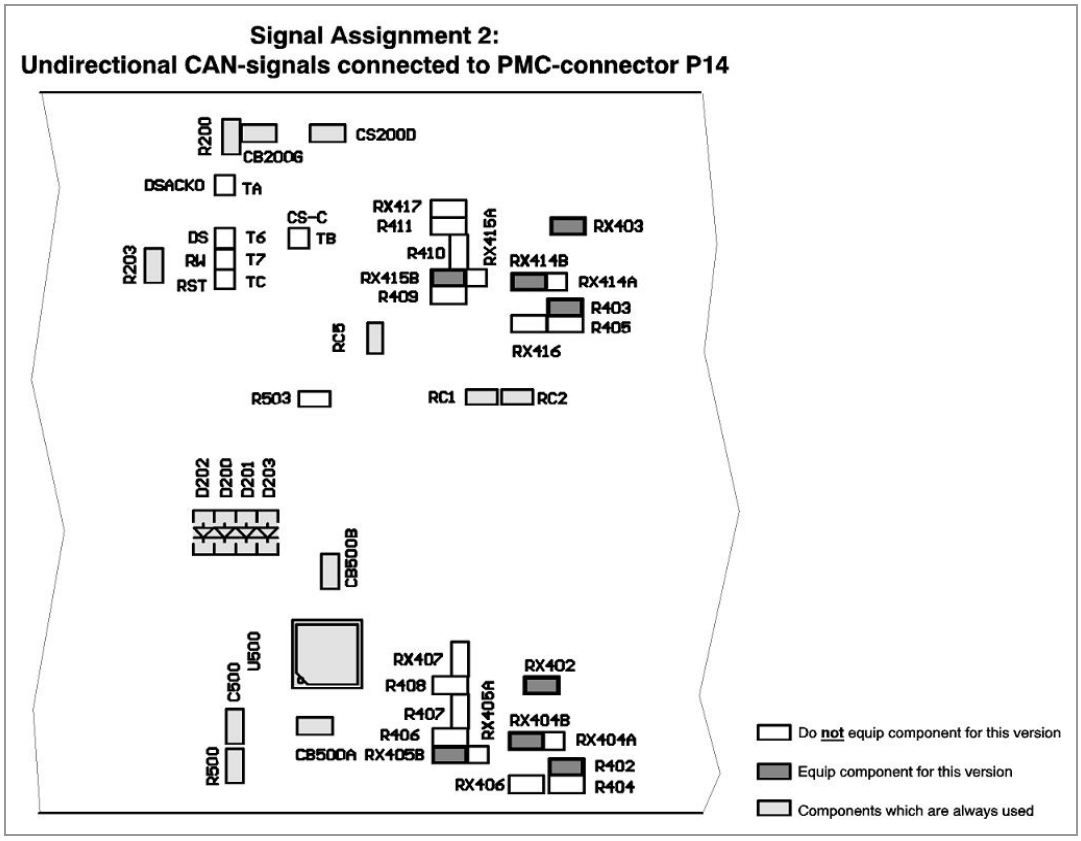


Figure 6: Component equipment version 2

Resistor values:	
CAN Net 1	*CAN Net 0*
R403 = 10 kΩ	R402 = 10 kΩ
RX403 = 0 Ω	RX402 = 0 Ω
R405 = n.e.	R404 = n.e.
R409 = n.e.	**RX404A = n.e., RX404B = 0 Ω**
R410 = n.e.	**RX405A = n.e., RX405B = 0 Ω**
R411 = n.e.	R406 = n.e.
RX414A = n.e., RX414B = 0 Ω	RX406 = n.e.
RX415A = n.e., RX415B = 0 Ω	R407 = n.e.
RX416 = n.e.	RX407 = n.e.
RX417 = n.e.	R408 = n.e.

n.e. ... component not equipped
Differences in equipment compared to component equipment version 1 are printed in bold characters.

