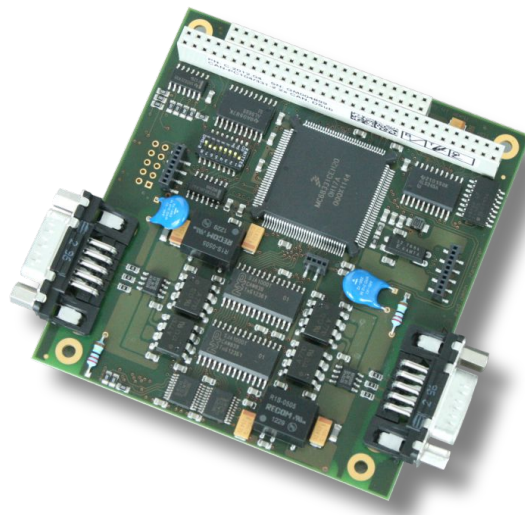




CAN-PC104/200

Passive CAN-PC104-CAN Interface



Hardware Installation and Technical Data

to Product C.2013.04



NOTE

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This manual contains important information and instructions on safe and efficient handling of the CAN-PC104/200. 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
1.6	2.1	Address range corrected.	2005-02-07
	3.6	Header in code example corrected.	
1.7	-	Safety Information inserted	2015-12-07
	1.1, 4.3	CAN controller 82527 and 81C91-versions and no longer applicable	
	1., 4.2	CAN-TTL-connector deleted,	
	2.2	Chapter revised	
	3.	Chapter revised	
	4.4	Chapter revised	
	-	CAN-TTL connector X402 not equipped, chapter 5.2 deleted	
	-	DeviceNet option no longer applicable, chapter 5.3 deleted	
	-	MicroMatch version deleted (chapter)	
	6.,7.	Chapters revised	
8.	Chapter "Order Information" moved and revised		

Technical details are subject to change without further notice.

Classification of Warning Messages and Safety Instructions

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



This is the safety alert symbol.

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

DANGER, WARNING, CAUTION

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



DANGER

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



WARNING

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



CAUTION

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

NOTICE

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



NOTICE

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



NOTICE

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

INFORMATION



INFORMATION

Notes to point out something important or useful.



Safety Instructions

- When working with the CAN-PC104/200 follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-PC104/200 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 CAN-PC104/200 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 CAN-PC104/200 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 CAN-PC104/200 from dust, moisture and steam.
- Protect the CAN-PC104/200 from shocks and vibrations.
- The CAN-PC104/200 may become warm during normal use. Always allow adequate ventilation around the CAN-PC104/200 and use care when handling.
- Do not operate the CAN-PC104/200 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 CAN-PC104/200 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 11 *before* you touch the CAN-PC104/200, 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.

Intended Use

The intended use of the CAN-PC104/200 is the operation as PC/104-CAN-Interface.

The guarantee given by esd does not cover damages which result from improper use, usage not in accordance with regulations or disregard of safety instructions and warnings.

- The CAN-PC104/200 is intended for indoor installation only.
- The operation of the CAN-PC104/200 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-PC104/200 for medical purposes is prohibited.

Service Note

The CAN-PC104/200 does not contain any parts that require maintenance by the user. The CAN-PC104/200 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.

Number Representation

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

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1. Overview

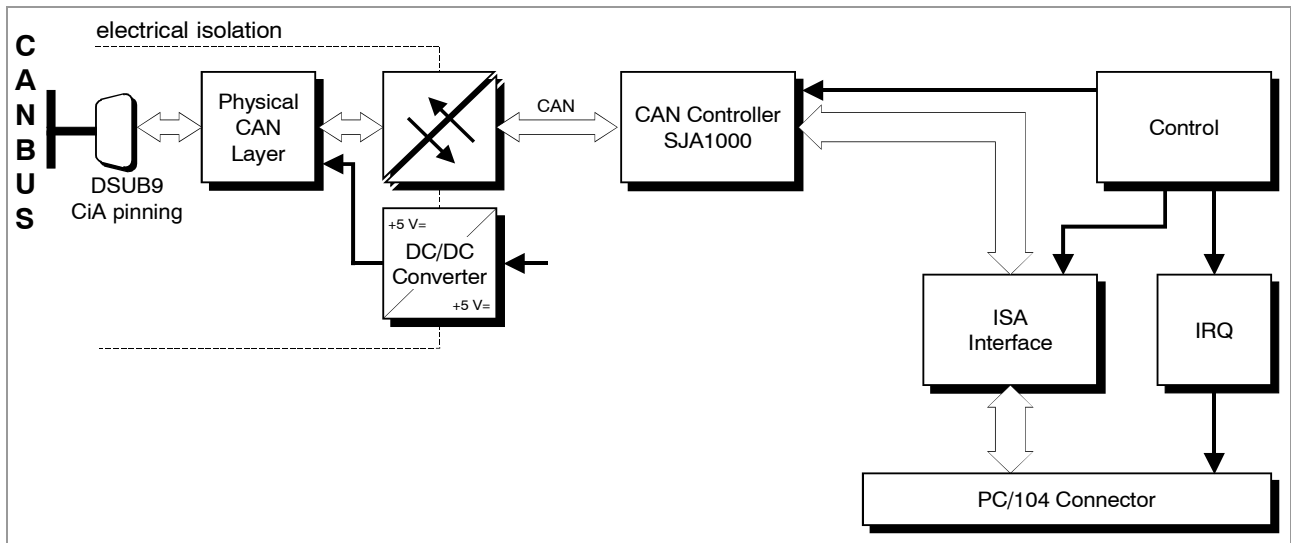


Figure 1: Block circuit diagram of CAN-PC104/200

The CAN-PC104/200 board is a CAN-module for the PC/104-bus (PC/104, 8 bit). It uses a SJA1000 CAN controller. The module can be operated in FULL- or BASIC-CAN.

The CAN-interface is ISO11898-compliant and allows a maximum data-transfer rate of 1 Mbit/s. The bit rate, like many other properties of the CAN-interfaces, can be set by means of software. The CAN-interface is electrically insulated from other potentials by means of optocouplers and DC/DC-converters.