4.2.3 Signal Assignment 3: Differential Signals to P14

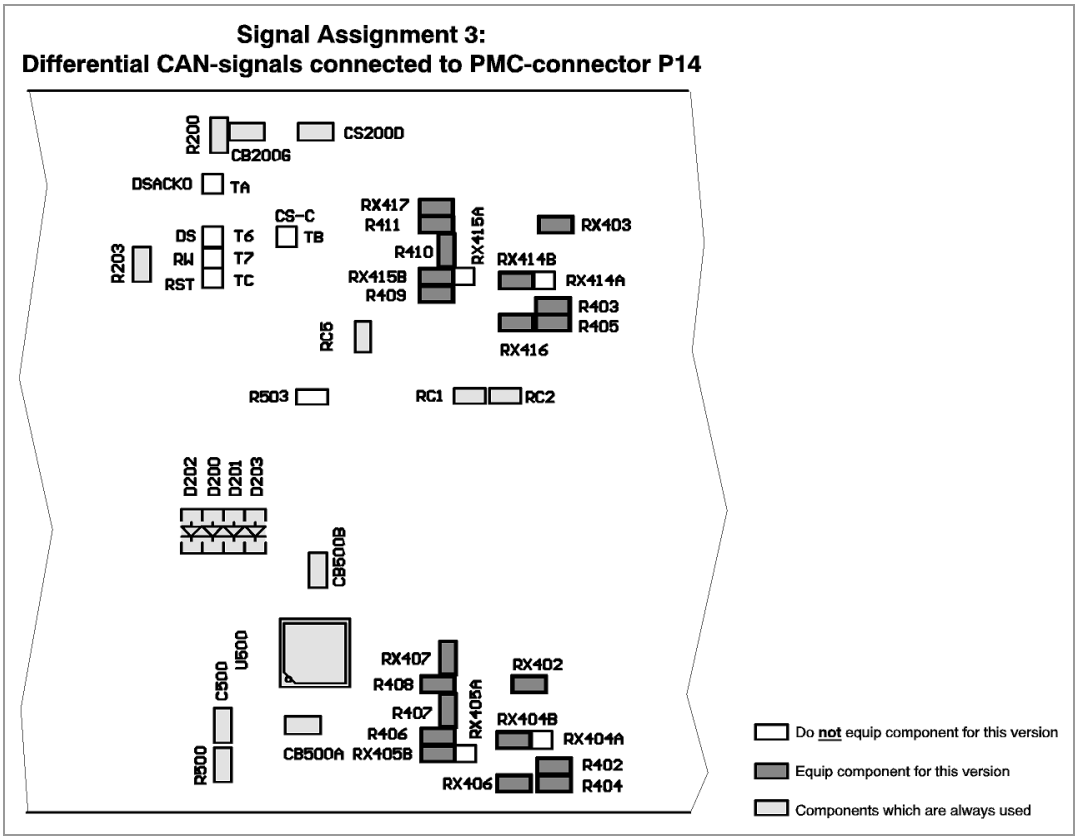


Figure 7: Component equipment version 3

Resistor values:	
CAN Net 1	*CAN Net 0*
R403 = 10 kΩ	R402 = 10 kΩ
RX403 = 0 Ω	RX402 = 0 Ω
R405 = 10 kΩ	**R404 = 10 kΩ**
R409 = 10 kΩ	**RX404A = n.e., RX404B = 0 Ω**
R410 = 220 Ω	**RX405A = n.e., RX405B = 0 Ω**
R411 = 10 kΩ	**R406 = 10 kΩ**
RX414A = n.e., RX414B = 0 Ω	**RX406 = 0 Ω**
RX415A = n.e., RX415B = 0 Ω	**R407 = 220 Ω**
RX416 = 0 Ω	**RX407 = 0 Ω**
RX417 = 0 Ω	**R408 = 10 kΩ**

n.e. ... component not equipped
Differences in equipment compared to component equipment version 1 are printed in bold characters.

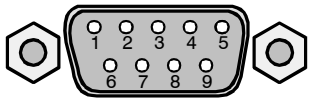
5. Connector Pin Assignment

5.1 CAN (X400, X401)

The signals are identically assigned to the connector of CAN net 0 interface (X400) and optional CAN net 1 interface (X401). The connectors are male 9-pole DSUB-connectors.

Device connector: 9-pin DSUB connector, male

Pin Position:



Pin Assignment:

Signal	Pin		Signal
(CANx_GND)	6	1	reserved
CANx_H	7	2	CANx_L
reserved	8	3	CANx_GND
reserved	9	4	reserved
		5	Shield

Signal Description:

CANx_L, CANx_H ... CAN signal lines of CAN net x (PMC-CAN/331-3.3-1: x ... 0
PMC-CAN/331-3.3-2: x ... 0, 1)
CANx_GND ... reference potential of the local CAN physical layer x
(CANx_GND)... optional reference potential of the local CAN physical layer
Shield ... shielding (connected with the case of the 9-pin DSUB connector)
reserved ... reserved for future applications, do not connect!

5.2 PMC-Connector P11

Pin	Signal Name	Signal Name	Pin
1	-	-12V	2
3	GND	INTA*	4
5	-	-	6
7	BUSMODE1*=GND	+5V	8
9	-	-	10
11	GND	-	12
13	CLK	GND	14
15	GND	-	16
17	-	+5V	18
19	V(I/O)	AD31	20
21	AD28	AD27	22
23	AD25	GND	24
25	GND	C/BE3*	26
27	AD22	AD21	28
29	AD19	+5V	30
31	V(I/O)	AD17	32
33	FRAME*	GND	34
35	GND	IRDY*	36
37	DEVSEL*	+5V	38
39	GND	LOCK*	40
41	-	-	42
43	PAR	GND	44
45	V(I/O)	AD15	46
47	AD12	AD11	48
49	AD09	+5V	50
51	GND	C/BE0*	52
53	AD06	AD05	54
55	AD04	GND	56
57	V(I/O)	AD03	58
59	AD02	AD01	60
61	AD00	+5V	62
63	GND	-	64

Notes:
Connector design is in accordance with PMC SPECIFICATION IEEE1386.1-2001.
The -12V supply voltage is connected to blocking capacitors only. There is no active current consumer at the module.
-...This pin is not assigned on the module.

5.3 PMC-Connector P12

Pin	Signal Name	Signal Name	Pin
1	+12V	-	2
3	-	shorted to pin 5	4
5	shorted to pin 4	GND	6
7	GND	-	8
9	-	-	10
11	-	3.3V	12
13	RST*	-	14
15	3.3V	-	16
17	-	GND	18
19	AD30	AD29	20
21	GND	AD26	22
23	AD24	3.3V	24
25	IDSEL	AD23	26
27	3.3V	AD20	28
29	AD18	GND	30
31	AD16	C/BE2*	32
33	GND	-	34
35	TRDY*	3.3V	36
37	GND	STOP*	38
39	PERR*	GND	40
41	3.3V	SERR*	42
43	C/BE1*	GND	44
45	AD14	AD13	46
47	M66EN=GND	AD10	48
49	AD08	3.3V	50
51	AD07	-	52
53	3.3V	-	54
55	-	GND	56
57	-	-	58
59	GND	-	60
61	-	3.3V	62
63	GND	-	64

Notes:
Connector design is in accordance with PMC SPECIFICATION IEEE1386.1-2001.
The +12V supply voltage is connected to blocking capacitors only. There is no active current consumer at the module.
-...This pin is not assigned on the module.

5.4 PMC-I/O-Connector P14

The Rx/Tx-signals of the CAN controllers can be assigned to PMC-connector P14. The signals are only available, if the configuration resistors (see chapter of the same name) are accordingly set.

Attention: The signals are TTL-level and are not electrically isolated from the micro controller units!