1.1 PCB View with Connectors

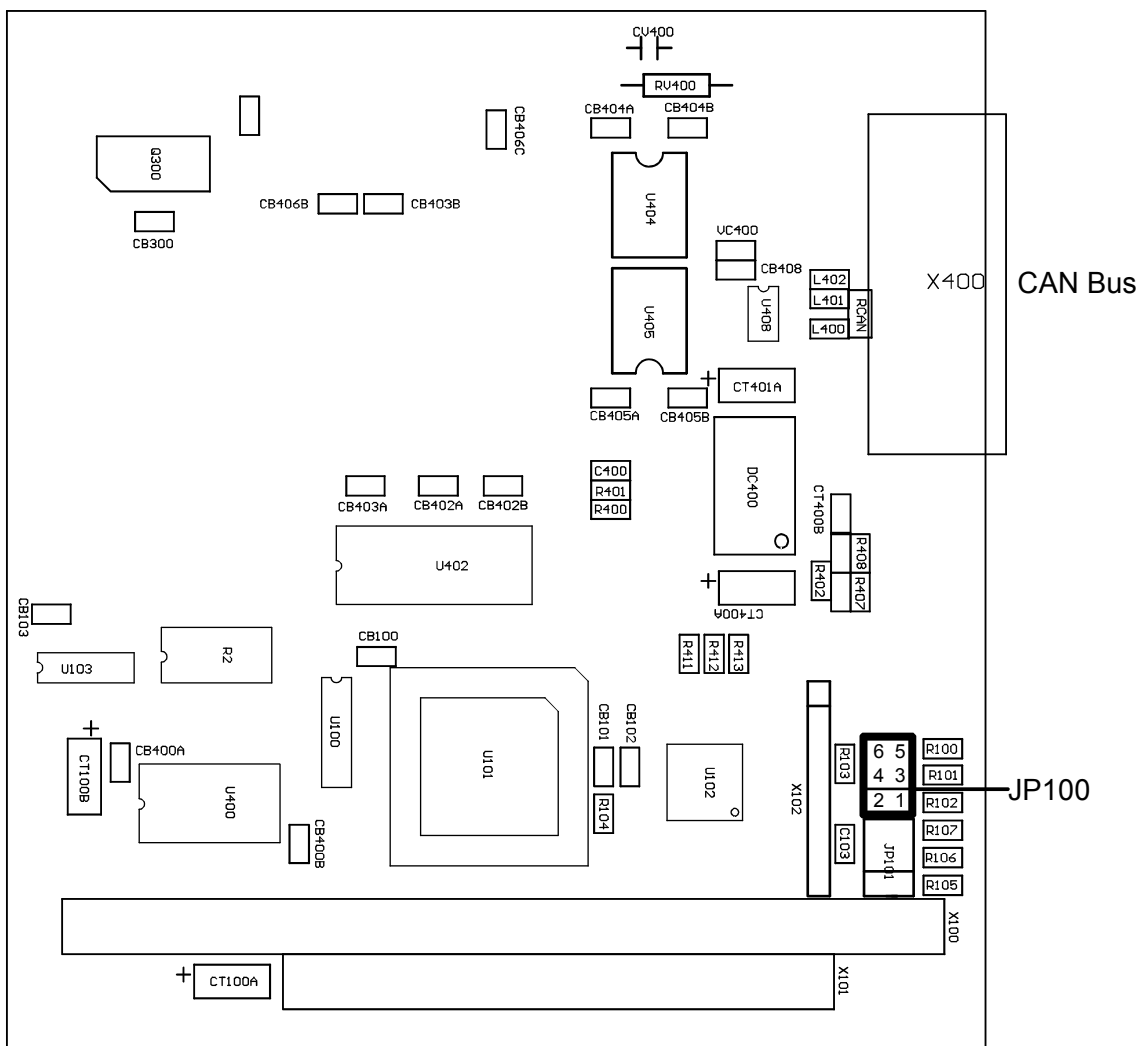


Figure 2: PCB top view

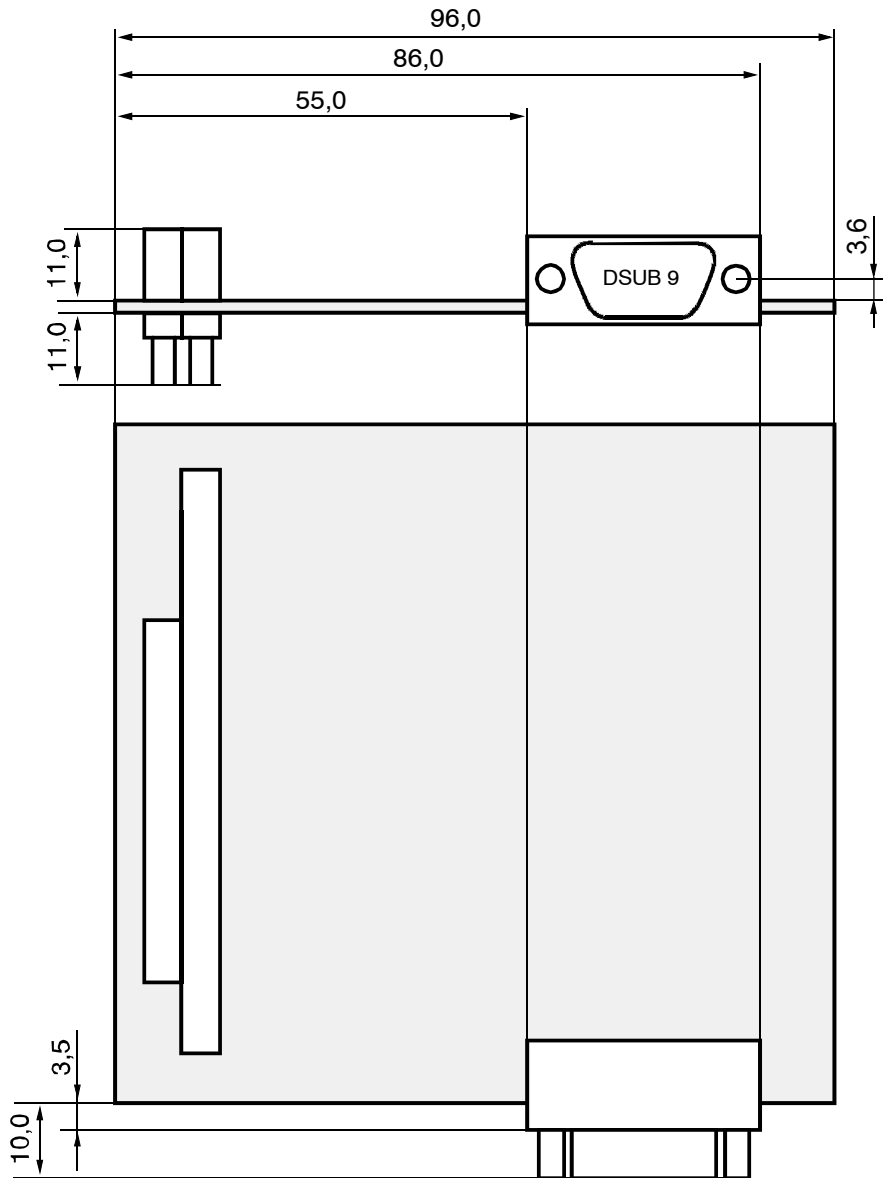


NOTICE

Read chapter “Hardware Installation” on page 11, before you start with the installation of the hardware!

See also page 20 for signal assignment of the connectors.

1.2 Connector Position and Board Dimensions



All listed values are in millimetres.

Figure 3: CAN-PC104/200 technical drawing

2. Hardware Installation

2.1 Before Starting Hardware Installation

During the hardware installation it may be necessary to change the PC/104-I/O-port address. The default address is **0x1E8...0x1E7**. The CAN module covers 8 data bytes. Furthermore it is necessary to set the interrupt during the following software installation.

The interrupt has to be set by software. There are no jumpers or switches to set the interrupt. The interrupt setting is described in the installation chapter in the software manual.

Make sure that there will be no address conflict with other boards of the PC/104-systems and that there will be no conflict with other interrupts!

Windows NT/2000/XP Users:

In order to avoid address and interrupt conflicts, the used address ranges should be checked before starting the hardware installation.

This can be done in Windows NT 4.0 e.g. by selecting *Programs/Administrative Tools (Common)/Windows NT Diagnostics*. In the dialogue box *Windows NT Diagnostics* call *Resources* and there select *I/O Port*. A list with the used and available address ranges appears.

Make sure that the default value of the CAN-PC104/200 is in a free memory area. If it is not, note one free memory area (which corresponds to the choices stated in Figure 4 on page 13) and change the CAN-PC104/200 address by means of the jumper field during the hardware installation described below.

In the same dialogue box call *Interrupts*. A list with the used interrupt lines appears. Note a free interrupt, because you have to select an interrupt for the CAN module during the software installation. (The complete **software** installation sequence is described in the software manual 'NTCAN-API, Part 2: Installation Guide'.)

Windows 9x/ME Users:

If you use a Windows 9x/ME operating system **first read the software installation guide** in the appendix of the manual 'NTCAN API, Part 2: Installation Guide' and then start with the installation sequence!

2.2 Installing the Hardware and Setting the PC/104-Bus Address

The CAN-PC104/200 module can be used in all PC/104-compatible systems (e.g. portable industry PCs or fixed control plants). The carrier system will therefore be described by the general term 'computer' below.



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 CAN-PC104/200 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 CAN-PC104/200, because your clothes might be electrostatically charged as well.

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 if not yet done.
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. Remove the computer cover.
5. Select a free position in the PC/104-bus stack.
There are no restrictions in choosing a position in the stack for this module as long as there are only 16-bit modules between it and the CPU.
6. Make sure that there will be no address conflict with other PC/104 boards. (See chapter 'Before Starting Hardware Installation' above.)

If you have to change the address of the board, go on with step 7 otherwise go on with step 8.

7. Setting the PC/104-bus-I/O-port address

The address is set via the jumper JP100. Next to it is the jumper field JP101, which is *not* being evaluated. The position of the jumper fields can be taken from figure 2 on page 9.

jumper pins:	5	3	1
	O	O	O
address selection bits:	S2	S1	S0
jumper pins:	O	O	O
	6	4	2

Table 1: Jumper field JP100 (As seen on component layer, CAN-bus connectors pointing to the top)

The hardware address has to be given to the driver during the software installation. The menu of the Windows NT installation program offers a choice of the following addresses:

Address Range	Jumper JP100
reserved	
0x100 - 0x107 HEX	
0x1E0 - 0x1E7 HEX	
0x1E8 - 0x1EF HEX (default setting)	
0x250 - 0x257 HEX	
0x2A0 - 0x2A7 HEX	
0x390 - 0x397 HEX	
0x3F0 - 0x3F7 HEX	

Figure 4: Choices of addresses supported by the installation program

All other jumper combinations are not being supported by the installation program.

If you are working with Windows 9x/ME, you have to set the jumpers as proposed by the Windows-Hardware Wizard.

8. Install the CAN module at the selected PC/104-stack position.
9. Close the computer case.

Hardware Installation

10. Connect the CAN wire.

Please note that the CAN bus 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 correct wiring of CAN networks (see from page 25)!

The CAN interface is connected via the DSUB connector (X400).

11. Connect the computer to mains again (mains connector or safety fuse).

12. Switch on the power supply of the computer, the peripheral devices and the other CAN devices again.

13. End of hardware installation.

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

3. Accessing the Controllers

3.1 Introduction

This chapter describes the addresses and registers of the CAN-controller on the board.

The information given here is only important for programmers who do *not* use the driver software available from esd for the module!

3.2 Address Range

The address range for the access to individual controller is eight bytes. The basis address can be set by means of jumpers. Access to individual controllers is controlled by different offsets for this basis address. The following functions have been assigned to the individual offsets:

- 0 : (CS-C0) generating the chip-select signal for controller 0 (SJA1000)
- 1 : (ALE) generating the address-latch signal for controllers 0 (and 2)
- 2 : not assigned
- 3 : (IRQ) setting the IRQ
- 4 : (CS-C1) not applicable (generating the chip-select signal for controller 1 (82527))
- 5 : (CS-C2) not applicable (generating the chip-select signal for controller 2 (SAE81C91))
- 6 : not assigned
- 7 : (ALE+Hold) not applicable (generating the address-latch signal for controller 1 (82527))

3.3 Access Sequence

The controller has the register access split into two cycles. This can be seen in an I/O-action which is generally divided into two (output: write twice / input: write read) operations.

When accessing the controller for the first time, the register address has to be specified as date in the controller. By writing this date in a certain offset for the basis address of the board, 'ALE' is signalled to the controllers and the data is therefore stored as address in the controller.

During the second access the register contents are transferred as date. This, again, is made via a certain controller-specific offset for the basis address of the board. This offset accesses the controller via its 'CS' signal.