	Signal Name of Signal Assignment				Signal Name of Signal Assignment		
Pin	1	2	3	Pin	1	2	3
1	-	-	-	2	-	-	-
3	-	-	-	4	-	-	-
5	-	-	-	6	-	-	-
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
41	-	-	-	42	-	-	-
43	-	-	-	44	-	-	-
45	-	-	-	46	-	-	-
47	-	-	-	48	-	GND	GND
49	-	RX10*	RX10*	50	-	GND	GND
51	-	TX10*	TX10*	52	-	GND	GND
53	-	-	RX11*	54	-	GND	GND
55	-	-	TX11*	56	-	GND	GND
57	-	-	RX01*	58	-	GND	GND
59	-	RX00*	RX00*	60	-	GND	GND
61	-	-	TX01*	62	-	GND	GND
63	-	TX00*	TX00*	64	-	GND	GND

Notes:
-...This pin is not assigned on the module.

5.5 Options: DeviceNet- and ISO-11898 CAN Adapter

5.5.1 CAN-ADA-DN (C.2012.25) and CAN-ADA-ISO11898 (C.2012.26)

The adapters CAN-ADA-DN (C.2012.25) and CAN-ADA-ISO11898 (C.2012.26) can be connected with a ribbon cable to a backplane connector of the board which carries the PMC module. According to the adapter used the CAN-TTL signals led through the backplane can then be transferred to a DeviceNet- or a CAN-ISO11898-Interface.

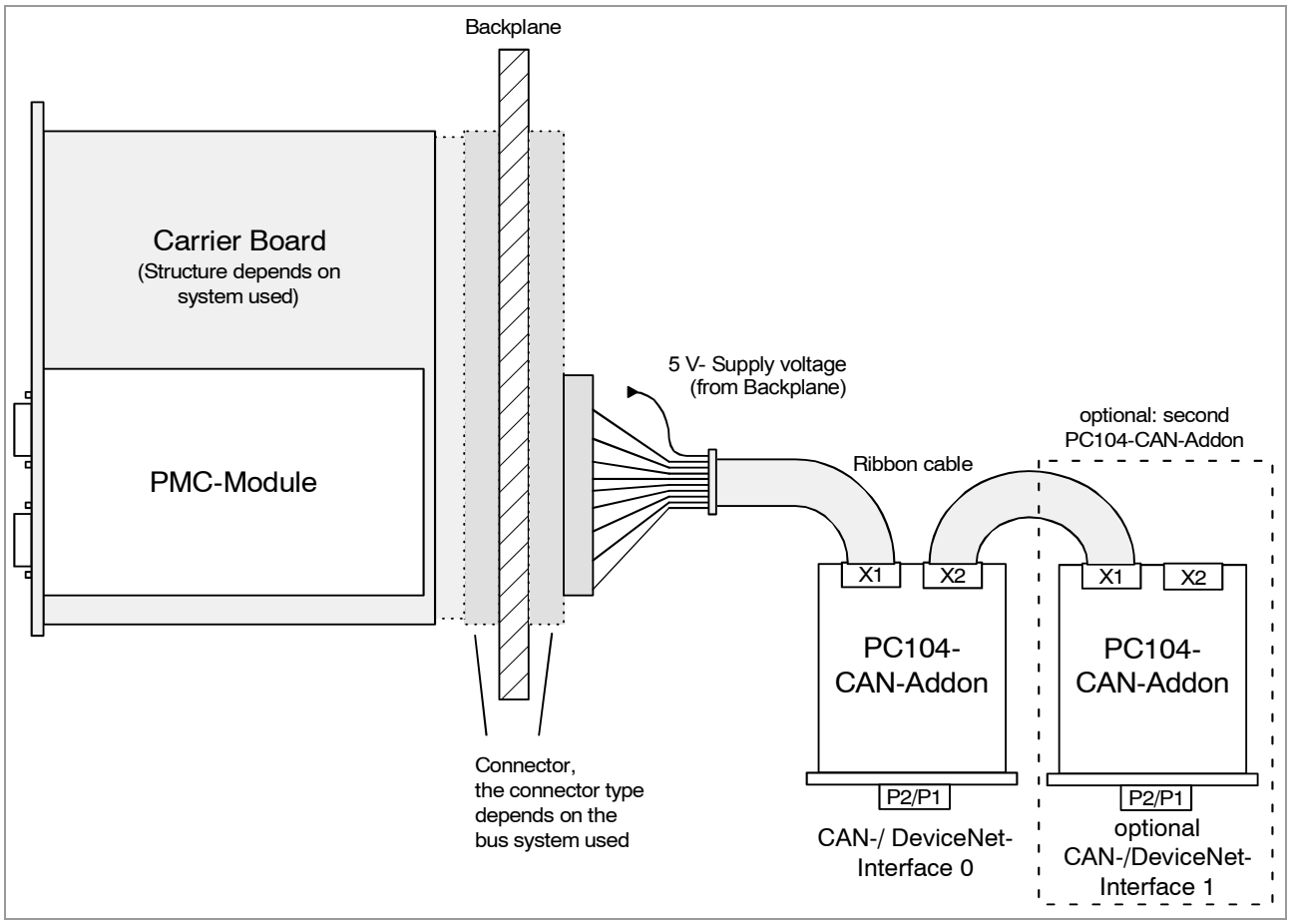


Figure 8: Wiring CAN-ADA-ISO11898 /- DN adapter

Both adapter versions are equipped with two post connectors (X1, X2). The ribbon cable with the CAN-TTL signals is connected to post connector X1. A second adapter can be connected via post connector X2. The adapter version CAN-ADA-ISO11898 is equipped with a CAN interface with DSUB9 connector and adapter version CAN-ADA-DN is equipped with a DeviceNet-Interface.

For further information about the adapters please refer to the manual ‘CAN-ADA-ISO11898 / CAN-ADA-DN’.

5.5.2 CAN-PHYSLAY-HSP (C.1201.01)

The adapter CAN-PHYSLAY (C.1201.01) can be connected with a ribbon cable to the backplane connector of the board which carries the PMC module. The CAN-TTL signals led through the backplane can then be transferred via a 8-pole strip or via 4 wires directly soldered on the adapter board to a CAN-ISO11898-Interface.