3.4 Setting the Board Interrupt

A special feature is the selection of the board interrupt to be used. By means of offset '3' information about the IRQ-number and activation or deactivation of the IRQs can be stored in a latch on the board. This latch has got a bit-by-bit access. With a fictitious write date on the latch bits 0...2 and bit 7 are important. Bits 0...2 in the date select one of the bits in the latch. Bit 7 in the date contains the value of the selected bit in the latch. The bits in the latch have got the following meaning:

- 0: (L0) *selection nibble for IRQ*
- 1: (L1) “
- 2: (L2) “
- 3: (L3) “
- 4: not used
- 5: not used
- 6: activate selection
- 7: change IRQ-output from Tri-state into driven status

By means of *Selection nibble* one from ten IRQs within the PC104 PC can be selected:

L3	L2	L1	L0	IRQ
0	0	0	0	free
0	0	0	1	free
0	0	1	0	free
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	free
0	1	1	1	7
1	0	0	0	free
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	free
1	1	1	0	14
1	1	1	1	15

Table 2: Selecting the interrupt

3.5 Examples

The C-code extracts shown below represent examples for write or read accesses and IRQ-settings:

SJA1000:

```
void canOut
(
  int reg,
  int value
)
{
  outp(canIoPort+1,reg);
  outp(canIoPort+0,value);
}

int canInp
(
  int reg
)
{
  outp(canIoPort+1,reg);
  return (inp (canIoPort+0));
}
```

Activate IRQ:

```
il = level;
for (i=0;i<4;i++)
{
  stat=i;
  if (il & 0x01)
  {
    stat |= 0x80;
  }

  outp (canIoPort+3,stat);
  il=il>>1;
}
outp (canIoPort+3,0x87);
outp (canIoPort+3,0x86);
```

Deactivate IRQ :

```
(delete selection completely)

outp (canIoPort+3,0x07);
outp (canIoPort+3,0x06);

for (i=0;i<4;i++)
  outp (canIoPort+3,i);
```

4. Technical Data

4.1 General Technical Data

Ambient temperature	0...50°C
Humidity	90 %, non-condensing
Power Supply	via PC/104-bus, nominal voltage: 5 V ±5%, current (20°C, all CAN controllers equipped): $I_{TYP} = 250 \text{ mA}$
Connectors	X100 (64-pole PC/104 PCB connector) - PC/104 bus X101 (40-pole PC/104 PCB connector) - PC/104 bus X400 (DSUB9/male) - CAN interface 1 (ISO11898) The following connectors are only equipped for programming and service: X102 (8-pole male connector) - ISP programming
Dimensions	95.9 mm x 90.2 mm
Weight	< 150 g

Table 3: General technical data

4.2 PC/104 Bus

Host bus	PC/104
PC/104-data bus	8 bit
Interrupt	1 out of 12
Connectors	PC/104 PCB connectors, 40-pole and 64-pole

Table 4: PC/104 bus data

4.3 CAN Interface

Number	1 CAN interface
CAN controller	SJA1000
CAN protocol	Basic- or Full-CAN
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
Electrical isolation of the CAN interface from other units	separation of CAN interfaces from each other and from PC/104-bus potentials by optocouplers and DC/DC converters


Table 5: Data of the CAN interface

4.4 Software Support

Software drivers are available for Windows®, Linux®, VxWorks® and QNX® systems. Other drivers are available on request.

CANopen® and J1939 protocol libraries are available.

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

	<p>INFORMATION</p> <p>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):</p> <p>“NTCAN-API Part 1: Application Developers manual” and “NTCAN-API Part 2: Installation Guide”</p>
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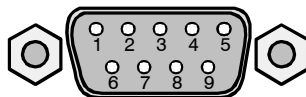
A few basic C-program codes are contained for initialization, setting the bit rate and for CAN-read and write accesses.

5. Connector Pin Assignment

5.1 CAN Interface at DSUB9 (X400)

Device connector: 9-pin DSUB connector, male

Pin Position:



Pin Assignment:

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

Signal Description:

CAN_L, CAN_H ... CAN signal lines

CAN_GND ... reference potential of the local CAN physical layer

Shield ... shielding (connected with the case of the 9-pin DSUB connector)

reserved ... reserved for future applications, do not connect!

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 observed.

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 Light Industrial Environment (*Single Twisted Pair Cable*)

6.2.1 General Rules

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 $120 \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22 \text{ mm}^2$) 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 <ul style="list-style-type: none"> • 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 $120 \Omega \pm 10\%$) 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.

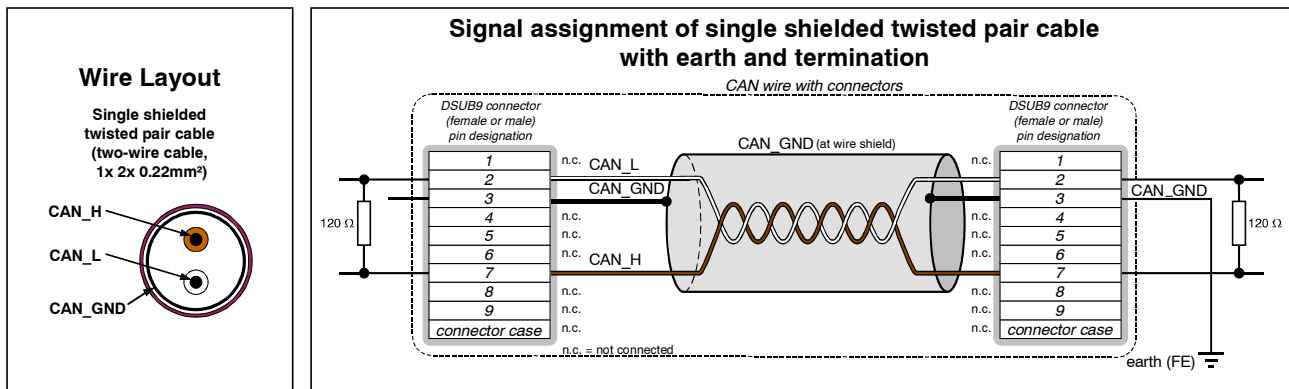


Figure 5: CAN wiring for light industrial environment

6.2.2 Cabling

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

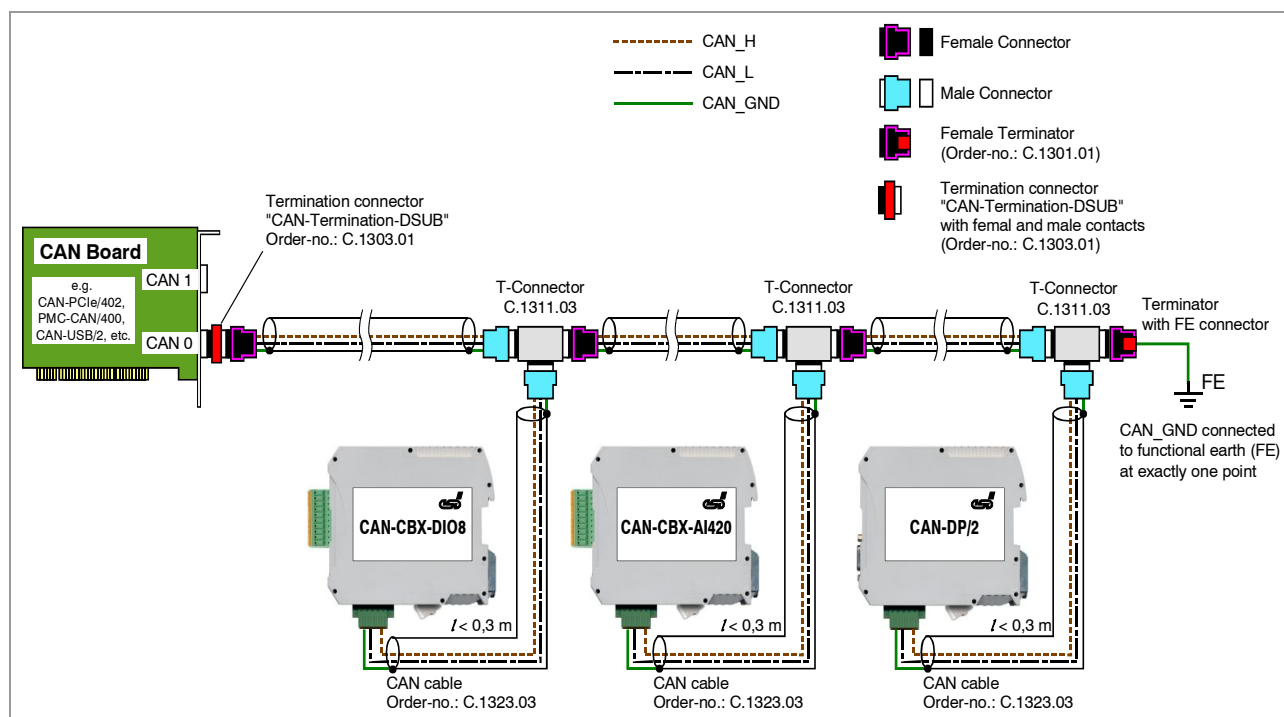


Figure 6: Example for proper wiring with single shielded single twisted pair wires

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).
- 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.

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

6.3.1 General Rules

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

1	A cable type with a wave impedance of about $120 \Omega \pm 10\%$ with an adequate conductor cross-section ($\geq 0.22 \text{ mm}^2$) 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 <ul style="list-style-type: none"> • 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 $120 \Omega \pm 10\%$) 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 can not be avoided, double shielded cables are recommended.