For every CAN channel one CAN-PHYSLAY-HSP adapter is required.

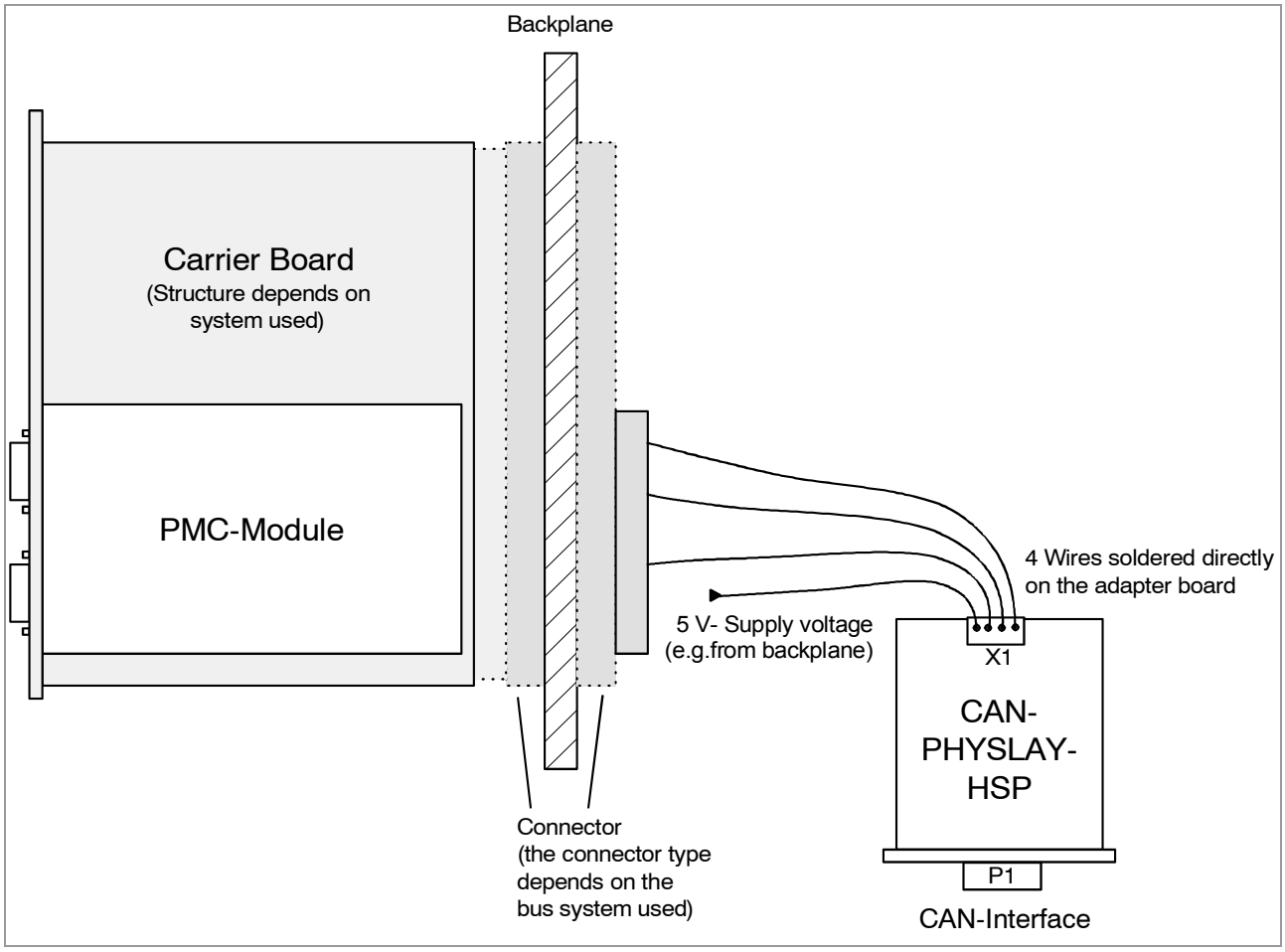


Figure 9: Wiring CAN-PHYSLAY-HSP adapter

For further information about the adapter please refer to the manual CAN-PHYSLAY-HSP.

6. Correct Wiring of Electrically Isolated CAN Networks

For the CAN wiring all applicable rules and regulations (EU, DIN), e.g. regarding electromagnetic compatibility, security distances, cable cross-section or material, have to be met.

6.1 Standards concerning CAN Wiring

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

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

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

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

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

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

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

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

6.2.1 General Rules

NOTICE
esd only grants the compliance with directive 2014/30/EU, if the CAN wiring is carried out with single shielded **double twisted** pair cables that match the requirements of ISO 11898-2.

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

1	A cable type with a wave impedance of about 120 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) has to be used. The voltage drop over the wire has to be considered.
2	For heavy industrial environment use a four-wire CAN cable. Connect • two twisted wires to the data signals (CAN_H, CAN_L) and • the other two twisted wires to the reference potential (CAN_GND) and • the cable shield to functional earth (FE) at least at one point.
3	The reference potential CAN_GND has to be connected to the functional earth (FE) at exactly **one** point.
4	A CAN bus line must not branch (exception: short cable stubs) and has to be terminated with the characteristic impedance of the line (generally 120 Ω ±10%) at both ends (between the signals CAN_L and CAN_H and **not** to CAN_GND).
5	Keep cable stubs as short as possible (l < 0.3 m).
6	Select a working combination of bit rate and cable length.
7	Keep away CAN cables from disturbing sources. If this can not be avoided, double shielded cables are recommended.