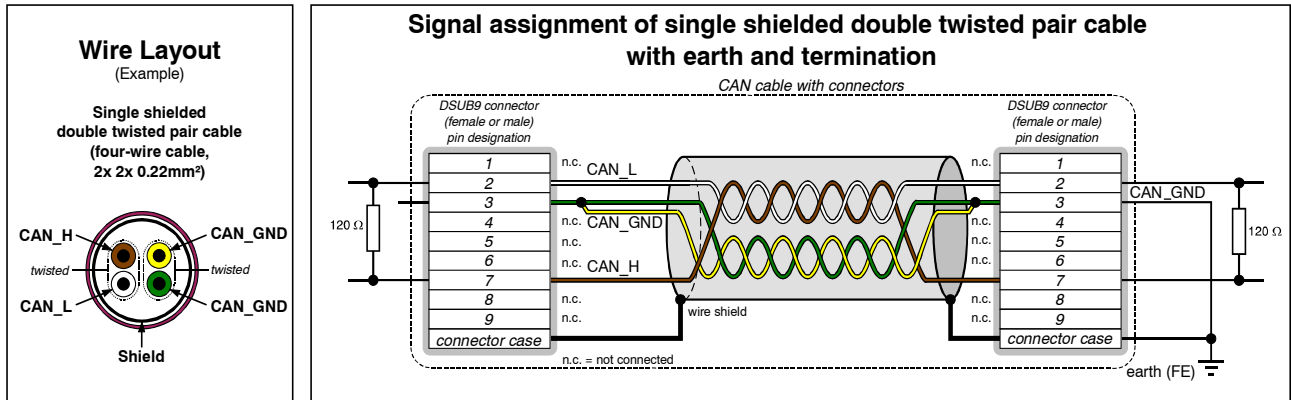


Figure 7: CAN wiring for heavy industrial environment

6.3.2 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!

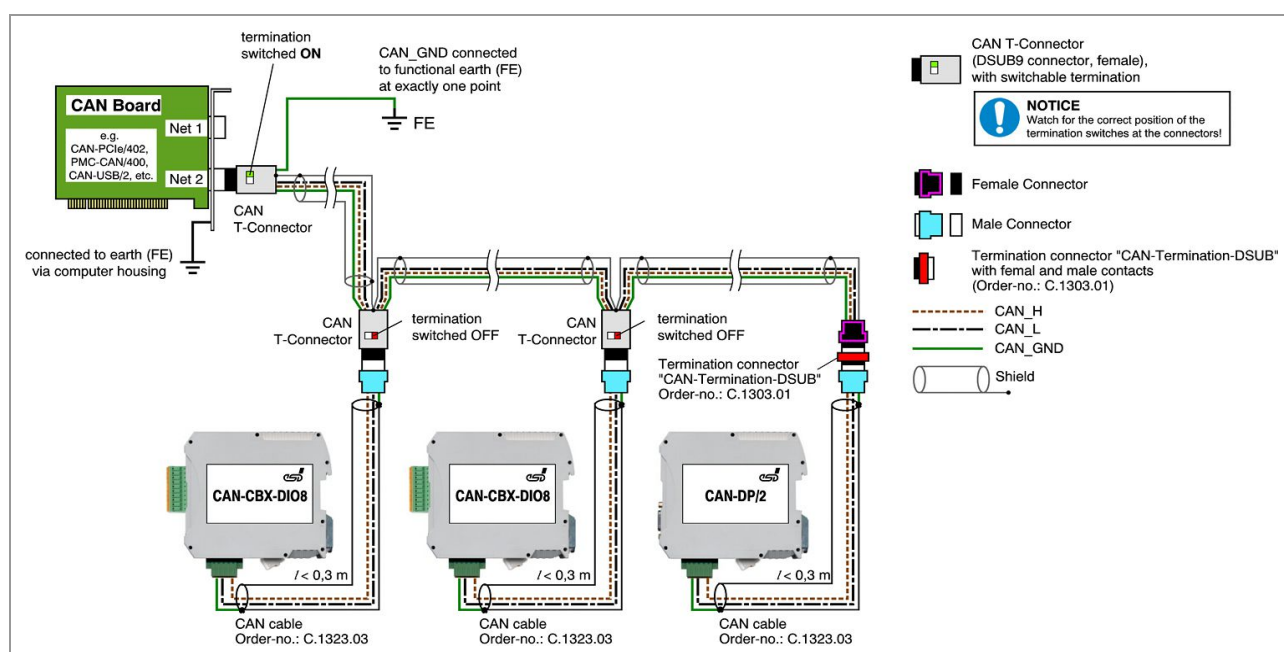


Figure 8: Example of proper wiring with single shielded double twisted pair cables

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).
- 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).