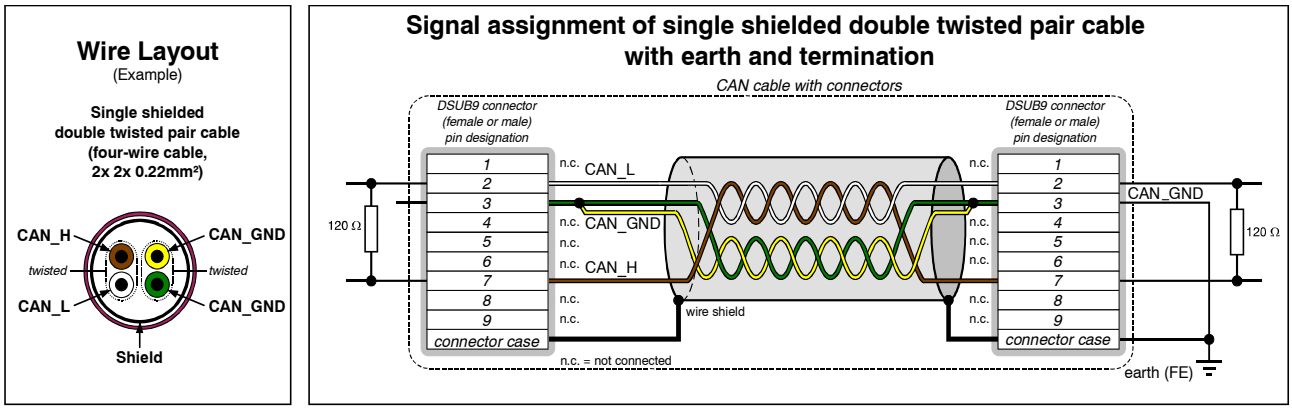


Figure 10: CAN wiring for heavy industrial environment

6.2.2 Device Cabling

NOTICE
If single shielded *double* twisted pair cables are used, realize the T-connections by means of connectors that support connection of two CAN cables at one connector where the cable's shield is looped through e.g. DSUB9 connector from ERNI (ERBIC CAN BUS MAX, order no.:154039).

The usage of esd's T-connector type C.1311.03 is not recommended for single shielded *double* twisted pair cables because the shield potential of the conductive DSUB housing is not looped through this T-connector type.

If a mixed application of single twisted and double twisted cables is unavoidable, take care that the CAN_GND line is not interrupted!

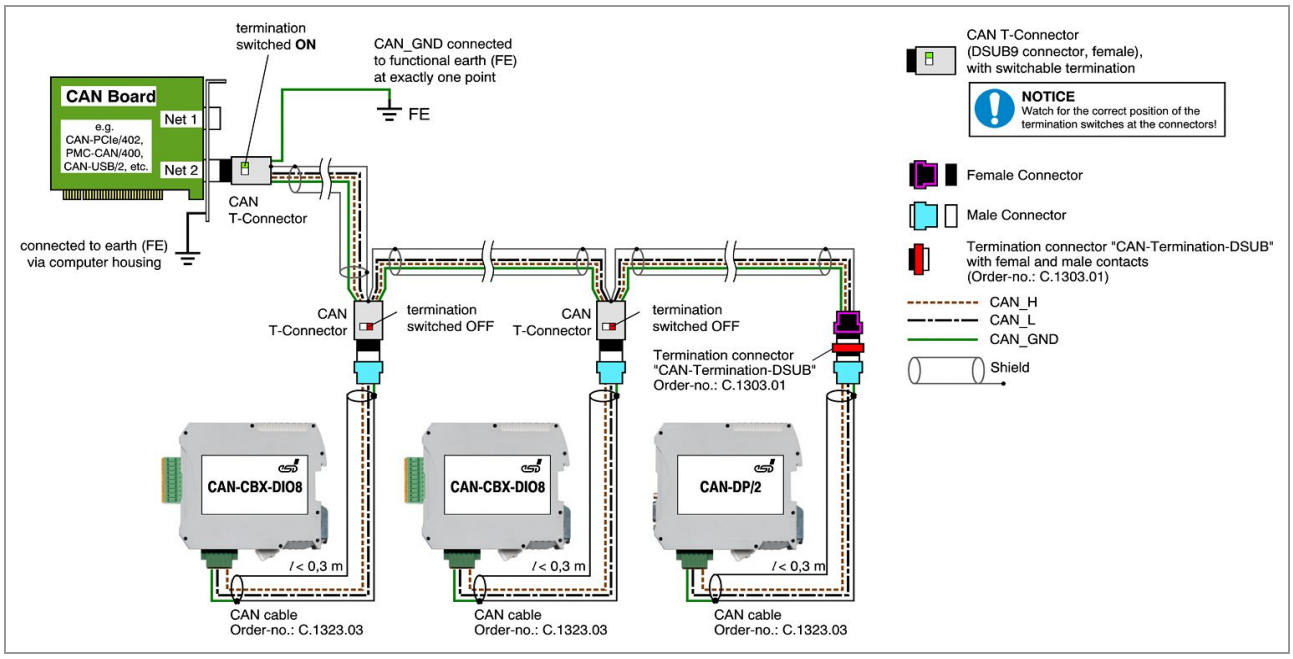


Figure 11: Example of proper wiring with single shielded double twisted pair cables

6.2.3 Termination

- A termination resistor has to be connected at both ends of the CAN bus.
  If an integrated CAN termination resistor which is equipped at the CAN interface at the end of the bus is connected, this one has to be used for termination instead of an external CAN termination plug.

- 9-pin DSUB-termination connectors with integrated termination resistor and male and female contacts (gender changer) are available from esd (order no. C.1303.01).

- 9-pin DSUB-connectors with integrated switchable termination resistor can be ordered e.g. from ERNI (ERBIC CAN BUS MAX, female contacts, order no.:154039).

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

6.3.1 General Rules

NOTICE
esd only grants the compliance with directive 2014/30/EU, if the CAN wiring is carried out with single shielded **double twisted** pair cables that match the requirements of ISO 11898-2. See previous chapter: 'Heavy Industrial Environment (Double Twisted Pair Cable)'.

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

1	A cable type with a wave impedance of about 120 Ω ±10% with an adequate conductor cross-section (≥ 0.22 mm²) has to be used. The voltage drop over the wire has to be considered.
2	For light industrial environment use at least a two-wire CAN cable. Connect • the two twisted wires to the data signals (CAN_H, CAN_L) and • the cable shield to the reference potential (CAN_GND).
3	The reference potential CAN_GND has to be connected to the functional earth (FE) at exactly **one** point.
4	A CAN net must not branch (exception: short cable stubs) and has to be terminated with the characteristic impedance of the line (generally 120 Ω ±10%) at both ends (between the signals CAN_L and CAN_H and **not** at CAN_GND).
5	Keep cable stubs as short as possible (l < 0.3 m).
6	Select a working combination of bit rate and cable length.
7	Keep away cables from disturbing sources. If this cannot be avoided, double shielded wires are recommended.

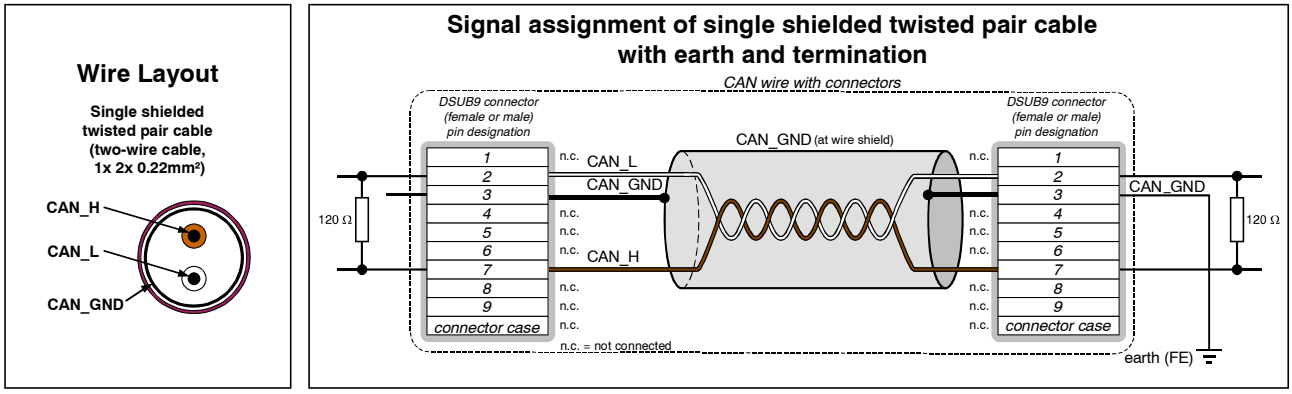


Figure 12: CAN wiring for light industrial environment

6.3.2 Cabling

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

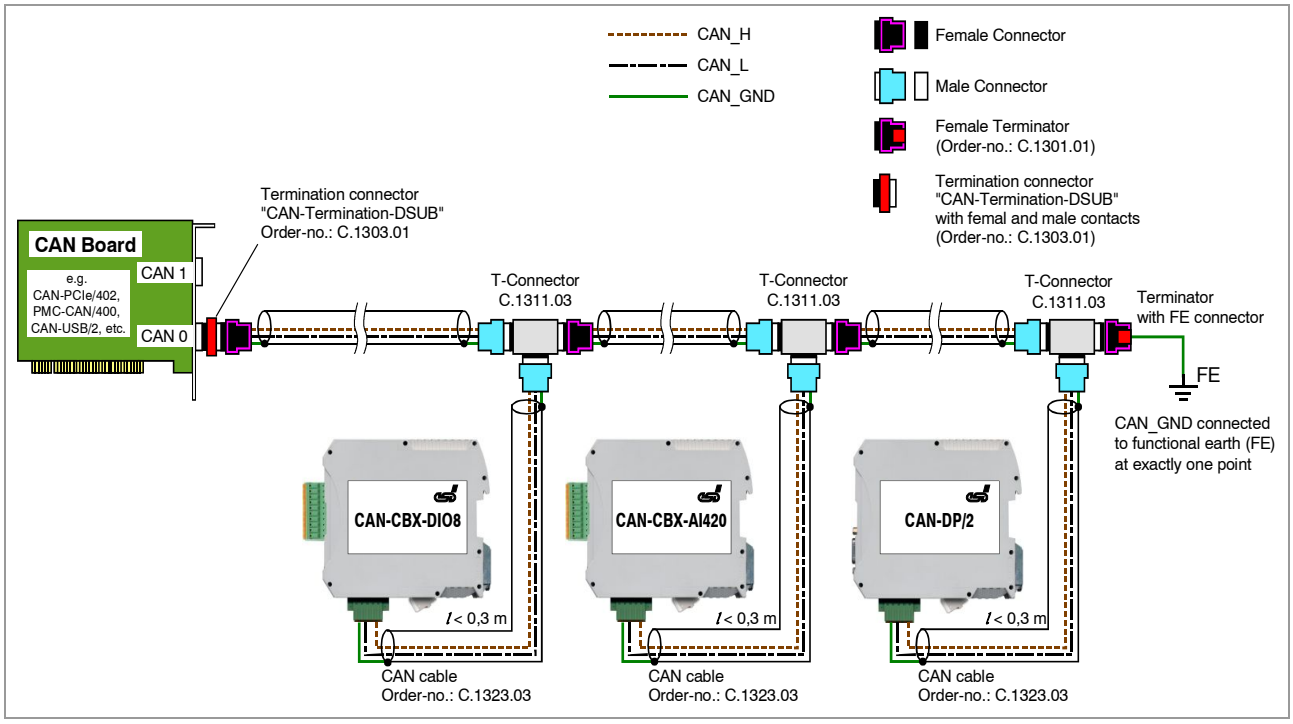


Figure 13: Example for proper wiring with single shielded single twisted pair wires

6.3.3 Termination

- A termination resistor has to be connected at both ends of the CAN bus.
  If an integrated CAN termination resistor which is equipped at the CAN interface at the end of the bus is connected, this one has to be used for termination instead of an external CAN termination plug.