6.4 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 I_{max} [m]	CiA recommendations (07/95) for reachable wire lengths I_{min} [m]
1000	37	25
800	59	50
666.6	80	-
500	130	100
333.3	180	-
250	270	250
166	420	-
125	570	500
100	710	650
83.3	850	-
66.6	1000	-
50	1400	1000
33.3	2000	-
20	3600	2500
12.5	5400	-
10	7300	5000

Table 6: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

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

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 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**.

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.

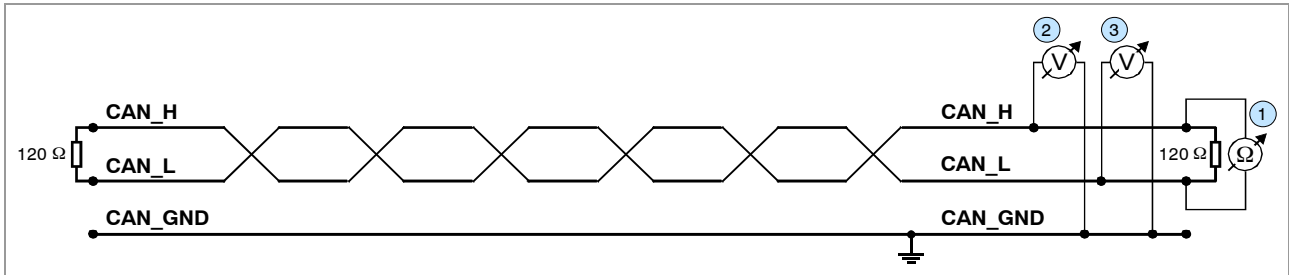


Figure 9: Simplified diagram of a CAN network

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.

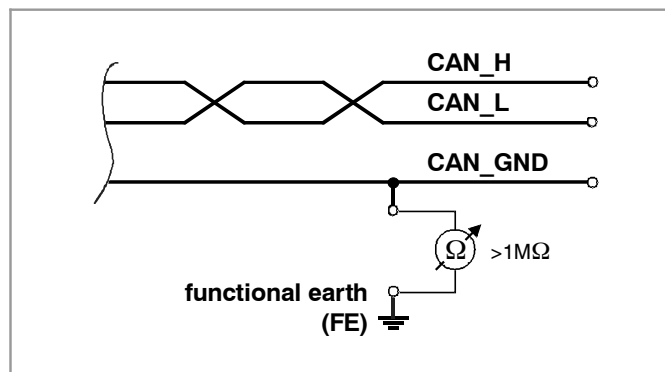


Figure 10: Simplified schematic diagram of ground test measurement

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.

CAN Troubleshooting Guide

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 k Ω 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 %).

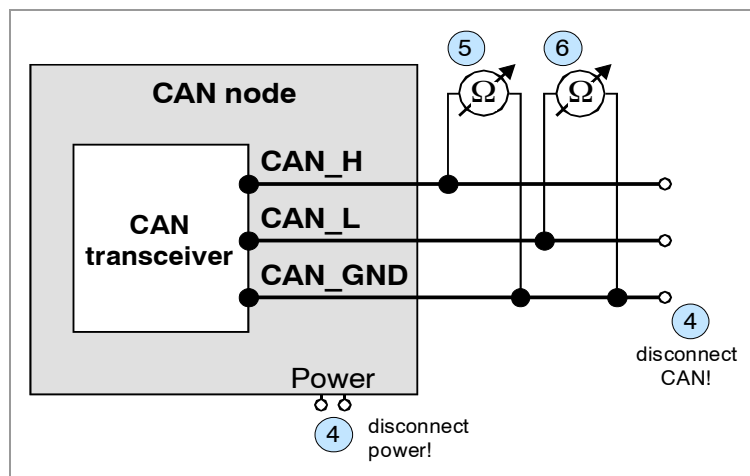


Figure 11: Measuring the internal resistance of CAN transceivers

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. Order Information

Type	Description	Order No.
CAN-PC104/200 1xCAN2.0A/B-Phil	CAN-PC104/200 Passive PC104 to CAN Interface Board with Philips SJA1000 CAN Controller, - 1 CAN 2.0A/B-Interface - Physical Layer according to ISO11898, electrically isolated	C.2013.04
CAN layer 2 drivers for Windows and Linux are included in delivery.		
Software:		
CAN-layer 2 object licences including CD-ROM: CAN-DRV-LCD VxWorks CAN-DRV-LCD QNX		C.1101.55 C.1101.32
CANopen object licences including CD-ROM: CANopen-DRV-LCD Windows/Linux CANopen-DRV-LCD VxWorks CANopen-DRV-LCD QNX		C.1101.06 C.1101.18 C.1101.17
J1939 Stack for esd CAN hardware: J1939 stack for Windows (object code) J1939 stack for Linux (object code)		C.1130.10 C.1130.11
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.
CAN-PC104/200-ME	Hardware manual in English	C.2013.21
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 7: 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.