- 9-pin DSUB-termination connectors with integrated termination resistor and male and female contacts (gender changer) are available from esd (order no. C.1303.01).

- DSUB termination connectors with male contacts (order no. C.1302.01) or female contacts (order no. C.1301.01) and additional functional earth contact are available, if CAN termination and grounding of CAN_GND is required.

6.4 Electrical Grounding

- For CAN devices with electrical isolation the CAN_GND must be connected between the CAN devices.
- CAN_GND should be connected to the earth potential (FE) at **exactly one** point of the network.
- Each *CAN interface with electrical connection to earth potential* acts as a grounding point. For this reason it is recommended not to connect more than one *CAN device with electrical connection to earth potential.*
- Grounding can be made e.g. at a termination connector (e.g. order no. C.1302.01 or C.1301.01).

6.5 Bus Length

Bit rate [Kbit/s]	Typical values of reachable wire length **with esd interface** l_{max} [m]	**CiA recommendations** (07/95) for reachable wire lengths l_{min} [m]
1000	37	25
800	59	50
666.6̄	80	-
500	130	100
333.3̄	180	-
250	270	250
166	420	-
125	570	500
100	710	650
83,3̄	850	-
66.6̄	1000	-
50	1400	1000
33.3̄	2000	-
20	3600	2500
12.5	5400	-
10	7300	5000

Table 4: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

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

NOTICE
Please note the recommendations of ISO 11898 regarding to the configuration of the cable cross-section in dependance of the cable length.

6.6 Examples for CAN Cables

esd recommends the following two-wire and four-wire cable types for CAN network design. These cable types are used by esd for ready-made CAN cables, too.

6.6.1 Cable for light industrial Environment Applications (Two-Wire)

Manufacturer	Cable Type
U.I. LAPP GmbH Schulze-Delitzsch-Straße 25 70565 Stuttgart Germany www.lappkabel.com	e.g. UNITRONIC ®-BUS CAN UL/CSA (1x 2x 0.22) (UL/CSA approved) Part No.: 2170260 UNITRONIC ®-BUS-FD P CAN UL/CSA (1x 2x 0.25) (UL/CSA approved) Part No.: 2170272
ConCab GmbH Äußerer Eichwald 74535 Mainhardt Germany www.concab.de	e. g. BUS-PVC-C (1x 2x 0.22 mm²) Order No.: 93 022 016 (UL appr.) BUS-Schleppflex-PUR-C (1x 2x 0.25 mm²) Order No.: 94 025 016 (UL appr.)

6.6.2 Cable for heavy industrial Environment Applications (Four-Wire)

Manufacturer	Cable Type
U.I. LAPP GmbH Schulze-Delitzsch-Straße 25 70565 Stuttgart Germany www.lappkabel.com	e.g. UNITRONIC ®-BUS CAN UL/CSA (2x 2x 0.22) (UL/CSA approved) Part No.: 2170261 UNITRONIC ®-BUS-FD P CAN UL/CSA (2x 2x 0.25) (UL/CSA approved) Part No.: 2170273
ConCab GmbH Äußerer Eichwald 74535 Mainhardt Germany www.concab.de	e. g. BUS-PVC-C (2x 2x 0.22 mm²) Order No.: 93 022 026 (UL appr.) BUS-Schleppflex-PUR-C (2x 2x 0.25 mm²) Order No.: 94 025 026 (UL appr.)

INFORMATION
Ready-made CAN cables with standard or custom length can be ordered from **esd**.

7. CAN Troubleshooting Guide

The CAN Troubleshooting Guide is a guide to find and eliminate the most frequent hardware-error causes in the wiring of CAN networks.

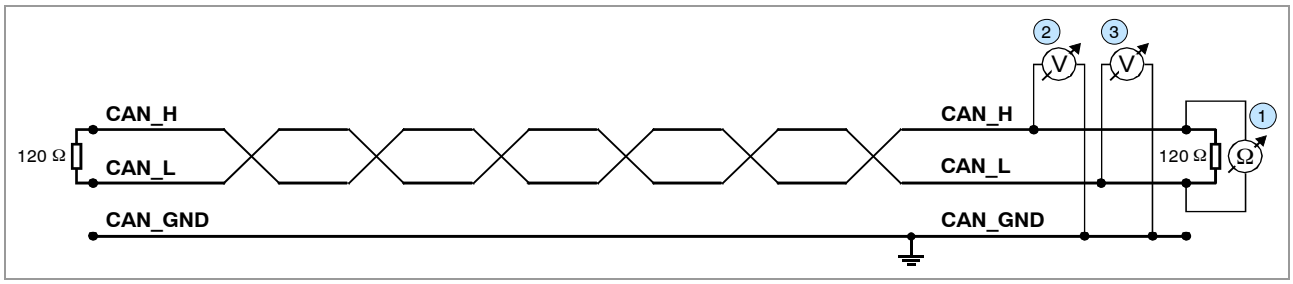


Figure 14: Simplified diagram of a CAN network

7.1 Termination

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

To test it ,please

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

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

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

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

7.2 Electrical Grounding

The CAN_GND of the CAN network should be connected to the functional earth potential (FE) at only **one** point. This test will check if the CAN_GND is grounded in several places.
To test it, please

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

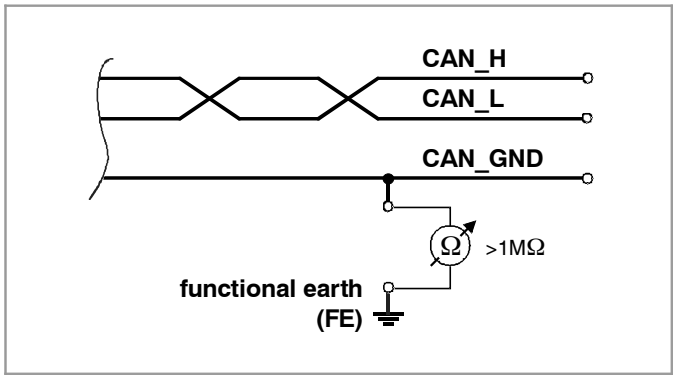


Figure 15: Simplified schematic diagram of ground test measurement

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

7.3 Short Circuit in CAN Wiring

A CAN bus might possibly still be able to transmit data if there is a short circuit between CAN_GND and CAN_L, but generally the error rate will increase strongly. Make sure that there is no short circuit between CAN_GND and CAN_L!

7.4 CAN_H/CAN_L-Voltage

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

To test for faulty transceivers, please

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

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

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

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

7.5 CAN Transceiver Resistance Test

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

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

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

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

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

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

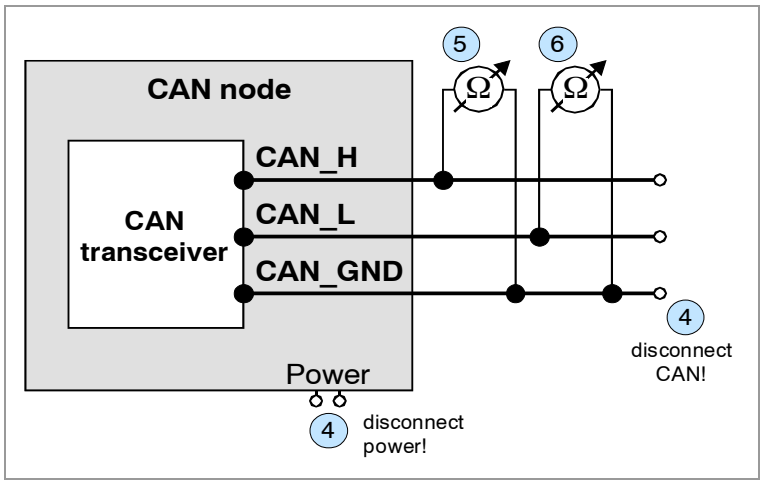


Figure 16: Measuring the internal resistance of CAN transceivers

7.6 Support by esd

If you have executed the fault diagnostic steps of this troubleshooting guide and you even can not find a solution for your problem our support department will be able to assist.
Please contact our support via email at **support@esd.eu** or by phone **+40-511-37298-130**.

8. Declaration of Conformity

EU-KONFORMITÄTSERKLÄRUNG
EU DECLARATION OF CONFORMITY

Adresse *Address*	**esd electronic system design gmbh** **Vahrenwalder Str. 207** **30165 Hannover** **Germany**

esd erklärt, dass das Produkt *esd declares, that the product*	Typ, Modell, Artikel-Nr. *Type, Model, Article No.*
PMC-CAN/331/-3.3-1 1x CAN	**C.2039.01**
PMC-CAN/331/-3.3-2 2x CAN	**C.2039.02**
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-K00-0332-08**
Das Produkt entspricht damit der EU-Richtlinie „EMV" *Therefore the product conforms to the EU Directive 'EMC'*	**2014/30/EU**
Das Produkt entspricht der EU-Richtlinie „RoHS" *The product conforms to the EU Directive 'RoHS'*	**2011/65/EU**

Diese Erklärung verliert ihre Gültigkeit, wenn das Produkt nicht den Herstellerunterlagen entsprechend eingesetzt und betrieben wird, oder das Produkt abweichend modifiziert wird.
This declaration loses its validity if the product is not used or run according to the manufacturer's documentation or if non-compliant modifications are made.

Name / *Name*	T. Ramm
Funktion / *Title*	CE-Koordinator / *CE Coordinator*
Datum / *Date*	Hannover, 2015-11-19

Thorsten Ramm

Rechtsgültige Unterschrift / *authorized signature*

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9. Order Information

Type	Description	Order No.
PMC-CAN/331-3.3-1	1x CAN network (ISO 11898-2), signalling voltage 3.3V or 5V, power supply voltage 3.3V and 5V	C.2039.01
PMC-CAN/331-3.3-2	2x CAN network (ISO 11898-2), signalling voltage 3.3V or 5V, power supply voltage 3.3V and 5V	C.2039.02
CAN layer 2 drivers for Windows and Linux are included in delivery.		
Adapter:		
CAN-ADA-DN	DeviceNet adapter, CAN-TTL-signals at DeviceNet interface, TTL-signals of the second CAN interface can be connected through	C.2012.25
CAN-ADA-ISO11898	CAN adapter, CAN-TTL signals at CAN interface with DSUB9 connector (ISO11898), TTL-signals of the second CAN interface can be connected through	C.2012.26
CAN-PHYSLAY-HSP	CAN-TTL signals at CAN interface with DSUB9 connector (ISO11898)	C.1201.01
Software:		
CAN-layer 2 object licences including CD-ROM: CAN-DRV-LCD RTX CAN-DRV-LCD VxWorks CAN-DRV-LCD QNX		 C.1101.35 C.1101.55 C.1101.32
CANopen object licences including CD-ROM: CANopen-DRV-LCD Windows/Linux CANopen-DRV-LCD RTX CANopen-DRV-LCD VxWorks CANopen-DRV-LCD QNX		 C.1101.06 C.1101.16 C.1101.18 C.1101.17
J1939 Stack for esd CAN hardware: J1939 stack for Windows (object code) J1939 stack for Linux (object code) J1939 Stack for RTX (object code)		 C.1130.10 C.1130.11 C.1130.12
For detailed information about the driver availability for your operating system, please contact our sales team.		

PDF Manuals
Manuals are available in English and usually in German as well. For availability of English manuals see table below.
Please download the manuals as PDF documents from our esd website www.esd.eu for free.

Manuals		Order No.
PMC-CAN/331-3.3-ME	Hardware manual in English for C.2039.01 and C.2039.02	C.2039.21
CAN-API-ME	NTCAN-API manual 1/2: Application Developers Manual NTCAN-API manual 2/2: Installation Guide	C.2001.21
CANopen-ME	CANopen manuals in English	C.2002.21

Table 5: 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.